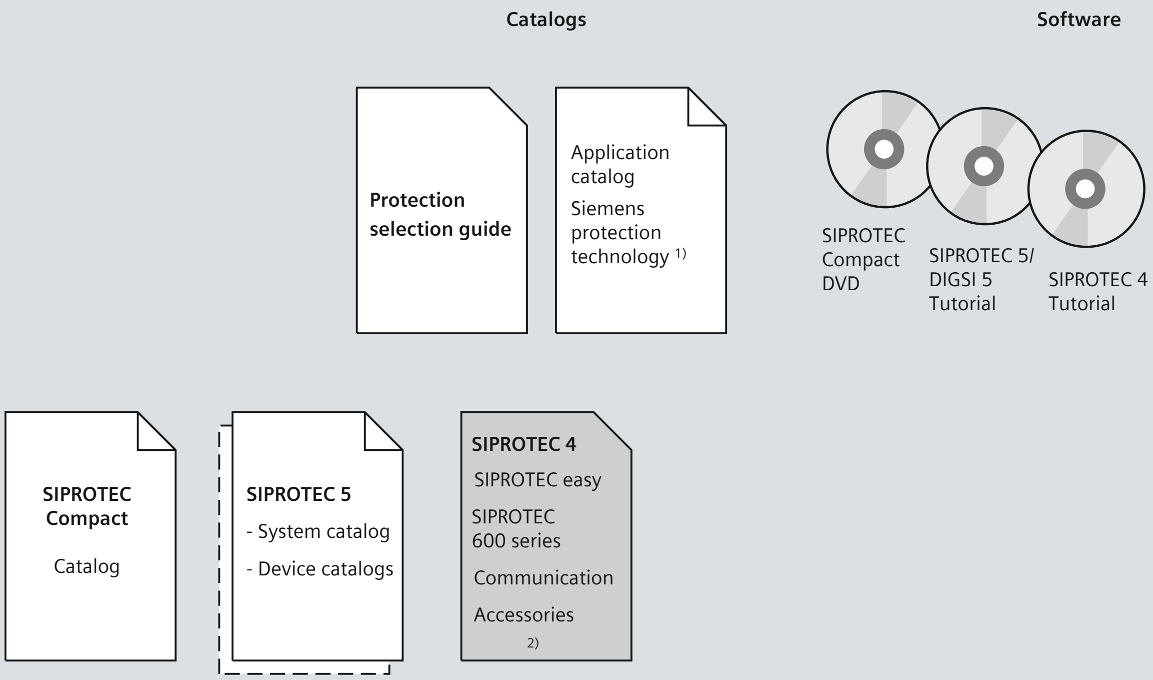
SIEMENS

Protection Systems

SIPROTEC 4, SIPROTEC easy, SIPROTEC 600 Series, Communication, Accessories

Catalog SIP · Edition No. 6

Answers for infrastructure.



[1] In preparation

[2] only in English

Overview of Siemens protection catalogs

SIPROTEC 4, SIPROTEC series 600, SIPROTEC easy, communication and accessories:
This catalog describes the features of the device series SIPROTEC 4, SIPROTEC series 600 and SIPROTEC easy, as well as their devices. In further chapters, the accessories of the complete SIPROTEC family for communication, auxiliary relays and test equipment are described.

Application catalog – Siemens protection technology:
This catalog gives an overview of the features for the complete Siemens protection system family, and describes typical protection applications and communication solutions. Furthermore it contains practical configuring aids for, e.g., instrument transformer layouts.

Protection selection guide:
The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

SIPROTEC Compact catalog:
The SIPROTEC Compact catalog describes the features of the SIPROTEC Compact series and presents the available devices and their application possibilities.

SIPROTEC 5 catalogs:
The system catalog describes the features of the SIPROTEC 5 system. The SIPROTEC 5 device catalogs describe device-specific features such as scope of functions, hardware and application.

SIEMENS

SIPROTEC 4, SIPROTEC easy, SIPROTEC 600 Series, Communication, Accessories

Contents

Catalog SIP · Edition No. 6

Supersedes Catalog SIP · 2008

Product Index

Product Index

Product Selection

Relay Selection Guide

	Device application			Distance protection							Line differential protection							
			Device family	SIPROTEC 4				SIPROTEC 5			SIPROTEC 600 Series	SIPROTEC Compact	SIPROTEC 4		SIPROTEC 5			
ANSI	Functions	Abbr.	Type	7SA522	7SA61	7SA63	7SA64	7SA84 1)	7SA86 1)	7SA87 1)	7SD60	7SD80	7SD610	7SD5	7SD84 1)	7SD86 1)	7SD87 1)	
	Protection functions for 3-pole tripping	3-pole		■	■	■	■	■	■	■	■	■	■	■	■	■	■	
	Protection functions for 1-pole tripping	1-pole		●	●	●	●	–	–	■	–	–	●	●	–	–	■	
14	Locked rotor protection	$I>$ + $V<$		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
21	Distance protection	$Z<$		■	■	■	■	■	■	■	–	–	–	●	–	–	–	
FL	Fault locator	FL		■	■	■	■	■	■	■	–	–	–	●	■	■	■	
24	Overexcitation protection	V/f		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
25	Synchrocheck, synchronizing function	Sync		●	●	●	●	●	●	●	–	–	–	–	●	●	●	
27	Undervoltage protection	$V<$		●	●	●	●	●	●	●	–	●	●	●	●	●	●	
27TN/59TN	Stator ground fault 3rd harmonics	$V0<,>$(3rd Harm.)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
32	Directional power supervision	$P>$, $P<$		■	■	■	■	●	●	●	–	–	■	■	●	●	●	
37	Undercurrent, underpower	$I<$, $P<$		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
38	Temperature supervision	θ>		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
40	Underexcitation protection	$1/X_D$		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
46	Unbalanced-load protection	$I2>$		–	–	–	–	●	●	●	–	–	–	–	●	●	●	
47	Phase-sequence-voltage supervision	LA, LB, LC		■	■	■	■	■	■	■	–	–	–	–	■	■	■	
48	Start-time supervision	I^2_{start}		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
49	Thermal overload protection	θ, I^2t		–	■	■	■	●	●	●	–	■	■	■	●	●	●	
50	Definite time-overcurrent protection	$I>$		■	■	■	■	■	■	■	●	■	■	■	■	■	■	
50Ns	Sensitive ground-current protection	$I_{Ns}>$		●	●	●	●	●	●	●	–	–	–	●	●	●	●	
50L	Load-jam protection	$I>_L$		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
50BF	Circuit-breaker failure protection	CBFP		●	●	●	●	●	●	●	●	■	■	■	●	●	●	
51	Inverse time-overcurrent protection	I_P		■	■	■	■	■	■	■	–	■	■	■	■	■	■	
55	Power factor	cos φ		■	■	■	■	■	■	■	–	–	■	■	■	■	■	
59	Overvoltage protection	$V>$		●	●	●	●	●	●	●	–	●	●	●	●	●	●	
59R, 27R	Rate-of-voltage-change protection	dV/dt		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
64	Sensitive ground-fault protection (machine)			–	–	–	–	–	–	–	–	–	–	–	–	–	–	
66	Restart inhibit	I^2t		–	–	–	–	–	–	–	–	–	–	–	–	–	–	
67	Directional overcurrent protection	$I>, < (V,I)$		●	●	●	●	●	●	●	–	●	■	–	●	●	●	

■ = basic ● = optional (additional price) – = not available

1) in preparation
2) via CFC
More functions on page 1/6

	Combined line differential and distance protection		Overcurrent and feeder protection/ feeder automation												Generator and motor protection			Transformer protection			Busbar protection	
	SIPROTEC 5		SIPROTEC easy		SIPROTEC 600 Series		SIPROTEC Compact			SIPROTEC 4				SIPROTEC 5	SIPROTEC Compact	SIPROTEC 4		SIPROTEC 4			SIPROTEC 600 Series	SIPROTEC 4
	7SL86 1)	7SL87 1)	7SJ45	7SJ46	7SJ600	7SJ602	7SJ80	7SJ81	7SC80 1)	7SJ61	7SJ62	7SJ63	7SJ64	7SJ86 1)	7SK80	7UM61	7UM62	7UT612	7UT613	7UT63	7SS60	7SS52
	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	–	■	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	■	–
	–	–	–	–	–	–	–	–	–	●	●	●	●	–	■	●	●	–	–	–	–	–
	■	■	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
	■	■	–	–	–	–	●	–	●	–	●	●	●	●	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	●	●	–	–
	●	●	–	–	–	–	●	–	–	–	●	–	●	●	–	–	–	–	–	–	–	–
	●	●	–	–	–	–	●	–	●	–	●	●	●	●	●	■	■	–	●	●	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
	●	●	–	–	–	–	●	–	●	–	●	–	●	●	●	●	●	–	●	●	–	–
	–	–	–	–	–	■	■	■	–	■	■	■ 2)	■	■ 2)	■	●	●	–	–	–	–	–
	–	–	–	–	–	●	–	–	–	●	●	●	●	–	■	●	●	●	●	●	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–
	●	●	–	–	■	■	■	■	■	■	■	■	■	■	■	●	●	■	■	■	–	–
	■	■	–	–	–	–	●	–	–	■	■	■	■	■	●	■	■	■	■	■	–	–
	–	–	–	–	–	–	–	–	–	●	●	●	●	–	■	●	●	–	–	–	–	–
	●	●	–	–	■	■	■	■	–	■	■	■	■	■	■	■	■	●	●	●	–	–
	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	–	●
	●	●	–	–	–	●	●	●	–	●	●	●	●	–	●	■	■	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	●	●	●	●	–	■	–	–	–	–	–	–	–
	●	●	–	–	■	■	■	■	■	■	■	■	■	●	■	–	–	●	●	●	–	■
	■	■	■	■	■	■	■	■	■ 1)	■	■	■	■	■	■	■	■	●	●	●	–	●
	■	■	–	–	–	–	●	–	●	–	●	■ 2)	●	■ 2)	●	●	●	■	■	■	–	–
	●	●	–	–	–	●	●	–	●	–	●	●	●	●	●	●	●	–	●	●	–	–
	–	–	–	–	–	–	–	–	–	–	●	–	●	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	■	■	–	–	–	–	–
	–	–	–	–	–	●	–	–	–	●	●	●	●	–	■	●	●	–	–	–	–	–
	●	●	–	–	–	–	●	–	●	–	●	●	●	●	●	■	■	–	–	–	–	–

Relay Selection Guide

	Device application			Bay controller					Breaker management		Syn-chro-nizing	Voltage and frequency protection	
			Device family	SIPROTEC 4			SIPROTEC 5		SIPROTEC 4	SIPROTEC 5	SIPROTEC 4	SIPROTEC 600 Series	SIPROTEC Compact
ANSI	Functions	Abbr.	Type	6MD61	6MD63	6MD66	6MD85[1]	6MD86[1]	7VK61	7VK87[1]	7VE6	7RW60	7RW80
	Protection functions for 3-pole tripping	3-pole		–	–	–	●	●	■	■	●	■	■
	Protection functions for 1-pole tripping	1-pole		–	–	–	–	–	■	■	–	–	–
14	Locked rotor protection	$I> + V<$		–	–	–	–	–	–	–	–	–	–
21	Distance protection	$Z<$		–	–	–	–	–	–	–	–	–	–
FL	Fault locator	FL		–	–	–	–	–	–	–	–	–	–
24	Overexcitation protection	V/f		–	–	–	–	–	–	–	–	●	●
25	Synchrocheck, synchronizing function	Sync		–	–	●	●	■	●	■	■	–	●
27	Undervoltage protection	$V<$		–	–	–	●	●	●	●	●	■	■
27TN/59TN	Stator ground fault 3rd harmonics	$V0<,>_{(3^{rd}\text{ Harm.})}$		–	–	–	–	–	–	–	–	–	–
32	Directional power supervision	$P>, P<$		–	–	–	●	●	–	●	–	–	–
37	Undercurrent, underpower	$I<, P<$		–	–	–	–	–	–	–	–	–	–
38	Temperature supervision	θ>		–	–	–	–	–	–	–	–	–	–
40	Underexcitation protection	$1/X_D$		–	–	–	–	–	–	–	–	–	–
46	Unbalanced-load protection	$I2>$		–	–	–	–	–	–	–	–	–	–
47	Phase-sequence-voltage supervision	LA, LB, LC		–	–	–	–	–	–	–	–	■	■
48	Start-time supervision	I^2_{start}		–	–	–	–	–	–	–	–	–	–
49	Thermal overload protection	θ, I^2t		–	–	–	–	–	–	–	–	–	–
50	Definite time-overcurrent protection	$I>$		–	–	–	●	●	●	●	–	–	–
50Ns	Sensitive ground-current protection	$I_{Ns}>$		–	–	–	–	–	–	●	–	–	–
50L	Load-jam protection	$I>_L$		–	–	–	–	–	–	–	–	–	–
50BF	Circuit-breaker failure protection	CBFP		–	–	●	–	●	■	■	–	–	–
51	Inverse time-overcurrent protection	I_P		–	–	–	●	●	●	●	–	–	–
55	Power factor	cos φ		–	–	–	–	–	–	–	–	–	–
59	Overvoltage protection	$V>$		–	–	–	●	●	●	●	●	■	■
59R, 27R	Rate-of-voltage-change protection	dV/dt		–	–	–	–	–	–	–	–	–	■
64	Sensitive ground-fault protection (machine)			–	–	–	–	–	–	–	–	–	–
66	Restart inhibit	I^2t		–	–	–	–	–	–	–	–	–	–
67	Directional overcurrent protection	$I>, < (V,I)$		–	–	–	●	●	–	●	–	–	–

■ = basic ● = optional (additional price) – = not available

1) in preparation
2) via CFC
More functions on page 1/8

Table continued on next page

Relay Selection Guide

Device application				Distance protection							Line differential protection						
			Device family	SIPROTEC 4				SIPROTEC 5			SIPROTEC 600 Series	SIPROTEC Compact	SIPROTEC 4		SIPROTEC 5		
ANSI	Functions	Abbr.	Type	7SA522	7SA61	7SA63	7SA64	7SA84 1)	7SA86 1)	7SA87 1)	7SD60	7SD80	7SD610	7SD5	7SD84 1)	7SD86 1)	7SD87 1)
67Ns	Sensitive ground-fault detection for systems with resonant or isolated neutral	$I_N>, \angle (V,I)$		●	●	●	●	● 1)	● 1)	● 1)	–	–	–	●	● 1)	● 1)	● 1)
68	Power-swing blocking	$\Delta Z/\Delta t$		●	●	●	●	●	●	●	–	–	–	●	–	–	–
74TC	Trip-circuit supervision	TCS		■	■	■	■	■	■	■	–	■	■	■	■	■	■
78	Out-of-step protection	$\Delta Z/\Delta t$		●	●	●	●	●	●	●	–	–	–	●	–	–	–
79	Automatic reclosing	AR		●	●	●	●	●	●	●	–	●	●	●	●	●	●
81	Frequency protection	$f<, f>$		●	●	●	●	●	●	●	–	●	●	●	●	●	●
	Vector-jump protection	$\Delta\varphi_U>$		–	–	–	–	–	–	–	–	–	–	–	–	–	–
81LR	Load restoration	LR		–	–	–	–	–	–	–	–	–	–	–	–	–	–
85	Teleprotection			■	■	■	■	■	■	■	■	■	■	■	–	–	–
86	Lockout			■	■	■	■	■	■	■	–	■	■	■	■	■	■
87	Differential protection	ΔI		–	–	–	–	–	–	–	■	■	■	■	■	■	■
87N	Differential ground-fault protection	ΔI_N		–	–	–	–	–	–	–	■	■	–	–	–	–	–
	Broken-wire detection for differential protection			–	–	–	–	–	–	–	–	–	■	■	■	■	■
90V	Automatic voltage control			–	–	–	–	–	–	–	–	–	–	–	–	–	–
PMU	Synchrophasor measurement	PMU		–	–	–	–	● 1)	● 1)	● 1)	–	–	–	–	● 1)	● 1)	● 1)
	Further functions																
	Measured values			■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Switching-statistic counters			■	■	■	■	■	■	■	–	■	■	■	■	■	■
	Logic editor			■	■	■	■	■	■	■	–	■	■	■	■	■	■
	Inrush-current detection			–	–	–	–	■	■	■	●	■	■	■	■	■	■
	External trip initiation			■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Control			■	■	■	■	■	■	■	–	■	■	■	■	■	■
	Fault recording of analog and binary signals			■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Monitoring and supervision			■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Protection interface, serial			●	●	●	●	●	●	●	–	■	■	■	■	■	■
	No. Setting groups			4	4	4	4	8	8	8	–	4	4	4	8	8	8
	Battery charger/-monitor			–	–	–	–	–	–	–	–	–	–	–	–	–	–

■ = basic ● = optional (additional price) – = not available

1) in preparation
2) via CFC

	Combined line differential and distance protection		Overcurrent and feeder protection/ feeder automation												Generator and motor protection			Transformer protection			Busbar protection	
	SIPROTEC 5		SIPROTEC easy		SIPROTEC 600 Series		SIPROTEC Compact			SIPROTEC 4				SIPROTEC 5	SIPROTEC Compact	SIPROTEC 4		SIPROTEC 4			SIPROTEC 600 Series	SIPROTEC 4
	7SL86 1)	7SL87 1)	7SJ45	7SJ46	7SJ600	7SJ602	7SJ80	7SJ81	7SC80 1)	7SJ61	7SJ62	7SJ63	7SJ64	7SJ86 1)	7SK80	7UM61	7UM62	7UT612	7UT613	7UT63	7SS60	7SS52
	● 1)	● 1)	–	–	–	●	●	–	–	–	●	●	●	–	●	■	■	–	–	–	–	–
	●	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
	■	■	–	–	■	■	■	■	–	■	■	■	■	■	■	■	■	■	■	■	–	–
	●	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–
	●	●	–	–	●	●	●	–	–	●	●	●	●	●	–	–	–	–	–	–	–	–
	●	●	–	–	–	–	●	–	●	–	●	●	●	●	●	■	■	–	●	●	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	■	■	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
	■	■	–	–	–	–	■	■	–	■	■	■	■	■	■	■	■	–	–	–	■	–
	■	■	–	–	–	–	–	–	–	–	–	–	–	–	–	–	■	■	■	■	■	■
	–	–	–	–	–	●	●	–	–	●	●	●	●	–	–	●	●	●	●	●	–	–
	■	■	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	■	■	■	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	● 1)	● 1)	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
	■	■	–	–	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	■	■	–	–	–	–	■	■	■	■	■	■	■	■	■	■	■	■	■	■	–	–
	■	■	–	–	–	–	■	■	■	■	■	■	■	■	■	■	■	■	■	■	–	■
	■	■	–	–	–	–	■	■	■	■	■	■	■	■	■	–	●	■	■	■	–	–
	■	■	–	–	■	■	■	■	■	■	■	■ 2)	■	■	■	■	■	■	■	■	–	■
	■	■	–	–	–	–	■	■	■	■	■	■	■	■	■	■	■	■	■	■	–	–
	■	■	–	–	■	■	■	■	■	■	■	■	■	■	■	–	–	■	■	■	■	■
	■	■	–	–	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	■	■	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–	–	–
	8	8	1	1	1	1	4	4	4	4	4	4	4	8	4	4	4	4	4	4	1	1
	–	–	–	–	–	–	–	–	● 1)	–	–	–	–	–	–	–	–	–	–	–	–	–

Relay Selection Guide

	Device application			Bay controller					Breaker management		Synchronizing	Voltage and frequency protection	
			Device family	SIPROTEC 4			SIPROTEC 5		SIPROTEC 4	SIPROTEC 5	SIPROTEC 4	SIPROTEC 600 Series	SIPROTEC Compact
ANSI	Functions	Abbr.	Type	6MD61	6MD63	6MD66	6MD85[1)]	6MD86[1)]	7VK61	7VK87 [1)]	7VE6	7RW60	7RW80
67Ns	Sensitive ground-fault detection for systems with resonant or isolated neutral	$I_N>, \angle (V,I)$		–	–	–	–	–	–	–	–	–	–
68	Power-swing blocking	$\Delta Z/\Delta t$		–	–	–	–	–	–	–	–	–	–
74TC	Trip-circuit supervision	TCS		–	–	–	■	■	■	■	■	■	■
78	Out-of-step protection	$\Delta Z/\Delta t$		–	–	–	–	–	–	–	–	–	–
79	Automatic reclosing	AR		–	–	●	–	●	■	■	–	–	–
81	Frequency protection	$f<, f>$		–	–	–	●	●	–	●	●	■	■
	Vector-jump protection	$\Delta\varphi_U>$		–	–	–	–	–	–	–	●	–	●
81LR	Load restoration	LR		–	–	–	–	–	–	–	–	–	●
85	Teleprotection			–	–	–	–	–	–	–	–	–	–
86	Lockout			–	–	–	–	–	■	■	–	–	■
87	Differential protection	ΔI		–	–	–	–	–	–	–	–	–	–
87N	Differential ground-fault protection	ΔI_N		–	–	–	–	–	–	–	–	–	–
	Broken-wire detection for differential protection			–	–	–	–	–	–	–	–	–	–
90V	Automatic voltage control			–	–	–	–	–	–	–	–	–	–
PMU	Synchrophasor measurement	PMU		–	–	–	● 1)	● 1)	–	● 1)	–	–	–
	Further functions												
	Measured values			●	■	■	■	■	■	■	■	■	■
	Switching-statistic counters			■	■	■	■	■	■	■	■	–	■
	Logic editor			–	■	■	■	■	■	■	■	–	■
	Inrush-current detection			–	–	–	●	●	–	■	–	–	–
	External trip initiation			–	–	–	–	–	■	■	●	●	■
	Control			■	■	■	■	■	■	■	■	–	■
	Fault recording of analog and binary signals			■	■	●	■	■	■	■	■	■	■
	Monitoring and supervision			■	■	■	■	■	■	■	■	■	■
	Protection interface, serial			–	–	–	●	●	–	●	–	–	–
	No. Setting groups			4	4	4	8	8	4	8	4	1	4
	Battery charger/-monitor			–	–	–	–	–	–	–	–	–	–

■ = basic ● = optional (additional price) – = not available

1) in preparation
2) via CFC

Overview/Applications

SIPROTEC Relay Families

Solutions for today's and future power supply systems – for more than 100 years

SIPROTEC has established itself on the energy market for decades as a powerful and complete system family of numerical protection relays and bay controllers from Siemens.

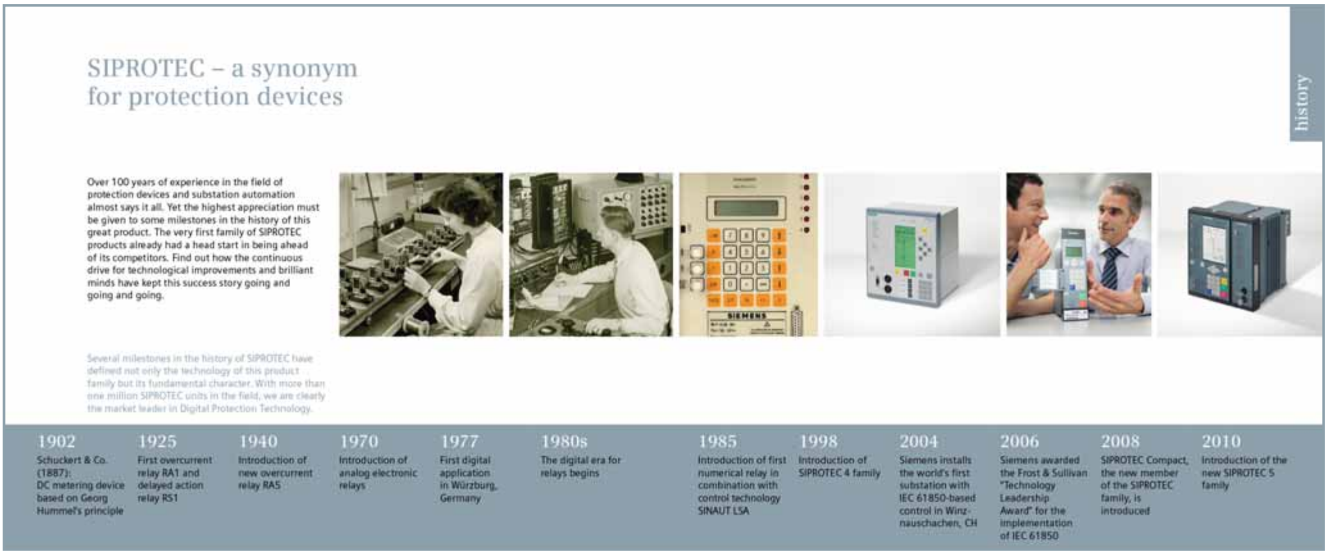
SIPROTEC protection relays from Siemens can be consistently used throughout all applications in medium and high voltage. With SIPROTEC, operators have their systems firmly and safely under control, and have the basis to implement cost-efficient solutions for all duties in modern, intelligent and "smart" grids. Users can combine the units of the different SIPROTEC device series at will for solving manifold duties – because SIPROTEC stands for continuity, openness and future-proof design.

As the innovation driver and trendsetter in the field of protection systems for 100 years, Siemens helps system operators to design their grids in an intelligent, ecological, reliable and efficient way, and to operate them economically. As a pioneer, Siemens has decisively influenced the development of numerical protection systems (Fig. 2/2). The first application went into operation in Würzburg, Germany, in 1977. Consistent integration of protection and control functions for all SIPROTEC devices was the innovation step in the 90ies. After release of the communication standard IEC 61850 in the year 2004, Siemens was the first manufacturer worldwide to put a system with this communication standard into operation.

Fig. 2/1

How can system operators benefit from this experience?

- Proven and complete applications
- Easy integration into your system
- Highest quality of hardware and software
- Excellent operator friendliness of devices and tools
- Easy data exchange between applications
- Extraordinary consistency between product- and system-engineering
- Reduced complexity by easy operation
- Siemens as a reliable, worldwide operating partner.



SIPROTEC – a synonym for protection devices

Over 100 years of experience in the field of protection devices and substation automation almost says it all. Yet the highest appreciation must be given to some milestones in the history of this great product. The very first family of SIPROTEC products already had a head start in being ahead of its competitors. Find out how the continuous drive for technological improvements and brilliant minds have kept this success story going and going and going.

Several milestones in the history of SIPROTEC have defined not only the technology of this product family but its fundamental character. With more than one million SIPROTEC units in the field, we are clearly the market leader in Digital Protection Technology.

1902	Schuckert & Co. (1887): DC metering device based on Georg Hummel's principle
1925	First overcurrent relay RA1 and delayed action relay RS1
1940	Introduction of new overcurrent relay RA5
1970	Introduction of analog electronic relays
1977	First digital application in Würzburg, Germany
1980s	The digital era for relays begins
1985	Introduction of first numerical relay in combination with control technology SINAUT LSA
1998	Introduction of SIPROTEC 4 family
2004	Siemens installs the world's first substation with IEC 61850-based control in Winznauschachen, CH
2006	Siemens awarded the Frost & Sullivan "Technology Leadership Award" for the implementation of IEC 61850
2008	SIPROTEC Compact, the new member of the SIPROTEC family, is introduced
2010	Introduction of the new SIPROTEC 5 family

Fig. 2/2 SIPROTEC – Pioneer over generations

SIPROTEC Relay Families

SIPROTEC easy

SIPROTEC easy are CT power supplied or auxiliary power supplied, numerical overcurrent-time protection relays, which can be used as line and transformer protection (back-up protection) in electrical power supply systems with single-ended supply. They offer definite-time and inverse-time overcurrent protection functions according to IEC and ANSI. The comfortable operation via DIP switch is self-explanatory and simple.

- Two-stage overcurrent-time protection
- Saving the auxiliary power supply by operation via integrated current transformer supply
- Cost-efficient due to the use of instrument transformers with low ratings
- Tripping via pulse output (24 V DC / 0.1 Ws) or tripping relay output
- Simple, self-explanatory parameterization and operation via DIP switch directly at the device
- Easy installation due to compact assembly on DIN rail.

Fig. 2/3 SIPROTEC easy

SIPROTEC Compact (series 600)

The devices of the SIPROTEC Compact series (series 600) are compact, numerical protection devices for application in medium-voltage or industrial power supply systems. The corresponding device types are available for the different applications such as overcurrent-time protection, line differential protection, transient earth-fault relay or busbar protection.

- Space-saving due to compact design
- Reliable process connections by means of solid terminal blocks
- Effective fault evaluation by means of integrated fault recording and SIGRA 4
- Communication interface
- Operable and evaluable via DIGSI 4
- Different device types available for directional and non-directional applications.

Fig. 2/4 SIPROTEC Compact (series 600)

SIPROTEC Compact – Maximum protection-minimum space

Perfect protection, smallest space reliable and flexible protection for energy distribution and industrial systems with minimum space requirements. The devices of the SIPROTEC Compact family offer an extensive variety of functions in a compact and thus space-saving 1/6 x 19" housing. The devices can be used as main protection in medium-voltage applications or as back-up protection in high-voltage systems.

SIPROTEC Compact provides suitable devices for many applications in energy distribution, such as the protection of feeders, lines or motors. Moreover, it also performs tasks such as system decoupling, load shedding, load restoration, as well as voltage and frequency protection.

The SIPROTEC Compact series is based on millions of operational experience with SIPROTEC 4 and a further-developed, compact hardware, in which many customer suggestions were integrated. This offers maximum reliability combined with excellent functionality and flexibility.

- Simple installation by means of pluggable current and voltage terminal blocks
- Thresholds adjustable via software (3 stages guarantee a safe and reliable recording of input signals)
- Easy adjustment of secondary current transformer values (1 A/5 A) to primary transformers via DIGSI 4
- Quick operations at the device by means of 9 freely programmable function keys
- Clear overview with six-line display
- Easy service due to buffer battery replaceable at the front side
- Use of standard cables via USB port at the front
- Integration in the communication network by means of two further communication interfaces
- High availability due to integrated redundancy (electrical or visual) for IEC 61850 communication
- Reduction of wiring between devices by means of cross-communication via Ethernet (IEC 61850 GOOSE)
- Time synchronization to the millisecond via Ethernet with SNTP for targeted fault evaluation
- Adjustable to the protection requirements by means of “flexible protection functions”
- Comfortable engineering and evaluation via DIGSI 4.

Fig. 2/5 SIPROTEC Compact

Fig. 2/6 SIPROTEC Compact – rear view

Fig. 2/7 Feeder automation relay 7SC80

SIPROTEC Relay Families

SIPROTEC 5 – the new benchmark for protection, automation and monitoring of transmission grids

The SIPROTEC 5 series is based on the long field experience of the SIPROTEC device series, and has been especially designed for the new requirements of modern high-voltage systems. For this purpose, SIPROTEC 5 is equipped with extensive functionalities and device types. With the holistic and consistent engineering tool DIGSI 5, a solution has also been provided for the increasingly complex processes, from the design via the engineering phase up to the test and operation phase.

Thanks to the high modularity of hardware and software, the functionality and hardware of the devices can be tailored to the requested application and adjusted to the continuously changing requirements throughout the entire life cycle.

Besides the reliable and selective protection and the complete automation function, SIPROTEC 5 offers an extensive database for operation and monitoring of modern power supply systems. Synchrophasors (PMU), power quality data and extensive operational equipment data are part of the scope of supply.

- Powerful protection functions guarantee the safety of the system operator's equipment and employees
- Individually configurable devices save money on initial investment as well as storage of spare parts, maintenance, expansion and adjustment of your equipment
- Clear and easy-to-use of devices and software thanks to user-friendly design
- Increase of reliability and quality of the engineering process
- High reliability due to consequent implementation of safety and security
- Powerful communication components guarantee safe and effective solutions
- Full compatibility between IEC 61850 Editions 1 and 2
- Efficient operating concepts by flexible engineering of IEC 61850 Edition 2
- Comprehensive database for monitoring of modern power grids
- Optimal smart automation platform for transmission grids based on integrated synchrophasor measurement units (PMU) and power quality functions.

Fig. 2/8 SIPROTEC 5 – modular hardware

Fig. 2/9 SIPROTEC 5 – rear view

Fig. 2/10 Application in the high-voltage system

SIPROTEC 4 – the proven, reliable and future-proof protection for all applications

SIPROTEC 4 represents a worldwide successful and proven device series with more than 1 million devices in field use.

Due to the homogenous system platform, the unique engineering program DIGSI 4 and the great field experience, the SIPROTEC 4 device family has gained the highest appreciation of users all over the world. Today, SIPROTEC 4 is considered the standard for numerical protection systems in all fields of application.

SIPROTEC 4 provides suitable devices for all applications from power generation and transmission up to distribution and industrial systems.

SIPROTEC 4 is a milestone in protection systems. The SIPROTEC 4 device series implements the integration of protection, control, measuring and automation functions optimally in one device. In many fields of application, all tasks of the secondary systems can be performed with one single device. The open and future-proof concept of SIPROTEC 4 has been ensured for the entire device series with the implementation of IEC 61850.

- Proven protection functions guarantee the safety of the systems operator's equipment and employees
- Comfortable engineering and evaluation via DIGSI 4
- Simple creation of automation solutions by means of the integrated CFC
- Targeted and easy operation of devices and software thanks to user-friendly design
- Powerful communication components guarantee safe and effective solutions
- Maximum experience worldwide in the use of SIPROTEC 4 and in the implementation of IEC 61850 projects
- Future-proof due to exchangeable communication interfaces and integrated CFC.

Fig. 2/11 SIPROTEC 4

Fig. 2/12 SIPROTEC 4 rear view

Fig. 2/13 SIPROTEC 4 in power plant application

SIPROTEC Relay Families

To fulfill vital protection redundancy requirements, only those functions that are interdependent and directly associated with each other are integrated into the same unit. For backup protection, one or more additional units should be provided.

All relays can stand fully alone. Thus, the traditional protection principle of separate main and backup protection as well as the external connection to the switchyard remain unchanged.

"One feeder, one relay" concept

Analog protection schemes have been engineered and assembled from individual relays. Interwiring between these relays and scheme testing has been carried out manually in the workshop.

Data sharing now allows for the integration of several protection and protection-related tasks into one single numerical relay. Only a few external devices may be required for completion of the total scheme. This has significantly lowered the costs of engineering, assembly, panel wiring, testing and commissioning. Scheme failure probability has also been lowered.

Engineering has moved from schematic diagrams toward a parameter definition procedure. The powerful user-definable logic of SIPROTEC 4 allows flexible customized design for protection, control and measurement.

Measuring included

For many applications, the accuracy of the protection current transformer is sufficient for operational measuring. The additional measuring current transformer was required to protect the measuring instruments under short-circuit conditions. Due to the low thermal withstand capability of the measuring instruments, they could not be connected to the protection current transformer. Consequently, additional measuring core current transformers and measuring instruments are now only necessary where high accuracy is required, e.g., for revenue metering.

Corrective rather than preventive maintenance

Numerical relays monitor their own hardware and software. Exhaustive self-monitoring and failure diagnostic routines are not restricted to the protection relay itself but are methodically carried through from current transformer circuits to tripping relay coils.

Equipment failures and faults in the current transformer circuits are immediately reported and the protection relay is blocked.

Thus, service personnel are now able to correct the failure upon occurrence, resulting in a significantly upgraded availability of the protection system.

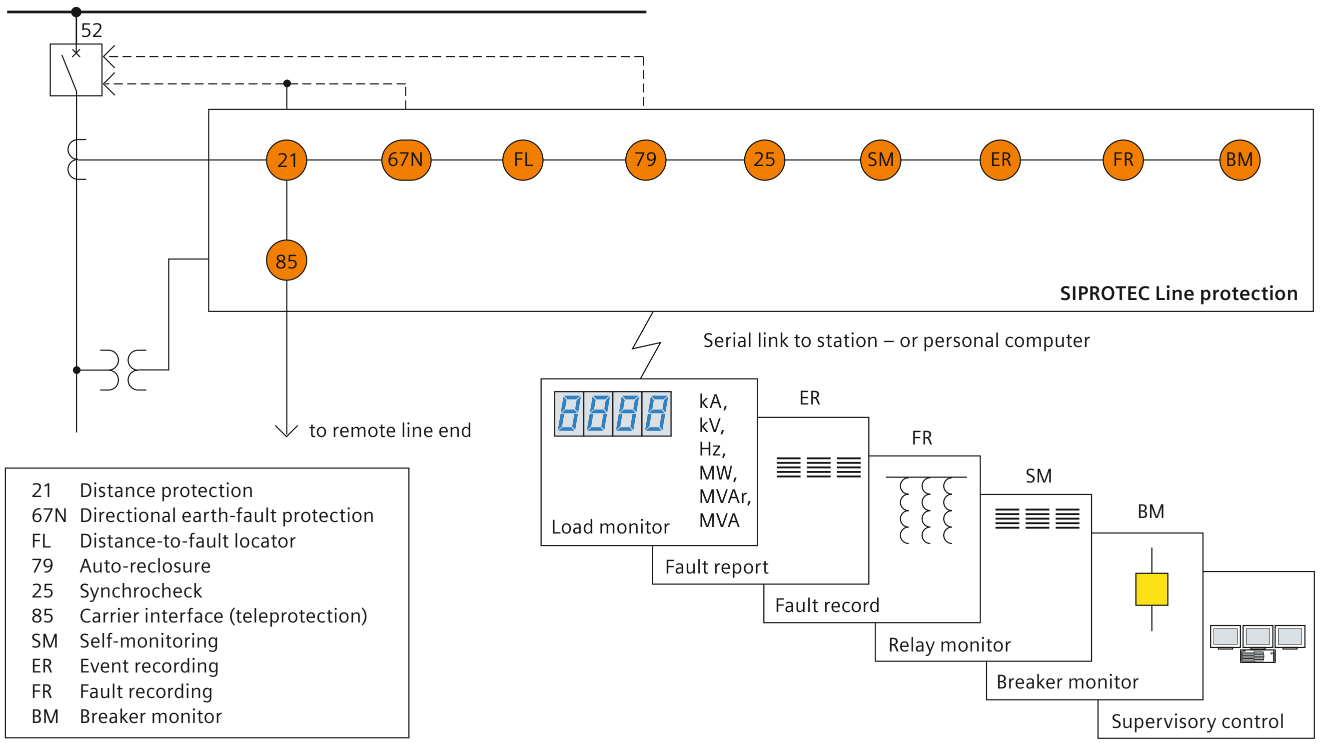


Fig. 2/14 Numerical relays offer increased information availability

Adaptive relaying

Numerical relays now offer reliable, convenient and comprehensive matching to changing conditions. Matching may be initiated either by the relay's own intelligence or from other systems via contacts or serial telegrams. Modern numerical relays contain a number of parameter sets that can be pretested during commissioning of the scheme. One set is normally operative. Transfer to the other sets can be controlled via binary inputs or a serial data link (Fig. 2/15).

There are a number of applications for which multiple setting groups can upgrade the scheme performance, for example:

- For use as a voltage-dependent control of overcurrent-time relay pickup values to overcome alternator fault current decrement to below normal load current when the automatic voltage regulator (AVR) is not in automatic operation
- For maintaining short operation times with lower fault currents, e.g., automatic change of settings if one supply transformer is taken out of service
- For "switch-onto-fault" protection to provide shorter time settings when energizing a circuit after maintenance so that normal settings can be restored automatically after a time delay
- For auto-reclosure programs, that is, instantaneous operation for first trip and delayed operation after unsuccessful reclosure
- For cold load pickup problems where high starting currents may cause relay operation
- For "ring open" or "ring closed" operation.

Implemented functions

SIPROTEC relays are available with a variety of protective functions (please refer to Fig. 2/17). The high processing power of modern numerical units allows further integration of non-protective add-on functions.

The question as to whether separate or combined relays should be used for protection and control cannot be unambiguously answered. In transmission-type substations, separation into independent hardware units is still preferred, whereas a trend toward higher function integration can be observed on the distribution level. Here, the use of combined feeder / line relays for protection, monitoring and control is becoming more common (Fig. 2/16).

Relays with protection functions only and relays with combined protection and control functions are being offered. SIPROTEC 4 relays offer combined protection and control functions. SIPROTEC 4 relays support the "one relay one feeder" principle, and thus contribute to a considerable reduction in space and wiring requirements.

With the well-proven SIPROTEC 4 family, Siemens supports both stand-alone and combined solutions on the basis of a single hardware and software platform. The user can decide within wide limits on the configuration of the control and protection, and the reliability of the protection functions (Fig. 2/17).

The following solutions are available within one relay family:

- Separate control and protection relays
- Feeder protection and remote control of the line circuit-breaker via the serial communication link
- Combined relays for protection, monitoring and control.

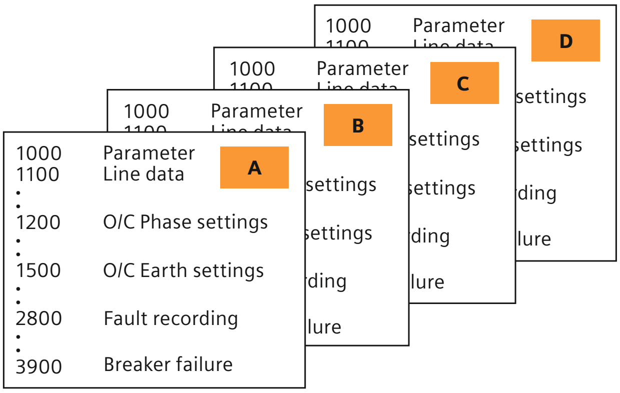
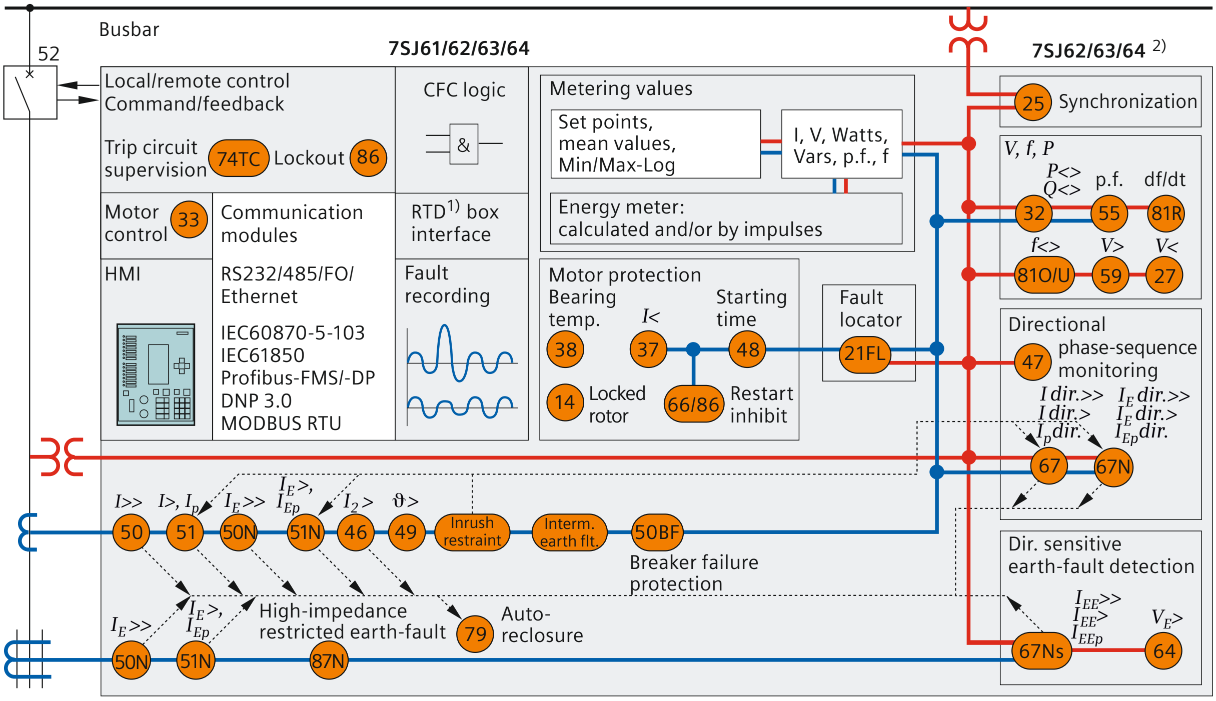


Fig. 2/15 Alternate parameter groups

Fig. 2/16 Left: switchgear with numerical relay (7SJ62) and traditional control; right: switchgear with combined protection and control relay (7SJ64)

SIPROTEC Relay Families



1) RTD = resistance temperature detector

2) VT connection for 7SJ62/63/64 only

Fig. 2/17 SIPROTEC 4 relays 7SJ61 / 62 / 63, 64 implemented functions

Terminals: Standard relay version with screw-type terminals

Current terminals	
Connection	W_{max} =12 mm
Ring cable lugs	*d1* =5 mm
Wire size	2.7 – 4 mm^2 (AWG 13 – 11)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	2.7 – 4 mm^2 (AWG 13 – 11)
Voltage terminals	
Connection	W_{max} =10 mm
Ring cable lugs	*d1* = 4 mm
Wire size	1.0 – 2.6 mm^2 (AWG 17 – 13)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	0.5 – 2.5 mm^2 (AWG 20 – 13)
Some relays are alternatively available with plug-in voltage terminals	
Current terminals	
Screw type (see standard version)	
Voltage terminals	
2-pin or 3-pin connectors	
Wire size	0.5 – 1.0 mm^2
	0.75 – 1.5 mm^2
	1.0 – 2.5 mm^2

Mechanical Design

SIPROTEC 4 relays are available in 1 / 3 to 1 / 1 of 19” wide housings with a standard height of 243 mm. Their size is compatible with that of other relay families. Therefore, compatible exchange is always possible (Fig. 2/18 to Fig. 2/20).

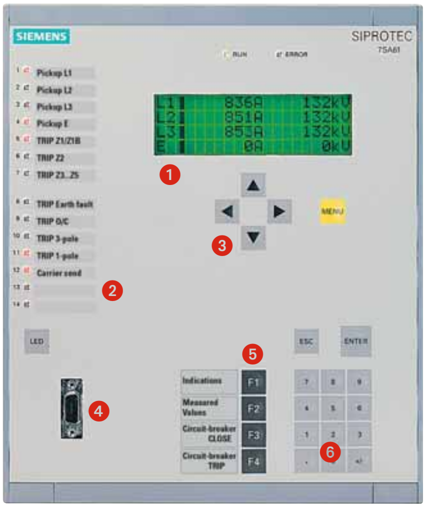
All wires (cables) are connected at the rear side of the relay with or without ring cable lugs. A special relay version with a detached cable-connected operator panel (Fig. 2/21) is also available. It allows, for example, the installation of the relay itself in the low-voltage compartment, and of the operator panel separately in the door of the switchgear.

Fig. 2/18 1 / 1 of 19" housing

Fig. 2/19 1 / 2 of 19" housing

Fig. 2/20 1 / 3 of 19" housing

Fig. 2/21 SIPROTEC 4 combined protection, control and monitoring relay with detached operator panel



① On the backlit LCD display, process and device information can be displayed as text.

② Freely assignable LEDs are used to display process or device information. The LEDs can be labeled according to user requirements. An LED reset key resets the LEDs and can be used for LED testing.

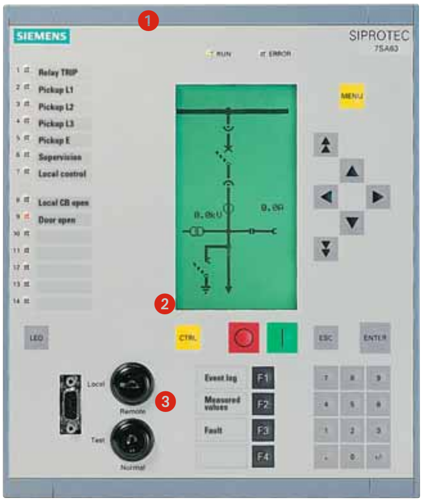
③ Keys for navigation

④ RS232 operator interface (for DIGSI)

⑤ 4 configurable function keys permit the user to execute frequently used actions simply and fast.

⑥ Numerical keys

Fig. 2/22 Local operation: All operator actions can be executed and information displayed via an integrated user interface. Two alternatives for this interface are available.



① Process and relay information can be displayed on the large illuminated LC display either graphically in the form of a mimic diagram or as text in various lists.

② The keys mainly used for control of the switchgear are located on the "control axis" directly below the display.

③ Two key-operated switches ensure rapid and reliable changeover between "local" and "remote" control, and between "interlocked" and "non-interlocked" operation.

Fig. 2/23 Additional features of the interface with graphic display

SIPROTEC Relay Families

Apart from the relay-specific protection functions, the SIPROTEC 4 units have a multitude of additional functions that

- provide the user with information for the evaluation of faults
- facilitate adaptation to customer-specific application
- facilitate monitoring and control of customer installations.

Operational measured values

The large scope of measured and limit values permits improved power system management as well as simplified commissioning.

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available depending on the relay type

- Currents I_{L1}, I_{L2}, I_{L3}, I_N, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, $3V_0$
- Power Watts, V_{ars}, V_A / P, Q, S
- Power factor p.f. (cos φ)
- Frequency
- Energy ± kWh ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values (some types)

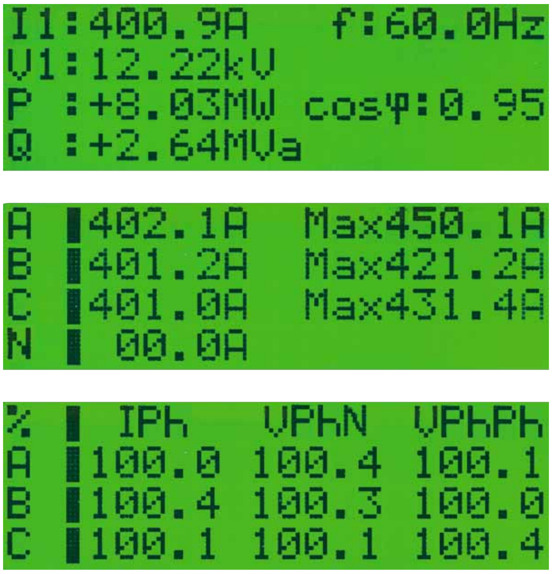
For internal metering, the unit can calculate energy metered values from the measured current and voltage values. If an external meter with a metering pulse output is available, some SIPROTEC 4 types can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Operational indications and fault indications with time stamp

The SIPROTEC 4 units provide extensive data for fault analysis as well as control. All indications listed here are stored, even if the power supply is disconnected.

- Fault event log
  The last eight network faults are stored in the unit. All fault recordings are time-stamped with a resolution of 1 ms.
- Operational indications
  All indications that are not directly associated with a fault (e.g., operating or switching actions) are stored in the status indication buffer. The time resolution is 1 ms (Fig. 2/24, Fig. 2/25).

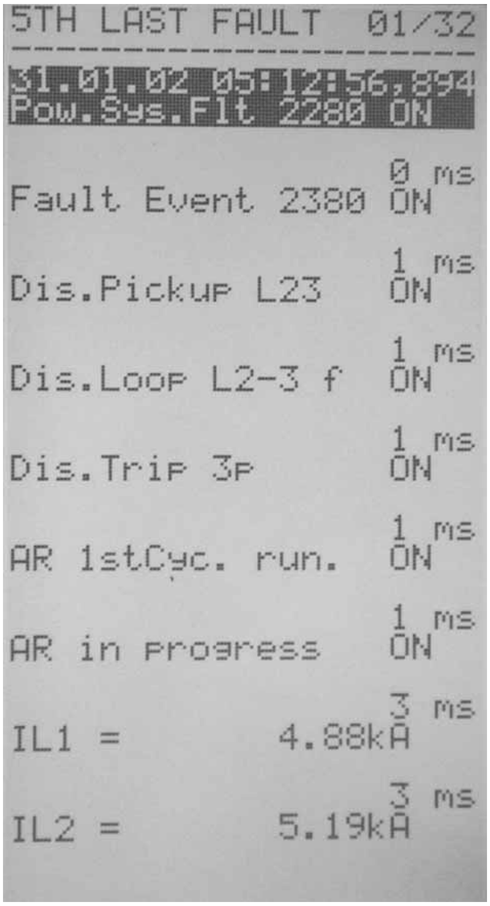


```
I1:400.9A    f:60.0Hz
V1:12.22kV
P :+8.03MW cosφ:0.95
Q :+2.64MVa
```

```
A |402.1A   Max450.1A
B |401.2A   Max421.2A
C |401.0A   Max431.4A
N |  00.0A
```

```
% |  IPh    VPhN   VPhPh
A |100.0  100.4  100.1
B |100.4  100.3  100.0
C |100.1  100.1  100.4
```

Fig. 2/24 Operational measured values



```
5TH LAST FAULT   01/32
---------------------
31.01.02 05:12:56,894
Pow.Sys.Flt  2280  ON
                  0 ms
Fault Event  2380 ON
                  1 ms
Dis.Pickup L23    ON
                  1 ms
Dis.Loop L2-3 f   ON
                  1 ms
Dis.Trip 3p       ON
                  1 ms
AR 1stCyc. run.   ON
                  1 ms
AR in progress    ON
                  3 ms
IL1 =        4.88kA
                  3 ms
IL2 =        5.19kA
```

Fig. 2/25 Fault event log on graphical display of the device

Display editor

A display editor is available to design the display on SIPROTEC 4 units with graphic display. The predefined symbol sets can be expanded to suit the user. The drawing of a single-line diagram is extremely simple. Load monitoring values (analog values) and any texts or symbols can be placed on the display where required.

Four predefined setting groups for adapting relay settings

The settings of the relays can be adapted quickly to suit changing network configurations. The relays include four setting groups that can be predefined during commissioning or even changed remotely via a DIGSI 4 modem link. The setting groups can be activated via binary inputs, via DIGSI 4 (local or remote), via the integrated keypad or via the serial substation control interface.

Fault recording up to five or more seconds

The sampled values for phase currents, earth (ground) currents, line and zero-sequence currents are registered in a fault record. The record can be started using a binary input, on pickup or when a trip command occurs. Up to eight fault records may be stored. For test purposes, it is possible to start fault recording via DIGSI 4. If the storage capacity is exceeded, the oldest fault record in each case is overwritten.

For protection functions with long delay times in generator protection, the RMS value recording is available. Storage of relevant calculated variables (V_1, V_E, I_1, I_2, I_{EE}, P, Q, f-f_n) takes place at increments of one cycle. The total time is 80 s.

Time synchronization

A battery-backed clock is a standard component and can be synchronized via a synchronization signal (DCF77, IRIG B via satellite receiver), binary input, system interface or SCADA (e.g., SICAM). A date and time is assigned to every indication.

Selectable function keys

Four function keys can be assigned to permit the user to perform frequently recurring actions very quickly and simply.

Typical applications are, for example, to display the list of operating indications or to perform automatic functions such as “switching of circuit-breaker”.

Continuous self-monitoring

The hardware and software are continuously monitored. If abnormal conditions are detected, the unit immediately signals. In this way, a great degree of safety, reliability and availability is achieved.

Reliable battery monitoring

The battery provided is used to back up the clock, the switching statistics, the status and fault indications, and the fault recording in the event of a power supply failure. Its function is checked by the processor at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated. Regular replacement is therefore not necessary.

All setting parameters are stored in the Flash EPROM and are not lost if the power supply or battery fails. The SIPROTEC 4 unit remains fully functional.

Commissioning support

Special attention has been paid to commissioning. All binary inputs and output contacts can be displayed and activated directly. This can significantly simplify the wiring check for the user. Test telegrams to a substation control system can be initiated by the user as well.

CFC: Programming logic

With the help of the CFC (Continuous Function Chart) graphic tool, interlocking schemes and switching sequences can be configured simply via drag and drop of logic symbols; no special knowledge of programming is required. Logical elements, such as AND, OR, flip-flops and timer elements are available. The user can also generate user-defined annunciations and logical combinations of internal or external signals.

Communication interfaces

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards commonly used in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards.

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

SIPROTEC Relay Families

Retrofitting: Communication modules

It is possible to supply the relays directly with two communication modules for the service and substation control interfaces, or to retrofit the communication modules at a later stage. The modules are mounted on the rear side of the relay. As a standard, the time synchronization interface is always supplied.

The communication modules are available for the entire SIPROTEC 4 relay range. Depending on the relay type, the following protocols are available: IEC 60870-5-103, PROFIBUS DP, MODBUS RTU, DNP 3.0 and Ethernet with IEC 61850. No external protocol converter is required.

With respect to communication, particular emphasis is placed on the requirements in energy automation:

- Every data item is time-stamped at the source, that is, where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g., fault records or parameter data files). The user can apply these features without any additional programming effort.
- For reliable execution of a command, the relevant signal is first acknowledged in the unit involved. When the command has been enabled and executed, a check-back indication is issued. The actual conditions are checked at every command-handling step. Whenever they are not satisfactory, controlled interruption is possible.

Fig. 2/26 Protection relay

Fig. 2/27 Communication module, optical

Fig. 2/28 Communication module RS232,RS485

Fig. 2/29 Communication module, optical ring

The following interfaces can be applied:

① **Service interface (optional)**
Several protection relays can be centrally operated with DIGSI 4, e.g., via a star coupler or RS485 bus. On connection of a modem, remote control is possible. This provides advantages in fault clearance, particularly in unmanned power stations. (Alternatively, the external temperature monitoring box can be connected to this interface.)

② **System interface (optional)**
This is used to carry out communication with a control system and supports, depending on the module connected, a variety of communication protocols and interface designs.

③ **Time synchronization interface**
A synchronization signal (DCF 77, IRIG B via satellite receiver) may be connected to this input if no time synchronization is executed on the system interface. This offers a high-precision time tagging.

Fig. 2/30 Rear view with wiring, terminal safety cover and serial interfaces

Safe bus architecture

- Fiber-optic double ring circuit via Ethernet
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without interruption. If a unit were to fail, there is no effect on the communication with the rest of the system (Fig. 2/31).
- RS485 bus
  With this data transmission via copper wires, electromagnetic interference is largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any faults (Fig. 2/32).
- Star structure
  The relays are connected with a fiber-optic cable with a star structure to the control unit. The failure of one relay / connection does not affect the others (Fig. 2/33).

Depending on the relay type, the following protocols are available:

- IEC 61850 protocol
  Since 2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between feeder units so as to set up simple masterless systems for feeder and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.
- IEC 60870-5-103
  IEC 60870-5-103 is an internationally standardized protocol for efficient communication between the protection relays and a substation control system. Specific extensions that are published by Siemens can be used.
- PROFIBUS DP
  For connection to a SIMATIC PLC, the PROFIBUS DP protocol is recommended. With the PROFIBUS DP, the protection relay can be directly connected to a SIMATIC S5 / S7. The transferred data are fault data, measured values and control commands.

Substation automation system

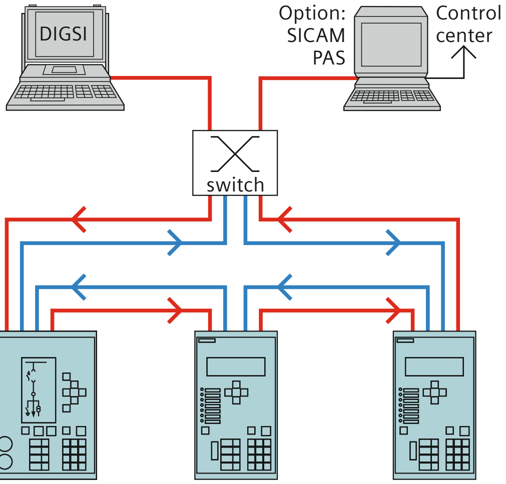


Fig. 2/31 Ring bus structure for station bus with Ethernet and IEC 61850

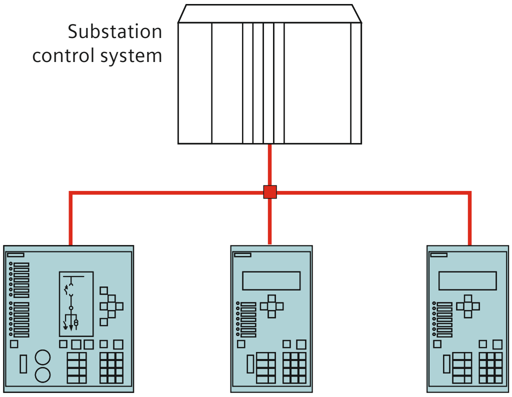


Fig. 2/32 PROFIBUS: Electrical RS485 bus wiring

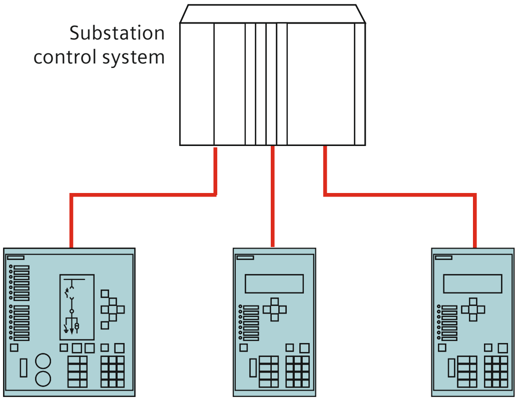


Fig. 2/33 IEC 60870-5-103: Star structure with fiber-optic cables

SIPROTEC Relay Families

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2-compliant with DNP 3.0, which is supported by a number of protection unit manufacturers.

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions required for operating medium-voltage or high-voltage substations. The main application is reliable control of switching and other processes. The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the relay via binary inputs.

Therefore, it is possible to detect and indicate both the OPEN and CLOSED positions or a faulty or intermediate breaker position. The switchgear can be controlled via:

- Integrated operator panel
- Binary inputs
- Substation control system
- DIGSI 4.

Automation

With the integrated logic, the user can set specific functions for the automation of the switchgear or substation by means of a graphic interface (CFC). Functions are activated by means of function keys, binary inputs or via the communication interface.

Switching authority

The following hierarchy of switching authority is applicable: LOCAL, DIGSI 4 PC program, REMOTE. The switching authority is determined according to parameters or by DIGSI 4. If the LOCAL mode is selected, only local switching operations are possible. Every switching operation and change of breaker position is stored in the status indication memory with detailed information and time tag.

Fig. 2/34 Protection engineer at work

Command processing

The SIPROTEC 4 protection relays offer all functions required for command processing, including the processing of single and double commands, with or without feedback, and sophisticated monitoring. Control actions using functions, such as runtime monitoring and automatic command termination after output check of the external process, are also provided by the relays. Typical applications are:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable feeder interlocking
- Operating sequences combining several switching operations, such as control of circuit-breakers, disconnectors (isolators) and earthing switches
- Triggering of switching operations, indications or alarms by logical combination of existing information (Fig. 2/34).

The positions of the circuit-breaker or switching devices are monitored by feedback signals. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication changes as a consequence of a switching operation or due to a spontaneous change of state.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Typical Protection Schemes

1. Cables and overhead lines

Radial systems

Notes:

1) Auto-reclosure (ANSI 79) only with overhead lines.
2) Negative sequence overcurrent protection 46 as sensitive backup protection against asymmetrical faults.

General notes:

- The relay at the far end (D) is set with the shortest operating time. Relays further upstream have to be time-graded against the next downstream relay in steps of about 0.3 s.
- Inverse time or definite time can be selected according to the following criteria:
  - Definite time:
    Source impedance is large compared to the line impedance, that is, there is small current variation between near and far end faults.
  - Inverse time:
    Longer lines, where the fault current is much less at the far end of the line than at the local end.
  - Strong or extreme inverse-time:
    Lines where the line impedance is large compared to the source impedance (high difference for close-in and remote faults), or lines where coordination with fuses or reclosers is necessary. Steeper characteristics also provide higher stability on service restoration (cold load pickup and transformer inrush currents).

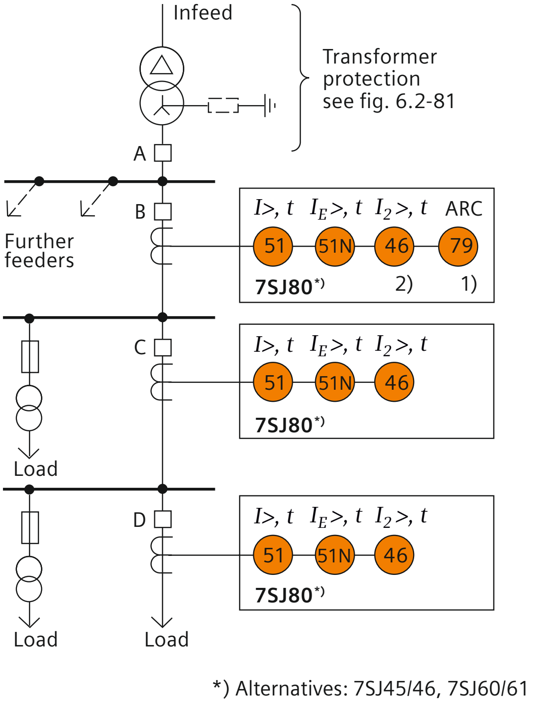


Fig. 2/35 Radial systems

Ring-main circuit

General notes:

- Operating time of overcurrent relays to be coordinated with downstream fuses of load transformers (preferably with strong inverse-time characteristic with about 0.2 s grading-time delay)
- Thermal overload protection for the cables (option)
- Negative sequence overcurrent protection (46) as sensitive protection against asymmetrical faults (option).

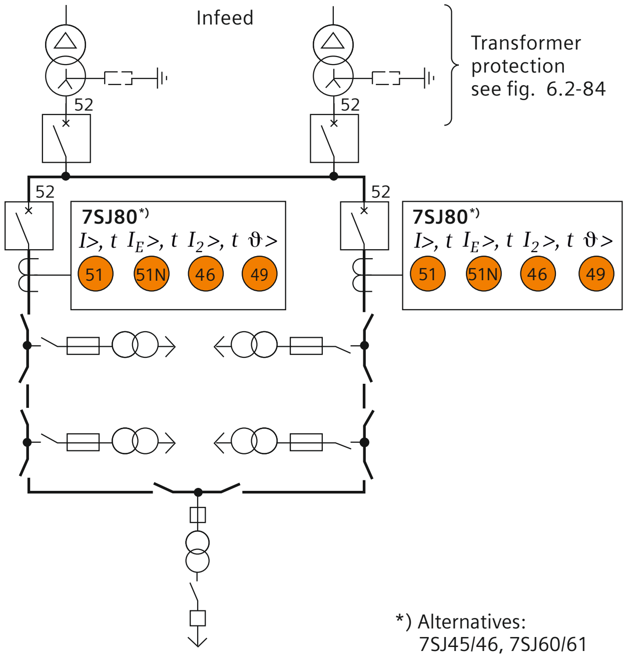


Fig. 2/36 Ring-main circuit

Typical Protection Schemes

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local, via binary input or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker bypassing the internal control function, manual detection using a binary input is implemented.

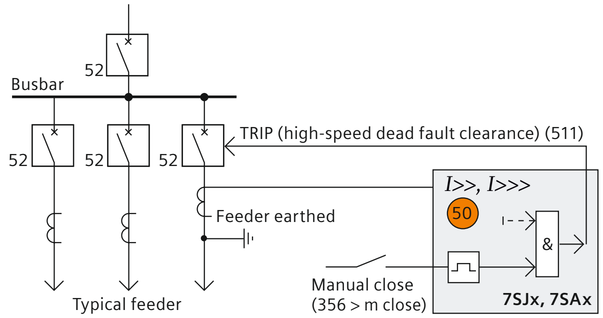


Fig. 2/37 Switch-onto-fault protection

Directional comparison protection (cross-coupling)

Cross-coupling is used for selective protection of sections fed from two sources with instantaneous tripping, that is, without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated overcurrent-time protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

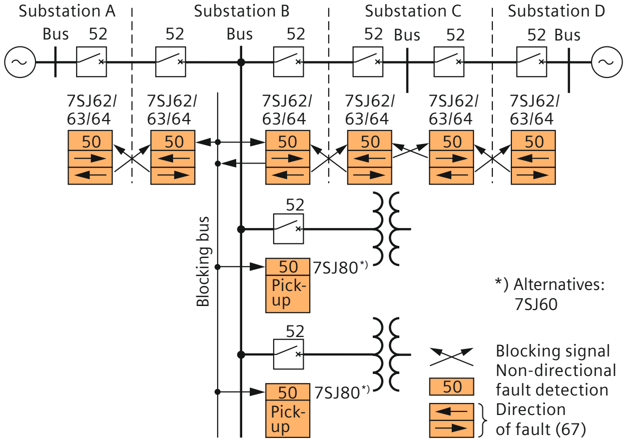


Fig. 2/38 Directional comparison protection

Distribution feeder with reclosers

General notes:

- The feeder relay operating characteristics, delay times and auto-reclosure cycles must be carefully coordinated with downstream reclosers, sectionalizers and fuses.
  The 50 / 50N instantaneous zone is normally set to reach out to the first main feeder sectionalizing point. It has to ensure fast clearing of close-in faults and prevent blowing of fuses in this area ("fuse saving"). Fast auto-reclosure is initiated in this case. Further time-delayed tripping and reclosure steps (normally two or three) have to be graded against the recloser.
- The overcurrent relay should automatically switch over to less sensitive characteristics after long breaker interruption times in order to enable overriding of subsequent cold load pickup and transformer inrush currents.

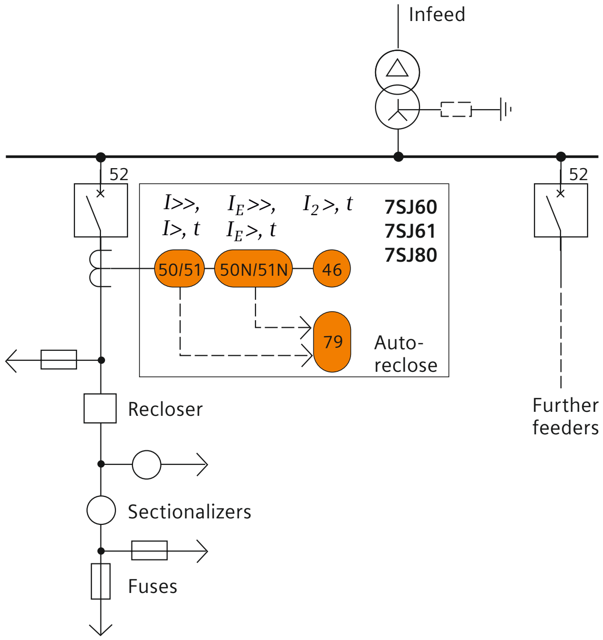


Fig. 2/39 Distribution feeder with reclosers

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder that has previously been disconnected by overcurrent protection.

SIPROTEC 7SJ61 allows up to nine reclosing shots. The first four dead times can be set individually. Reclosing can be blocked or initiated by a binary input or internally. After the first trip in a reclosing sequence, the high-set instantaneous elements (I>>>, I>>, I_E>>) can be blocked. This is used for fuse-saving applications and other similar transient schemes using simple overcurrent relays instead of fuses. The low-set definite-time (I>, I_E>) and the inverse-time (I_p, I_{Ep}) overcurrent elements remain operative during the entire sequence.

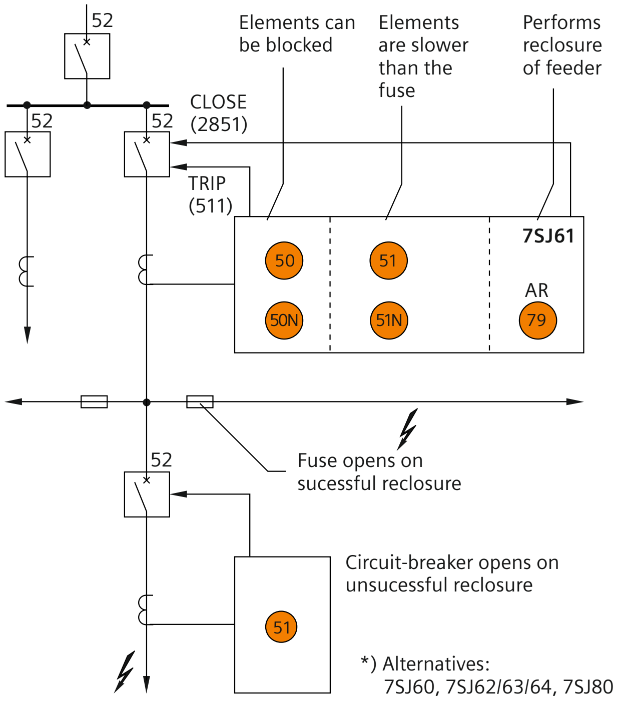


Fig. 2/40 3-pole multishot auto-reclosure (AR, ANSI 79)

Parallel feeder circuit

General notes:

- The preferred application of this circuit is in the reliable supply of important consumers without significant infeed from the load side.
- The 67 / 67N directional overcurrent protection trips instantaneously for faults on the protected line. This saves one time-grading interval for the overcurrent relays at the infeed.
- The 51 / 51N overcurrent relay functions must be time-graded against the relays located upstream.

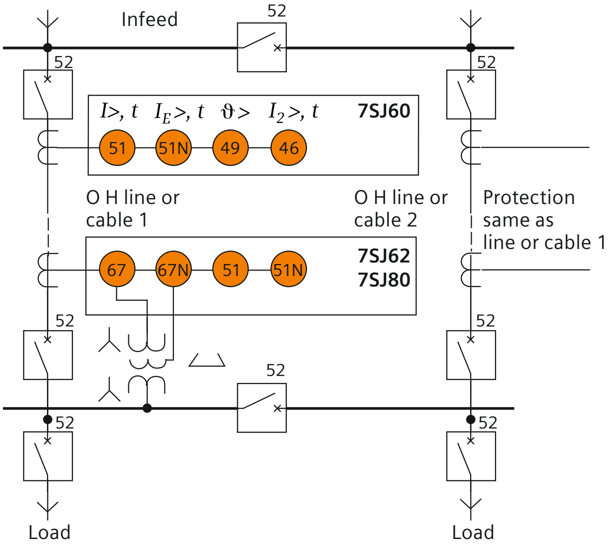


Fig. 2/41 Parallel feeder circuit

Typical Protection Schemes

Reverse-power monitoring at double infeed

If a busbar is fed from two parallel infeeds and a fault occurs on one of them, only the faulty infeed should be tripped selectively in order to enable supply to the busbar to continue from the remaining supply. Unidirectional devices that can detect a short-circuit current or energy flow from the busbar toward the incoming feeder should be used. Directional time-overcurrent protection is usually set via the load current. However, it cannot clear weak-current faults. The reverse-power protection can be set much lower than the rated power, thus also detecting the reverse-power flow of weak-current faults with fault currents significantly below the load current.

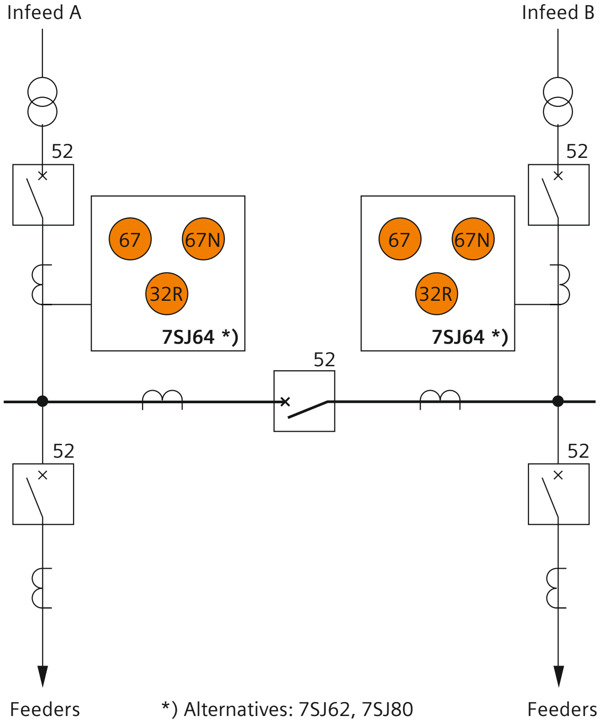


Fig. 2/42 Reverse-power monitoring at double infeed

Synchronization function

Note:

Also available in relays 7SA6, 7SD5, 7SA522, 7VK61.

General notes:

- When two subsystems must be interconnected, the synchronization function monitors whether the subsystems are synchronous and can be connected without risk of losing stability.
- This synchronization function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local / remote).

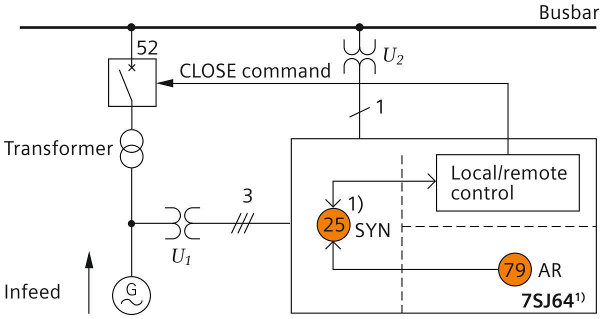


Fig. 2/43 Synchronization function

Cables or short overhead lines with infeed from both ends

Notes:

1) Auto-reclosure only with overhead lines

2) Differential protection options:

- Type 7SD5 or 7SD610 with direct fiber-optic connection up to about 100 km or via a 64 kbit / s channel (optical fiber, microwave)
- Type 7SD52 or 7SD610 with 7XV5662 (CC-CC) with 2 and 3 pilot wires up to about 30 km
- Type 7SD80 with pilot wire and/or fibre optic protection data interface.

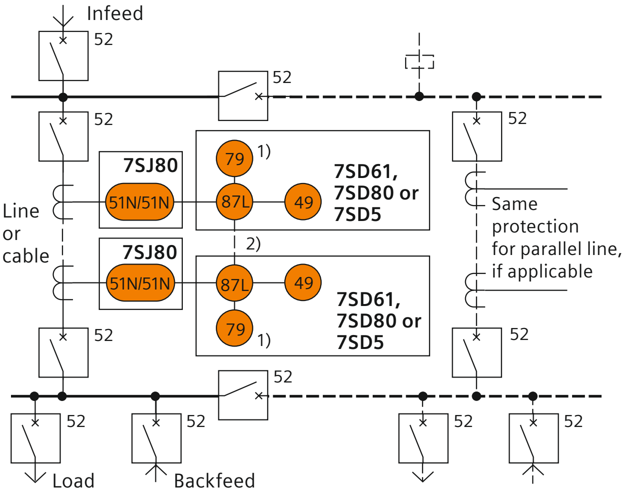


Fig. 2/44 Cables or short overhead lines with infeed from both ends

Overhead lines or longer cables with infeed from both ends

Notes:

1) Teleprotection logic (85) for transfer trip or blocking schemes. Signal transmission via pilot wire, power line carrier, digital network or optical fiber (to be provided separately). The teleprotection supplement is only necessary if fast fault clearance on 100 % line length is required, that is, second zone tripping (about 0.3 s delay) cannot be accepted for far end faults. For further application notes on teleprotection schemes, refer to the table on the following page.

2) Directional earth-fault protection 67N with inverse-time delay against high-resistance faults

3) Single or multishot auto-reclosure (79) only with overhead lines.

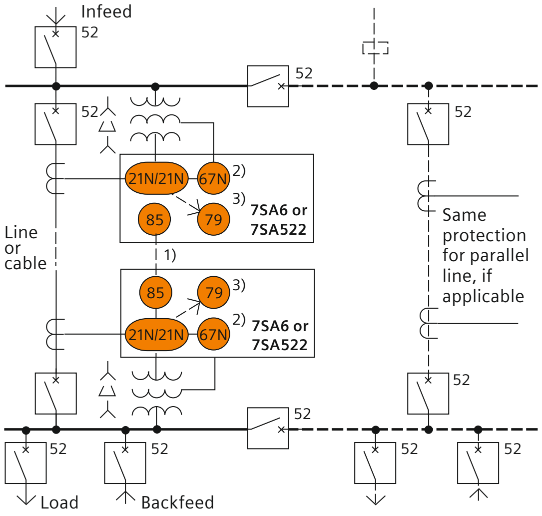


Fig. 2/45 Overhead lines or longer cables with infeed from both ends

Subtransmission line

Note:

Connection to open delta winding if available. Relays 7SA6 / 522 and 7SJ62 can, however, also be set to calculate the zero-sequence voltage internally.

General notes:

- Distance teleprotection is proposed as main protection and time-graded directional overcurrent as backup protection.
- The 67N function of 7SA6 / 522 provides additional high-resistance earth-fault protection. It can be used in parallel with the 21 / 21N function.
- Recommended teleprotection schemes: PUTT on medium and long lines with phase shift carrier or other secure communication channel POTT on short lines. BLOCKING with On / Off carrier (all line lengths).

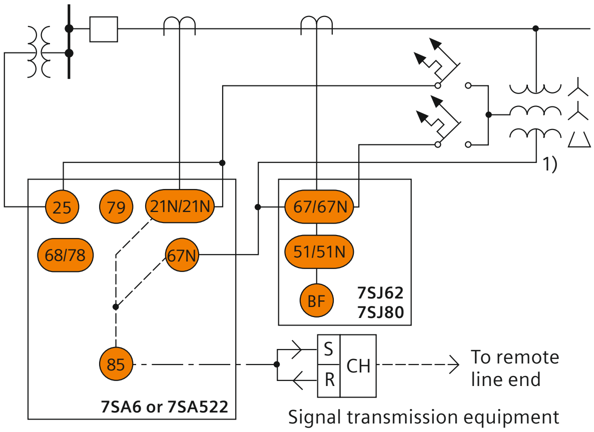


Fig. 2/46 Subtransmission line

Typical Protection Schemes

		Permissive underreach transfer trip (PUTT)	**Permissive overreach transfer trip (POTT)**	**Blocking**	**Unblocking**
Preferred application	Signal transmission system	Dependable and secure communication channel: • Power line carrier with frequency shift modulation. HF signal coupled to 2 phases of the protected line, or even better, to a parallel circuit to avoid transmission of the HF signal through the fault location. • Microwave radio, especially digital (PCM) • Fiber-optic cables		Reliable communication channel (only required during external faults) • Power line carrier with amplitude modulation (ON / OFF). The same frequency may be used on all terminals)	Dedicated channel with continuous signal transfer • Power line carrier with frequency shift keying. Continuous signal transmission must be permitted.
	Characteristic of line	Best suited for longer lines – where the underreach zone provides sufficient resistance coverage	• Excellent coverage on short lines in the presence of fault resistance. • Suitable for the protection of multi-terminal lines with intermediate infeed	All line types – preferred practice in the US	Same as POTT
Advantages		• Simple technique • No coordination of zones and times with the opposite end required. The combination of different relay types therefore presents no problems	• Can be applied without underreaching zone 1 stage (e.g., overcompensated series uncompensated lines) • Can be applied on extremely short lines (impedance less than minimum relay setting) • Better for parallel lines as mutual coupling is not critical for the overreach zone • Weak infeed terminals are no problem (Echo and Weak Infeed logic is included)	Same as POTT	Same as POTT but: • If no signal is received (no block and no uncompensated block) then tripping by the overreach zone is released after 20 ms
Drawbacks		• Overlapping of the zone 1 reaches must be ensured. On parallel lines, teed feeders and tapped lines, the influence of zero sequence coupling and intermediate infeeds must be carefully considered to make sure a minimum overlapping of the zone 1 reach is always present. • Not suitable for weak infeed terminals	• Zone reach and signal timing coordination with the remote end is necessary (current reversal)	Same as POTT • Slow tripping – all teleprotection trips must be delayed to wait for the eventual blocking signal • Continuous channel monitoring is not possible	Same as POTT

Table 2/1 Application criteria for frequently used teleprotection schemes

Transmission line with reactor (Fig. 2/47)

Notes:

1) 51N only applicable with earthed reactor neutral.
2) If phase CTs at the low-voltage reactor side are not available, the high-voltage phase CTs and the CT in the neutral can be connected to a restricted earth-fault protection using one 7VH60 high-impedance relay.

General notes:

- Distance relays are proposed as main 1 and main 2 protection. Duplicated 7SA6 is recommended for series-compensated lines.
- Operating time of the distance relays is in the range of 15 to 25 ms depending on the particular fault condition. These tripping times are valid for faults in the underreaching distance zone (80 to 85 % of the line length). Remote end faults must be cleared by the superimposed teleprotection scheme. Its overall operating time depends on the signal transmission time of the channel, typically 15 to 20 ms for frequency shift audio-tone PLC or microwave channels, and lower than 10 ms for ON / OFF PLC or digital PCM signaling via optical fibers. Teleprotection schemes based on distance relays therefore have operating times on the order of 25 to 30 ms with digital PCM coded communication. With state-of-the-art two-cycle circuit-breakers, fault clearing times well below 100 ms (4 to 5 cycles) can normally be achieved.
- Dissimilar carrier schemes are recommended for main 1 and main 2 protection, for example, PUTT, and POTT or Blocking / Unblocking.
- Both 7SA522 and 7SA6 provide selective 1-pole and / or 3-pole tripping and auto-reclosure. The earth-current directional comparison protection (67N) of the 7SA6 relay uses phase selectors based on symmetrical components. Thus, 1-pole auto-reclosure can also be executed with high-resistance faults. The 67N function of the 7SA522 relay can also be used as time-delayed directional overcurrent backup.
- The 67N functions are provided as high-impedance fault protection. 67N is often used with an additional channel as a separate carrier scheme. Use of a common channel with distance protection is only possible if the mode is compatible (e.g., POTT with directional comparison). The 67N may be blocked when function 21 / 21N picks up. Alternatively, it can be used as time-delayed backup protection.

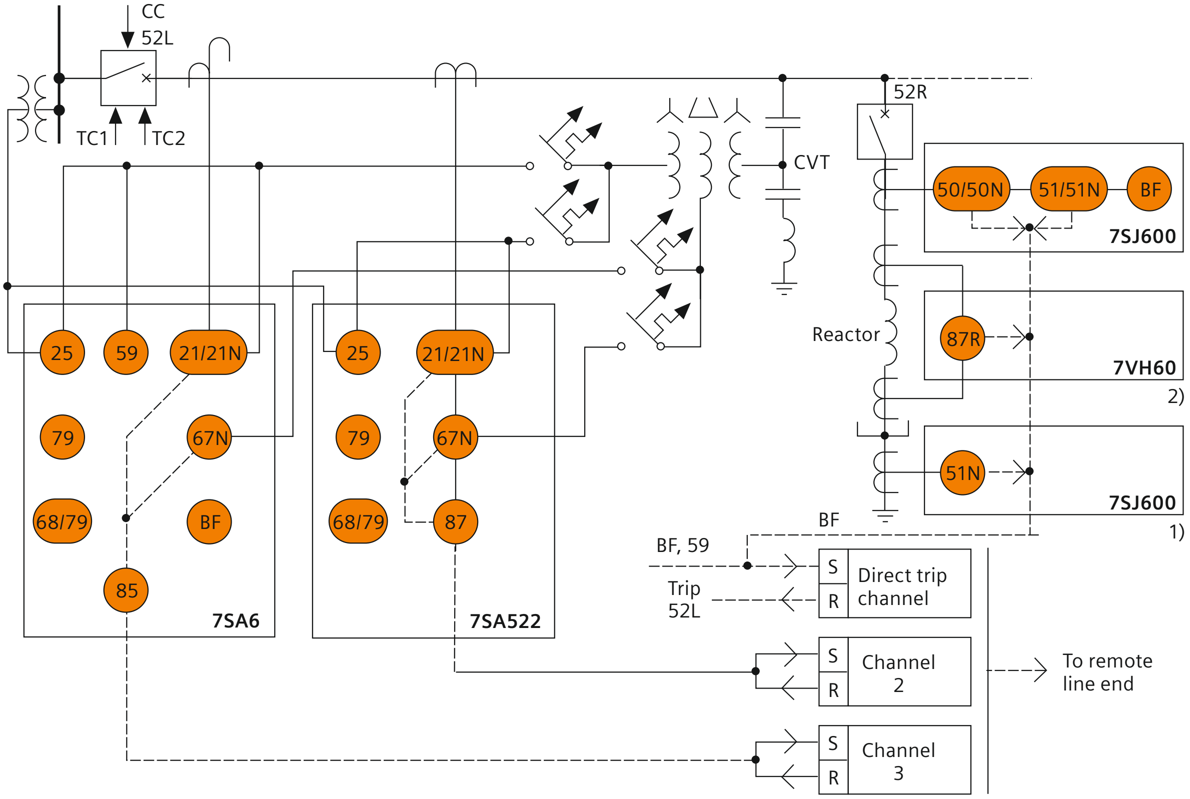


Fig. 2/47 Transmission line with reactor

Typical Protection Schemes

Transmission line or cable (with wide-band communication)

General notes:

- Digital PCM-coded communication (with n × 64 kbit / s channels) between line ends is becoming more and more frequently available, either directly by optical or microwave point-to-point links, or via a general-purpose digital communication network.
  In both cases, the relay-type current differential protection 7SD52 / 61 can be applied. It provides absolute phase and zone selectivity by phase-segregated measurement, and is not affected by power swing or parallel line zero-sequence coupling effects. It is, furthermore, a current-only protection that does not need a VT connection. For this reason, the adverse effects of CVT transients are not applicable.
  This makes it particularly suitable for double and multi-circuit lines where complex fault situations can occur.
  The 7SD5 / 61 can be applied to lines up to about 120 km in direct relay-to-relay connections via dedicated optical fiber cores (see also application "Cables or short overhead lines with infeed from both ends", page 2/21), and also to much longer distances of up to about 120 km by using separate PCM devices for optical fiber or microwave transmission. The 7SD5 / 61 then uses only a small part (64 to 512 kbit / s) of the total transmission capacity (on the order of Mbits / s).
- The 7SD52 / 61 protection relays can be combined with the distance relay 7SA52 or 7SA6 to form a redundant protection system with dissimilar measuring principles complementing each other (Fig. 2/48). This provides the highest degree of availability. Also, separate signal transmission ways should be used for main 1 and main 2 line protection, e.g., optical fiber or microwave, and power line carrier (PLC).
  The current comparison protection has a typical operating time of 15 ms for faults on 100 % line length, including signaling time.

General notes for Fig. 2/49:

- SIPROTEC 7SD5 offers fully redundant differential and distance relays accommodated in one single bay control unit, and provides both high-speed operation of relays and excellent fault coverage, even under complicated conditions. Precise distance-to-fault location avoids time-consuming line patrolling, and reduces the downtime of the line to a minimum.
- The high-speed distance relay operates fully independently from the differential relay. Backup zones provide remote backup for upstream and downstream lines and other power system components

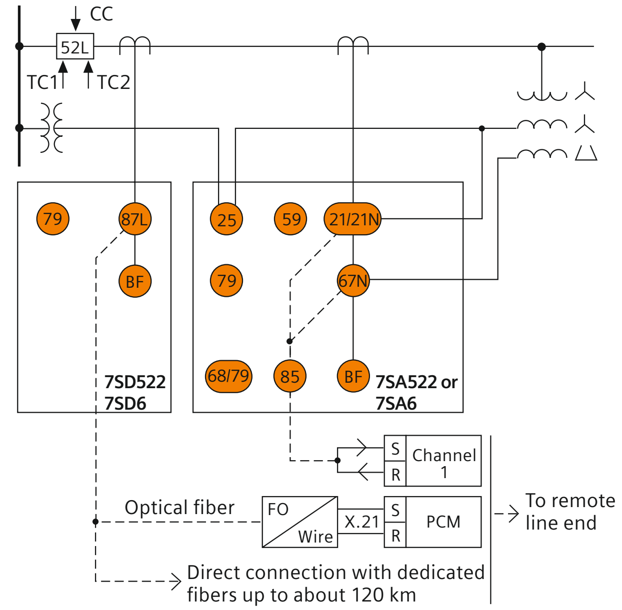


Fig. 2/48 Redundant transmission line protection

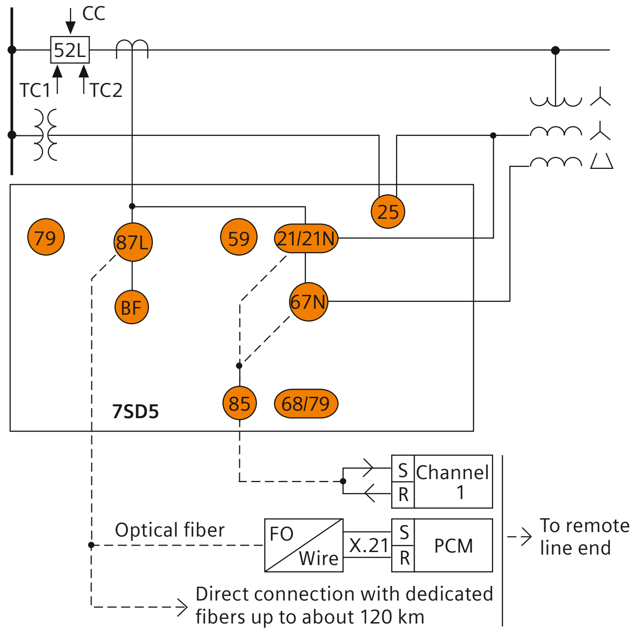


Fig. 2/49 Transmission line protection with redundant algorithm in one device

Transmission line, one-breaker-and-a-half terminal

Notes:

1) When the line is switched off and the line line disconnector (isolator) is open, high through-fault currents in the diameter may cause maloperation of the distance relay due to unequal CT errors (saturation).
   Normal practice is therefore to block the distance protection (21 / 21N) and the directional earth-fault protection (67N) under this condition via an auxiliary contact of the line line disconnector (isolator). A standby overcurrent function (50 / 51N, 51 / 51N) is released instead to protect the remaining stub between the breakers ("stub" protection).
2) Overvoltage protection only with 7SA6 / 52.

General notes:

- The protection functions of one diameter of a breaker-and-a-half arrangement are shown.
- The currents of two CTs have each to be summed up to get the relevant line currents as input for main 1 and 2 line protection.
- The location of the CTs on both sides of the circuit-breakers is typical for substations with dead-tank circuit-breakers. Live-tank circuit-breakers may have CTs only on one side to reduce cost. A fault between circuit-breakers and CT (end fault) may then still be fed from one side even when the circuit-breaker has opened. Consequently, final fault clearing by cascaded tripping has to be accepted in this case.
- The 7VK61 relay provides the necessary end fault protection function and trips the circuit-breakers of the remaining infeeding circuits.

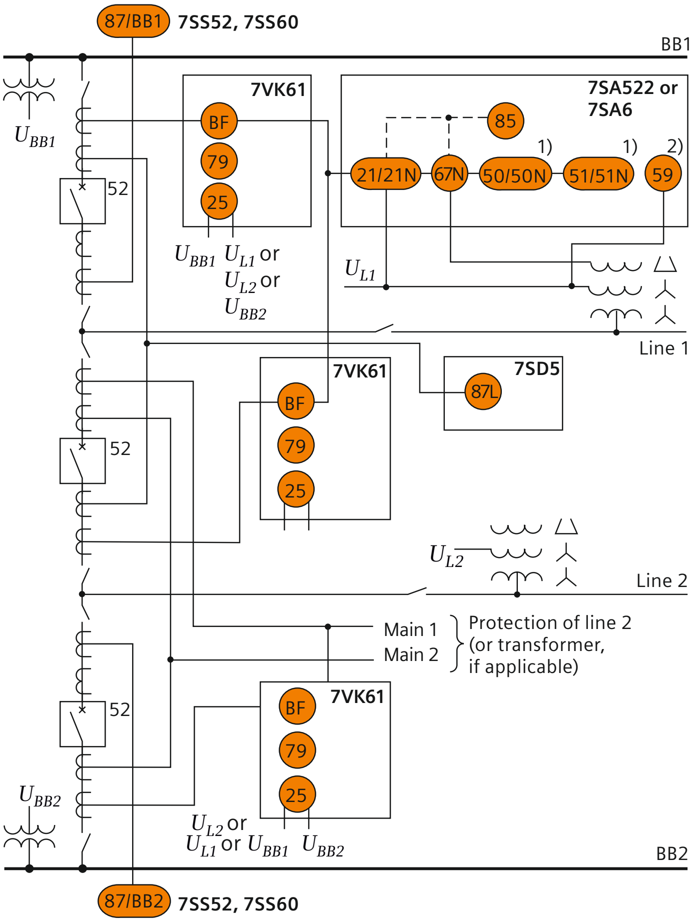


Fig. 2/50 Transmission line, one-breaker-and-a-half terminal, using 3 breaker management relays 7VK61

Typical Protection Schemes

General notes for Fig. 2/50 and 2/51:

- For the selection of the main 1 and main 2 line protection schemes, the comments of application examples “Transmission with reactor”, page 2/23 and “Transmission line or cable”, page 2/24 apply.
- Auto-reclosure (79) and synchrocheck function (25) are each assigned directly to the circuit-breakers and controlled by main 1 and 2 line protection in parallel. In the event of a line fault, both adjacent circuit-breakers have to be tripped by the line protection. The sequence of auto-reclosure of both circuit-breakers or, alternatively, the auto-reclosure of only one circuit-breaker and the manual closure of the other circuit-breaker, may be made selectable by a control switch.
- A coordinated scheme of control circuits is necessary to ensure selective tripping interlocking and reclosing of the two circuit-breakers of one line (or transformer feeder).
- The voltages for synchrocheck have to be selected according to the circuit-breaker and disconnector (isolator) position by a voltage replica circuit.

General notes for Fig. 2/51:

- In this optimized application, the 7VK61 is only used for the center breaker. In the line feeders, functions 25, 79 and BF are also performed by transmission line protection 7SA522 or 7SA6.

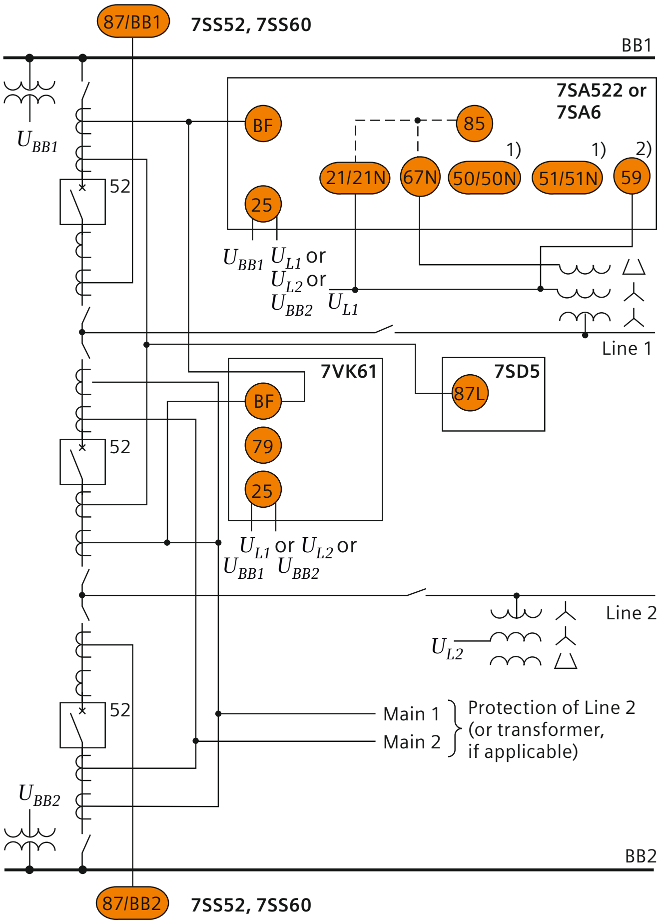


Fig. 2/51 Tranmission line, breaker-and-a-half terminal, using 1 breaker management relay 7VK61

2. Transformers

Small transformer infeed

General notes:

- Earth faults on the secondary side are detected by current relay 51N. However, it has to be time-graded against downstream feeder protection relays.
- The restricted earth-fault relay 87N can optionally be applied to achieve fast clearance of earth faults in the transformer secondary winding.
  Relay 7VH60 is of the high-impedance type and requires class × CTs with equal transformation ratios.
- Primary circuit-breaker and relay may be replaced by fuses.

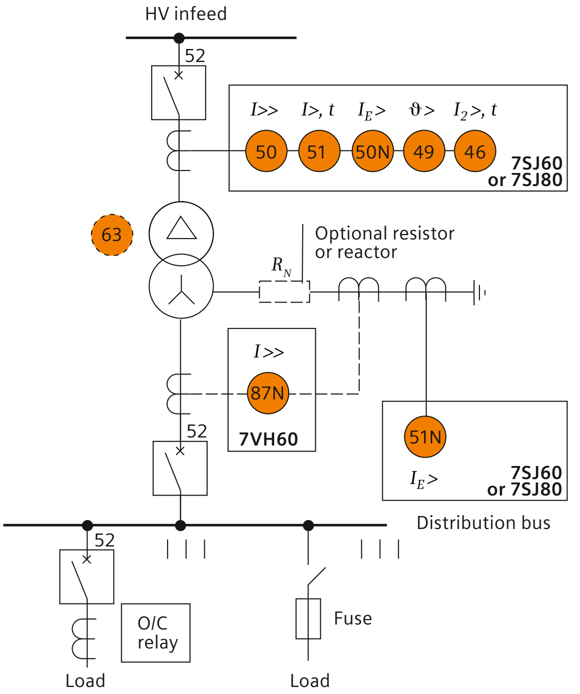


Fig. 2/52 Small transformer infeed

Large or important transformer infeed

General note:

- Relay 7UT612 provides numerical ratio and vector group adaptation. Matching transformers as used with traditional relays are therefore no longer applicable.

Notes:

1) If an independent high-impedance-type earth-fault function is required, the 7VH60 earth-fault relay can be used instead of the 87N inside the 7UT612. However, class × CT cores would also be necessary in this case (see small transformer protection).
2) 51 and 51N may be provided in a separate 7SJ60 if required.

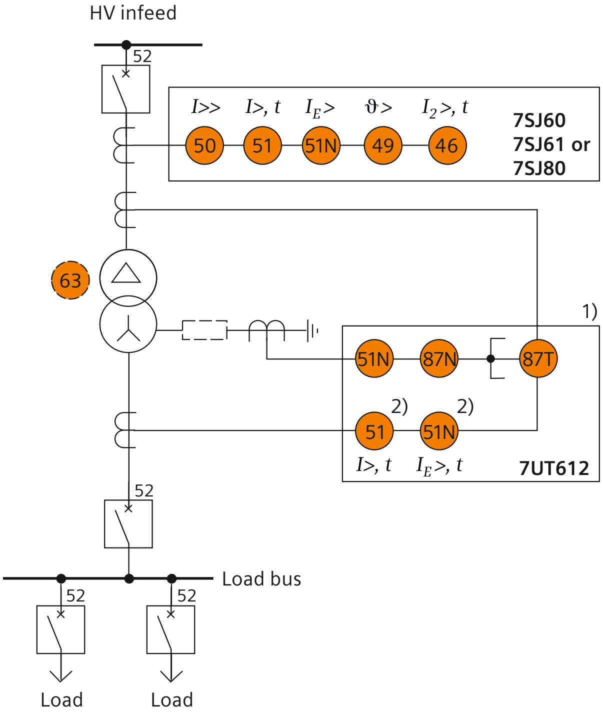


Fig. 2/53 Large or important transformer infeed

Typical Protection Schemes

Dual infeed with single transformer

General notes:

- Line CTs are to be connected to separate stabilizing inputs of the differential relay 87T in order to ensure stability in the event of line through-fault currents.
- Relay 7UT613 provides numerical ratio and vector group adaptation. Matching transformers, as used with traditional relays, are therefore no longer applicable.

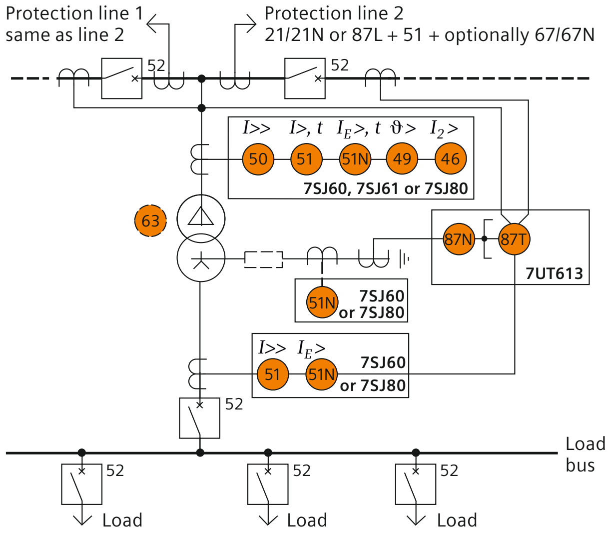


Fig. 2/54 Dual infeed with single transformer

Parallel incoming transformer feeders

Note:

The directional functions 67 and 67N do not apply for cases where the transformers are equipped with the transformer differential relays 87T.

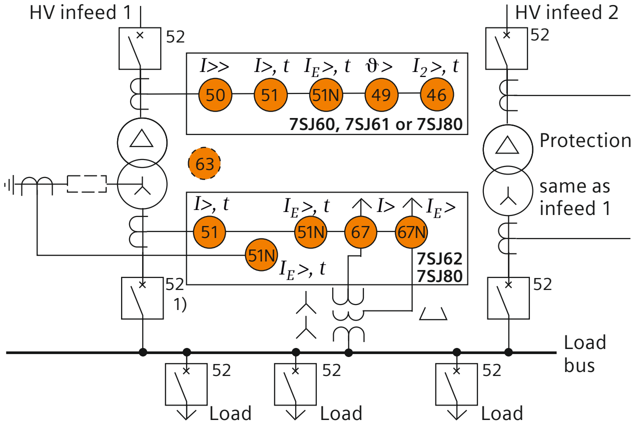


Fig. 2/55 Parallel incoming transformer feeders

Parallel incoming transformer feeders with bus tie

General notes:

- Overcurrent relay 51, 51N each connected as a partial differential scheme. This provides simple and fast busbar protection and saves one time-grading step.

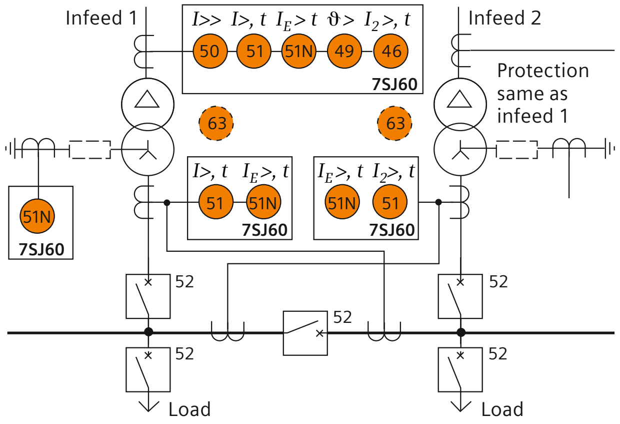


Fig. 2/56 Parallel incoming transformer feeders with bus tie

Three-winding transformer

Notes:

1) The zero-sequence current must be blocked before entering the differential relay with a delta winding in the CT connection on the transformer side with earthed starpoint. This is to avoid false operation during external earth faults (numerical relays provide this function by calculation). About 30 % sensitivity, however, is then lost in the event of internal faults. Optionally, the zero-sequence current can be regained by introducing the winding neutral current in the differential relay (87T). Relay type 7UT613 provides two current inputs for this purpose. By using this feature, the earth-fault sensitivity can be upgraded again to its original value.
   Restricted earth-fault protection (87T) is optional. It provides backup protection for earth faults and increased earth-fault sensitivity (about 10 % IN, compared to about 20 to 30 % IN of the transformer differential relay). Separate class × CT-cores with equal transmission ratio are also required for this protection.
2) High impedance and overcurrent in one 7SJ61.

General notes:

- In this example, the transformer feeds two different distribution systems with cogeneration. Restraining differential relay inputs are therefore provided at each transformer side.
- If both distribution systems only consume load and no through-feed is possible from one MV system to the other, parallel connection of the CTs of the two MV transformer windings is admissible, which allows the use of a two-winding differential relay (7UT612).

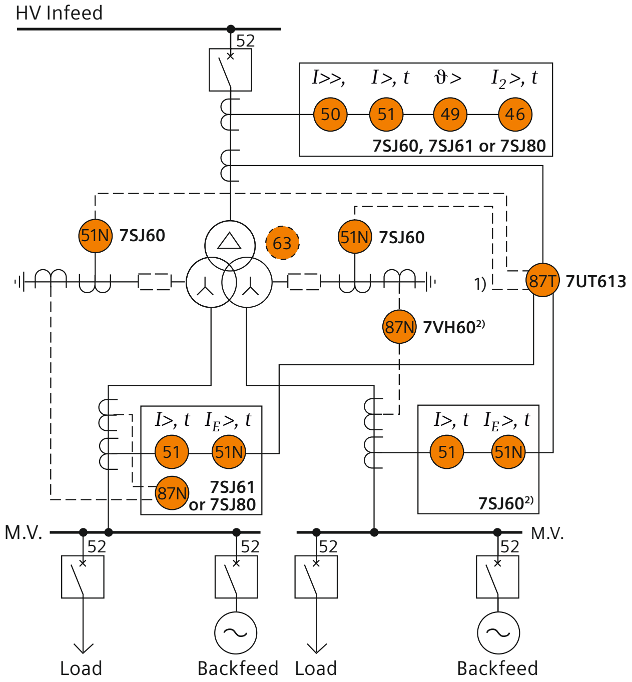


Fig. 2/57 Three-winding transformer

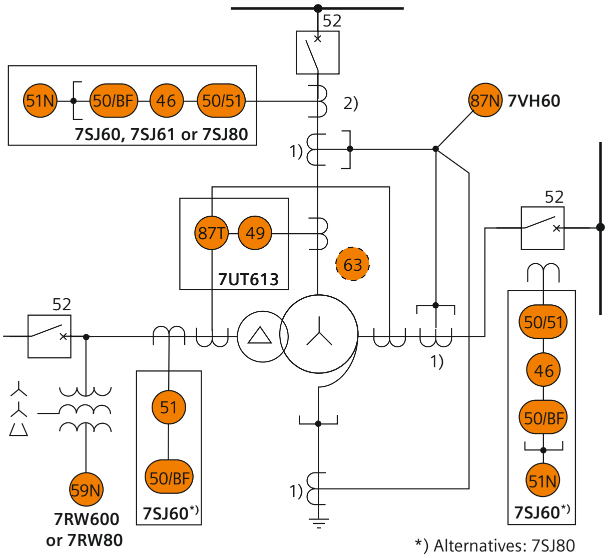
Autotransformer

Notes:

1) 87N high-impedance protection requires special class × current transformer cores with equal transformation ratios.
2) The 7SJ60 relay can alternatively be connected in series with the 7UT613 relay to save this CT core.

General note:

- Two different protection schemes are provided: 87T is chosen as the low-impedance three-winding version (7UT613). 87N is a 1-phase high-impedance relay (7VH60) connected as restricted earth-fault protection. (In this example, it is assumed that the phase ends of the transformer winding are not accessible on the neutral side, that is, there exists a CT only in the neutral earthing connection.).



*) Alternatives: 7SJ80

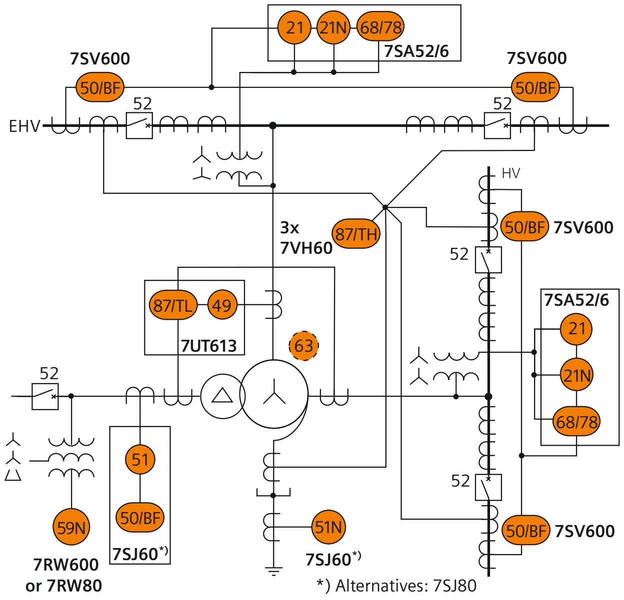
Fig. 2/58 Autotransformer

Typical Protection Schemes

Large autotransformer bank

General notes:

- The transformer bank is connected in a breaker-and-a-half arrangement.
  Duplicated differential protection is proposed:
- Main 1: Low-impedance differential protection 87TL (7UT613) connected to the transformer bushing CTs.
- Main 2: High-impedance differential overall protection 87TL (7VH60). Separate class × cores and equal CT ratios are required for this type of protection.
- Backup protection is provided by distance protection relay (7SA52 and 7SA6), each "looking" with an instantaneous first zone about 80 % into the transformer and with a time-delayed zone beyond the transformer.
- The tertiary winding is assumed to feed a small station supply system with isolated neutral.



*) Alternatives: 7SJ80

Fig. 2/59 Large autotransformer bank

3. Motors

Small and medium-sized motors < about 1 MW

a) With effective or low-resistance earthed infeed ($I_E \geq I_{N\ Motor}$)

General note:

- Applicable to low-voltage motors and high-voltage motors with low-resistance earthed infeed ($I_E \geq I_{N\ Motor}$)

b) With high-resistance earthed infeed ($I_E \leq I_{N\ Motor}$)

Notes:

1) Core-balance CT.

2) Sensitive directional earth-fault protection (67N) only applicable with infeed from isolated or Petersen coil earthed system (for dimensioning of the sensitive directional earth-fault protection, see also application circuit page 2/33 and Fig. 2/68)

3) The 7SJ602 relay can be applied for isolated and compensated systems.

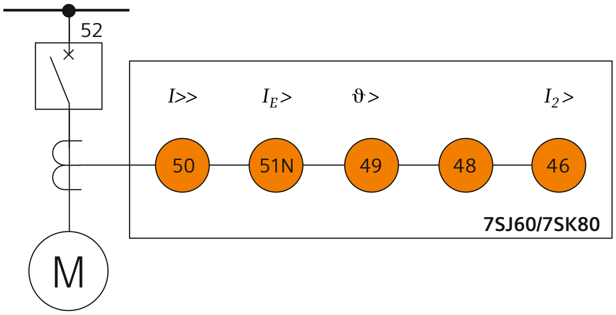


Fig. 2/60 Motor protection with effective or low-resistance earthed infeed

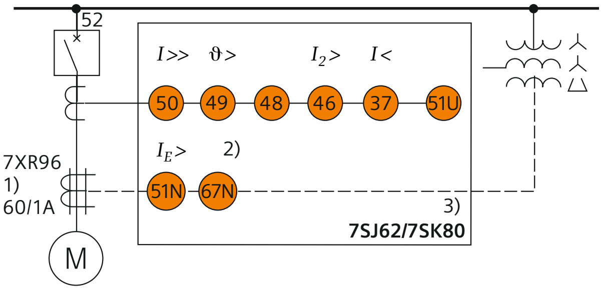


Fig. 2/61 Motor protection with high-resistance earthed infeed

Large HV motors > about 1 MW

Notes:

1) Core-balance CT.
2) Sensitive directional earth-fault protection (67N) only applicable with infeed from isolated or Petersen coil earthed system.
3) This function is only needed for motors where the startup time is longer than the safe stall time tE. According to IEC 60079-7, the tE time is the time needed to heat up AC windings, when carrying the starting current I_A, from the temperature reached in rated service and at maximum ambient air temperature to the limiting temperature. A separate speed switch is used to supervise actual starting of the motor. The motor circuit-breaker is tripped if the motor does not reach speed in the preset time. The speed switch is part of the motor supply itself.
4) Pt100, Ni100, Ni120
5) 49T only available with external temperature detector device (RTD-box 7XV5662)

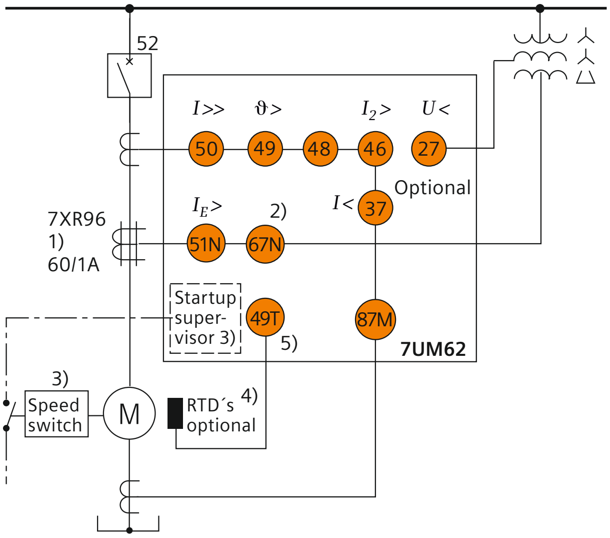


Fig. 2/62 Protection of large HV motors > about 1 MW

Cold load pickup

By means of a binary input that can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable amount of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady-state conditions.

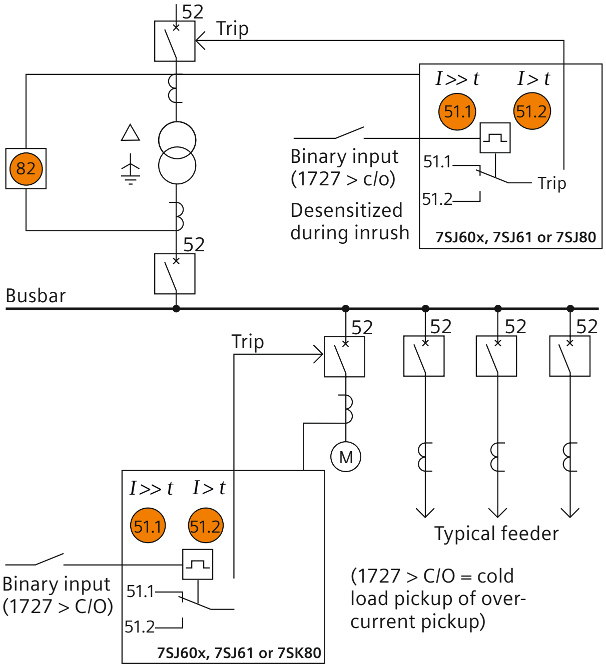


Fig. 2/63 Cold load pickup

Typical Protection Schemes

4. Generators

Generators < 500 kW (Fig. 2/64 and Fig.2/65)

Note:

If a core-balance CT is provided for sensitive earth-fault protection, relay 7SJ602 with separate earth-current input can be used.

Generators, typically 1–3 MW

(Fig. 2/66)

Note:

Two VTs in V connection are also sufficient.

Generators > 1–3 MW

(Fig. 2/67)

Notes:

1) Functions 81 and 59 are required only where prime mover can assume excess speed and the voltage regulator may permit rise of output voltage above upper limit.

2) Differential relaying options:
  - – Low-impedance differential protection 87.
  - – Restricted earth-fault protection with low-resistance earthed neutral (Fig. 2/66).

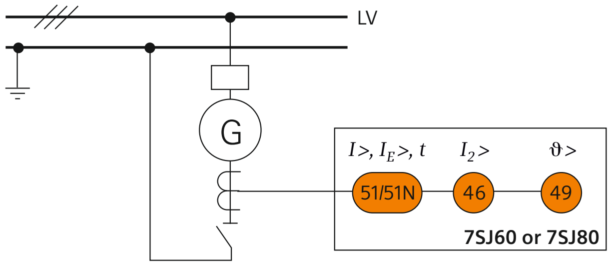


Fig. 2/64 Generator with solidly earthed neutral

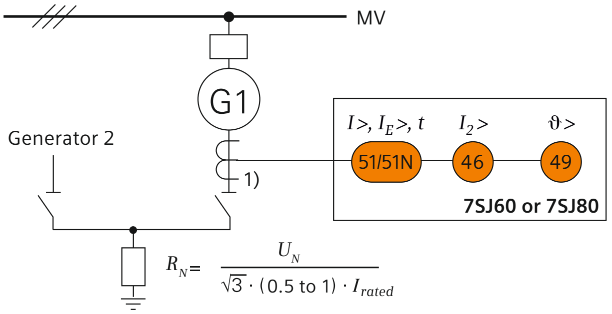


Fig. 2/65 Generator with resistance-earthed neutral

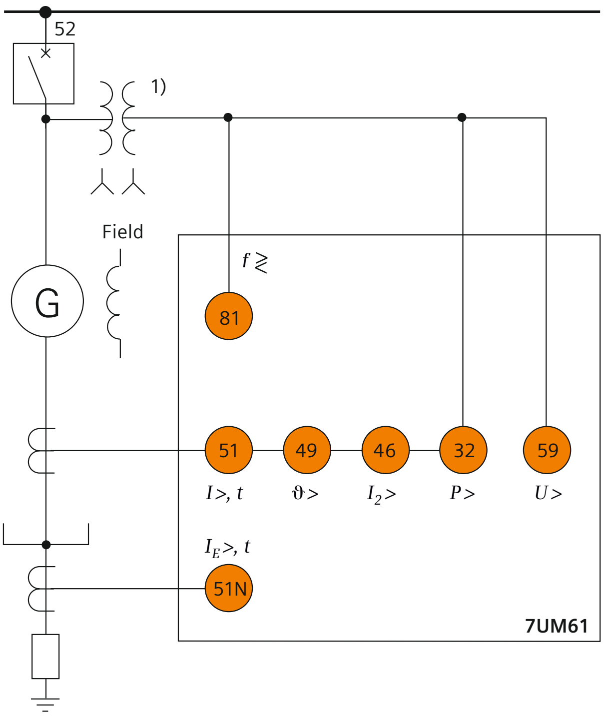


Fig. 2/66 Protection for generators 1–3 MW

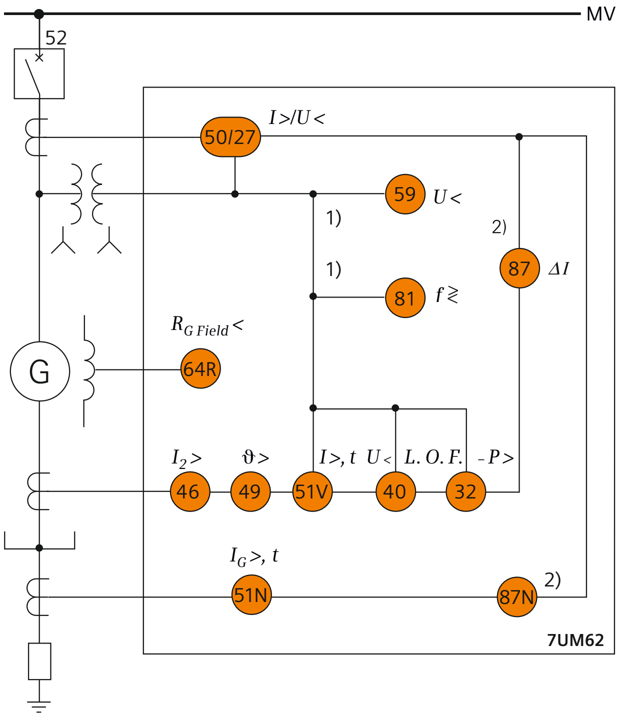


Fig. 2/67 Protection for generators >1–3 MW

Generators > 5 –10 MW feeding into a system with isolated neutral

(Fig. 2/68)

General notes:

- The setting range of the directional earth-fault protection (67N) in the 7UM6 relay is 2–1,000 mA. Depending on the current transformer accuracy, a certain minimum setting is required to avoid false operation on load or transient currents.
- In practice, efforts are generally made to protect about 90 % of the machine winding, measured from the machine terminals. The full earth current for a terminal fault must then be ten times the setting value, which corresponds to the fault current of a fault at 10 % distance from the machine neutral.

Relay earth-current input connected to:	**Minimum relay setting:**	**Comments:**
Core-balance CT 60 / 1 A: 1 single CT 2 parallel CTs 3 parallel Cts 4 parallel CTs	 2 mA 5 mA 8 mA 12 mA	
Three-phase CTs in residual (Holmgreen) connection	1 A CT: 50 mA 5 A CT: 200 mA	In general not suitable for sensitive earth-fault protection
Three-phase CTs in residual (Holmgreen) connection with special factory calibration to minimum residual false currents (≤ 2 mA)	2–3 ‰ of secondary rated CT current $I_{n\ SEC}$ 10–15 mA with 5 A CTs	1 A CTs are not recommended in this case

For the most sensitive setting of 2 mA, we therefore need 20 mA secondary earth current, corresponding to (60 / 1) × 20 mA = 1.2 A primary.

If sufficient capacitive earth current is not available, an earthing transformer with resistive zero-sequence load can be installed as earth-current source at the station busbar. The smallest standard earthing transformer TGAG 3541 has a 20 s short-time rating of input connected to: S_G = 27 kVA

In a 5 kV system, it would deliver:

$$I_{G\,20\,\mathrm{s}} = \frac{\sqrt{3}\cdot S_G}{U_N} = \frac{\sqrt{3}\cdot 27{,}000\ \mathrm{VA}}{5{,}000\ \mathrm{V}} = 9.4\ \mathrm{A}$$

corresponding to a relay input current of 9.4 A × 1 / 60 A = 156 mA. This would provide a 90 % protection range with a setting of about 15 mA, allowing the use of 4 parallel connected core-balance CTs. The resistance at the 500 V open-delta winding of the earthing transformer would then have to be designed for

$$R_B = U^2_{SEC} / S_G = 500\ U^2 / 27{,}000\ \mathrm{VA} = 9.26\ \Omega\ (27\ \mathrm{kW},\ 20\ \mathrm{s})$$

For a 5 MVA machine and 600 / 5 A CTs with special calibration for minimum residual false current, we would get a secondary current of $I_{G\ SEC}$ = 9.4 A / (600 / 5) = 78 mA.

With a relay setting of 12 mA, the protection range would in this case be $100\left(1-\frac{12}{78}\right) = 85\ \%$.

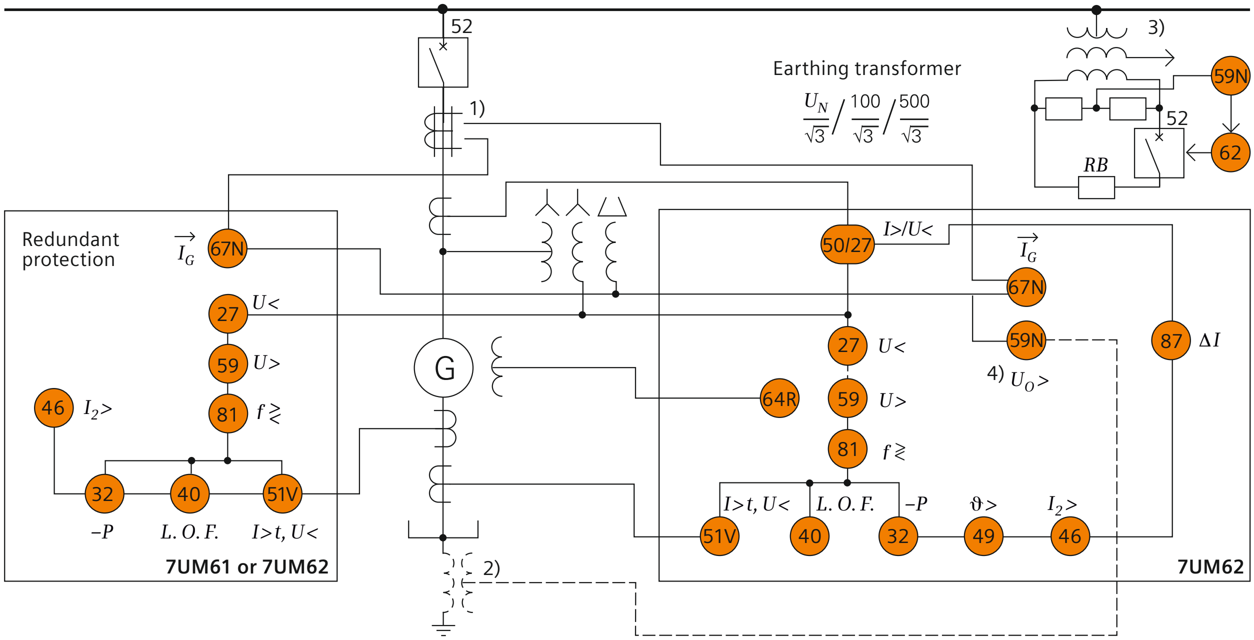


Fig. 2/68 Protection for generators > 5 –10 MW

Typical Protection Schemes

Notes (Fig. 2/68):

1) The standard core-balance CT 7XR96 has a transformation ratio of 60 / 1 A.
2) Instead of an open-delta winding at the terminal VT, a 1-phase VT at the machine neutral could be used as zero-sequence polarizing voltage.
3) The earthing transformer is designed for a short-time rating of 20 s. To prevent overloading, the load resistor is automatically switched off by a time-delayed zero-sequence voltage relay (59N + 62) and a contactor (52).
4) During the startup time of the generator with the open circuit-breaker, the earthing source is not available. To ensure earth-fault protection during this time interval, an auxiliary contact of the circuit-breaker can be used to change over the directional earth-fault relay function (67N) to a zero-sequence voltage detection function via binary input.

Generators > 50 – 100 MW in generator transformer unit connection

(Fig. 2/69)

Notes:

1) 100 % stator earth-fault protection based on 20 Hz voltage injection
2) Sensitive rotor earth-fault protection based on 1–3 Hz voltage injection
3) Non-electrical signals can be incoupled in the protection via binary inputs (BI)
4) Only used functions shown; further integrated functions available in each relay type; for more information, please refer to part 1 of this catalog.

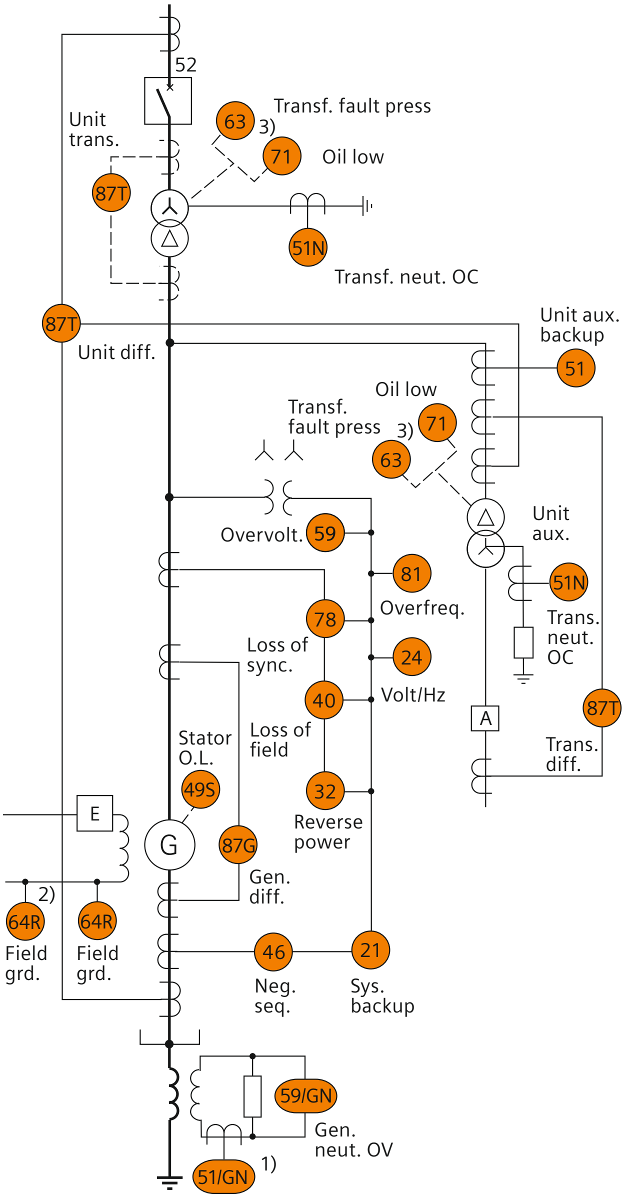


Fig. 2/69 Protections for generators > 50 MW

Relay type	Functions4)	Number of relays required
7UM62	21, 24, 32, 40, 46, 49 51GN 1), 59GN, 59, 64R, 64R 2), 78 81, 87G, via BI: 71, 63	2
7UM61 or 7UM62	51, 51N, optionally 21, 59, 81, via BI: 71, 63	1
7UT612	87T, 51N, optionally	1 2
7UT613	87T	1

Fig. 2/70 Assignment for functions to relay type

Synchronization of a generator

Fig. 2/71 shows a typical connection for synchronizing a generator. Paralleling device 7VE6 acquires the line and generator voltage, and calculates the differential voltage, frequency and phase angle. If these values are within a permitted range, a CLOSE command is issued after a specified circuit-breaker make time. If these variables are out of range, the paralleling device automatically sends a command to the voltage and speed controller. For example, if the frequency is outside the range, an actuation command is sent to the speed controller. If the voltage is outside the range, the voltage controller is activated.

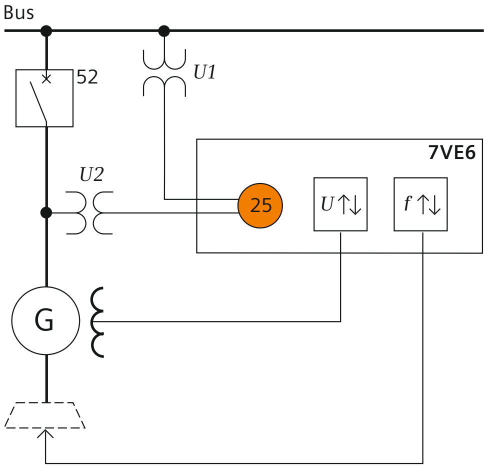


Fig. 2/71 Synchronization of a generator

5. Busbars

Busbar protection by overcurrent relays with reverse interlocking

General note:

- Applicable to distribution busbars without substantial ($< 0.25 \times I_N$) backfeed from the outgoing feeders.

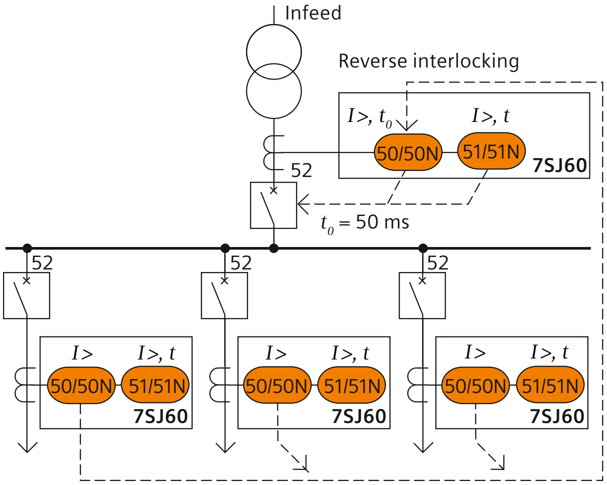


Fig. 2/72 Busbar protection by O / C relays with reverse interlocking

Typical Protection Schemes

High-impedance busbar protection

General notes:

- Normally used with single busbar, and one-breaker-and-a-half schemes.
- Requires separate class X current transformer cores. All CTs must have the same transformation ratio.

Note:

A varistor is normally applied across the relay input terminals to limit the voltage to a value safely below the insulation voltage of the secondary circuits.

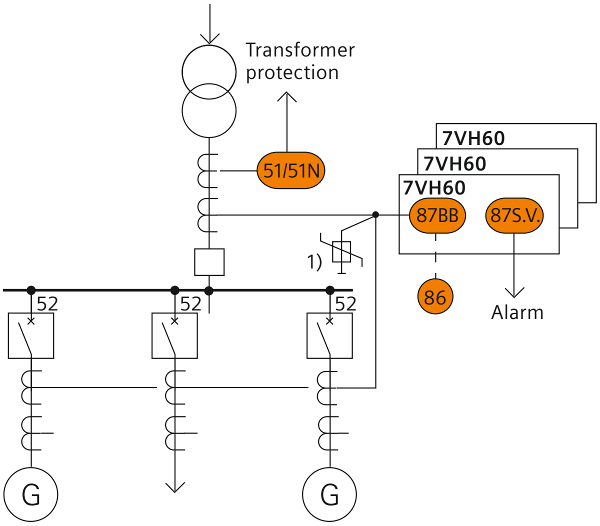


Fig. 2/73 High-impedance busbar protection

Low-impedance busbar protection 7SS60

General notes:

- Normally used with single busbar, one-breaker-and-a-half, and double busbar schemes, different transformation ratios can be adapted by matching transformers.
- Unlimited number of feeders.
- Feeder protection can be connected to the same CT core.

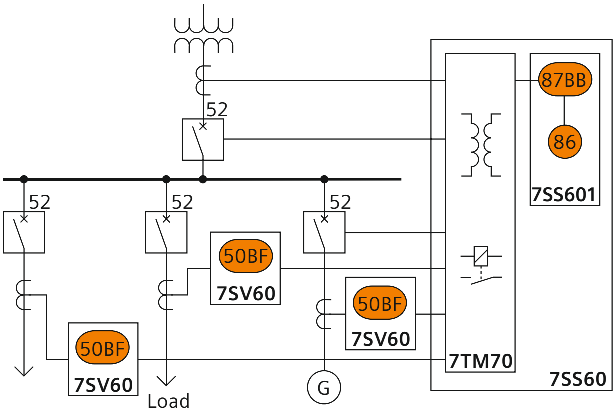


Fig. 2/74 Low-impedance busbar protection 7SS60

Distributed busbar protection 7SS52

General notes:

- Suitable for all types of busbar schemes.
- Preferably used for multiple busbar schemes where a disconnector (isolator) replica is necessary.
- The numerical busbar protection 7SS52 provides additional breaker failure protection.
- Different CT transformation ratios can be adapted numerically.
- The protection system and the disconnector (isolator) replica are continuously self-monitored by the 7SS52.
- Feeder protection can be connected to the same CT core.

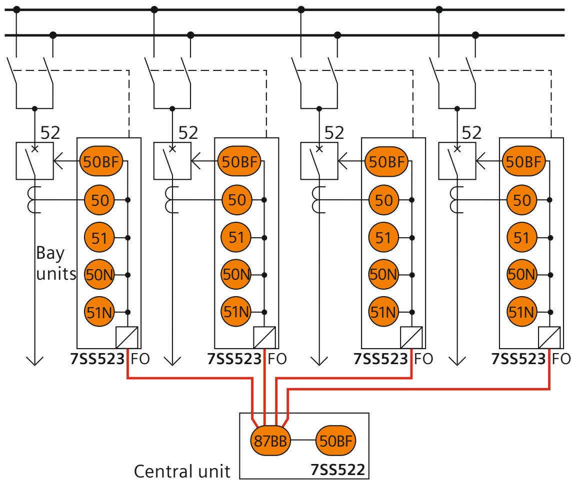


Fig. 2/75 Distributed busbar protection 7SS52

6. Power systems

Load shedding

In unstable power systems (e.g., isolated systems, emergency power supply in hospitals), it may be necessary to isolate selected loads from the power system to prevent overload of the overall system. The overcurrent-time protection functions are effective only in the case of a short-circuit.

Overloading of the generator can be measured as a frequency or voltage drop.

(Protection functions 27 and 81 available in 7RW600, 7SJ6 and 7SJ8.)

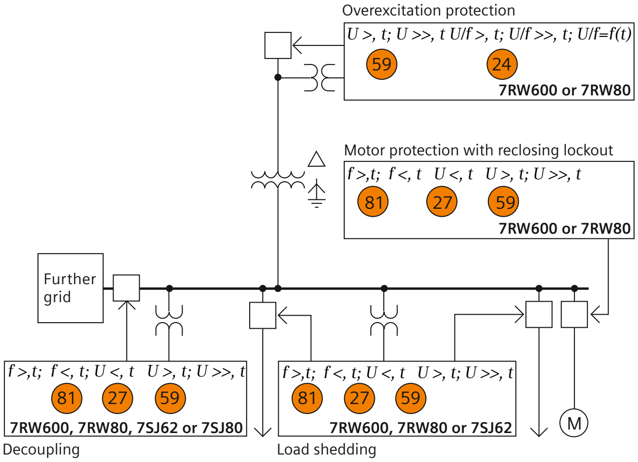


Fig. 2/76 Load shedding

Load shedding with rate-of-frequency-change protection

The rate-of-frequency-change protection calculates, from the measured frequency, the gradient or frequency change df / dt. It is thus possible to detect and record any major active power loss in the power system, to disconnect certain consumers accordingly and to restore the system to stability. Unlike frequency protection, rate-of-frequency-change protection reacts before the frequency threshold is undershot. To ensure effective protection settings, it is recommended to consider requirements throughout the power system as a whole. The rate-of-frequency-change protection function can also be used for the purposes of system decoupling. Rate-of-frequency-change protection can also be enabled by an underfrequency state.

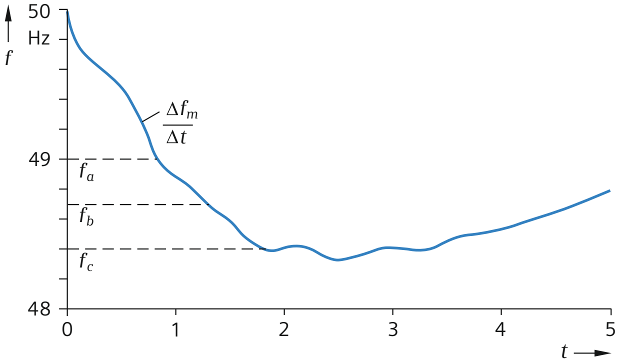


Fig. 2/77 Load shedding with rate-of-frequency-change protection

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for the trip circuit supervision.

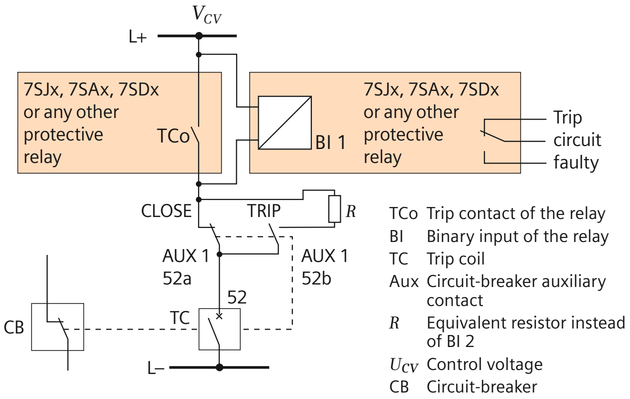


Fig. 2/78 Trip circuit supervision (ANSI 74TC)

Typical Protection Schemes

Disconnecting facility with flexible protection function

General note:

The SIPROTEC protection relay 7SJ64 disconnects the switchgear from the utility power system if the generator feeds energy back into the power system (protection function P reverse>). This functionality is achieved by using flexible protection. Disconnection also takes place in the event of frequency or voltage fluctuations in the utility power system (protection functions
$f<$, $f>$, $U<$, $U>$, $I_{dir}>$, $I_{Edir}>$/ 81, 27, 59, 67, 67N).

Notes:

1) The transformer is protected by differential protection and inverse or definite-time overcurrent protection functions for the phase currents. In the event of a fault, the circuit-breaker CB1 on the utility side is tripped by a remote link. Circuit-breaker CB2 is also tripped.

2) Overcurrent-time protection functions protect feeders 1 and 2 against short-circuits and overload caused by the connected loads. Both the phase currents and the zero currents of the feeders can be protected by inverse and definite-time overcurrent stages. The circuit-breakers CB4 and CB5 are tripped in the event of a fault.

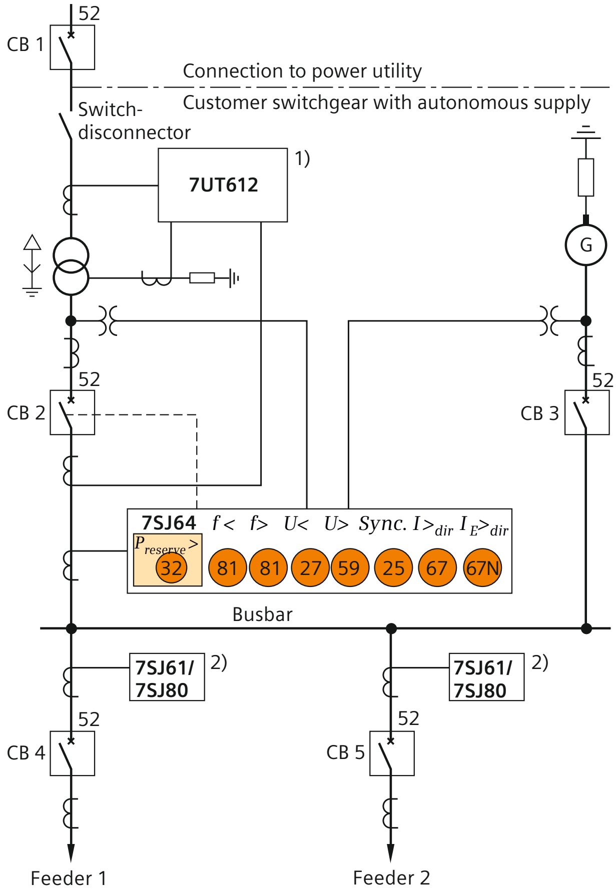


Fig. 2/79 Example of a switchgear with autonomous generator supply

Protection Coordination

Typical applications and functions

Relay operating characteristics and their settings must be carefully coordinated in order to achieve selectivity. The aim is basically to switch off only the faulty component and to leave the rest of the power system in service in order to minimize supply interruptions and to ensure stability.

Sensitivity

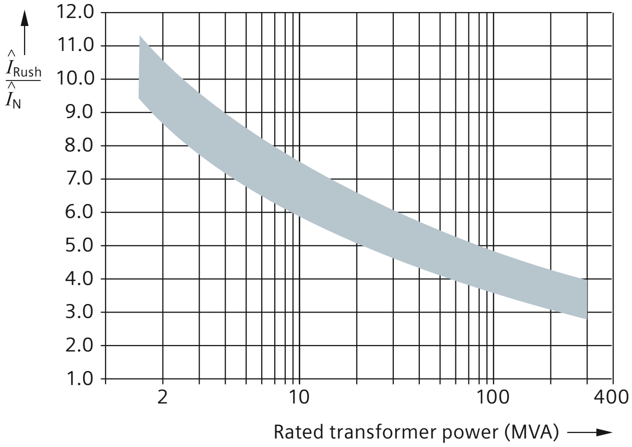
Protection should be as sensitive as possible in order to detect faults at the lowest possible current level. At the same time, however, it should remain stable under all permissible load, overload and through-fault conditions. For more information: http://www.siemens.com/systemplanning. The Siemens engineering programs SINCAL and SIGRADE are especially designed for selective protection grading of protection relay systems. They provide short-circuit calculations, international standard characteristics of relays, fuses and circuit-breakers for easy protection grading with respect to motor starting, inrush phenomena, and equipment damage curves.

Phase-fault overcurrent relays

The pickup values of phase overcurrent relays are normally set 30 % above the maximum load current, provided that sufficient short-circuit current is available. This practice is recommended particularly for mechanical relays with reset ratios of 0.8 to 0.85. Numerical relays have high reset ratios near 0.95 and allow, therefore, about a 10 % lower setting. Feeders with high transformer and/or motor load require special consideration.

Transformer feeders

The energizing of transformers causes inrush currents that may last for seconds, depending on their size (Fig. 2/79). Selection of the pickup current and assigned time delay have to be coordinated so that the inrush current decreases below the relay overcurrent reset value before the set operating time has elapsed. The inrush current typically contains only about a 50 % fundamental frequency component. Numerical relays that filter out harmonics and the DC component of the inrush current can therefore be set to be more sensitive. The inrush current peak values of Fig. 2/80 will be reduced to more than one half in this case. Some digital relay types have an inrush detection function that may block the trip of the overcurrent protection resulting from inrush currents.



Time constant of inrush current			
Nominal power (MVA)	0.5 … 1.0	1.0 … 10	> 10
Time constant (s)	0.16 … 0.2	0.2 … 1.2	1.2 … 720

Fig. 2/80 Peak value of inrush current

Earth-fault protection relays

Earth-current relays enable a much more sensitive setting, because load currents do not have to be considered (except 4-wire circuits with 1-phase load). In solidly and low-resistance earthed systems, a setting of 10 to 20 % rated load current can generally be applied. High-resistance earthing requires a much more sensitive setting, on the order of some amperes primary. The earth-fault current of motors and generators, for example, should be limited to values below 10 A in order to avoid iron burning. In this case, residual-current relays in the start point connection of CTs cannot be used; in particular, with rated CT primary currents higher than 200 A. The pickup value of the zero-sequence relay would be on the order of the error currents of the CTs. A special core-balance CT is therefore used as the earth-current sensor. The core-balance CT 7XR96 is designed for a ratio of 60/1 A. The detection of 6 A primary would then require a relay pickup setting of 0.1 A secondary. An even more sensitive setting is applied in isolated or Petersen coil earthed systems where very low earth currents occur with 1-phase-to-earth faults. Settings of 20 mA and lower may then be required depending on the minimum earth-fault current. Sensitive directional earth-fault relays (integrated into the relays 7SJ62, 63, 64, 7SJ80, 7SK80, 7SA6) allow settings as low as 5 mA.

Protection Coordination

Motor feeders

The energization of motors causes a starting current of initially 5 to 6 times the rated current (locked rotor current).

A typical time-current curve for an induction motor is shown in Fig. 2/81.

In the first 100 ms, a fast-decaying asymmetrical inrush current also appears. With conventional relays, it was common practice to set the instantaneous overcurrent stage of the short-circuit protection 20 to 30 % above the locked rotor current with a short-time delay of 50 to 100 ms to override the asymmetrical inrush period.

Numerical relays are able to filter out the asymmetrical current component very rapidly so that the setting of an additional time delay is no longer applicable.

The overload protection characteristic should follow the thermal motor characteristic as closely as possible. The adaptation is made by setting the pickup value and the thermal time constant, using the data supplied by the motor manufacturer. Furthermore, the locked-rotor protection timer has to be set according to the characteristic motor value.

Time grading of overcurrent relays (51)

The selectivity of overcurrent protection is based on time grading of the relay operating characteristics. The relay closer to the infeed (upstream relay) is time-delayed against the relay further away from the infeed (downstream relay). The calculation of necessary grading times is shown in Fig. 2/81 by an example for definite-time overcurrent relays.

The overshoot times take into account the fact that the measuring relay continues to operate due to its inertia, even if when the fault current is interrupted. This may be high for mechanical relays (about 0.1 s) and negligible for numerical relays (20 ms).

Inverse-time relays (51)

For the time grading of inverse-time relays, in principle the same rules apply as for the definite-time relays. The time grading is first calculated for the maximum fault level and then checked for lower current levels (Fig. 2/82).

If the same characteristic is used for all relays, or if when the upstream relay has a steeper characteristic (e.g., very much over normal inverse), then selectivity is automatically fulfilled at lower currents.

Differential relay (87)

Transformer differential relays are normally set to pickup values between 20 and 30 % of the rated current. The higher value has to be chosen when the transformer is fitted with a tap changer.

Restricted earth-fault relays and high-resistance motor / generator differential relays are, as a rule, set to about 10 % of the rated current.

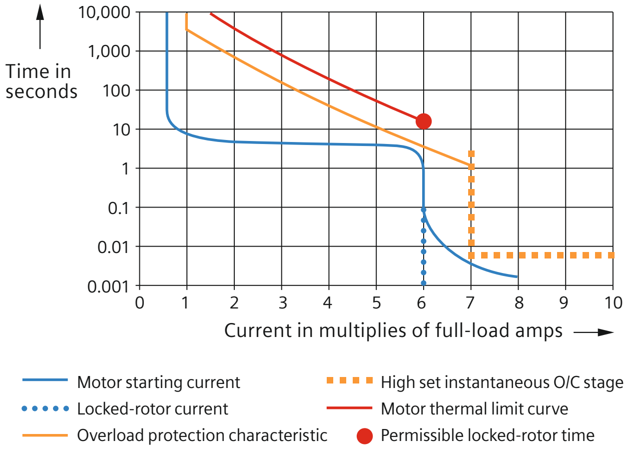


Fig. 2/81 Typical motor current-time characteristics

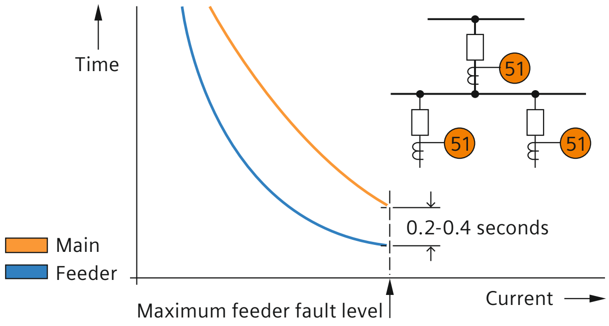


Fig. 2/82 Coordination of inverse-time relays

Instantaneous overcurrent protection (50)

This is typically applied on the final supply load or on any protection relay with sufficient circuit impedance between itself and the next downstream protection relay. The setting at transformers, for example, must be chosen about 20 to 30 % higher than the maximum through-fault current. The relay must remain stable during energization of the transformer.

Calculation example

The feeder configuration of Fig. 2/84 and the associated load and short-circuit currents are given. Numerical overcurrent relays 7SJ60 with normal inverse-time characteristics are applied.

The relay operating times, depending on the current, can be derived from the diagram or calculated with the formula given in Fig. 2/85.

The I_p / I_N settings shown in Fig. 2/84 have been chosen to get pickup values safely above maximum load current.

This current setting should be lowest for the relay farthest downstream. The relays further upstream should each have equal or higher current settings.

The time multiplier settings can now be calculated as follows:

Station C:

- For coordination with the fuses, we consider the fault in location F1.
  The short-circuit current $I_{scc.}$ max. related to 13.8 kV is 523 A.
  This results in 7.47 for I / I_p at the overcurrent relay in location C.
- With this value and $T_p = 0.05$, an operating time of $t_A = 0.17$ s can be derived from Fig. 2/85.

This setting was selected for the overcurrent relay to get a safe grading time over the fuse on the transformer low-voltage side. Safety margin for the setting values for the relay at station C are therefore:

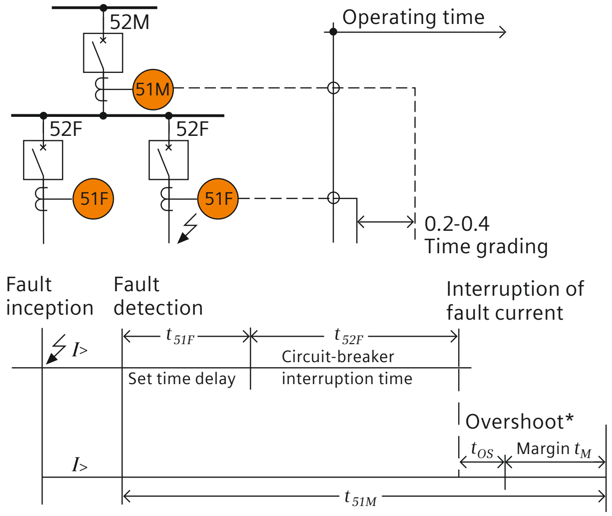
- Pickup current: $I_p / I_N = 0.7$
- Time multiplier: $T_p = 0.05$.

Station B:

The relay in B has a primary protection function for line B-C and a backup function for the relay in C. The maximum through-fault current of 1.395 A becomes effective for a fault in location F2. For the relay in C, an operating time time of 0.11 s ($I / I_p = 19.93$) is obtained.

It is assumed that no special requirements for short operating times exist and therefore an average time grading interval of 0.3 s can be chosen. The operating time of the relay in B can then be calculated.

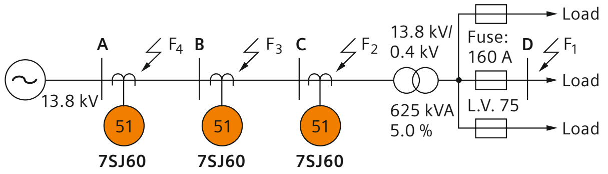
- $t_B = 0.11 + 0.3 = 0.41$ s
- Value of $I_p / I_N = \dfrac{1{,}395 \text{ A}}{220 \text{ A}} = 6.34$ (Fig. 2/84)
- With the operating time 0.41 s and $I_p / I_N = 6.34$, $T_p = 0.11$ can be derived from Fig. 2/85.



*also called overtravel or coasting time

Time grading	
$t_{rs} = t_{51M} - t_{51F} = t_{52F} + t_{OS} + t_M$	
Example 1	t_{TG} =0.10 s + 0.15 s + 0.15 s = 0.40 s
Oil circuit-breaker	t_{52F} = 0.10 s
Mechanical relays	t_{OS} = 0.15 s
Safety margin for measuring errors, etc.	t_M = 0.15 s
Example 2	t_{TG} = 0.08 + 0.02 + 0.10 = 0.20 s
Vacuum circuit-breaker	t_{52F} = 0.08 s
Numerical relays	t_{OS} = 0.02 s
Safety margin	t_M = 0.10 s

Fig. 2/83 Time grading of overcurrent-time relays



Station	Max. load A	$I_{SCC.}$ max^* A	CT ratio	I_p / I_N**	I_{prim}*** A	$I / I_p = \dfrac{I_{scc.\ max}}{I_{prim}}$
A	300	4,500	400 / 5	1.0	400	11.25
B	170	2,690	200 / 5	1.1	220	12.23
C	50	1,395	100 / 5	0.7	70	19.93
D	–	523	–	–	–	–

*) $I_{SCC.\ max}$ = Maximum short-circuit current
**) I_p / I_N = Relay current multiplier setting
***) I_{prim} = Primary setting current corresponding to I_p / I_N

Fig. 2/84 Time grading of inverse-time relays for a radial feeder

Protection Coordination

The setting values for the relay at station B are:

- Pickup current: $I_p/I_N = 1.1$
- Time multiplier $T_p = 0.11$

Given these settings, the operating time of the relay in B for a close fault in F3 can also be checked: The short-circuit current increases to 2,690 A in this case (Fig. 2/84). The corresponding I/I_p value is 12.23.

- With this value and the set value of $T_p = 0.11$, an operating time of 0.3 s is obtained again (Fig. 2/85).

Station A:

- Adding the time grading interval of 0.3 s, the desired operating itme is $t_A = 0.3 + 0.3 = 0.6$ s.

Following the same procedure as for the relay in station B, the following values are obtained for the relay in station A:

- Pickup current: $I_p / I_N = 1.0$
- Time multiplier $T_p = 0.17$
- For the close-in fault at location F4, an operating time of 0.48 s is obtained.

The normal way

To prove the selectivity over the whole range of possible short-circuit currents, it is normal practice to draw the set of operating curves in a common diagram with double log scales. These diagrams can be calculated manually and drawn point-by-point or constructed by using templates.

Today, computer programs are also available for this purpose. Fig. 2/86 shows the relay coordination diagram for the selected example, as calculated by the Siemens program SIGRADE (Siemens Grading Program). For further information: http://www.siemens.com/systemplanning.

Note:

To simplify calculations, only inverse-time characteristics have been used for this example. About 0.1 s shorter operating times could have been reached for high-current faults by additionally applying the instantaneous zones *I*>> of the 7SJ60 relays.

Coordination of overcurrent relays with fuses and low-voltage trip devices

The procedure is similar to the above-described grading of overcurrent relays. A time interval of between 0.1 and 0.2 s is usually sufficient for a safe time coordination.

Strong and extremely inverse characteristics are often more suitable than normal inverse characteristics in this case. Fig. 2/87 shows typical examples.

Simple distribution substations use a power fuse on the secondary side of the supply transformers (Fig. 2/87a).

In this case, the operating characteristic of the overcurrent relay at the infeed has to be coordinated with the fuse curve.

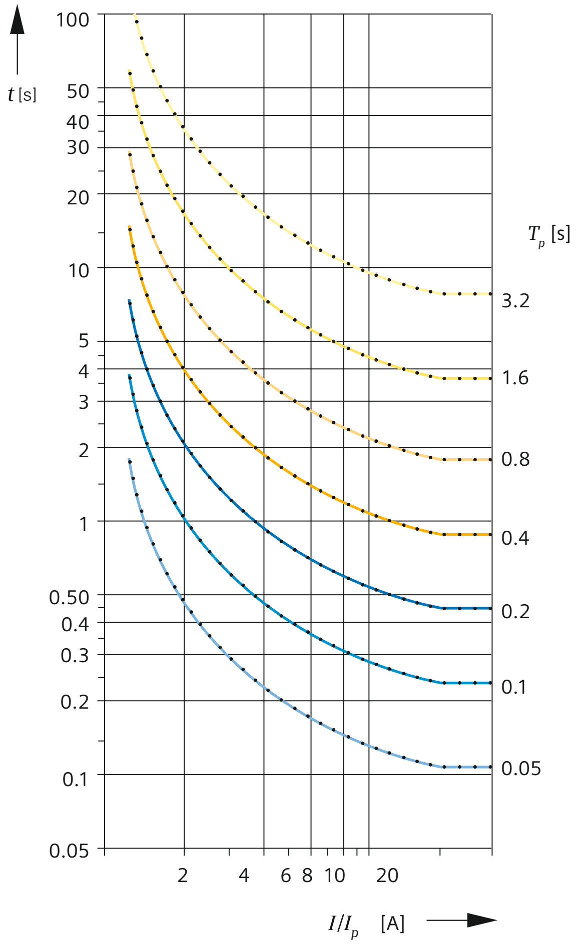


Fig. 2/85 Normal inverse-time characteristic of the 7SJ60 relay

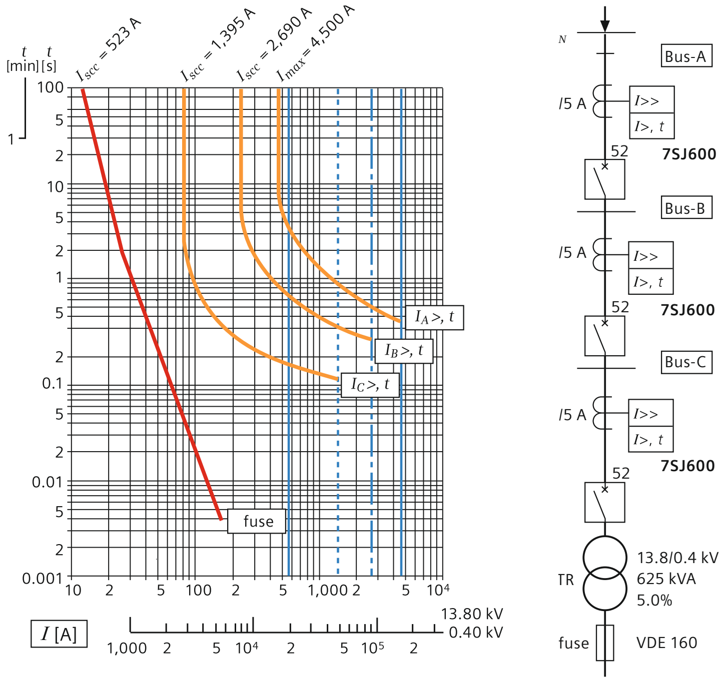
Normal inverse

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p(s)$$

Strong inverse characteristics may be used with expulsion-type fuses (fuse cutouts), while extremely inverse versions adapt better to current limiting fuses.

In any case, the final decision should be made by plotting the curves in the log-log coordination diagram.

Electronic trip devices of LV breakers have long-delay, short-delay and instantaneous zones. Numerical overcurrent relays with one inverse-time and two definite-time zones can closely be adapted to this (Fig. 2/87b).



Setting range	setting
$I_p = 0.10 - 4.00\ I_N$ $T_p = 0.05 - 3.2$ s $I>> = 0.1 - 25\ I_N$	$I_p = 1.0\ I_N$ $T_p = 0.17$ s $I>> = \infty$
$I_p = 0.10 - 4.00\ I_N$ $T_p = 0.05 - 3.2$ s $I>> = 0.1 - 25\ I_N$	$I_p = 1.0\ I_N$ $T_p = 0.11$ s $I>> = \infty$
$I_p = 0.10 - 4.00\ I_N$ $T_p = 0.05 - 3.2$ s $I>> = 0.1 - 25\ I_N$	$I_p = 0.7\ I_N$ $T_p = 0.05$ s $I>> = \infty$
HRC fuse 160 A	

Fig. 2/86 Overcurrent-time grading diagram

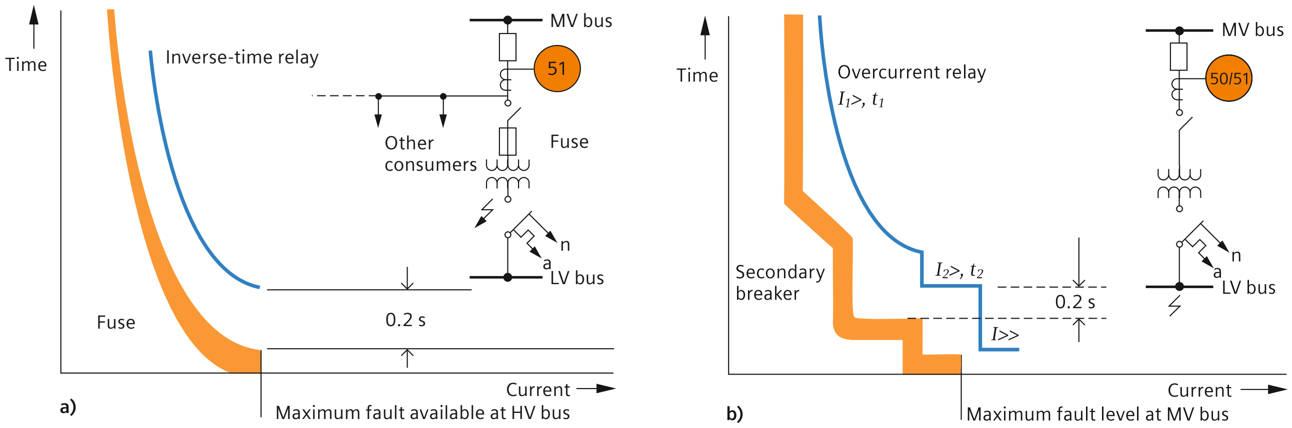


Fig. 2/87 Coordination of an overcurrent relay with an MV fuse and low-voltage breaker trip device

Coordination of distance relays

The distance relay setting must take into account the limited relay accuracy, including transient overreach (5 %, according to IEC 60255-6), the CT error (1 % for class 5P and 3 % for class 10P) and a security margin of about 5 %. Furthermore, the line parameters are often only calculated, not measured. This is a further source of errors. A setting of 80 to 85 % is therefore common practice; 80 % is used for mechanical relays, while 85 % can be used for the more accurate numerical relays.

Where measured line or cable impedances are available, the protected zone setting may be extended to 90 %. The second and third zones have to keep a safety margin of about 15 to 20 % to the corresponding zones of the following lines. The shortest following line always has to be considered (Fig. 2/88).

As a general rule, the second zone should at least reach 20 % over the next station to ensure backup for busbar faults, and the third zone should cover the longest following line as backup for the line protection.

Protection Coordination

Grading of zone times

The first zone normally operates undelayed. For the grading of the time delays of the second and third zones, the same rules as for overcurrent relays apply (Fig. 2/83, page 41). For the quadrilateral characteristics (relays 7SA6 and 7SA5), only the reactance values (X values) have to be considered for the protected zone setting. The setting of the R values should cover the line resistance and possible arc or fault resistances. The arc resistance can be roughly estimated as follows:

$$R_{Arc} = \frac{2.5 \cdot l_{arc}}{I_{SCC\ Min}} \ [\Omega]$$

l_{arc} = Arc length in mm

$I_{SCC\ Min}$ = Minimum short-circuit current in kA

- Typical settings of the ratio R / X are:
  - Short lines and cables (≤ 10 km): R / X =2 to 6
  - Medium line lengths < 25 km: R / X =2
  - Longer lines 25 to 50 km: R / X =1

Shortest feeder protectable by distance relays

The shortest feeder that can be protected by underreaching distance zones without the need for signaling links depends on the shortest settable relay reactance.

$$X_{Prim\ Min} = X_{Relay\ Min} \cdot \frac{VT_{ratio}}{CT_{ratio}}$$

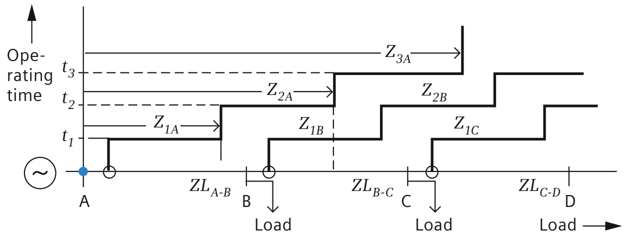
$$l_{min} = \frac{X_{Prim\ Min}}{X'_{Line}}$$

The shortest setting of the numerical Siemens relays is 0.05 Ω for 1 A relays, corresponding to 0.01 Ω for 5 A relays. This allows distance protection of distribution cables down to the range of some 500 meters.

Breaker failure protection setting

Most numerical relays in this guide provide breaker failure (BF) protection as an integral function. The initiation of the BF protection by the internal protection functions then takes place via software logic. However, the BF protection function may also be initiated externally via binary inputs by an alternate protection. In this case, the operating time of intermediate relays (BFI time) may have to be considered. Finally, the tripping of the infeeding breakers requires auxiliary relays, which add a small time delay (BFI) to the overall fault clearing time. This is particularly the case with one-breaker-and-a-half or ring bus arrangements where a separate breaker failure relay (7SV600 or 7VK61) is used per breaker (Fig. 2/83, Fig. 2/84).

The decisive criterion of BF protection time coordination is the reset time of the current detector (50BF), which must not be exceeded under any condition during normal current interruption. The reset times specified in the Siemens numerical relay manuals are valid for the worst-case condition: interruption of a fully offset short-circuit current and low current pickup setting (0.1 to 0.2 times rated CT current).



$Z_{1A} = 0.85 \cdot ZL_{A-B}$

$Z_{2A} = 0.85 \cdot (ZL_{A-B} + Z_{1B})$

$Z_{2A} = 0.85 \cdot (ZL_{A-B} + Z_{2B})$

Fig. 2/88 Grading of distance zones

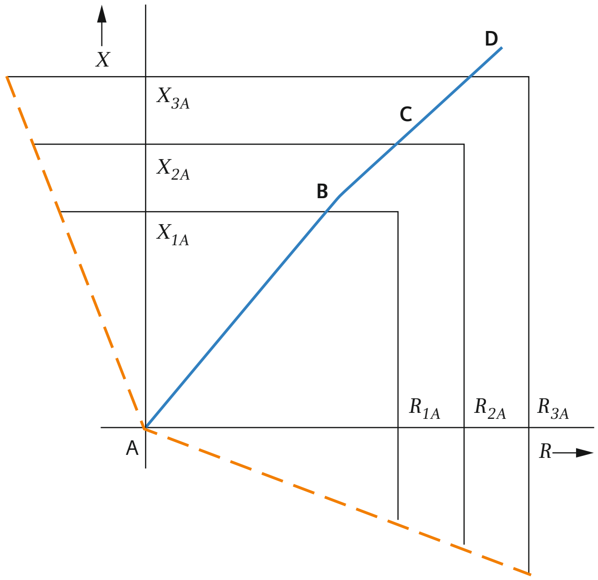


Fig. 2/89 Operating characteristics of Siemens distance relays

The reset time is 1 cycle for EHV relays (7SA6 / 52, 7VK61) and 1.5 to 2 cycles for distribution type relays (7SJ**).

Fig. 2/90 (next page) shows the time chart for a typical breaker failure protection scheme. The stated times in parentheses apply for transmission system protection and the times in square brackets for distribution system protection.

High-impedance differential protection; verification of design

The following design data must be established: CT data

The prerequisite for high-impedance scheme is that all CTs used for that scheme must have the same ratio. They should also be of low leakage flux design according to Class PX of IEC 60044-1 (former Class X of BS 3938) or TPS of IEC 60044-6, when used for high-impedance busbar protection scheme. When used for restricted earth-fault differential protection of e.g. a transformer winding especially in solidly grounded networks, CTs of Class 5P according to IEC 60044-1 can be used as well. In each case the excitation characteristic and the secondary winding resistance are to be provided by the manufacturer. The knee-point voltage of the CT must be at least twice the relay pickup voltage to ensure operation on internal faults.

The relay

The relay can be either:
a) dedicated design high-impedance relay, e.g., designed as a sensitive current relay 7VH60 or 7SG12 (DAD-N) with external series resistor R_{stab}. If the series resistor is integrated into the relay, the setting values may be directly applied in volts, as with the relay 7VH60 (6 to 60V or 24 to 240 V); or
b) digital overcurrent protection relay with sensitive current input, like 7SJ6 or 7SR1 (Argus-C). To the input of the relay a series stabilizing resistor R_{stab} will be then connected as a rule in order to obtain enough stabilization for the high-impedance scheme. Typically, a non-linear resistor V (varistor) will be also connected to protect the relay and wiring against overvoltages.

Sensitivity of the scheme

For the relay to operate in the event of an internal fault, the primary current must reach a minimum value to supply the relay pickup current (I_{set}), the varistor leakage current (I_{var}) and the magnetizing currents of all parallel-connected CTs at the set pickup voltage. A low relay voltage setting and CTs with low magnetizing current therefore increase the protection sensitivity

Stability during external faults

This check is made by assuming an external fault with maximum through-fault current and full saturation of the CT in the faulty feeder. The saturated CT is then substituted with its secondary winding resistance R_{CT}, and the appearing relay voltage VR corresponds to the voltage drop of the in-feeding currents (through-fault current) across R_{CT} and R_{lead}. The current (voltage) at the relay must, under this condition, stay reliably below the relay pickup value.

In practice, the wiring resistances R_{lead} may not be equal. In this case, the worst condition with the highest relay voltage (corresponding to the highest through-fault current) must be sought by considering all possible external feeder faults.

Setting

The setting is always a trade-off between sensitivity and stability. A higher voltage setting leads not only to enhanced through-fault stability but also to higher CT magnetizing and

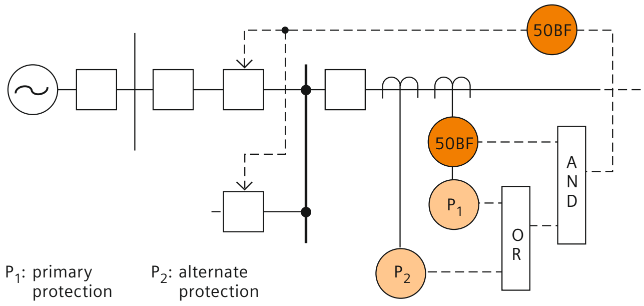


Fig. 2/90 Breaker failure protection, logic circuit

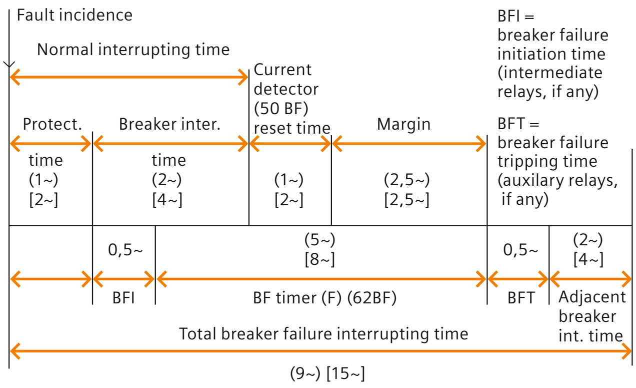
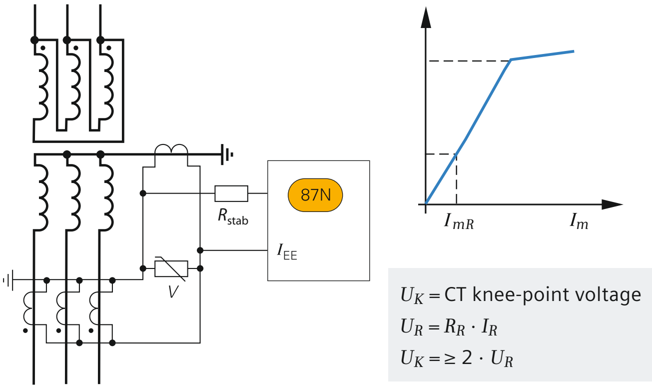


Fig. 2/91 Time coordination of BF time setting



U_K = CT knee-point voltage
$U_R = R_R \cdot I_R$
$U_K = \geq 2 \cdot U_R$

Fig. 2/92 Principle connection diagram for high-impedance restricted earth-fault protection of a winding of the transformer using SIPROTEC digital overcurrent relay (e.g. 7SJ61)

Relay setting U_{rms}	**C**	**β**	**Varistor type**
≤ 125	450	0.25	600 A / S1 / S256
125 – 240	900	0.25	600 A / S1 / S1088

Protection Coordination

Calculation example:

Restricted earth fault protection for the 400 kV winding of 400 MVA power transformer with $I_{r,\,400\,kV} = 577$ A installed in a switchgear with rated withstand short-circuit current of 40 kA.

Given:

N = 4 CTs connected in parallel; $I_{pn} / I_{sn} = 800$ A / 1 A – CT ratio;
$U_k = 400$ V – CT Knee-point voltage;
$I_m = 20$ mA – CT magnetizing current at U_k;
$R_{CT} = 3\ \Omega$ – CT internal resistance;
$R_{lead} = 2\ \Omega$ – secondary wiring (lead) resistance
Relay: 7SJ612; Time overcurrent 1Phase input used with setting range $I_{set} =$ 0.003 A to 1.5 A in steps of 0.001 A; relay internal burden
$R_{relay} = 50\ \text{m}\Omega$

Stability calculation

$$U_{s,min} = I_{k,\,max,\,thr} \frac{I_{sn}}{I_{pn}} (R_{CT} + R_{lead}) = 10{,}000 \frac{1}{800} (3+2) = 62.6 \text{ V}$$

with $I_{k,\,max,\,thr}$ taken as $16 \cdot I_{r,\,400kV} = 16 \cdot 577$ A = 9,232 A, rounded up to 10 kA.

The actual stability voltage for the scheme U_s can be taken with enough safety margin as $\boldsymbol{U_s = 130\,V}$ (remembering that $2U_s < U_k$).

Fault setting calculation

For the desired primary fault sensitivity of 125 A, which is approx. 22 % of the rated current of the protected winding $I_{r,\,400\,kV}$ (i.e. $I_{p,\,des} = 125$ A) the following current setting can be calculated:

$$I_{set} = I_{p,des} \frac{I_{sn}}{I_{pn}} - N \cdot I_m \frac{U_s}{U_k} = 125 \frac{1}{800} - 4 \cdot 0.02 \frac{130}{400} = 0.13\ A$$

Stabilizing resistor calculation

From the $\boldsymbol{U_s}$ and $\boldsymbol{I_{set}}$ values calculated above the value of the stabilizing resistor $\boldsymbol{R_{stab}}$ can be calculated:

$$R_{stab} = \frac{U_s}{I_{set}} - R_{relay} = \frac{130}{0.13} - 0.05 = \approx 1{,}000\ \Omega$$

where the relay resistance can be neglected.

The stabilizing resistor R_{stab} can be chosen with a necessary minimum continuous power rating $P_{\text{stab,cont}}$ of:

$$P_{stab,cont} \geq \frac{U_s^2}{R_{stab}} = \frac{130^2}{1000} = 16.9\ W$$

Moreover, R_{stab} must have a short time rating large enough to withstand the fault current levels before the fault is cleared. The time duration of 0.5 seconds can be typically considered ($P_{\text{stab,0.5s}}$) to take into account longer fault clearance times of back-up protection.
The rms voltage developed across the stabilizing resistor is decisive for the thermal stress of the stabilizing resistor. It is calculated according to formula:

$$U_{rms,relay} = 1.3 \cdot \sqrt[4]{U_k^{\,3} \cdot R_{stab} \cdot I_{k,\max,\text{int}} \frac{I_{sn}}{I_{pn}}} = 1.3 \cdot \sqrt[4]{400^3 \cdot 1000 \cdot 50} = 1738.7V$$

The resulting short-time rating P_{stab}, 0.5 s equals to:

$$P_{stab,0.5s} \geq \frac{U_{rms,relay}^{\ \ 2}}{R_{stab}} = \frac{1739^2}{1000} = 3023W$$

Check whether the voltage limitation by a varistor is required

The relay should normally be applied with an external varistor which should be connected across the relay and stabilizing resistor input terminals. The varistor limits the voltage across the terminals under maximum internal fault conditions. The theoretical voltage which may occur at the terminals can be determined according to following equation:

$$U_{k,\,max,\,int} = I_{k,\,max,\,int} \frac{I_{sn}}{I_{pn}} (R_{relay} + R_{stab}) = 40{,}000 \frac{1}{800} (0.05+1000) = 50003 \text{ V}$$

with $I_{k,max,int}$ taken as the rated short-circuit current of the switchgear = 40 kA.

The resulting maximum peak voltage across the panel terminals
(i.e. tie with relay and Rstab connected in series):

$$\hat{U}_{\max,relay} = 2\sqrt{2U_k\left(U_{k,\max,\text{int}} - U_k\right)} = 2\sqrt{2 \cdot 400(50003 - 400)} = 12600V$$

Since $U_{max,\,relay} > 1.5$ kV the varistor is necessary.

Exemplarily, a METROSIL of type 600A / S1 / Spec.1088 can be used ($\beta = 0.25$, $C = 900$).
This Metrosil leakage current at voltage setting $U_s = 130$ V equals to

$$I_{rms} = 0.52 \left(\frac{U_{set,\,rms} \cdot \sqrt{2}}{C} \right)^{1/\beta} = 0.91 \text{ mA}$$

and can be neglected by the calculations, since its influence on the proposed fault-setting is negligible.

varistor leakage currents, resulting consequently in a higher primary pickup current.

A higher voltage setting also requires a higher knee-point voltage of the CTs and therefore greater size of the CTs. A sensitivity of 10 to 20 % of I_r (rated current) is typical for restricted earth-fault protection. With busbar protection, a pickup value ≥ Ir is normally applied. In networks with neutral earthing via impedance the fault setting shall be revised against the minimum earth fault conditions.

Non-linear resistor (varistor)

Voltage limitation by a varistor is needed if peak voltages near or above the insulation voltage (2 kV … 3kV) are expected. A limitation to $U_{rms} = 1{,}500$ V is then recommended. This can be checked for the maximum internal fault current by applying the formula shown for $U_{max\ relay}$. A restricted earth-fault protection may sometimes not require a varistor, but a busbar protection in general does. However, it is considered a good practice to equip with a varistor all high impedance protection installations. The electrical varistor characteristic of a varistor can be expressed as $U = C\,I^{\,\beta}$ where C and β are the varistor constants.

CT requirements for protection relays

Instrument transformers

Instrument transformers must comply with the applicable IEC recommendations IEC 60044 and 60186 (PT), ANSI / IEEE C57.13 or other comparable standards.

Voltage transformers (VT)

Voltage transformers (VT) in single-pole design for all primary voltages have typical single or dual secondary windings of 100, 110 or 115 V / √3 with output ratings between 10 and 50 VA suitable from most application with digital metering and protection equipment, and accuracies of 0.1 % to 6 % to suit the particular application. Primary BIL values are selected to match those of the associated switchgear.

Current transformers

Current transformers (CT) are usually of the single-ratio type with wound or bar-type primaries of adequate thermal rating. Single, double or triple secondary windings of 1 or 5 A are standard. 1 A rating should, however, be preferred, particularly in HV and EHV stations, to reduce the burden of the connected lines. Output power (rated burden in VA), accuracy and saturation characteristics (rated symmetrical short-circuit current limiting factor) of the cores and secondary windings must meet the requirements of the particular application.The CT classification code of IEC is used in the following:

- Measuring cores
  These are normally specified 0.2 % or 0.5 % accuracy (class 0.2 or class 0.5), and an rated symmetrical short-circuit current limiting factor FS of 5 or 10.
  The required output power (rated burden) should be higher than the actually connected burden. Typical values are 2.5, 5 or 10 VA. Higher values are normally not necessary when only electronic meters and recorders are connected.
  A typical specification could be: 0.5 FS 10, 5 VA.
- Cores for billing values metering
  In this case, class 0.25 FS is normally required.
- Protection cores
  The size of the protection core depends mainly on the maximum short-circuit current and the total burden (internal CT burden, plus burden of connected lines plus relay burden)
  Furthermore, a transient dimensioning factor has to be considered to cover the influence of the DC component in the short-circuit current.

Glossary of used abbreviations (according to IEC 60044-6, as defined)

K_{ssc} = Rated symmetrical short-circuit current factor (example: CT cl. 5P20 → $K_{ssc} = 20$)

K'_{ssc} = Effective symmetrical short-circuit current factor

K_{td} = Transient dimensioning factor

$I_{ssc\,max}$ = Maximum symmetrical short-circuit current

I_{pn} = CT rated primary current

I_{sn} = CT rated secondary current

R_{ct} = Secondary winding d.c. resistance at 75 °C / 167 °F (or other specified temperature)

R_b = Rated resistive burden

R'_b = $R_{lead} + R_{relay}$ = connected resistive burden

T_P = Primary time constant (net time constant)

U_K = Kneepoint voltage (r.m.s.)

R_{relay} = Relay burden

$R_{lead} = \frac{2 \cdot \rho \cdot l}{A}$

with

l = Single conductor length from CT to relay in m

ρ = Specific resistance = 0.0175 $\Omega\text{mm}^2/\text{m}$ (copper wires) at 20 °C / 68 °F (or other specified temperature)

A = Conductor cross-section in mm^2

In general, an accuracy of 1 % in the range of 1 to 2 times nominal current (class 5 P) is specified. The rated symmetrical short-circuit current factor K_{SSC} should normally be selected so that at least the maximum short-circuit current can be transmitted without saturation (DC component is not considered).

This results, as a rule, in rated symmetrical short-circuit current factors of 10 or 20 depending on the rated burden of the CT in relation to the connected burden. A typical specification for protection cores for distribution feeders is 5P10, 10 VA or 5P20, 5 VA.

The requirements for protective current transformers for transient performance are specified in IEC 60044-6. In many practical cases, iron-core CTs cannot be designed to avoid saturation under all circumstances because of cost and space reasons, particularly with metal-enclosed switchgear.

The Siemens relays are therefore designed to tolerate CT saturation to a large extent. The numerical relays proposed in this guide are particularly stable in this case due to their integrated saturation detection function.

CT dimensioning formulae

$$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b} \text{ (effective)}$$

$$\text{with } K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\,max}}{I_{pn}} \text{ (required)}$$

The effective symmetrical short-circuit current factor K'_{SSC} can be calculated as shown in the table above.

The rated transient dimensioning factor K_{td} depends on the type of relay and the primary DC time constant. For relays with a required saturation free time from ≤ 0.4 cycle, the primary (DC) time constant TP has little influence.

CT design according to BS 3938 / IEC 60044-1 (2000)

IEC Class P can be approximately transfered into the IEC Class PX (BS Class X) standard definition by following formula:

$$U_k = \frac{(R_b + R_{ct}) \cdot I_n \cdot K_{ssc}}{1.3}$$

Example:
IEC 60044: 600 / 1, 5P10, 15 VA, $R_{ct} = 4\ \Omega$

IEC PX or BS: $U_K = \frac{(15 + 4) \cdot 1 \cdot 10}{1.3} = 146\text{ V}$
$R_{ct} = 4\ \Omega$

For *CT design according to ANSI / IEEE C 57.13* please refer to page 2/50.

The CT requirements mentioned in table 2/2 are simplified in order to allow fast CT calculations on the safe side. More accurate dimensioning can be done by more intensive calculation with Siemens's CTDIM (www.siemens.com / ctdim) program. Results of CTDIM are released by the relay manufacturer.

Adaption factor for 7UT6, 7UM62 relays in Fig. 2/92 (limited resolution of measurement)

$$F_{Adap} = \frac{I_{pn}}{I_{nO}} \cdot \frac{I_{Nrelay}}{I_{sn}} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}} \rightarrow \text{Request: } 1/8 \leq 8$$

7SD52, 53, 610, when transformer inside protected zone

$$\frac{I_{n\text{-}pri}\text{-}CT_{max}}{I_{n\text{-}pri}\text{-}CT_{min}} \cdot \frac{1}{\text{Transformer Ratio}^*} \leq 8$$

* If transformer in protection zone, else 1

$I_{n\text{-}pri}$-CT-Transf-Site ≤ 2 · I_n-Obj-Transf-Site AND

$I_{n\text{-}pri}$-CT-Transf-Site ≥ I_n-Obj-Transf-Site with

I_{nO} = Rated current of the protected object

U_{nO} = Rated voltage of the protected object

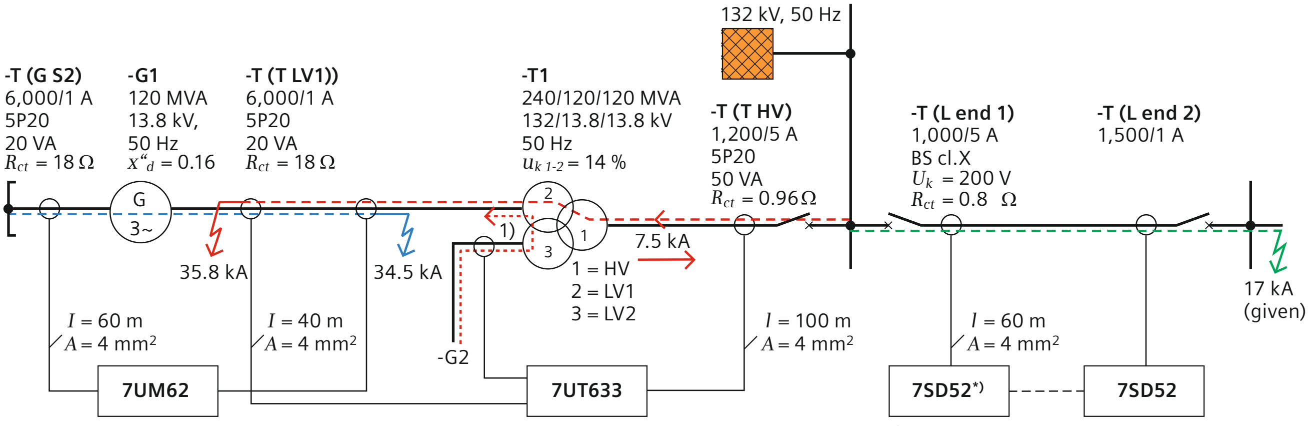
I_{Nrelay} = Rated current of the relay

S_{Nmax} = Maximun load of the protected object (for transformers: winding with max. load)

Protection Coordination

Relay type	**Transient dimensioning factor K_{td}**	**Min. required sym. short-circuit current factor K'_{ssc}**	**Min. required knee-point voltage U_k**
Overcurrent-time and motor protection 7SJ511, 512, 531 7SJ45, 46, 60 7SJ61, 62, 63, 64 7SJ80, 7SK80	–	$K'_{ssc} \geq \frac{I_{High\ set\ point}}{I_{pn}}$ at least: 20	$U_k \geq \frac{I_{High\ set\ point}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ at least: $\frac{20}{1.3} \cdot (R_{ct} + R'_b) \cdot I_{sn}$
Line differential protection (pilot wire) 7SD600	–	$K'_{ssc} \geq \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$ and: $\frac{3}{4} \leq \frac{(K'_{ssc} \cdot I_{pn})_{end1}}{(K'_{ssc} \cdot I_{pn})_{end2}} \leq \frac{4}{3}$	$U_k \geq \frac{I_{scc\ max\ (ext.\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and: $\frac{3}{4} \leq \frac{(U_k / (R_{ct} + R'_b) \cdot I_{pn} / I_{sn})_{end1}}{(U_k / (R_{ct} + R'_b) \cdot I_{pn} / I_{sn})_{end2}} \leq \frac{4}{3}$
Line differential protection (without distance function) 7SD52x, 53x, 610 (50 / 60 Hz)	Transformer 1.2 Busbar / Line 1.2 Gen. / Motor 1.2	$K'_{ssc} \geq$ $K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$ and (only for 7SS): $\frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}} \leq 100$ (measuring range)	$U_K \geq$ $K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and (only for 7SS): $\frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}} \leq 100$ (measuring range)
Tranformer / generator differential protection 7UT612, 7UT612 V4.0 7UT613, 633, 635, 7UT612 V4.6 7UM62	Transformer: 4 / 3 / 4 Busbar / Line: 4 / 3 / – Gen. / Motor: 5 / 5 / 5		
Busbar protection 7SS52, 7SS60	for stabilizing factors k ≥ 0.5 0.5		
Distance protection 7SA522, 7SA6, 7SD5xx (with distance function)	primary DC time constant T_p [ms] ≤ 30 / ≤ 50 / ≤ 100 / ≤ 200 K_{td} (a): 1 / 2 / 4 / 4 K_{td} (b): 4 / 5 / 5 / 5	$K'_{ssc} \geq$ $K_{td}\,(a) \cdot \frac{I_{scc\ max\ (close-in\ fault)}}{I_{pn}}$ and: $K_{td}\,(b) \cdot \frac{I_{scc\ max\ (zone\ 1-end\ fault)}}{I_{pn}}$	$U_K \geq$ $K_{td}\,(a) \cdot \frac{I_{scc\ max\ (close-in\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and: $K_{td}\,(b) \cdot \frac{I_{scc\ max\ (zone\ 1-end\ fault)}}{I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$

Table 2/2 CT requirements



*) without distance function

CB arrangement inside power station is not shown

x''_d = Generator direct axis subtransient reactance in p.u.

$u_{k\ 1\text{-}2}$ = Transformer impedance voltage HV side – LV side in %

R_{relay} = Assumed with 0.1 Ω, (power consumption for above relays is below 0.1 VA)

1) Current from side 3 is due to $u_{k\ 2\text{-}3}$ and x''_d of G2 in most cases negligible

Fig. 2/93 Example 1 – CT verification for 7UM62, 7UT6, 7SD52 (7SD53, 7SD610)

-T (G S2), 7UM62	-T (T LV1), 7UT633	-T (T HV), 7UT633	-T (L end 1), 7SD52
$I_{scc\ max\ (ext.\ fault)} = \frac{c \cdot S_{NG}}{\sqrt{3} \cdot U_{NG}\, x''_d}$ $= \frac{1.1 \cdot 120{,}000\ \text{kVA}}{\sqrt{3} \cdot 13.8\ \text{kV} \cdot 0.16} = 34{,}516\ \text{A}$	$I_{scc\ max\ (ext.\ fault)} = \frac{S_{NT}}{\sqrt{3} \cdot U_{NT}\, u_k''}$ $= \frac{120{,}000\ \text{kVA}}{\sqrt{3} \cdot 13.8\ \text{kV} \cdot 0.14} = 35{,}860\ \text{A}$	$I_{scc\ max\ (ext.\ fault)} = \frac{S_{NT}}{\sqrt{3} \cdot U_{NT}\, u_k''}$ $= \frac{240{,}000\ \text{kVA}}{\sqrt{3} \cdot 132\ \text{kV} \cdot 0.14} = 7{,}498\ \text{A}$	$I_{scc\ max\ (ext.\ fault)} = 17\ \text{kA}$ (given)
$K_{td} = 5$ (from table 2/2)	$K_{td} = 3$ (from table 2/2)	$K_{td} = 3$ (from table 2/2)	$K_{td} = 1.2$ (from table 2/2)
$K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$ $= 5 \cdot \frac{31{,}378\ \text{A}}{6{,}000\ \text{A}} = 28.8$	$K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$ $= 3 \cdot \frac{35{,}860\ \text{A}}{6{,}000\ \text{A}} = 17.9$	$K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$ $= 3 \cdot \frac{7{,}498\ \text{A}}{1{,}200\ \text{A}} = 18{,}7$	
$R_b = \frac{S_n}{I^2_{sn}} = \frac{20\ \text{VA}}{1\ \text{A}^2} = 20\ \Omega$	$R_b = \frac{S_n}{I^2_{sn}} = \frac{20\ \text{VA}}{1\ \text{A}^2} = 20\ \Omega$	$R_b = \frac{S_n}{I^2_{sn}} = \frac{50\ \text{VA}}{(5\ \text{A})^2} = 2\ \Omega$	
$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\ \text{mm}^2}{\text{m}} \cdot 60\ \text{m}}{4\ \text{mm}^2}$ $+ 0.1\ \Omega$ $= 0.625\ \Omega$	$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\ \text{mm}^2}{\text{m}} \cdot 640\ \text{m}}{4\ \text{mm}^2}$ $+ 0.1\ \Omega$ $= 0.450\ \Omega$	$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\ \text{mm}^2}{\text{m}} \cdot 100\ \text{m}}{4\ \text{mm}^2}$ $+ 0.1\ \Omega$ $= 0.975\ \Omega$	$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\ \text{mm}^2}{\text{m}} \cdot 60\ \text{m}}{4\ \text{mm}^2}$ $+ 0.1\ \Omega$ $= 0.625\ \Omega$
$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{18\ \Omega + 20\ \Omega}{18\ \Omega + 0.625\ \Omega} = 40.8$	$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{18\ \Omega + 20\ \Omega}{18\ \Omega + 0.450\ \Omega} = 41.2$	$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{0.96\ \Omega + 2\ \Omega}{0.96\ \Omega + 0.975\ \Omega} = 30.6$	$U_K \geq K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ $= 1.2 \cdot \frac{17{,}000\ \text{A}}{1.3 \cdot 1{,}000\ \text{A}} \cdot (0.8\ \Omega + 0.625\ \Omega) \cdot 5\ \text{A}$ $= 111.8\ \text{V}$
K'_{ssc} required = 28.8, K_{ssc} effective = 40.8 28.8 < 40.8 → CT dimensioning is ok	K'_{ssc} required = 17.9, K_{ssc} effective = 41.2 17.9 < 41.2 → CT dimensioning is ok	K'_{ssc} required = 18.7, K_{ssc} effective = 30.6 18.7 < 30.6 → CT dimensioning is ok	U_K required = 111.8 V, U_K effective = 200 V 111.8 V < 200 V → CT dimensioning is ok
$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{6{,}000\ \text{A} \cdot \sqrt{3} \cdot 13.8\ \text{kV}}{120{,}000\ \text{kVA}} \cdot \frac{1\ \text{A}}{1\ \text{A}}$ $= 1.195$ $1/8 \leq 1.195 \leq 8$ → ok!	$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{6{,}000\ \text{A} \cdot \sqrt{3} \cdot 13.8\ \text{kV}}{240{,}000\ \text{kVA}} \cdot \frac{1\ \text{A}}{1\ \text{A}}$ $= 0.598$ $1/8 \leq 0.598 \leq 8$ → ok!	$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{1{,}200\ \text{A} \cdot \sqrt{3} \cdot 132\ \text{kV}}{240{,}000\ \text{kVA}} \cdot \frac{5\ \text{A}}{5\ \text{A}}$ $= 1.143$ $1/8 \leq 1.143 \leq 8$ → ok!	$\frac{I_{pn\ max}}{I_{pn\ min}} \leq 8$ $\frac{1{,}500\ \text{A}}{1{,}000\ \text{A}} = 1.5 \leq 8$ → ok!

Table 2/3 Example 1 (continued) – verfication of the numerical differential protection

Attention (only for 7UT6 V4.0): When low-impedance REF is used, the request for the REF side (3-phase) is:

$^1/_4 \leq F_{Adap} \leq 4$, (for the neutral CT: $^1/_8 \leq F_{Adap} \leq 8$)

Further condition for 7SD52x, 53x, 610 relays (when used as line differential protection without transformer inside protected zone): Maximum ratio between primary currents of CTs at the end of the protected line:

$$\frac{I_{pn\ max}}{I_{pn\ min}} \leq 8$$

Protection Coordination

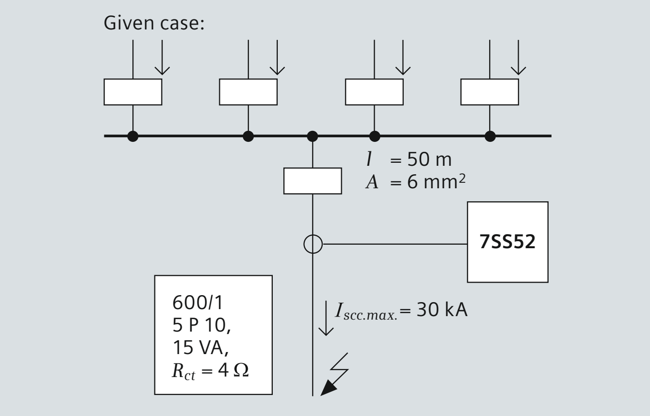


Fig. 2/94 Example 2

$$\frac{I_{scc\,max}}{I_{pn}} = \frac{30{,}000\text{ A}}{600\text{ A}} = 50$$

According to table 6.2-2, page 287 $K_{td} = {}^1/_2$

$$K'_{ssc} \geq \frac{1}{2} \cdot 50 = 25$$

$$R_b = \frac{15\text{ VA}}{1\text{ A}^2} = 15\,\Omega$$

$$R_{relay} = 0.1\,\Omega$$

$$R_{lead} = \frac{2 \cdot 0.0175 \cdot 50}{6} = 0.3\,\Omega$$

$$R'_b = R_{lead} + R_{relay} = 0.3\,\Omega + 0.1\,\Omega = 0.4\,\Omega$$

$$K'_{ssc} = \frac{4\,\Omega + 15\,\Omega}{4\,\Omega + 0.4\,\Omega} \cdot K_{ssc} = \frac{R_{ct} + R_b}{R_{ct} + R'_b} \cdot 10 = 43.2$$

Result:
The effective K'_{ssc} is 43.2, the required K'_{ssc} is 25. Therefore the stability criterion is fulfilled.

Relay burden
The CT burdens of the numerical relays of Siemens are below 0.1 VA and can therefore be neglected for a practical estimation. Exceptions are the busbar protection 7SS60 and the pilot-wire relays 7SD600.

Intermediate CTs are normally no longer necessary, because the ratio adaptation for busbar protection 7SS52 and transformer protection is numerically performed in the relay.

Analog static relays in general have burdens below about 1 VA.

Mechanical relays, however, have a much higher burden, up to the order of 10 VA. This has to be considered when older relays are connected to the same CT circuit.

In any case, the relevant relay manuals should always be consulted for the actual burden values.

Burden of the connection leads
The resistance of the current loop from the CT to the relay has to be considered:

$$R_{lead} = \frac{2 \cdot \rho \cdot l}{A}$$

l = Single conductor length from the CT to the relay in m

Specific resistance:

$\rho = 0.0175 \dfrac{\Omega \cdot \text{mm}^2}{\text{m}}$ (copper wires) at 20 °C / 68 °F

A = Conductor cross-section in mm²

CT design according to ANSI/IEEE C 57.13

Class C of this standard defines the CT by ist secondary terminal voltage at 20 times rated current, for which the ratio error shall not exceed 10 %. Standard classes are C100, C200, C400 and C800 for 5 A rated secondary current.

This terminal voltage can be approximately calculated from the IEC data as follows:

ANSI CT definition

$$U_{s.t.max} = 20 \cdot 5\text{ A} \cdot R_b \cdot \frac{K_{ssc}}{20}$$

with

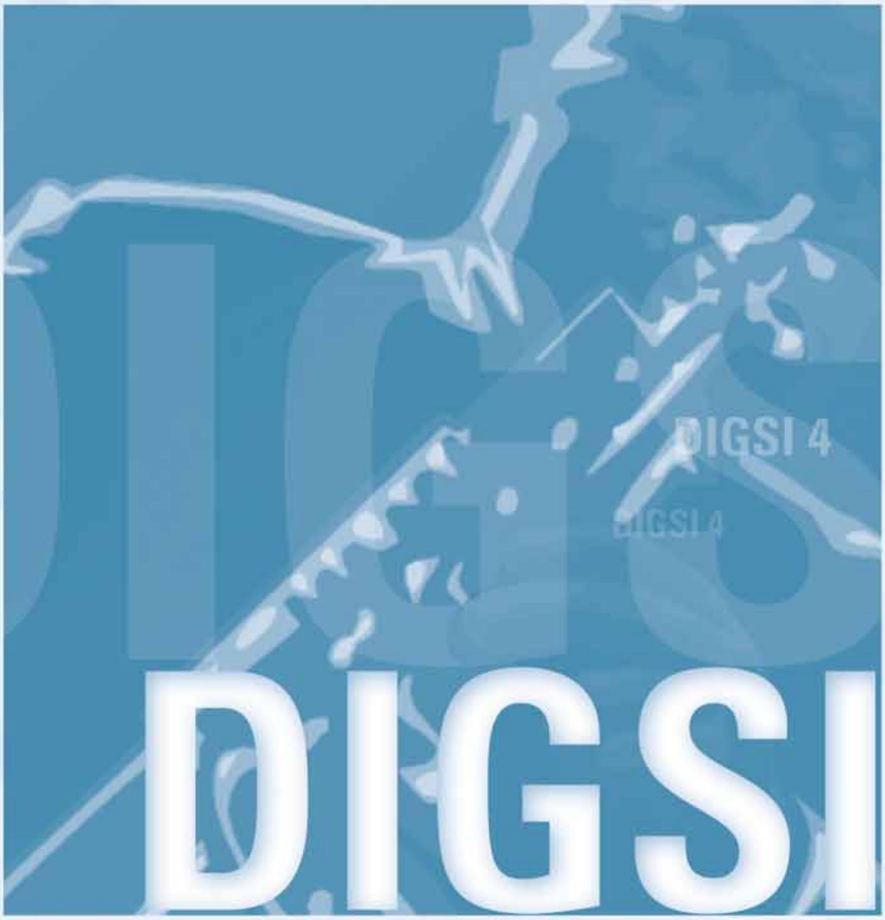
$R_b = \dfrac{P_b}{I_{sn}{}^2}$ and $I_{Nsn} = 5$ A, the result is

$$U_{s.t.max} = \frac{P_b \cdot K_{ssc}}{5\text{ A}}$$

Example:
IEC 60044 600/5, 5P20, 25 VA,

ANSI C57.13: $U_{s.t.max} = \dfrac{(25\text{ VA} \cdot 20)}{5\text{ A}} = 100$ V, acc. to class C100

Operating Programs



DIGSI 4, An Operating Software for all SIPROTEC Protection Relays

Description

The PC operating program DIGSI 4 is the user interface to the SIPROTEC devices, regardless of their version. It is designed with a modern, intuitive user interface. With DIGSI 4, SIPROTEC devices are configured and evaluated – it is the tailored program for industrial and energy distribution systems.

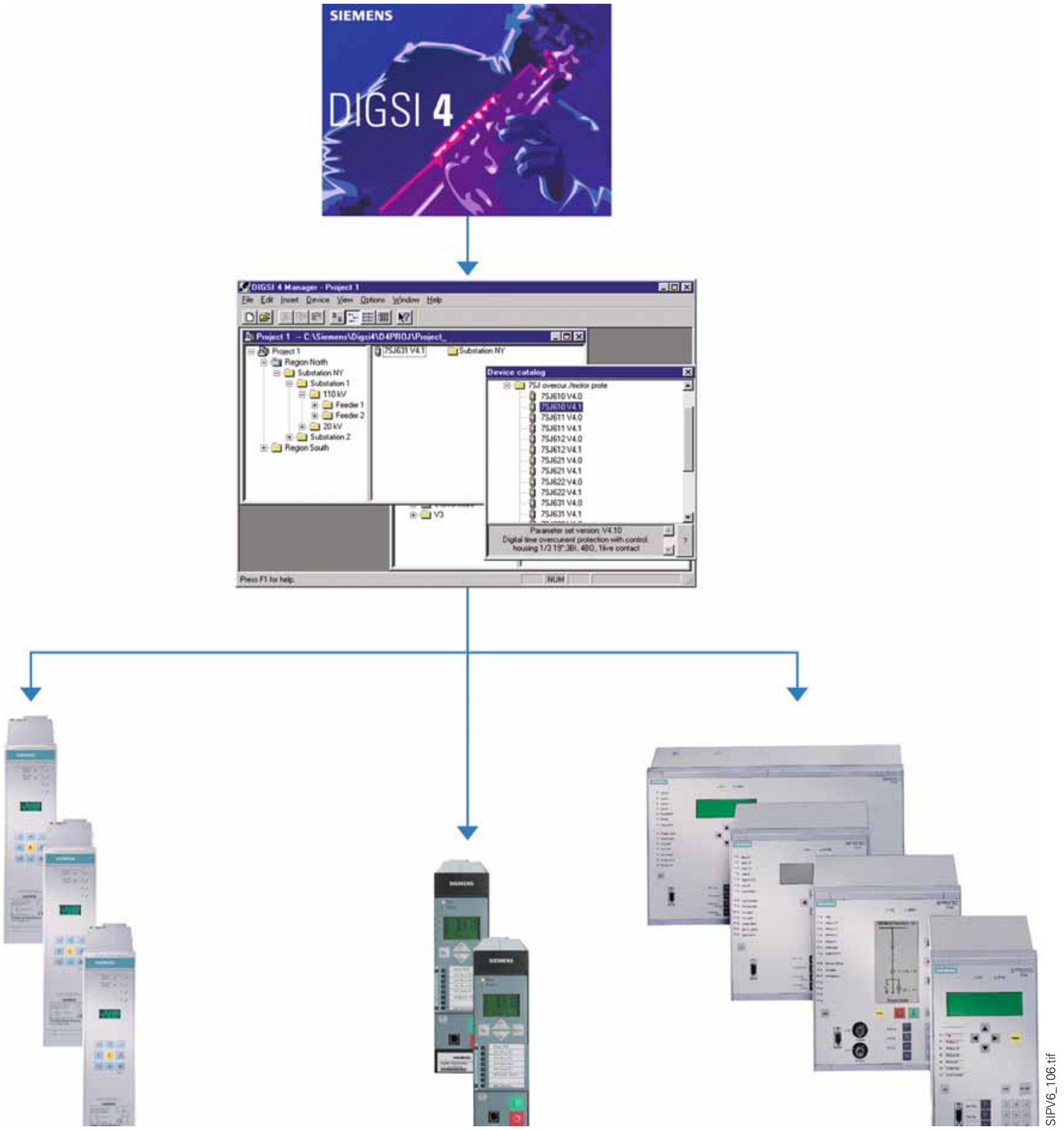


Fig. 3/1 DIGSI 4 operating program

Functions

Simple protection setting

From the numerous protection functions it is possible to easily select only those which are really required (see Fig. 3/2). This increases the clearness of the other menus.

Device setting with primary or secondary values

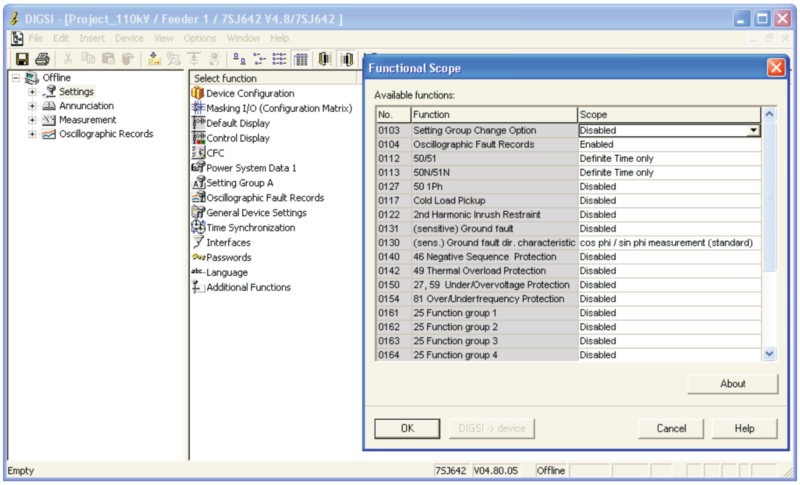
The settings can be entered and displayed as primary or secondary values. Switching over between primary and secondary values is done with one mouse click in the tool bar (see Fig. 3/2).

Assignment matrix

The DIGSI 4 matrix shows the user the complete configuration of the device at a glance (Fig. 3/3). For example, the assignment of the LEDs, the binary inputs and the output relays are displayed in one image. With one click, the assignment can be changed.

IEC 61850 system configurator

The IEC 61850 system configurator, which is started out of the system manager, is used to determine the IEC 61850 network structure as well as the extent of data exchange between the participants of an IEC 61850 station. To do this, subnets are added in the “network” working area – if required -, available participants are assigned to the subnets, and addressing is defined. The “assignment” working area is used to link data objects between the participants, e.g., the starting message of the *V*/inverse-time overcurrent protection *I*> -function of feeder 1, which is transferred to the incoming supply in order to prompt the reverse interlocking of the *V*/inverse-time overcurrent protection *I*>> function there (see Fig. 3/4).



Available functions:

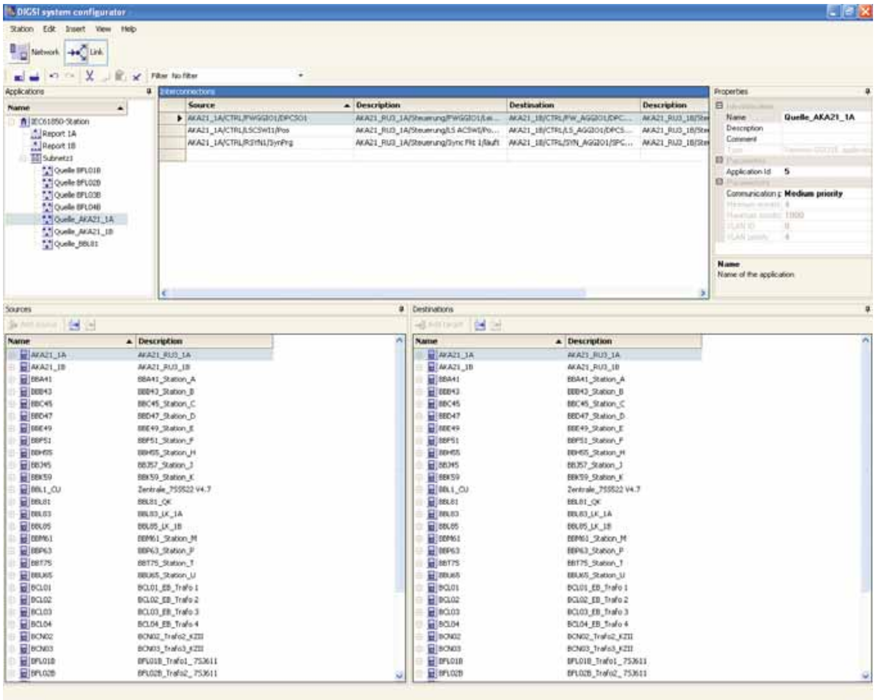
No.	Function	Scope
0103	Setting Group Change Option	Disabled
0104	Oscillographic Fault Records	Enabled
0112	50/51	Definite Time only
0113	50N/51N	Definite Time only
0127	50 1Ph	Disabled
0117	Cold Load Pickup	Disabled
0122	2nd Harmonic Inrush Restraint	Disabled
0131	(sensitive) Ground fault	Disabled
0130	(sens.) Ground fault dir. characteristic	cos phi / sin phi measurement (standard)
0140	46 Negative Sequence Protection	Disabled
0142	49 Thermal Overload Protection	Disabled
0150	27, 59 Under/Overvoltage Protection	Disabled
0154	81 Over/Underfrequency Protection	Disabled
0161	25 Function group 1	Disabled
0162	25 Function group 2	Disabled
0163	25 Function group 3	Disabled
0164	25 Function group 4	Disabled

LSP3.01-0017en.eps

Fig. 3/2 DIGSI 4, main menu, selection of protection functions

LSP3.01-0018en.ep

Fig. 3/3 DIGSI 4, assignment matrix



LSP3.01-0019en.eps

Fig. 3/4 DIGSI 4, IEC 61850 system configurator

Functions

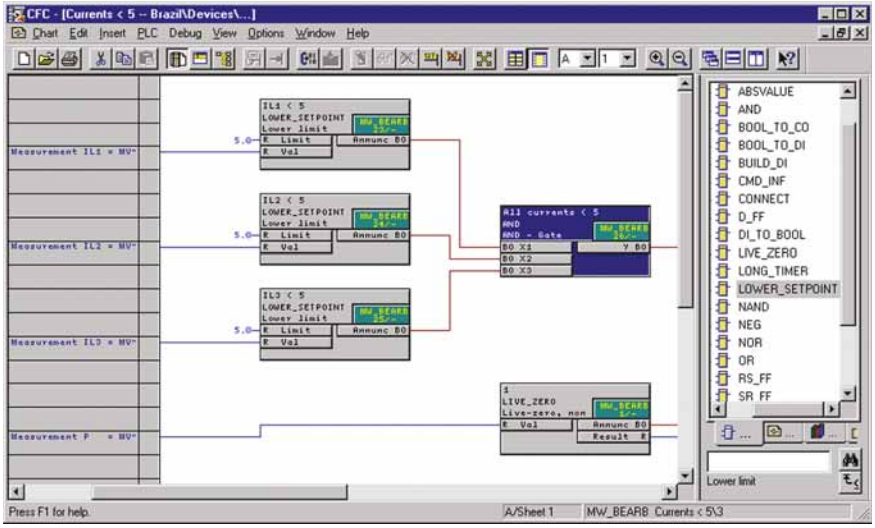
CFC: Projecting the logic instead of programming

With the CFC (continuous function chart), it is possible to link and derive information without software knowledge by simply drawing technical processes, interlocks and operating sequences.

Logical elements such as AND, OR, timers, etc., as well as limit value requests of measured values are available (Fig. 3/5).

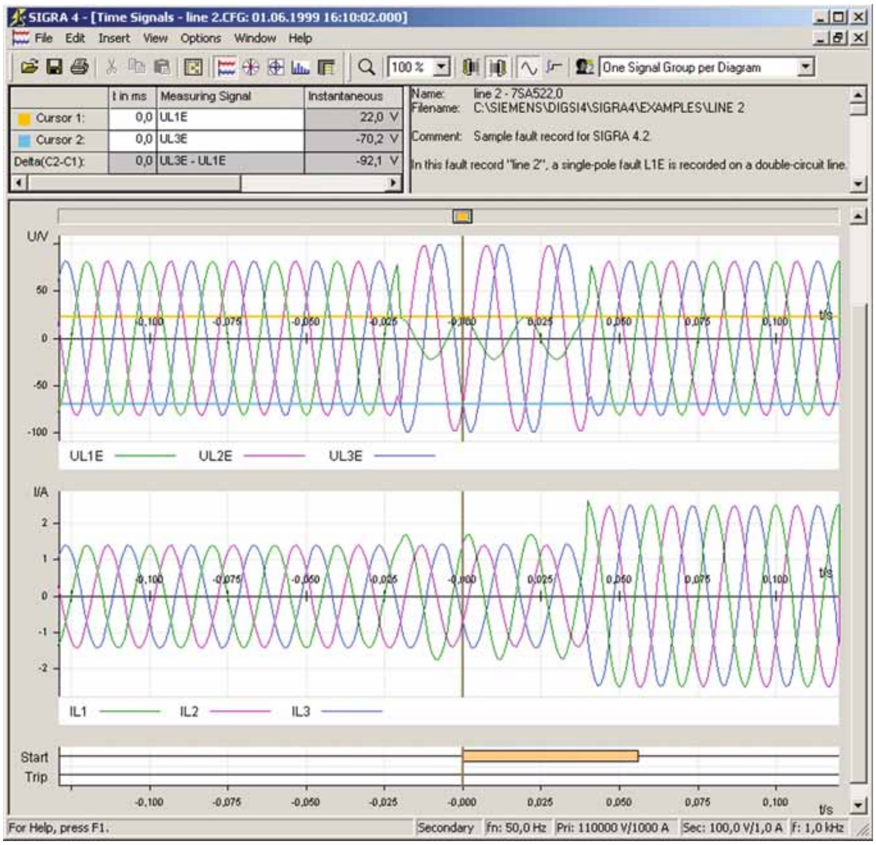
Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be set and read out in targeted way. Thus, a very simple wiring test is possible. Messages can be sent to the serial interface deliberately for test purposes.



LSP2324-afpen.tif

Fig. 3/5 CFC plan



	t in ms	Measuring Signal	Instantaneous
🟨 Cursor 1:	0,0	UL1E	22,0 V
🟦 Cursor 2:	0,0	UL3E	-70,2 V
Delta(C2-C1):	0,0	UL3E - UL1E	-92,1 V

Name: line 2 - 7SA522,0
Filename: C:\SIEMENS\DIGSI4\SIGRA4\EXAMPLES\LINE 2
Comment: Sample fault record for SIGRA 4.2
In this fault record "line 2", a single-pole fault L1E is recorded on a double-circuit line.

LSP2330.tif

Fig. 3/6 Typical time-signal representation

Selection and ordering data

Variants	Order No.
DIGSI 4	
Software for projecting and usage of all Siemens protection devices is running under MS Windows XP Prof. / MS Windows Server 2003, MS Windows 7 Professional and Ultimate/Enterprise. See product information for supported Service packs of operating systems. Incl. device templates, online manual and DIGSI cable: for all device types. Start Up manual (paper) Incl. service (upgrade, update, hotline) Operator language: German, English, French, Spanish, Italian, Chinese, Russian, Turkish are included. Delivery on DVD-ROM	
Basic	
Basic version with license for 10 computers (authorisation by serial number)	*7XS5400-0AA00*
Professional	
Basic version and additionally SIGRA (Fault record analysis), CFC Editor (Logic editor), Display Editor (Editor for control displays) and DIGSI 4 Remote (Remote operation) with license for 10 computers (authorisation by serial number)	*7XS5402-0AA00*
DIGSI 4 Professional + IEC 61850	
Professional version and IEC 61850 System Configurator with license for 10 computers (authorisation by serial number)	*7XS5403-0AA00*
Upgrade from DIGSI 4 Basis to DIGSI 4 Professional	*7XS5407-0AA00*
Upgrade from DIGSI 4 Basis to DIGSI 4 Professional + IEC61850	*7XS5408-0AA00*
SIPROTEC 4 Tutorial	
Multimedia information and training for: SIPROTEC 4, DIGSI 4, SIGRA 4 and IEC 61850 Incl. trial software, manuals and catalogs	*E50001-U310-D21-X-7100*
DIGSI 4 Basic + RecProtec	
DIGSI 4 Basic and additionally RecProtec (cyclic retrieval and archiving of fault records from SIPROTEC 4 devices) with license for 10 computers (DIGSI 4) and for 1 computer (RecProtec). Authorisation for DIGSI 4 by serial number, for RecProtec by floppydisk.	*7XS5400-0AA01*
DIGSI 4 Professional + RecProtec	
DIGSI 4 Professional and additionally RecProtec (cyclic retrieval and archiving of fault records, from SIPROTEC 4 devices) with license for 10 computers (DIGSI 4) and for 1 computer (RecProtec). Authorisation for DIGSI 4 by serial number, for RecProtec by floppydisk.	*7XS5402-0AA01*
DIGSI 4 Trial	
like DIGSI 4 Professional + IEC 61850, but only valid for 30 days (test version) (no authorisation required)	*7XS5401-1AA00*

Selection and ordering data

Variants	Order No.
DIGSI 4 Scientific	
like DIGSI 4 Professional + IEC 61850, only for university-level institutions with license for 10 PCs (authorisation by serial number)	*7XS5402-2AA00*
DIGSI 4 DVD Update	
Latest version of DIGSI 4 DVD includes DIGSI 4 and IEC 61850 System Configurator and SIGRA Incl. the latest Service packs. Current content of DIGSI 4 Update DVD can be found at www.siemens.com/siprotec	*7XS5490-0AA00*
IEC 61850 System Configurator	
Software for configuration of substations via IEC 61850-communication is running under MS Windows XP Prof./MS Windows Vista Home Premium, Business and Ultimate/MS Windows Server 2003. See product information for supported Service packs of operating systems Incl. electronic help Incl. service (update, hotline) Operator language: German, English, French, Spanish, Italian, Chinese, Russian, Turkish are included.	
IEC 61850 System Configurator for DIGSI 4 Professional	
Upgrade from DIGSI 4 Prof. to DIGSI 4 Prof. + IEC 61850 version with license for 10 computers (authorisation by serial number) For ordering the specification of a DIGSI 4 license number is required.	*7XS5460-0AA00*
IEC 61850 System Configurator for Reyrolle devices	
for System Configuration if no DIGSI 4 Prof. + IEC 61850 license is available Requires installed Reydisp Manager version with license for 10 computers (authorization by serial number) Delivery on DVD-ROM	*7XS5461-0AA00*
GOOSE Inspector for IEC 61850 Ethernet station bus with license for 1 PC	
PC-tool for online-monitoring of IEC 61850 GOOSE-telegrams Checking of all GOOSE connections on the station bus and validation with the configured connections in the system configurator (SCD) Contains installation CD with USB-dongle Recommended system requirements: Windows XP, 32 Bit, SP2 or SP3 Duo CPU at least 1.6 GHz; RAM 2 GB Network interface (Ethernet LAN, TCP/IP) Supported languages: English, German	*7XS5900-0AA00*

SIGRA 4
Powerful Analysis of all Protection Fault Records

Fig. 3/7

Description

It is of crucial importance after a line fault that the fault is quickly and fully analyzed so that the proper measures can be immediately derived from the evaluation of the cause. As a result, the original line condition can be quickly restored and the downtime reduced to an absolute minimum. It is possible with SIGRA 4 to display records from digital protection units and fault recorders in various views and measure them, as required, depending on the relevant task.

In addition to the usual time-signal display of the measured variables record, it is also designed to display vector diagrams, circle diagrams, bar charts for indicating the harmonics and data tables. From the measured values which have been recorded in the fault records, SIGRA 4 calculates further values, such as: absent quantities in the three-wire system, impedances, outputs, symmetrical components, etc. By means of two measuring cursors, it is possible to evaluate the fault trace simply and conveniently. With SIGRA, however, you can add additional fault records. The signals of another fault record (e.g. from the opposite end of the line) are added to the current signal pattern by means of Drag & Drop. SIGRA 4 offers the possibility to display signals from various fault records in one diagram and fully automatically synchronize these signals to a common time base. In addition to finding out the details of the line fault, the localization of the fault is of special interest.

A precise determination of the fault location will save time that can be used for the on-site inspection of the fault. This aspect is also supported by SIGRA 4 – with its "offline fault localization" feature.

SIGRA 4 can be used for all fault records using the COMTRADE file format.

The functional features and advantages of SIGRA 4 can, however, only be optimally shown on the product itself. For this reason, it is possible to test SIGRA 4 for 30 days with the trial version.

Function overview

- 6 types of diagrams: time signal representation (usual), circle diagram (e.g. for R/X), vector diagram (reading of angles), bar charts (e.g. for visualization of harmonics), table (lists values of several signals at the same instant) and fault locator (shows the location of a fault)
- Calculate additional values such as positive impedances, r.m.s. values, symmetric components, vectors, etc.
- Two measurement cursors, synchronized in each view
- Powerful zoom function
- User-friendly configuration via drag & drop
- Innovative signal configuration in a clearly-structured matrix
- Time-saving user profiles, which can be assigned to individual relay types or series
- Addition of other fault records to the existing fault record
- Synchronization of several fault records to a common time basis
- Easy documentation by copying diagrams to documents of other MS Windows programs
- Offline fault localization

Hardware requirements

- Pentium 4 with 1-GHz processor or similar
- 1 GB of RAM (2 GB recommended)
- Graphic display with a resolution of 1024 x 768 (1280 x 1024 recommended)
- 50 MB free storage space on the hard disk
- DVD-ROM drive
- Keyboard and mouse

Software requirements

- MS Windows XP Professional
- MS Windows Vista Home Premium, Business and Ultimate
- MS Windows Server 2003 Standard Edition with Service Pack 2 used as a Workstation computer
- MS Windows 7 Professional and Enterprise Ultimate

Functions

Different views of a fault record

In addition to the standard time signal representation, SIGRA 4 also supports the display of circle diagrams (e.g. R/X diagrams), vectors, which enable reading of angles, and bar charts (e.g. for visualization of harmonics). To do this, SIGRA uses the values recorded in the fault record to calculate additional values such as positive impedances, r.m.s. values, symmetric components, vectors, etc.

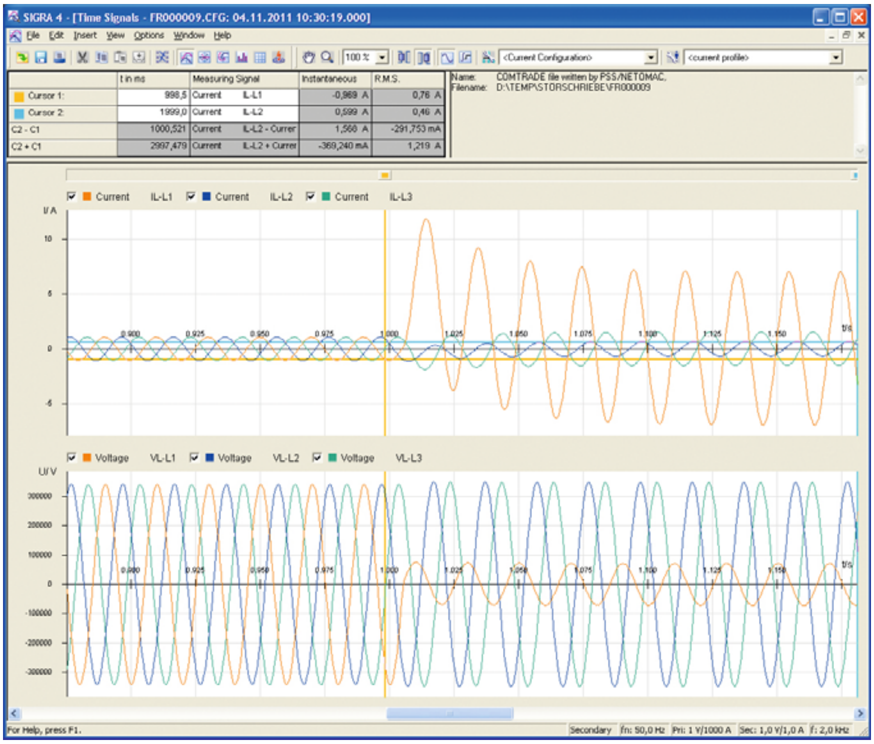
Measurement of a fault record

Two measurement cursors enable fast and convenient measurement of the fault record. The measured values of the cursor positions and their differences are presented in tables. The cursors operate interactively and across all views, whereby all cursor movement is synchronized in each view: In this manner, the cursor line enables simultaneous "intersection" of a fault occurrence in both a time signal characteristic and circle diagram characteristic. And of course a powerful zoom function ensures that you do not lose track of even the tiniest detail. The views of SIGRA 4 can accommodate any number of diagrams and in each diagram any number of signals.

Operational features

The main aim of the developers of SIGRA 4, who were assisted by ergonomic and design experts, was to produce a system that was simple, intuitive and user-friendly:

- The colours of all the lines have been defined so that they are clear and easily distinguishable. However, the colour, as well as the line style, the scale and other surface features, can be adjusted to suit individual requirements.
- Pop-up menus for each situation offer customized functionality – thus eliminating the need to browse through numerous menu levels (total operational efficiency).



SIGRA 4 - [Time Signals - FR000009.CFG: 04.11.2011 10:30:19.000]

	t in ms	Measuring Signal		Instantaneous	R.M.S.
Cursor 1:	998,5	Current	IL-L1	-0,969 A	0,76 A
Cursor 2:	1999,0	Current	IL-L2	0,599 A	0,46 A
C2 - C1	1000,521	Current	IL-L2 - Currer	1,568 A	-291,753 mA
C2 + C1	2997,479	Current	IL-L2 + Currer	-369,240 mA	1,219 A

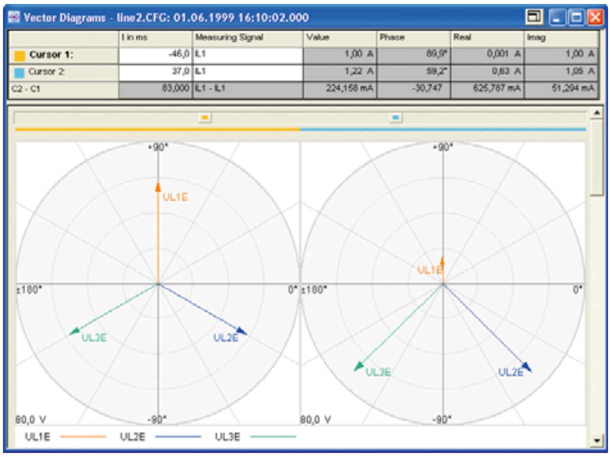
Name: COMTRADE file written by PSS/NETOMAC.
Filename: D:\TEMP\STORSCHRIEBE\FR000009

For Help, press F1.

Secondary fn: 50,0 Hz Pri: 1 V/1000 A Sec: 1,0 V/1,0 A f: 2,0 kHz

SIGRA_4_51_TimeSignals.tif

Fig. 3/8 Typical time signal representation

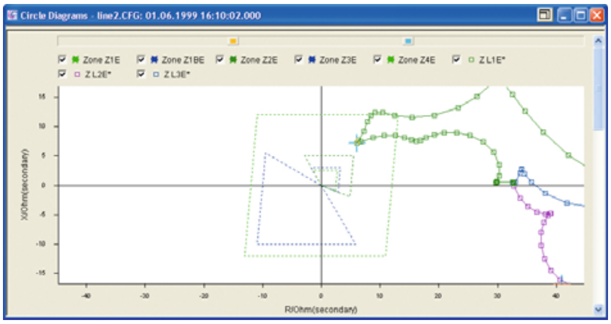


Vector Diagrams - line2.CFG: 01.06.1999 16:10:02.000

	t in ms	Measuring Signal	Value	Phase	Real	Imag
Cursor 1:	-46,0	IL1	1,00 A	89,9°	0,001 A	1,00 A
Cursor 2:	37,0	IL1	1,22 A	59,2°	0,63 A	1,05 A
C2 - C1	83,000	IL1 - IL1	224,158 mA	-30,747	625,787 mA	51,294 mA

SIGRA_4_51_VectorDiagram.tif

Fig. 3/9 Vector diagrams



Circle Diagrams - line2.CFG: 01.06.1999 16:10:02.000

SIGRA_4_51_CircleDiagram.tif

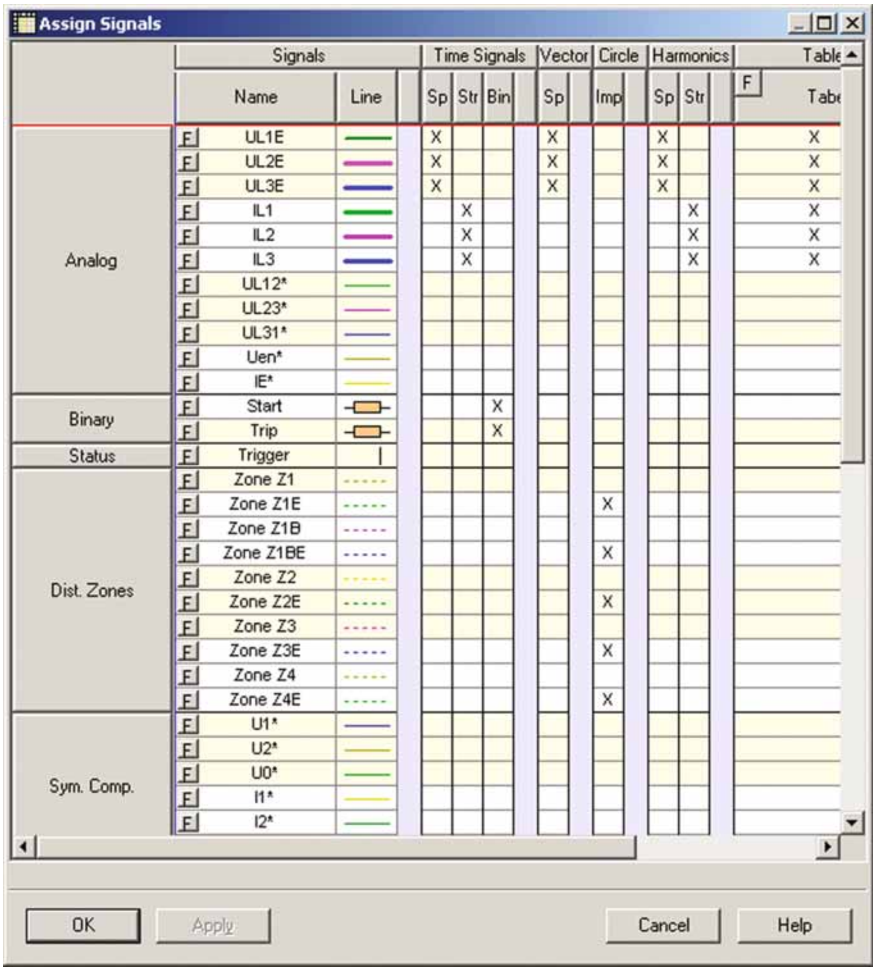
Fig. 3/10 Circle diagram

Functions

- Configuration of the individual diagrams is simple and intuitive: object-oriented, measured variables can be simply dragged and dropped from one diagram to another (also diagrams of different types).
- "Snap-to-grid" and "snap-to-object" movement of the cursor lines for easy and accurate placement.
- Redundancy: Most user tasks can be achieved via up to five different operational methods, thus ensuring quick and easy familiarization with the analysis software.
- Utilization of the available screen space is automatically optimized by an intelligent function that, like the "synchronous mouse cursors", has since been patented.

User friendly tools support you in your daily work:

- Storage of user defined views (e.g zoom, size), in so-called user profiles and to assign them to individual relay types or series. Then simply select from the toolbar and you can display each fault record quickly and easily as required. No need to waste time scrolling, zooming or resizing and moving windows.
- Additional fault records, e.g. from the other end of a line, can be added to existing records.
- A special function allows several fault records to be synchronized on a mutual time basis, thus considerably improving the quality of fault analysis.
- Fault localization with data from one line end the fault record data (current and voltage measurement) values are imported from the numerical protection unit into SIGRA 4. The fault localisator in SIGRA 4 is then started by the user and the result represented in % or in km of the line length, depending on the parameters assigned.
- Fault localization with data from both line ends. The algorithm of the implemented fault location does not need a zero-phase sequence system. Thus, measuring errors due to earth impedance or interference with the zero current of the parallel line are ruled out. Errors with contact resistance on lines with infeed from both ends are also correctly recorded.
  The above influences are eliminated due to the import of fault record data from both line ends into SIGRA. For this purpose, the imported data are synchronized in SIGRA and the calculation of the fault location is then started. Consequently, fault localization is independent from the zero-phase sequence system and the line infeed conditions and produces precise results to allow as fast an inspection of the fault location as possible.
- So-called marks, which users can insert at various instants as required, enable suitable commentary of the fault record. Each individual diagram can be copied to a document of another MS Windows program via the "clipboard": documenting fault records really could not be easier.

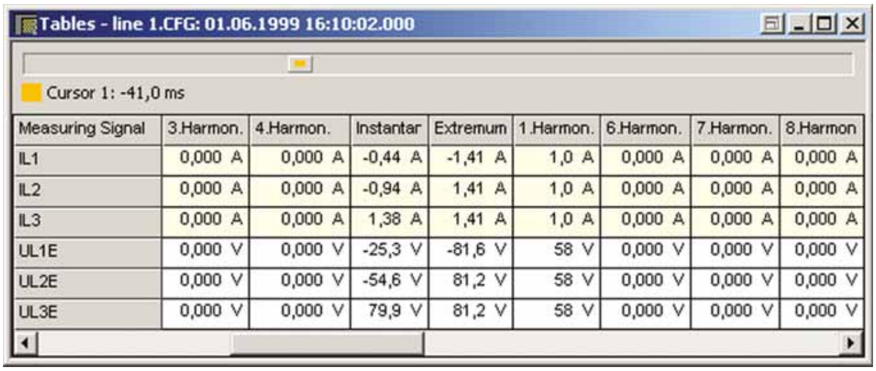


Assign Signals

	Signals			Time Signals			Vector	Circle	Harmonics		Table
		Name	Line	Sp	Str	Bin	Sp	Imp	Sp	Str	F Tabe
Analog	F	UL1E	—	X			X		X		X
	F	UL2E	—	X			X		X		X
	F	UL3E	—	X			X		X		X
	F	IL1	—		X					X	X
	F	IL2	—		X					X	X
	F	IL3	—		X					X	X
	F	UL12*	—								
	F	UL23*	—								
	F	UL31*	—								
	F	Uen*	—								
	F	IE*	—								
Binary	F	Start	-▭-			X					
	F	Trip	-▭-			X					
Status	F	Trigger	|								
Dist. Zones	F	Zone Z1	-----								
	F	Zone Z1E	-----					X			
	F	Zone Z1B	-----								
	F	Zone Z1BE	-----					X			
	F	Zone Z2	-----								
	F	Zone Z2E	-----					X			
	F	Zone Z3	-----								
	F	Zone Z3E	-----					X			
	F	Zone Z4	-----								
	F	Zone Z4E	-----					X			
Sym. Comp.	F	U1*	—								
	F	U2*	—								
	F	U0*	—								
	F	I1*	—								
	F	I2*	—								

LSP2333-afpen.tif

Fig. 3/11 Concise matrix for assigning signals to diagrams



Tables - line 1.CFG: 01.06.1999 16:10:02.000

Cursor 1: -41,0 ms

Measuring Signal	3.Harmon.	4.Harmon.	Instantar	Extremum	1.Harmon.	6.Harmon.	7.Harmon.	8.Harmon
IL1	0,000 A	0,000 A	-0,44 A	-1,41 A	1,0 A	0,000 A	0,000 A	0,000 A
IL2	0,000 A	0,000 A	-0,94 A	1,41 A	1,0 A	0,000 A	0,000 A	0,000 A
IL3	0,000 A	0,000 A	1,38 A	1,41 A	1,0 A	0,000 A	0,000 A	0,000 A
UL1E	0,000 V	0,000 V	-25,3 V	-81,6 V	58 V	0,000 V	0,000 V	0,000 V
UL2E	0,000 V	0,000 V	-54,6 V	81,2 V	58 V	0,000 V	0,000 V	0,000 V
UL3E	0,000 V	0,000 V	79,9 V	81,2 V	58 V	0,000 V	0,000 V	0,000 V

LSP2334-afpen.tif

Fig. 3/12 Table with values at a definite time

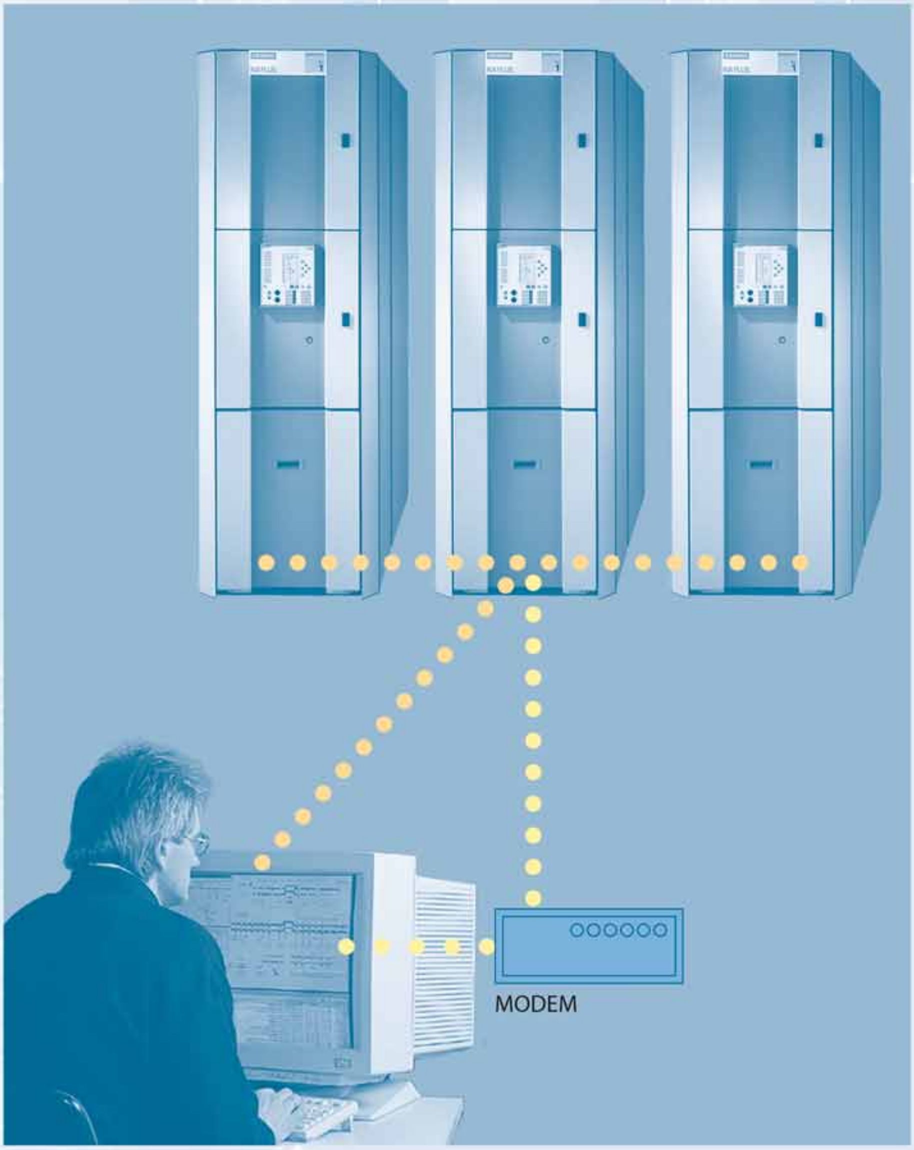
Scope of delivery

The software product is quick and easy to install from a CD-ROM. It has a comprehensive "help" system. An user-friendly and practical manual offers easy step-by-step instructions on how to use SIGRA.

Selection and ordering data

Variants	Order No.
SIGRA 4 Software for graphic visualisation, analysis and evaluation of fault and measurement records is running under MS Windows XP Prof./MS Windows Vista Home Premium, Business and Ultimate/MS Windows Server 2003, MS Windows 7 Professional and Ultimate/Enterprise. See product information for supported Service packs of operating systems. Incl. templates, online manual Incl. service (upgrade, update, hotline) Operator language: German, English, French, Spanish, Italian, Chinese, Russian, Turkish are included. Incl. multimedia tutorial on separate CD. Delivery on DVD-ROM	
SIGRA 4 for DIGSI with license for 10 PCs (authorisation by serial number) For ordering the specification of a DIGSI 4 serial number is required.	*7XS5410-0AA00*
SIGRA 4 Stand Alone with license for 10 PCs. Installation without DIGSI 4 (authorisation by serial number)	*7XS5416-0AA00*
SIGRA 4 Scientific Installation without DIGSI 4 only for university-level institutions with license for 10 PCs (authorisation by serial number)	*7XS5416-1AA00*
SIGRA 4 Trial like SIGRA 4 Stand Alone, but only valid for 30 days (test version) (no authorisation required)	*7XS5411-1AA00*
Upgrade SIGRA 4 Trial to SIGRA 4 Stand Alone like SIGRA 4 Stand Alone. For customers who want to unlock their trail version. With license for 10 PC	*7XS5416-2AA00*

Communication



Communication

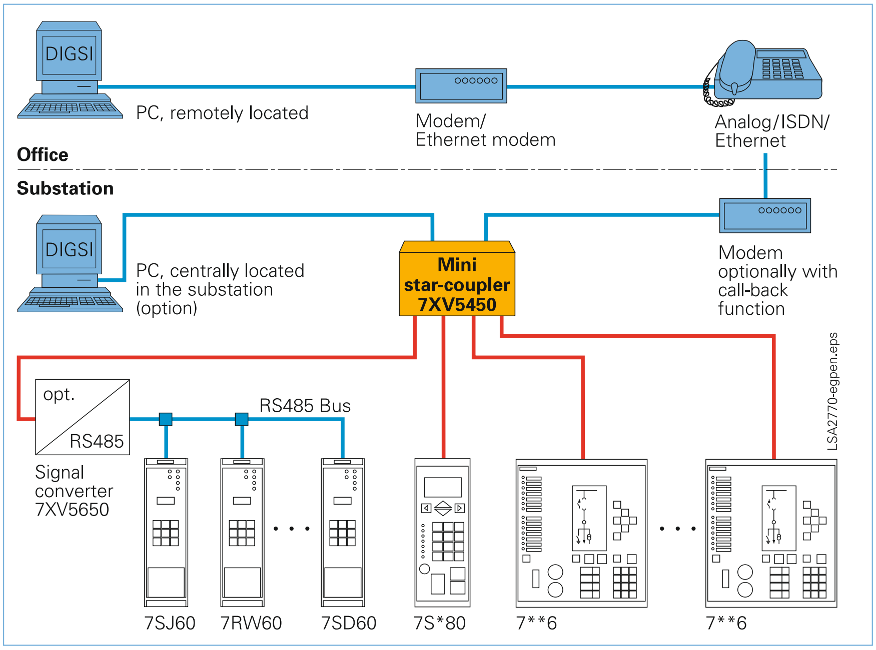


Fig. 4/1

Description

Communication interfaces on protection relays are becoming increasingly important for the efficient and economical operation of substations and networks. The interfaces can be used for:

- Accessing the protection relays from a PC using the DIGSI operating program. Remote access via modem, Ethernet modem is possible with a serial service port at the relay. This allows remote access to all data of the protection relay.
- Integrating the relays into control systems with IEC 60870-5-103 protocol, PROFIBUS-FMS protocol, PROFIBUS-DP protocol, DNP 3.0 protocol and MODBUS protocol.
  The standardized IEC 61850 protocol is available since Oct. 2004 and with its SIPROTEC units Siemens has provided this standard as the first manufacturer worldwide.
- Peer-to-peer communication of differential relays and distance relays to exchange real-time protection data via fiber-optic cables, communication network, telephone networks or analog pilot wires.

Function overview

Description

- Remote communication with DIGSI
- Remote communication with SIPROTEC 4 units
- Remote communication with SIPROTEC 3 units and SIPROTEC ‘600 units

Typical applications

- SIPROTEC 4 units on an RS485 bus
- SIPROTEC 4 units with FO/RS485
- Mixed system SIPROTEC 4, SIPROTEC 3 units, SIPROTEC ‘600 units
- Configuration with active star-coupler

Integration into substation control systems

Integration into the SICAM power automation system

Integration into other systems

Description

Remote communication with DIGSI

By using the remote communication functions of DIGSI it is possible to access relays from your office via the telephone network. So you do not have to drive to the substation at all and, if you need to carry out a quick fault analysis, for example, you can transfer the fault data into your office in just a few minutes so that you can use DIGSI to evaluate it.

Another alternative is the ability to access all the units of a substation from a central point within that station. This saves you having to connect your PC individually to all the relays in the station.

In both cases you need a few simple communication units and a PC with DIGSI and a remote communication component installed. The data traffic with DIGSI uses a secure protocol based on the IEC standard similar to IEC 60870-5-103 so that, amongst other things, the relays have unique addresses for accessing purposes. A high level of data integrity is achieved through the check sum incorporated in the telegram. Any telegrams that might become distorted during transmission are repeated. A comparison of parameters between relay and PC to ensure that they match also improves the integrity. There are other security functions too such as passwords and a substation modem call-back function which can also be triggered from events.

Remote communication with SIPROTEC 4 units

SIPROTEC 4 units are well equipped for remote communication. A separate serial service interface for the protection engineer, independent of the system interface, allows the units to be easily integrated into any communication configuration. The front interface then remains free for local operation. Together with a flexibility in the choice of interface, i.e. optical with an ST connector for multi-mode FO cables or electrical for RS232 or RS485 hardwired connections, it is easy to create the optimum solution for any particular application.

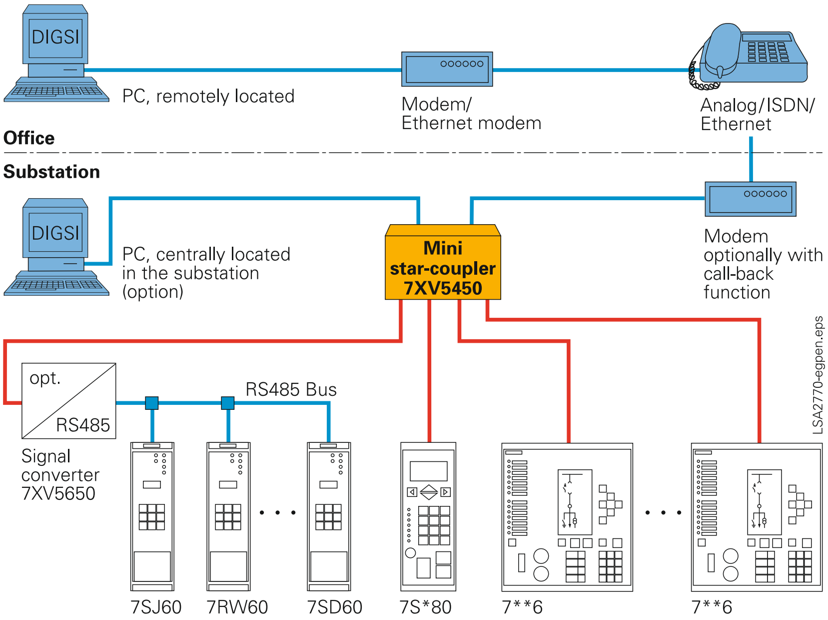


Fig. 4/2 Remote relay communication

With SIPROTEC 4 units you can also use PROFIBUS-FMS to provide a central link with DIGSI via the control system interface. For this you will need a PC with a special PROFIBUS card that must be connected to the PROFIBUS system. This solution is intended exclusively for SIPROTEC 4 units with PROFIBUS-FMS.

Since Oct. 2004, a relay can be accessed remotely with DIGSI via an Ethernet interface in the relay and with the IEC 61850 protocol. This allows access to the relays via an Ethernet network. Some relays include a Web server, so an Internet browser can also be used for remote access via Ethernet.

Remote communication with SIPROTEC 3 and series ‘600 relays

These relays are ideal for applications involving remote communication. When configuring the actual communication system, however, it is important to take into account the smaller number of relay interfaces compared with SIPROTEC 4 units.

In the case of SIPROTEC 3 units, communication is normally effected via the system interface at the back of the unit. If this interface is already being used for communication with the substation control system, the front interface can be used for the DIGSI communication instead. A suitable connector module is available to convert from electrical to optical interface.

Series ‘600 relays normally have one RS485 interface which can be used for communication either with the substation control system or with DIGSI.

SIPROTEC series ‘80 relays offer the same features regarding communication possibilities as SIPROTEC 4 devices.

Typical applications

An extensive range of communication components, such as modems, star couplers, optoelectric converters, prefabricated FO connection cables and electric connection cables (see part 12 of this catalog) allows you to create a variety of different solutions: FO connections immune to interference or cost-effective solutions using the two-wire RS485 electric bus.

The following examples give some indication of what configurations are possible, which items are needed for the purpose and what baud rates are possible.

Example 1: SIPROTEC 4 units on an RS485 bus

Remote communication is effected via a private or public telephone network with both analog or digital telephone lines being possible. An Ethernet network can also be used together with Ethernet modems. The 8N1 data format and an analog baud rate of 57.6/64 kbit/s have become established as the standard for serial modem links. The connection between modem and units is initially optical. An FO/RS485 converter 7XV5650 that can be installed close to the units then converts the signals for the RS485 bus. Up to 31 relays can be connected to the RS485 bus. Particularly in the case of modems, we recommend the use of the types of units listed in part 12. Other accessories can be found in the same part (see Fig. 4/3).

Example 2: SIPROTEC 4 units with FO/RS485

In the case of larger substations with longer distances we recommend the use of FO connection cables. The following example shows a mixed system of optical and electrical connections. Typically, all relays in a cubicle can be linked together via RS485 and the cubicles themselves can be connected to the star coupler via FO cables (see Fig. 4/4).

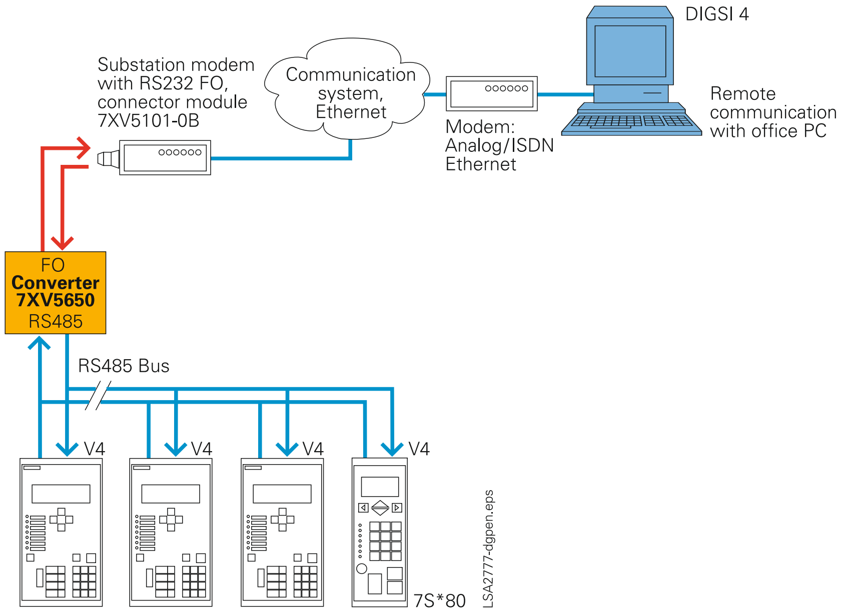


Fig. 4/3 SIPROTEC 4 units on an RS485 bus (Example 1)

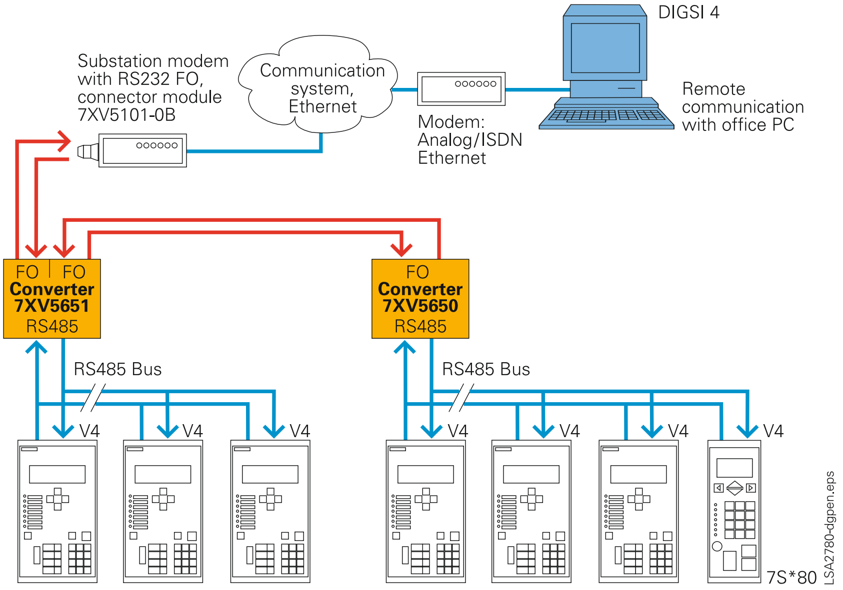


Fig. 4/4 Two groups of SIPROTEC 4 units on an RS485 bus (Example 2)

Typical applications

Example 3: Mixed system – SIPROTEC 4, SIPROTEC 3, series ‘600

Relays from different families can be integrated into a remote communication system, as illustrated in Example 3 (see Fig. 4/5). This example also shows how relays can be integrated by means of FO links and star couplers. With this kind of arrangement the baud rate for all links must be set at 19.2 kbaud because the SIPROTEC 3 units and the series ‘600 relays cannot support a higher baud rate. In this case we recommend to use the 7XV5550 active mini star-coupler (see Fig. 4/6).
Communication will then generally be at 57.6/64 kbit/s on the modem link. For any units that cannot operate at this baud rate the active star-coupler will convert the rate accordingly.

Example 4: Configuration with active star-coupler

With this configuration it is also possible to integrate relays that can only be connected via the front interface and whose maximum baud rates are less than 19.2 kbaud (see Fig. 4/6).

The following points must be noted with this type of configuration:

- One output of the active mini star-coupler is used to service several SIPROTEC 4 units through further star couplers or RS485 converters. On that output, a mixed system containing SIPROTEC 3 and series ‘600 relays should be avoided so that 57600 baud operation is possible for SIPROTEC 4 relays.
- Several SIPROTEC 3 units and series ‘600 relays can also be connected to another output of the active mini star-coupler (via mini star-couplers or RS485 converters). The baud rate for this output must be set less or equal to 19200 baud.
- Relays that are not available with communication functions according to IEC 60870-5-103 protocol (e.g. 7VE51, 7VK51, 7SV51 and older firmware versions of some relays) can also be connected via the active star-coupler as illustrated in Fig. 4/6. In this case one output must be assigned to each relay. The baud rate must be set according to the unit.

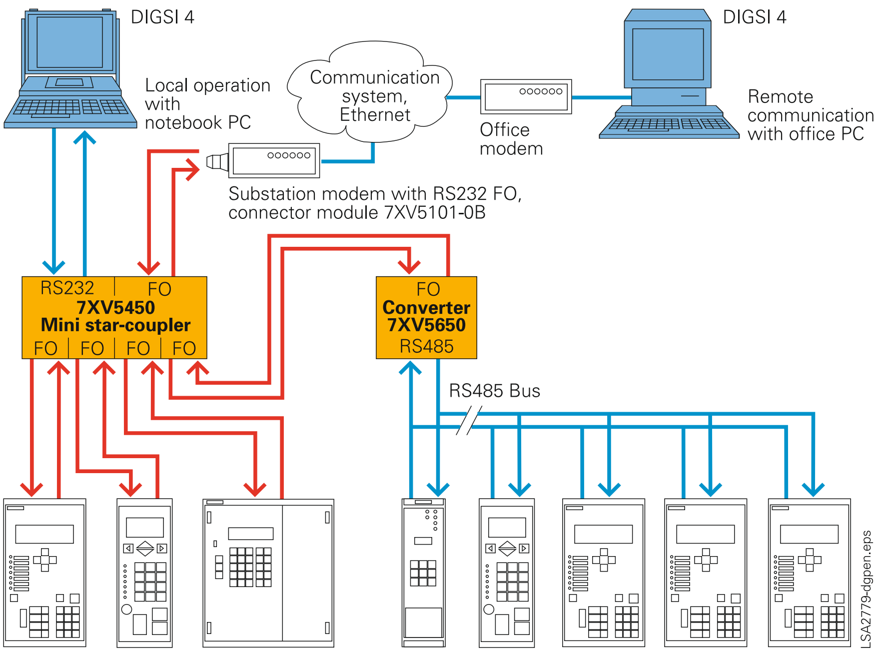


Fig. 4/5 Mixed system, FO/RS485 with units from different families (Example 3)

The solutions for central and/or remote communication with SIPROTEC units have easy upgrade compatibility. Different versions of relays can be integrated into a remote communication concept. This is supported by the substation and device management in the DIGSI software. A substation can be retrofitted with add-on remote communication components provided it has the communication connection available. And changing of the telephone line from, say, analog to digital does not necessitate the replacement of all components. Also, Ethernet networks can be used. The telephone modem is then replaced by an Ethernet modem. The infrastructure in the substation remains unchanged.

Typical applications

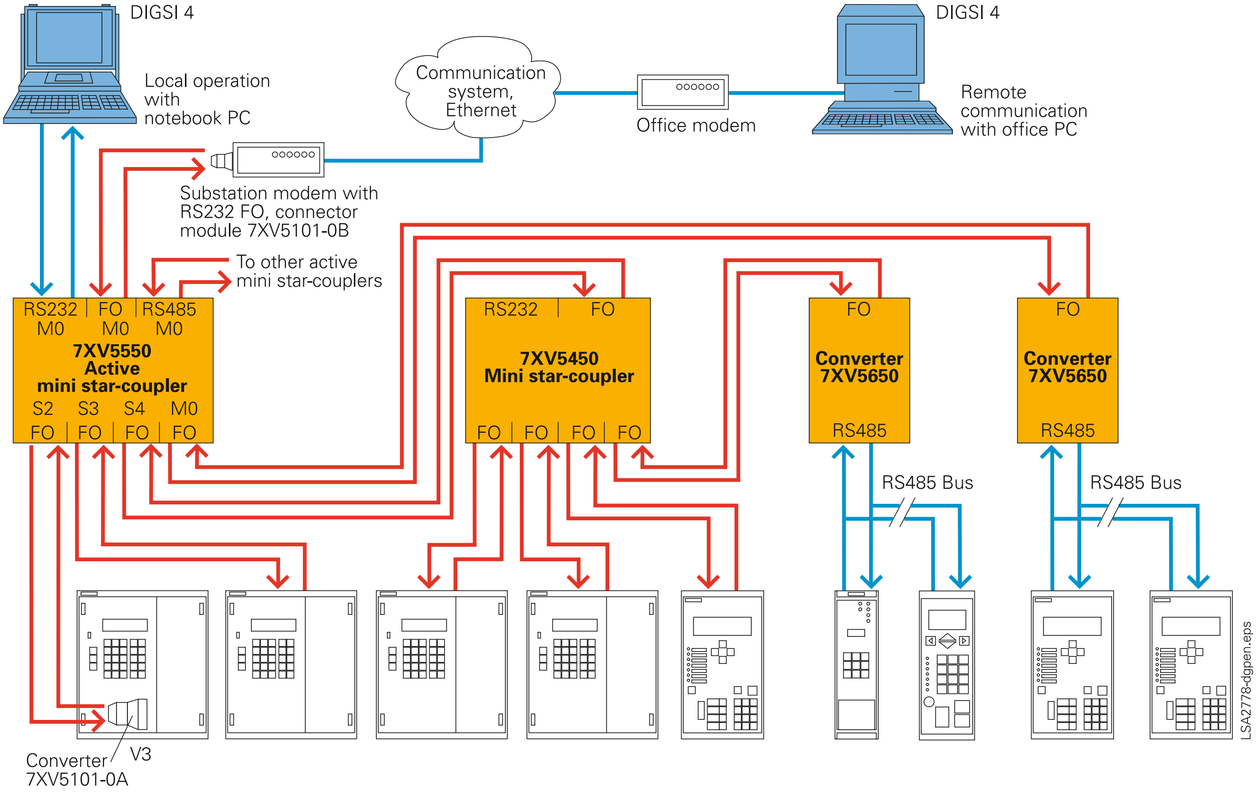


Fig. 4/6 Mixed system with relays from different families, with active star-coupler (Example 4)

Integration into substation control systems

Almost all SIPROTEC units can be integrated into substation control systems via communication interfaces.

The relays can be supplied as part of an integrated Siemens system offering all substation control and protection. In addition, the relays can also be integrated into other control systems via standard protocols. An integrated system offers type-tested functions, consistent configuration and optimally coordinated communication protocols. SICAM PAS and SICAM 1703 are two proven systems available from Siemens. These systems, also offer Ethernet communication with IEC 61850.

For situations where you would like to integrate SIPROTEC units into other control systems we can offer open communication interfaces. In addition to the IEC 60870-5-103 protocol that is available in almost all relays we can also offer other communication protocols for SIPROTEC 4 units like PROFIBUS-DP, MODBUS or DNP 3.0. IEC 61850 is available since Oct. 2004.

Relay type	*Substation control telegram*				
	IEC 61850	*IEC 60870-5-103*	*PROFIBUS-DP*	*MODBUS*	*DNP 3.0*
6MD61	V4.0	V4.0	V4.0		
6MD63	V4.6	V4.0	V4.2	V4.2	V4.2
6MD663/4	V4.6	V4.2	V4.2		
7SA522	V4.6	V4.0	V4.2		V4.2
7SA6..	V4.6	V4.0	V4.2		V4.2
7SD52.	V4.6	V4.0	V4.21		V4.21
7SD61	V4.6	V4.0	V4.2		V4.2
7SJ600		V1.0			
7SJ602		V1.0 / V3.5	V3.5	V3.5	
7SJ61/62/63	V4.6	V4.0	V4.2	V4.2	V4.2
7SJ64	V4.6	V4.0	V4.4	V4.4	V4.4
7S*80	V4.0	V4.0	V4.0	V4.0	V4.0
7UM61		V4.0	V4.0	V4.1	V4.1
7UM62	V4.6	V4.0	V4.0	V4.0	V4.1
7UT6.	V4.6 1)	V4.0	V4.0	V4.0	V4.0
7VE6	V4.6	V4.0	V4.0	V4.0	V4.0
7VK61	V4.6	V4.0	V4.0		V4.0

1) Not 7UT612

Integration into substation control systems

The table on page 4/7 shows which communication protocols are available in the various SIPROTEC relays starting with the firmware version. The latest version can be found on the Internet at www. siprotec.com.

IEC 61850 protocol

Since Oct. 2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations, Siemens was the first manufacturer to support the protocol in its devices. By means of this protocol, information can also be exchanged directly between bay units so as to enable the creation of simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

It will also be possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor will also provide a few items of unit specific information in browser windows.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit (and also control commands) can be transferred via published, Siemens-specific extensions.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred. The information is assignable to a mapping file with DIGSI.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit vendors. SIPROTEC units behave as MODBUS slaves, making their information available to a master or receiving information from it. Information is assignable to a mapping file with DIGSI.

DNP 3.0 protocol

Power supply corporations overseas use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels, SIPROTEC units behave as DNP slaves, supplying their information to a master system or receiving information from it. Information is assignable to a mapping file with DIGSI.

	Substation control port B					Port C
	IEC 61850	IEC 60870-5-103	PROFIBUS-DP	MODBUS	DNP 3.0	DIGSI
Alarms (relay → central unit)	√ with time stamp	√ with time stamp	√ with time stamp	√ with time stamp	√ with time stamp	√ with time stamp
Commands (BC/central unit → relay)	√	√	√	√	√	√
Measured values	√	√	√	√	√	√
Time synchronization	√	√	√	√	√	1)
Fault records (sampled values)	√	√	Separate port (with DIGSI)2)	Separate port (with DIGSI)2)	Separate port (with DIGSI)2)	
Protection settings	√ (with DIGSI)	Separate port (with DIGSI)3)	Separate port (with DIGSI)3)	Separate port (with DIGSI)3)	Separate port (with DIGSI)3)	√
Parameter group switchover	√	√	√	√	√	√

1) There is no time synchronization via this protocol. For time synchronization purposes it is possible to use a separate time synchronization interface (Port A in SIPROTEC 4 relays).

2) The transmission of fault records is not part of the protocol. They can be read out with DIGSI via the service interface Port C or the front operating interface.

3) This protocol does not support the transmission of protection settings. Only setting groups can be changed. For this purpose you should use the service interface or the front operating interface together with DIGSI.

Integration into the SICAM power automation system

SIPROTEC 4 is tailor-made for use with the SIMATIC-based SICAM power automation system. The SICAM family comprises the following components:

- SICAM 1703, the modern telecontrol system with automation and programmable logic functions
- SICAM PAS, the substation automation system based on dedicated hardware

Data management and communication is one of the strong points of the SICAM / SIPROTEC 4 system. Powerful engineering tools make working with SICAM convenient and easy. SIPROTEC 4 units are optimally matched for use in SICAM PAS. With SICAM and SIPROTEC 4 continuity exists at three crucial points:

- Data management
- Software architecture
- Communication

The ability to link SICAM/ SIPROTEC to other substation control, protection and automation components is assured, thanks to open interfaces such as IEC 60870-5-103 protocol and the Ethernet-based IEC 61850 protocol. Other protocols like PROFIBUS-DP, DNP 3.0 and MODBUS are also supported.

Integration into substation automation system

SIPROTEC 4 is tailor-made for use with the SICAM substation automation system. Over the low-cost electrical RS485 bus, the units exchange information with the control system. Units featuring IEC 60870-5-103 interfaces can be connected to SICAM interference free and radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers.

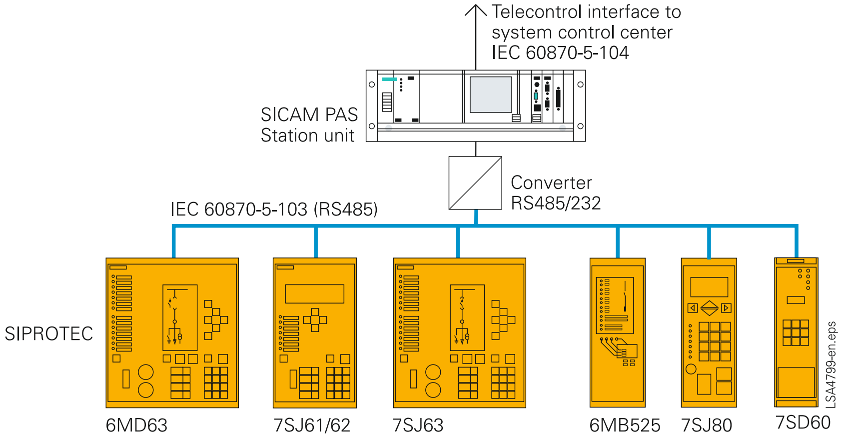


Fig. 4/7 Communication structure with substation automation system

Integration into the SICAM PAS power automation system

SIPROTEC 4 is tailor-made for use with the SICAM power automation system together with IEC 61850 protocol. Via the 100 Mbit/s Ethernet bus, the units are linked electrically or optically to the station PC with PAS. Connection may be simple or redundant. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. Units featuring an IEC 60870-5-103 interface or other serial protocols are connected via the Ethernet station bus to SICAM PAS by means of serial/Ethernet converters (see Fig. 4/8). DIGSI and the Web monitor can also be used over the same station bus.

Together with Ethernet/IEC 61850, an interference-free optical solution is also provided (see Fig. 4/9). The Ethernet interface in the relay includes an Ethernet switch. Thus, the installation of expensive external Ethernet switches can be avoided. The relays are linked in an optical ring structure.

Integrated SNMP (Simple Network Management Protocol) facility allows the supervision of the network from the station controller.

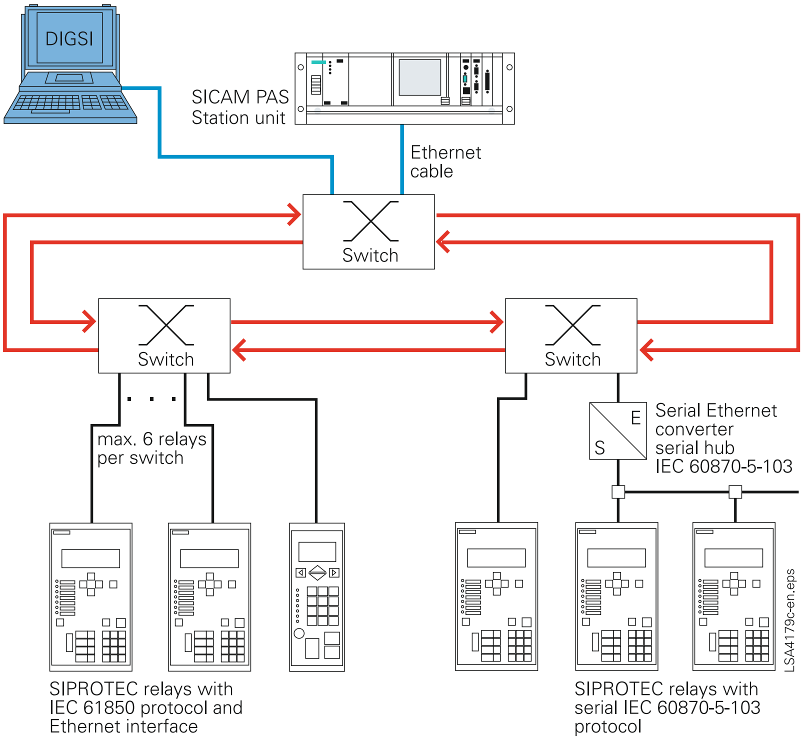


Fig. 4/8 Ethernet-based system with SICAM PAS with electrical Ethernet interface

Integration into a substation automation system of other makes

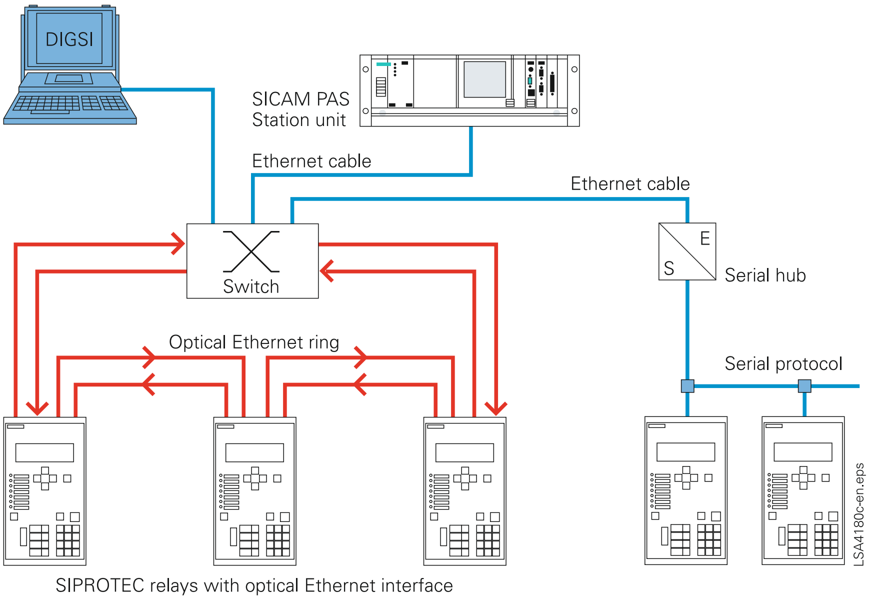


Fig. 4/9 Ethernet-based system with SICAM PAS with optical Ethernet interface

Thanks to the standardized interfaces, IEC 61850, IEC 60870-5-103, DNP3.0, MODBUS, PROFIBUS-DP, SIPROTEC units can also be integrated into non-Siemens systems or in SIMATIC S5/S7. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

Solution without substation control system

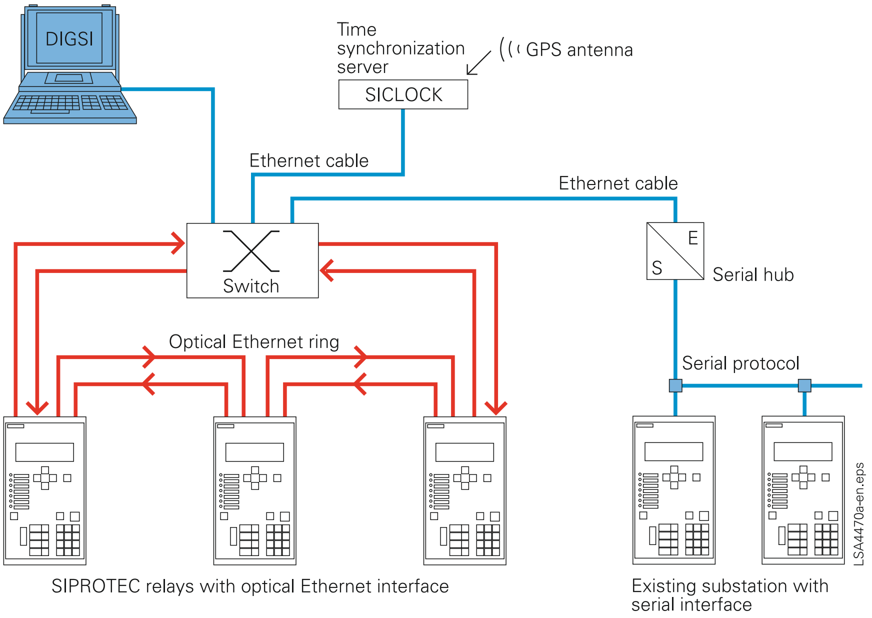


Fig. 4/10 Ethernet-based system with optical Ethernet interface and migration of relays with serial protocol

Ethernet-based communication with optical Ethernet interface between SIPROTEC protection relays without substation control offers many advantages:

- Fast remote access via DIGSI 4
- High-speed setting and parameterization with DIGSI 4
- Interlocking between different field devices and exchange of binary signals via GOOSE messages of IEC 61850
- Common time synchronization of all relays from central time synchronization server (eg. SICLOCK)

For automation of new substations (or plants) and modernization of existing substations you get future investment security, without additional investment.

Overcurrent Protection

SIPROTEC easy 7SJ45
Numerical Overcurrent Protection Relay Powered by CTs

Fig. 5/1 SIPROTEC easy 7SJ45 numerical overcurrent protectiona rely powered by current transformers (CT)

Description

The SIPROTEC easy 7SJ45 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The 7SJ45 relay does not require auxiliary voltage supply. It imports its power supply from the current transformers.

Function overview

- Operation without auxiliary voltage via integrated CT power supply
- Standard current transformers (1 A/5 A)
- Low power consumption: 1.4 VA at I_N (of the relay)
- Easy mounting due to compact housing
- Easy connection via screw-type terminals

Protection functions

- 2-stage overcurrent protection
- Definite-time and inverse-time characteristics (IEC/ANSI)
- High-current stage $I>>$ or calculated earth-current stage $I_E>$ or $I_{Ep}>$ selectable
- Trip with pulse output (24 V DC / 0.1 Ws) or relay output (changeover contact)
- Repetition of trip during circuit-breaker failure (relays with pulse output)
- Combination with electromechanical relays is possible due to the emulation algorithm

Monitoring functions

- Hardware and software are continuously monitored during operation

Front design

- Simple setting via DIP switches (self-explaining)
- Settings can be executed without auxiliary voltage – no PC
- Integrated mechanical trip indication optionally

Additional features

- Optional version available for most adverse environmental conditions (condensation permissible)
- Flush mounting or surface (rail) mounting

Application

The SIPROTEC easy 7SJ45 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The convenient setting with DIP switches is self-explanatory and simple.

The 7SJ45 relay does not require auxiliary voltage supply. It imports its power supply (1.4 VA at I_N, sum of all phases) from the current transformers.
Impulse output for low-energy trip release or contact output for additional auxiliary transformer are available. An optional integrated trip indication shows that a trip occurred.

ANSI	IEC	Protection functions
50	$I>>$	Instantaneous overcurrent protection
50, 51	$I>t$, I_p	Time-overcurrent protection (phase)
50N, 51N	$I_E>t$, I_{Ep}	Time-overcurrent protection (earth)

Construction

Within its compact housing the protection relay contains all required components for:

- Measuring and processing
- Alarm and command output
- Operation and indication (without a PC)
- Optional mechanical trip indication
- Auxiliary supply from current transformers
- Maintenance not necessary

The housing dimensions of the units are such that the 7SJ45 relays can in general be installed into the existing cutouts in cubicles. Alternative constructions are available (surface mounting and flush mounting). The compact housing permits easy mounting, and a version for the most adverse environmental conditions, even with extreme humidity, is also available.

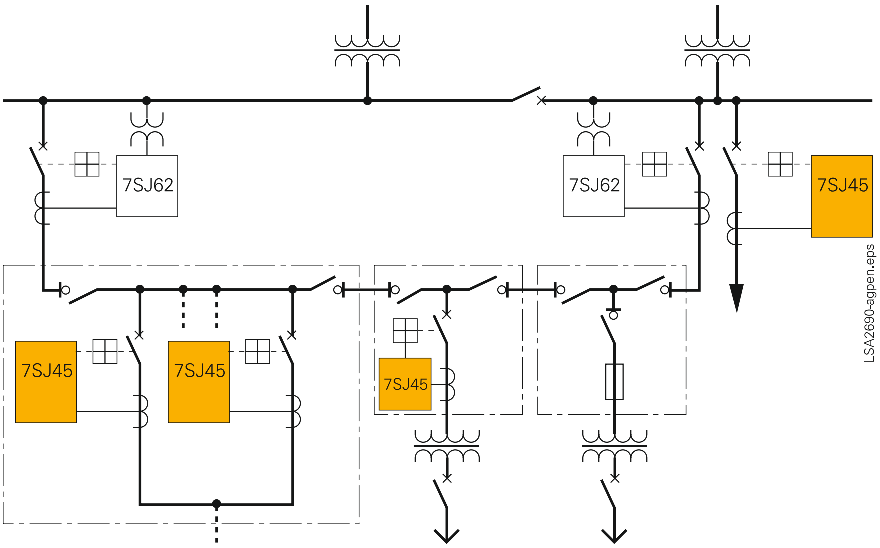


Fig. 5/2 Typical application

Fig. 5/3 Application in distribution switchgear

Fig. 5/4 Screw-type terminals

Protection functions

The overcurrent function is based on phase-selective measurement of the three phase currents.

The earth (ground) current I_E (Gnd) is calculated from the three line currents I_{L1} (A), I_{L2} (B), and I_{L3} (C).

The relay has always a normal stage for phase currents $I>$ (50/51). For the second stage, the user can choose between a high-current stage for phase currents $I>>$ (50) or a normal stage for calculated earth currents $I_E>$ (50N/51N).

The inverse-time overcurrent protection with integrating measurement method (disk emulation) emulates the behaviour of electromechanical relays.

The influence of high-frequency transients and transient DC components is largely suppressed by the implementation of numerical measured-value processing.

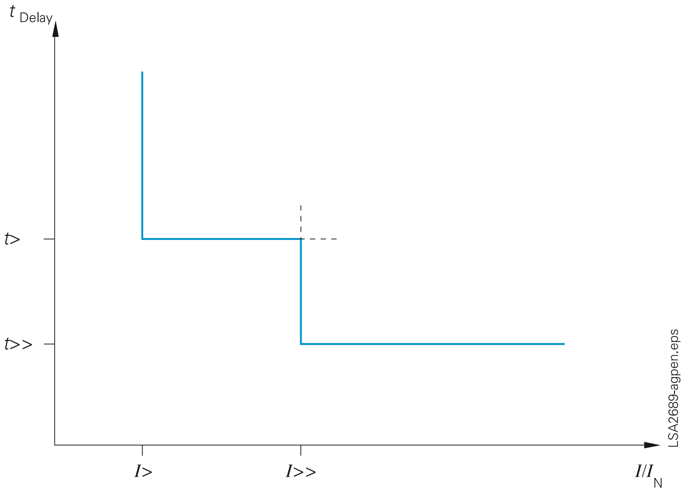


Fig. 5/5 Definite-time overcurrent characteristic

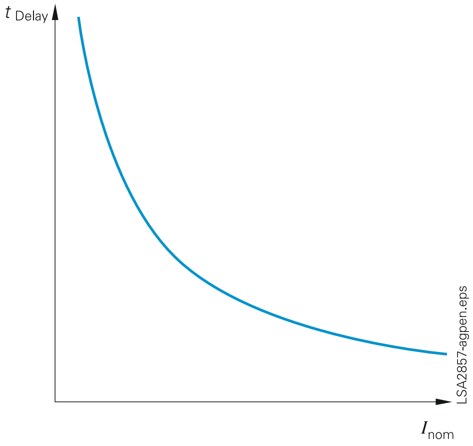


Fig. 5/6 **Inverse-time overcurrent characteristic**

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Moderately inverse/normal inverse	•	•
Very inverse	•	•
Extremely inverse	•	•

Connection diagrams

Pulse output or relay output are optionally available.

Pulse output

These relays require a low-energy trip release (24 V DC/0.1 Ws) in the circuit-breaker, and are intended for modern switchgear. In case of circuit-breaker failure, a repetition of the tripping signal is initiated.

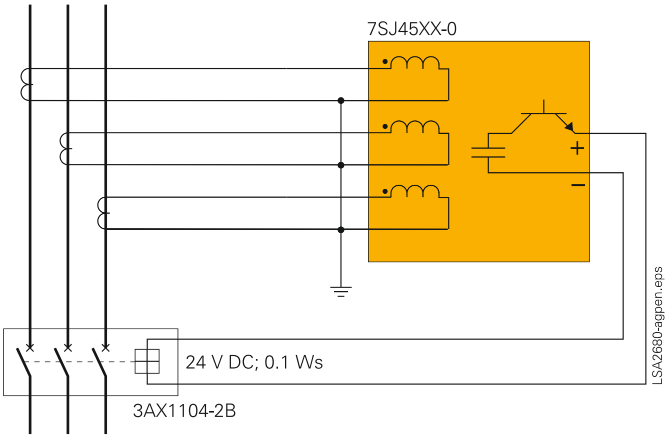


Fig. 5/7 Connection of 3 CTs with pulse output

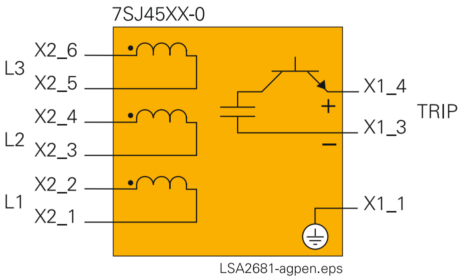


Fig. 5/8 Connection diagram 7SJ45 with impulse output

Relay output

These relays can be applied with all conventional switchgear. A transformer that provides the trip circuit energy, must be connected in the current transformer circuit.

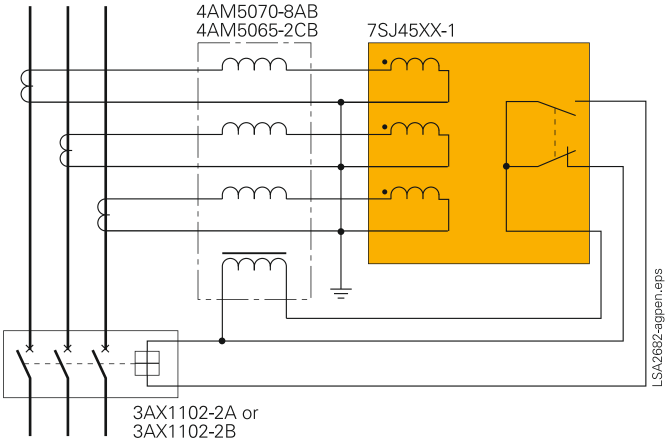


Fig. 5/9 Connection of 3 CTs with trigger transformer and relay output

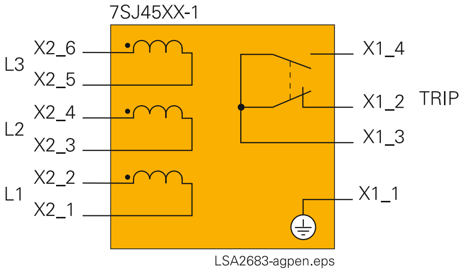


Fig. 5/10 Connection diagram 7SJ45 with relay output

Technical data

General unit data

Analog input

System frequency I_N	50 or 60 Hz (selectable)

Current transformer inputs

Rated current, normal earth current I_N	1 or 5 A
Power consumption At $I_N = 1 / 5$ A	 Approx. 1.4 VA at I_N (relay)
Rating of current transformer circuit Thermal (r.m.s.)	 50 · I_N for 1 s 15 · I_N for 10 s 2 · I_N continuous
Dynamic (peak)	100 · I_N for half a cycle
Recommended primary current transformers	10 P 10, 2.5 VA or according to the requirements and required tripping power

Output relays

Pulse output (7SJ45XX-0*)

Number	1 pulse output 24 V DC / 0.1 Ws

Relay output (7SJ45XX-1*)

Number	1 changeover contact	
Contact rating	Make Break	1000 W/VA 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ 250 V DC or ≤ 240 V AC	
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)	

Unit design

Housing	Flush mounting DIN 43700/IEC 61554 Adaptable for rail mounting (recommended for local mounting only)
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1.5 kg
Degree of protection according to IEC 60529	
Housing Front Rear	 IP 51 IP 20
Protection of personnel	IP1X

U_L-listing

Listed under “69CA”.

Electrical tests

Specifications

Standards	IEC 60255 (product standards) ANSI C37.90.0/.1/.2; UL508 See also standards for individual tests

Insulation tests

Standards	IEC 60255-5
Voltage test (routine test)	2.5 kV (r.m.s.), 50 Hz, 1 min
All circuits except for pulse output-earth	
Voltage test (type test) across open command contacts	 1.0 kV (r.m.s.), 50 Hz, 1 min
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6, IEC 60255-22, EN 50263 (product standards) EN 50082-2 (generic standard) EN 61000-6-2 IEC 61000-4 (basic standards)
High-frequency test IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; $R_i = 200\ \Omega$; 400 surges/s; duration ≥2 s
Electrostatic discharge IEC 60255-22-2, class III EN 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with radio-frequency field, amplitude-modulated IEC 60255-22-3 and IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 %; 1 kHz; AM
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % 30 V/M; 1890 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst duration = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; duration 1 min
High-energy surge voltage, IEC 61000-4-5 installation, class III Measuring inputs, binary outputs	Impulse: 1.2/50 µs Circuit groups to earth: 2 kV; 42 Ω, 0.5 µF Across circuit groups: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 60255-22-6 and IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 %; 1 kHz; $R_i = 150\ \Omega$
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 5 s; 50 Hz 0.5 mT; 50 Hz
Damped wave IEC 60694, IEC 61000-4-12, class III	2.5 kV (peak, polarity alternating) 100 kHz, 1 MHz, 10 MHz and 50 MHz , $R_i = 200\ \Omega$, duration ≥ 2 s
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 Not across open contacts	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 shots per s; duration ≥ 2 s; $R_i = 150\ \Omega$ to $200\ \Omega$
Fast transient surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	4 to 5 kV; 10/150 ns; 50 and 120 surges per ≥ 2 s; both polarities; duration ≥ 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz amplitude and pulse-modulated

EMC tests for interference emission; type test

Standard	EN 50081–* (generic)
Interference field strength IEC CISPR 22	30 to 1000 MHz, class B

Technical data

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz ± 0.075 mm amplitude: 60 to 150 Hz; 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60225-21-2; class I	Semi-sinusoidal 5 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Seismic vibration IEC 60255-21-3; class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4.0 mm amplitude (horizontal vector) 1 to 8 Hz: ± 2.0 mm amplitude (vertical vector) 8 to 35 Hz: 1 *g* acceleration (horizontal vector) 8 to 35 Hz: 0.5 *g* acceleration (vertical vector) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes

During transport (flush mounting)

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal 15 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal 10 *g* acceleration, duration 16 ms, each 1000 shocks in both directions of the 3 axes

Climatic stress tests

Temperatures

Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F With continuous current $2I_N$: –20 °C to +55 °C / –4 °F to +131 °F
Permissible temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Permissible temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F

Humidity

Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Functions

Overcurrent protection

Definite time (DT O/C ANSI 50/51)

Setting range / steps	
Current pickup $I>>$ (phases)	2 I_N to 20 I_N or deactivated, step 0.5 I_N
Current pickup $I>$ (phases) 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Current pickup $I_E>$ 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Delay times $T_I>>$	0 to 1575 ms, step 25 ms
Delay times $T_I>$	0 to 6300 ms, step 100 ms
The set time delays are pure delay times.	

Inverse time (IEC or ANSI 51)

Setting range / steps	
Current pickup I_p (phases) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Current pickup $I_{Ep}>$ (earth calculated) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Delay times T_{Ip} (IEC)	0.05 to 3.15 s, step 0.05 s
Delay times D (ANSI)	0.5 to 15.00 s, step 0.25 s
Trip times	
Total time delay impulse output	Approx. 32 ms
Total time delay relay output	Approx. 38 ms
Reset ratio	Approx. 0.95 (with definite time) Approx. 0.91 (with inverse time)
Tolerances	
Definite time (DT O/C 50/51) Current pickup $I>>$, $I>$, $I_E>$	5 % of the set value or 5 % of I_N (at threshold < I_N)
Delay times T	1 % or 30 ms
Inverse time (IEC or ANSI 51) Pickup thresholds	5 % of the set value or 5 % of I_N (at threshold < I_N)
Time behavior for $2 \leq I/I_p \leq 20$	5 % or 50 ms
Deviation of the measured values as a result of various interferences	
Frequency in the range of $0.95 < f/f_N < 1.05$	< 2.5 %
Frequency in the range of $0.9 < f/f_N < 1.1$	< 10 %
Harmonics up to 10 % 3rd and 5th harmonic	< 1 %
DC components	< 5 %
Temperature in the range of – 5 °C to 70 °C / 23 °F to 158 °F	< 0.5 %/10 K

---

* Note: The device allows minimum setting values of 0.5 I_N (3-phase). With single supply, operation is ensured from 0.8 I_N (7SJ45XX-0*; pulse output) or 1.3 I_N (7SJ45XX-1*; relay output) onwards (printed on the front).

Technical data

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC).

This unit conforms to the international standard IEC 60255.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2.

Selection and ordering data

Description	Order No.
SIPROTEC easy 7SJ45 *numerical overcurrent protection relay powered by CTs*	*7SJ450☐– ☐☐☐00 – ☐AA☐*
Current transformer I_N	
1 A	*1*
5 A	*5*
Trip	
Pulse output (for further details refer to “Accessories”)	*0*
Relay output (for further details refer to “Accessories”)	*1*
Unit design	
For rail mounting	*B*
For panel flush mounting	*E*
Region-specific functions	
Region World, 50/60 Hz; standard	*A*
Region World, 50/60 Hz; condensation-proof	*B*
IEC / ANSI	
IEC	*0*
ANSI	*1*
Indication (flag)	
Without	*0*
With	*1*

Accessories

Protection relay with pulse output	
Low energy trip release	*3AX1104-2B*
Protection relay with relay output	
Auxiliary transformers for the trip circuit (30 VA CTs recommended)	
1 A	*4AM5065-2CB00-0AN2*
5 A	*4AM5070-8AB00-0AN2*
Current transformer-operated trip release	
0.5 A (rated operating current)	*3AX1102-2A*
1 A (rated operating current)	*3AX1102-2B*

SIPROTEC easy 7SJ46 Numerical Overcurrent Protection Relay

Fig. 5/11 SIPROTEC easy 7SJ46 numerical overcurrent protection relay

Description

The SIPROTEC easy 7SJ46 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The 7SJ46 relay has an AC and DC auxiliary power supply with a wide range allowing a high degree of flexibility in its application.

Function overview

- Universal application due to integrated wide range AC/DC power supply.
- Standard current transformers (1 A/5 A)
- Easy mounting due to compact housing
- Easy connection via screw-type terminals

Protection functions

- 2-stage overcurrent protection
- Definite-time and inverse-time characteristics (IEC/ANSI)
- High-current stage I>> or calculated earth-current stage I_E> or I_{Ep}> selectable
- Two command outputs for “trip” or “pickup”
- Combination with electromechanical relays is possible due to the emulation algorithm

Monitoring functions

- One live contact for monitoring
- Hardware and software are continuously monitored during operation

Front design

- Simple setting via DIP switches (self-explaining)
- Settings can be executed without auxiliary voltage – no PC
- Individual phase pickup indication with stored or not stored LEDs
- Trip indication with separate LED

Additional features

- Optional version available for most adverse environmental conditions (condensation permissible)
- Flush mounting or surface (rail) mounting

Application

The SIPROTEC easy 7SJ46 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks.
It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The convenient setting with DIP switches is self-explanatory and simple.

The 7SJ46 relay has an AC and DC auxiliary power supply with a wide range allowing a high degree of flexibility in its application. Phase-selective indication of protection pickup is indicated with LEDs.

ANSI	IEC	Protection functions
50	*I*>>	Instantaneous overcurrent protection
50, 51	*I*>*t*, I_p	Time-overcurrent protection (phase)
50N, 51N	I_E>t, I_{Ep}	Time-overcurrent protection (earth)

Construction

Within its compact housing the protection relay contains all required components for:

- Measuring and processing
- Pickup and command output
- Operation and indication (without a PC)
- Wide range AC/DC power supply
- Maintenance not necessary (no battery)

The housing dimensions of the units are such that the 7SJ46 relays can in general be installed into the existing panel cutouts. Alternative constructions are available (rail mounting and flush mounting). The compact housing permits easy mounting, and a version for the most adverse environmental conditions, even with extreme humidity, is also available.

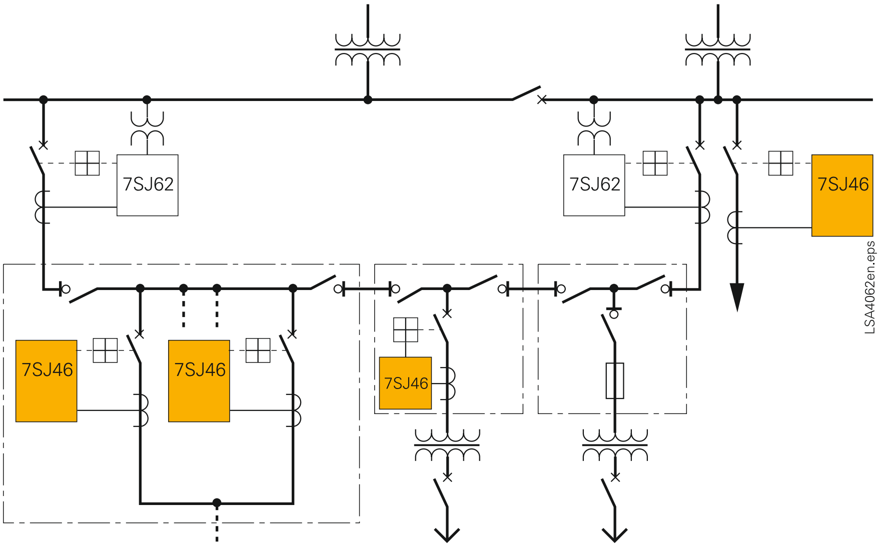


Fig. 5/12 Typical application

Fig. 5/13 Application in distribution switchgear

Fig. 5/14 Screw-type terminals

Protection functions

The overcurrent function is based on phase-selective measurement of the three phase currents.

The earth (ground) current I_E (Gnd) is calculated from the three line currents I_{L1} (A), I_{L2} (B), and I_{L3} (C).

The relay has always a normal stage for phase currents $I>$ (50/51).

For the second stage, the user can choose between a high-current stage for phase currents $I>>$ (50) or a normal stage for calculated earth currents $I_E>$ (50N/51N).

The inverse-time overcurrent protection with integrating measurement method (disk emulation) emulates the behavior of electromechanical relays.

The influence of high frequency transients and transient DC components is largely suppressed by the implementation of numerical measured-value processing.

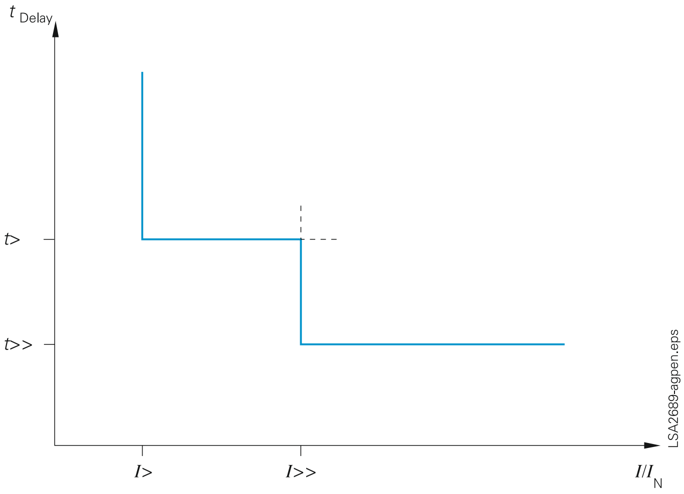


Fig. 5/15 Definite-time overcurrent characteristic

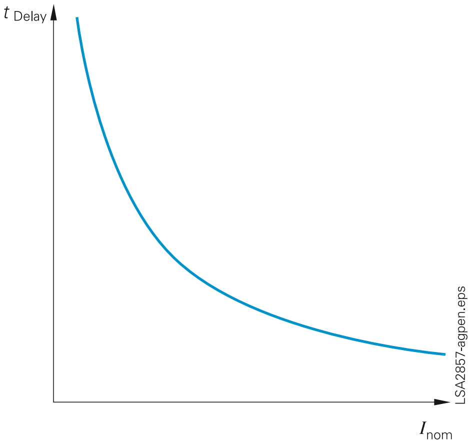


Fig. 5/16 Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Moderately inverse/normal inverse	•	•
Very inverse	•	•
Extremely inverse	•	•

Connection diagrams

The 7SJ46 has a trip contact, a contact which is adjustable for trip or pickup, and a live contact for the self-monitoring function.

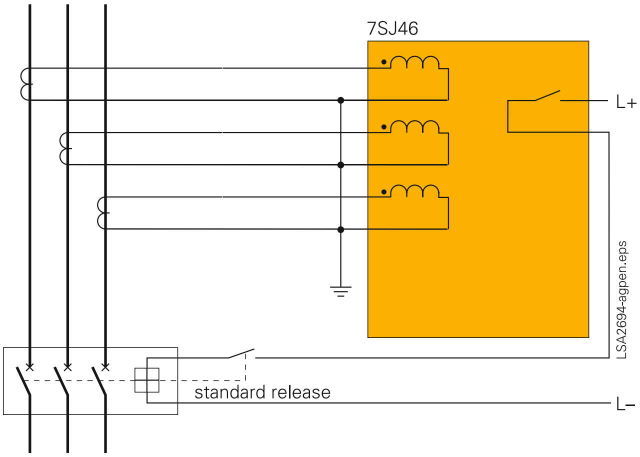


Fig. 5/17 Connection of 3 CTs

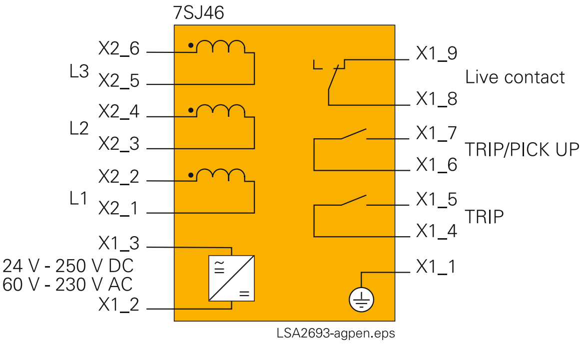


Fig. 5/18 Connection diagram 7SJ46

Technical data

General unit data

Analog input

System frequency f_N	50 or 60 Hz (selectable)

Current transformer inputs

Rated current, normal earth current I_N	1 or 5 A
Power consumption	
Per phase at $I_N = 1$ A	Approx. 0.01 VA at I_N
Per phase at $I_N = 5$ A	Approx. 0.2 VA at I_N (relay)
Rating of current transformer circuit	
Thermal (r.m.s.)	100 · I_N for 1 s 30 · I_N for 10 s 4 · I_N continuous
Dynamic (peak)	250 · I_N for half a cycle

Auxiliary voltage AC/DC powered

Input voltage range	24 to 250 V DC (± 20 %) 60 to 230 V AC (–20 %, +15 %)
Power consumption	DC – power supply: Approx. 1.5 W AC – power supply: Approx. 3 VA at 110 V approx. 5.5 VA at 230 V

Output relays

Number	2 (normally open), 1 live contact
Contact rating	Make 1000 W/VA Break 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ 250 V DC or ≤ 240 V AC
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)

Unit design

Housing	Flush mounting DIN 43700/IEC 61554 Adaptable for rail mounting recommended for local mounting only
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1 kg
Degree of protection according to IEC 60529	
Housing	
Front	IP 51
Rear	IP 20
Protection of personnel	IP 1X

U_L-listing

Listed under “69CA”.

Electrical tests

Specifications

Standards	IEC 60255 (product standards) ANSI C37.90.0/.1/.2; UL508 See also standards for individual tests

Insulation tests

Standards	IEC 60255-5
Voltage test (routine test) all circuits except auxiliary supply	2.5 kV (r.m.s.), 50 Hz; 1 min
Voltage test (routine test) auxiliary supply	3.5 kV DC; 30 s; both polarities
Voltage test (type test)	
Across open contacts	1.5 kV (r.m.s.), 50 Hz; 1 min
Across open live contact	1.0 kV (r.m.s.), 50 Hz; 1 min
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 μs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6, IEC 60255-22, EN 50263 (product standards) EN 50082-2 (generic standard) EN 61000-6-2 IEC 61000-4 (generic standards)
High-frequency tests IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; $R_i = 200\ \Omega$; 400 surges/s; duration ≥ 2 s
Electrostatic discharge IEC 60255-22-2, class III EN 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with radio-frequency field, amplitude-modulated IEC 60255-22-3 and IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 %; 1 kHz; AM
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % 30 V/m 1810 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; duration 1 min
High-energy surge voltage, IEC 61000-4-5 installation class III	Impulse: 1.2/50 μs
Auxiliary voltage	circuit groups to earth: 2 kV; 12 Ω, 9 μF between circuit groups: 1 kV; 2 Ω, 18 μF
Measuring inputs, binary outputs	circuit groups to earth: 2 kV; 42 Ω, 0.5 μF between circuit groups: 1 kV; 42 Ω, 0.5 μF
Line-conducted HF, amplitude-modulated. IEC 60255-22-6 and IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 %; 1 kHz; AM; $R_i = 150\ \Omega$
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 5 s; 50 Hz 0.5 mT; 50 Hz
Damped wave IEC 60694, IEC 61000-4-12, class III	2.5 kV (peak, polarity alternating) 100 kHz, 1 MHz, 10 MHz and 50 MHz , $R_i = 200\ \Omega$, duration ≥ 2 s
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 shots per s; duration ≥ 2 s; $R_i = 150\ \Omega$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	4 kV to 5 kV; 10/150 ns; 50 and 120 surges per s; both polarities; duration ≥ 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m 25 MHz to 1000 MHz amplitude and pulse-modulated

EMC tests for interference emission; type test

Standard	EN 50081–* (generic)
Conducted interference voltage, auxiliary voltage IEC CISPR 22, EN 55022, DIN EN VDE 0878 Part 22	150 kHz to 30 MHz, class B
Interference field strength IEC CISPR 22	30 MHz to 1000 MHz, class B

Technical data

Mechanical stress test

Vibration, shock and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60225-21-2; class I	Semi-sinusoidal 5 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Seismic vibration IEC 60255-21-3; class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4.0 mm amplitude (horizontal vector) 1 to 8 Hz: ± 2.0 mm amplitude (vertical vector) 8 to 35 Hz: 1 *g* acceleration (horizontal vector) 8 to 35 Hz: 0.5 *g* acceleration (vertical vector) Frequeny sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transport (flush mounting)	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal 15 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal 10 *g* acceleration, duration 16 ms, each 1000 shocks in both directions of the 3 axes

Climatic stress tests

Temperatures

Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F with continuous current 4 I_N: –20 °C to +55 °C / –4 °F to +131 °F
Maximum temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Maximum temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F

Humidity

Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Functions

Overcurrent protection

Definite time (DT O/C ANSI 50/51)	
Setting range / steps	
Current pickup $I>>$ (phases)	2 I_N to 20 I_N or deactivated, step 0.5 I_N
Current pickup $I>$ (phases)	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Current pickup $I_E>$ (earth calculated)	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Delay times $T_{I>>}$	0 to 1575 ms, step 25 ms
Delay times $T_{I>}$	0 to 6300 ms, step 100 ms
The set time delays are pure delay times.	
Inverse time (IEC or ANSI 51)	
Current pickup I_p (phases)	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Current pickup $I_{Ep}>$ (earth calculated)	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Delay times T_{Ip} (IEC)	0.05 to 3.15 s, step 0.05 s
Delay times D (ANSI)	0.5 to 15.00 s, step 0.25 s
Trip times	
Switch on to fault, relay output	Approx. 38 ms
Reset ratio	Approx. 0.95 (with definite time) Approx. 0.91 (with inverse time)
Tolerances	
Definite time (DT O/C 50/51)	
Current pickup $I>>$, $I>$, $I_E>$	5 % of the set value or 5 % of I_N (at threshold < I_N)
Delay times T	1 % or 30 ms
Inverse time (IEC or ANSI 51)	
Pickup thresholds	5 % of the set value or 5 % of I_N (at threshold < I_N)
Time behaviour for $2 \leq I/I_p \leq 20$	5 % or 50 ms
Deviation of the measured values as a result of various interferences	
Frequency in the range of $0.95 < f/f_N < 1.05$	< 2.5 %
Frequency in the range of $0.9 < f/f_N < 1.1$	< 10 %
Harmonics up to 10 % 3rd and 5th harmonic	< 1 %
DC components	< 5 %
Auxiliary supply voltage DC in the range of $0.8 \leq V_{aux}/V_{aux\,N} \leq 1.2$	< 1 %
Auxiliary supply voltage AC in the range of $0.8 \leq V_{aux}/V_{aux\,N} \leq 1.15$	< 1 %
Temperature in the range of –5 °C to 70 °C / 23 °F to 158 °F	< 0.5 %/10 K

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC).

This unit conforms to the international standard IEC 60255.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2.

c UL us LISTED

Selection and ordering data

Description	Order No.
SIPROTEC easy 7SJ46 *numerical overcurrent protection relay*	*7SJ460☐– 1☐☐00 – ☐AA0*
Current transformer I_N	
1 A	*1*
5 A	*5*
Unit design	
For rail mounting	*B*
For panel-flush mounting	*E*
Region-specific/functions	
Region World, 50/60 Hz; standard	*A*
Region World, 50/60 Hz; condensation-proof	*B*
IEC / ANSI	
IEC	*0*
ANSI	*1*

SIPROTEC 7SJ600
Numerical Overcurrent, Motor and Overload Protection Relay

Fig. 5/19 SIPROTEC 7SJ600 numerical overcurrent, motor and overload protection relay

Description

The SIPROTEC 7SJ600 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ600 provides definite-time and inverse-time overcurrent protection along with overload and negative-sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

Function overview

Feeder protection

- Overcurrent-time protection
- Earth-fault protection
- Overload protection
- Negative-sequence protection
- Cold load pickup
- Auto-reclosure
- Trip circuit supervision

Motor protection

- Starting time supervision
- Locked rotor

Control functions

- Commands for control of a circuit-breaker
- Control via keyboard, DIGSI 4 or SCADA system

Measuring functions

- Operational measured values I

Monitoring functions

- Fault event logging with time stamp (buffered)
- 8 oscillographic fault records
- Continuous self-monitoring

Communication

- Via personal computer and DIGSI 3 or DIGSI 4 (≥ 4.3)
- Via RS232 – RS485 converter
- Via modem
- IEC 60870-5-103 protocol, 2 kV-isolated
- RS485 interface

Hardware

- 3 current transformers
- 3 binary inputs
- 3 output relays
- 1 live status contact

Application

Wide range of applications

The SIPROTEC 7SJ600 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ600 provides definite-time and inverse-time overcurrent protection along with overload and negative-sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

The integrated control function allows simple control of a circuit-breaker or disconnector (electrically operated/motorized switch) via the integrated HMI, DIGSI 3 or DIGSI 4 (≥ 4.3) or SCADA (IEC 60870-5-103 protocol).

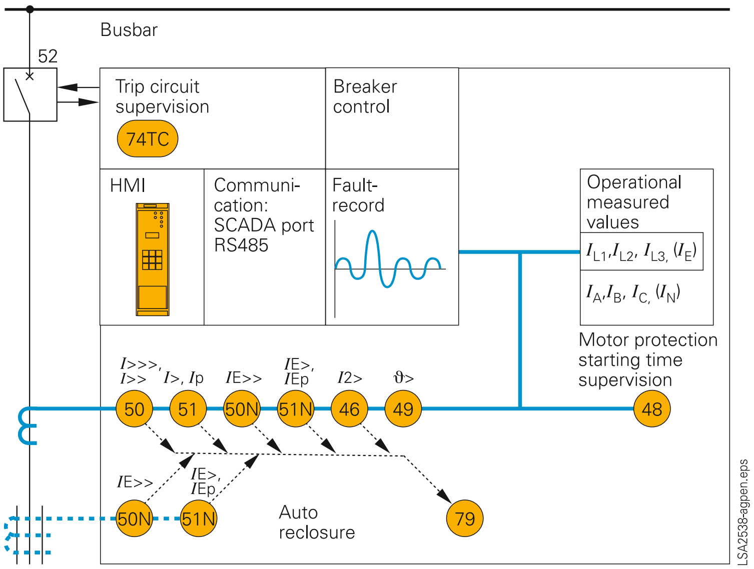


Fig. 5/20 Function diagram

ANSI	IEC	Protection functions
50, 50N	$I>, I>>, I>>>$ $I_E>, I_E>>$	Definite time-overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse time-overcurrent protection (phase/neutral)
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
74TC		Trip circuit supervision breaker control

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485)
- Power supply.

The rated CT currents applied to the SIPROTEC 7SJ600 can be 1 or 5 A.
This is selectable via a jumper inside the relay.

Two different housings are available. The flush-mounting/cubicle-mounting version has terminals accessible from the rear. The surface-mounting version has terminals accessible from the front.

Fig. 5/21
Rear view of flush-mounting housing

Protection functions

Definite-time characteristics

The definite-time overcurrent function is based on phase-selective measurement of the three phase currents and/or earth current.

Optionally, the earth (ground) current I_E (Gnd) is calculated or measured from the three line currents $I_{L1}(I_A)$, $I_{L2}(I_B)$ and $I_{L3}(I_C)$.

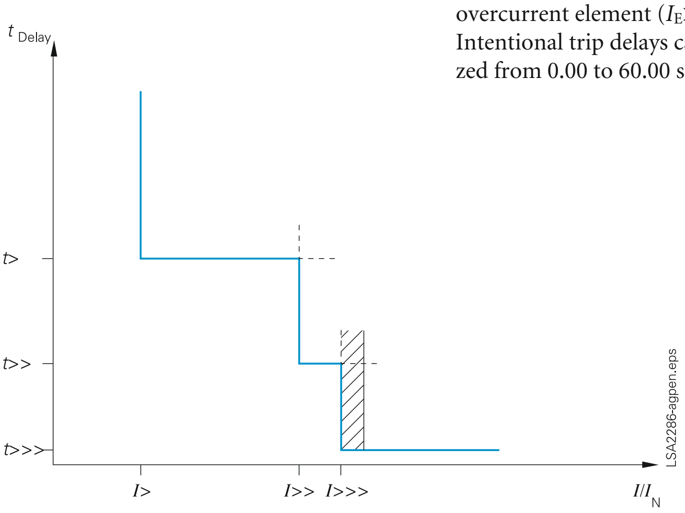


Fig. 5/22 Definite-time overcurrent characteristic

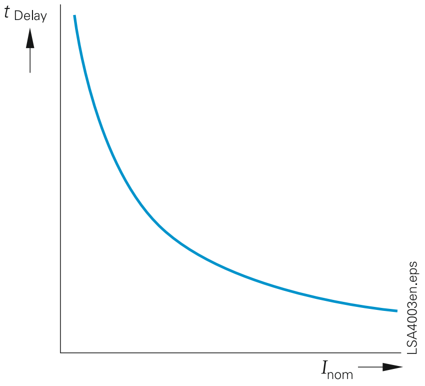


Fig. 5/23 Inverse-time overcurrent characteristic

The definite-time overcurrent protection for the 3 phase currents has a low-set overcurrent element (*I*>), a high-set overcurrent element (*I*>>) and a high-set instantaneous-tripping element (*I*>>>). Intentional trip delays can be parameterized from 0.00 to 60.00 seconds for the low-set and high-set overcurrent elements. The instantaneous zone *I*>>> trips without any intentional delay. The definite-time overcurrent protection for the earth (ground) current has a low-set overcurrent element (I_E>) and a high-set overcurrent element (I_E>>).
Intentional trip delays can be parameterized from 0.00 to 60.00 seconds.

Inverse-time characteristics

In addition, invese-time overcurrent protection characteristics (IDMTL) can be activated.

Available inverse-time characteristic

Characteristics acc.to	ANSI / IEEE	IEC 60255-3
Inverse	●	●
Short inverse	●	
Long inverse	●	●
Moderately inverse	●	
Very inverse	●	●
Extremely inverse	●	●
Definite inverse	●	
I squared *T*	●	

Protection functions

Thermal overload protection (ANSI 49)

The thermal overload protection function provides tripping or alarming based on a thermal model calculated from phase currents.

Thermal overload protection without preload

For thermal overload protection without consideration of the preload current, the following tripping characteristic applies only when

$I \geq 1.1 \cdot I_L$

For different thermal time constants T_L, the tripping time t is calculated in accordance with the following equation:

$$t = \frac{35}{\left(\frac{I}{I_L}\right)^2 - 1} \cdot T_L$$

$I =$ Load current

$I_2 =$ Pickup current

$T_L =$ Time multiplier

The reset threshold is above $1.03125 \cdot I/I_N$

Thermal overload protection with preload

The thermal overload protection with consideration of preload current constantly updates the thermal model calculation regardless of the magnitude of the phase currents. The tripping time t is calculated in accordance with the following tripping characteristic (complete memory in accordance with IEC 60255-8).

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

t = Tripping time after beginning of the thermal overload

$\tau = 35.5 \cdot T_L$

I_{pre} = Pre-load current

T_L = Time multiplier

I = Load current

k = k factor (in accordance with IEC 60255-8)

ln = Natural logarithm

I_N = Rated (nominal) current

For further details please refer to part 2 “Overview”.

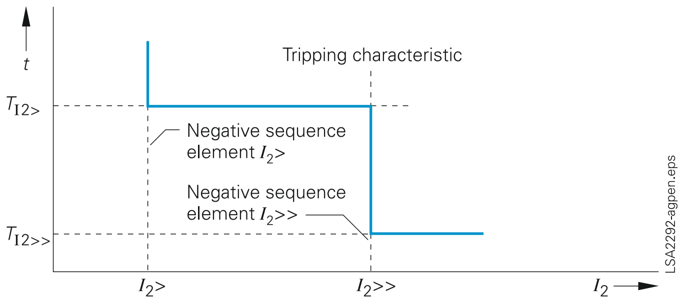


Fig. 5/24 Tripping characteristic of the negative-sequence protection function

Negative-sequence protection (I_2>>, I_2>/ANSI 46 Unbalanced-load protection)

The negative-sequence protection (see Fig. 5/24) detects a phase failure or load unbalance due to network asymmetry. Interruptions, short-circuits or crossed connections to the current transformers are detected.

Furthermore, low level single-phase and two-phase short-circuits (such as faults beyond a transformer) as well as phase interruptions can be detected.

This function is especially useful for motors since negative sequence currents cause impermissible overheating of the rotor.

In order to detect the unbalanced load, the ratio of negative phase-sequence current to rated current is evaluated.

I_2 = Negative-sequence current

T_{12} = Tripping time

Transformer protection

The high-set element permits current coordination where the overcurrent element functions as a backup for the lower-level protection relays, and the overload function protects the transformer from thermal overload. Low-current single-phase faults on the low voltage side that result in negative phase-sequence current on the high-voltage side can be detected with the negative-sequence protection.

Cold load pickup

By means of a binary input which can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable duration of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady state conditions.

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder which has previously been disconnected by time-overcurrent protection.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for the trip circuit monitoring.

Control

The relay permits circuit-breakers to be opened and closed without command feedback. The circuit-breaker/disconnector may be controlled by DIGSI, or by the integrated HMI, or by the LSA/SCADA equipment connected to the interface.

Protection functions

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker bypassing the internal control function, manual detection using a binary input is implemented.

Busbar protection (Reverse interlocking)

Binary inputs can be used to block any of the six current stages. Parameters are assigned to decide whether the input circuit is to operate in open-circuit or closed-circuit mode. In this case, reverse interlocking provides high-speed busbar protection in radial or ring power systems that are opened at one point. The reverse interlocking principle is used, for example, in medium-voltage power systems and in switchgear for power plants, where a high-voltage system transformer feeds a busbar section with several medium-voltage outgoing feeders.

Motor protection

For short-circuit protection, e.g. elements $I>>$ (50) and I_E (50N) are available. The stator is protected against thermal overload by $\vartheta_s>$ (49), the rotor by $I_2>$ (46), starting time supervision (48).

Motor starting time supervision (ANSI 48)

The start-up monitor protects the motor against excessively long starting. This can occur, for example, if the rotor is blocked, if excessive voltage drops occur when the motor is switched on or if excessive load torques occur. The tripping time depends on the current.

$$t_{TRIP} = \left(\frac{I_{start}}{I_{rms}}\right)^2 \cdot t_{start\ max}$$

for $I_{rms} > I_{start}$, reset ratio $\frac{I_N}{I_{start}}$

approx. 0.94

t_{TRIP} = Tripping time

I_{start} = Start-up current of the motor

$t_{start\ max}$ = Maximum permissible starting time

I_{rms} = Actual current flowing

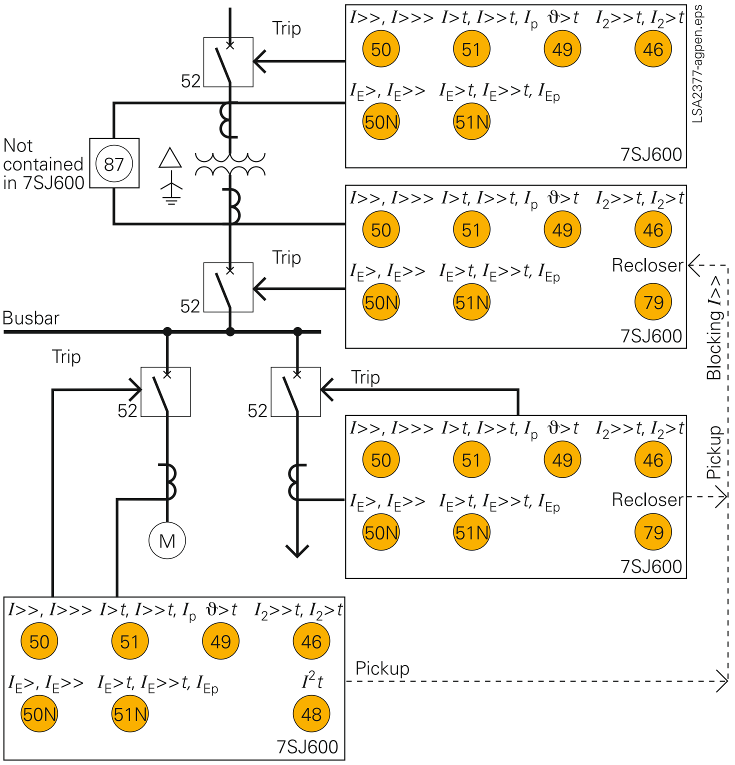


Fig. 5/25 Reverse interlocking

Features

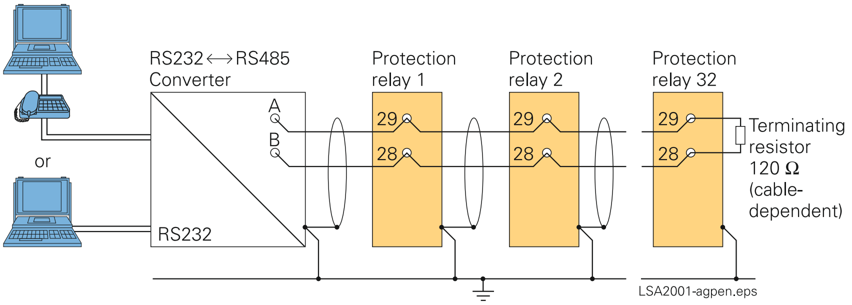


Fig. 5/26 Wiring communication
For convenient wiring of the RS485 bus, use bus cable system 7XV5103 (see part 15 of this catalog).

Serial data transmission

A PC can be connected to ease setup of the relay using the Windows-based program DIGSI which runs under MS-Windows. It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 operational indications. The SIPROTEC 7SJ600 transmits a subset of data via IEC 60870-5-103 protocol:

- General fault detection
- General trip
- Phase current I_{L2}
- User-defined message
- Breaker control
- Oscillographic fault recording

Connection diagrams

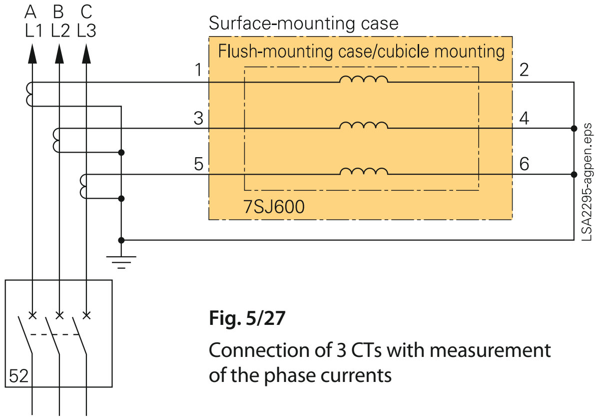


Fig. 5/27

Connection of 3 CTs with measurement of the phase currents

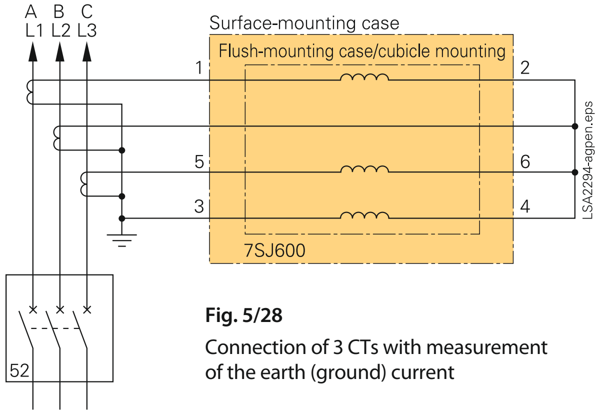


Fig. 5/28

Connection of 3 CTs with measurement of the earth (ground) current

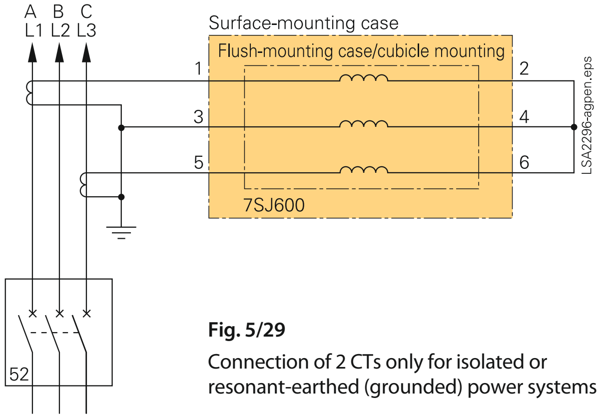


Fig. 5/29

Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

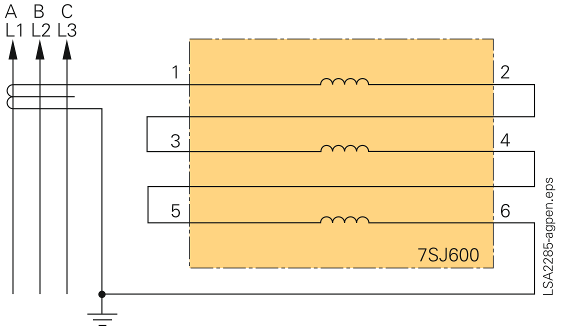


Fig. 5/30

Sensitive earth-fault protection
(3 -times increased sensitivity)

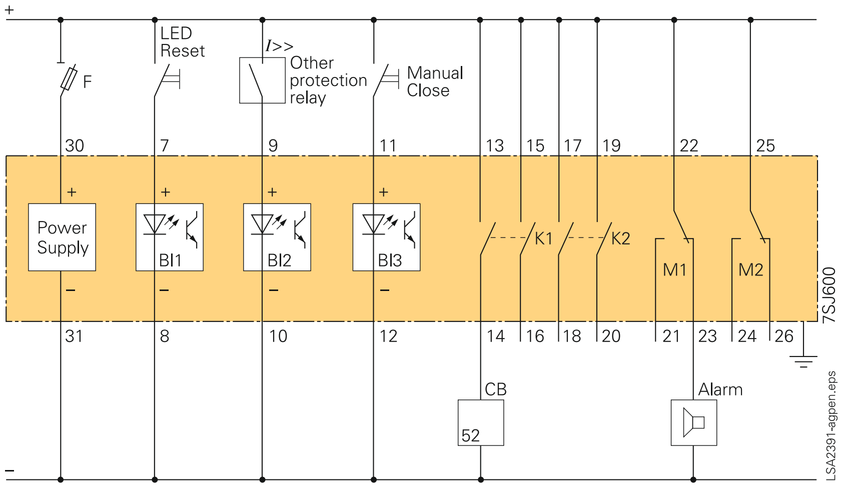


Fig. 5/31 Example of typical wiring

Technical data

General unit data

CT circuits

Rated current I_N	1 or 5 A
Rated frequency f_N	50/60 Hz (selectable)
Overload capability current path	
Thermal (r.m.s.)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
Dynamic (pulse current)	250 x I_N one half cycle
Power consumption	
Current input at I_N = 1 A	< 0.1 VA
at I_N = 5 A	< 0.2 VA

Power supply via integrated DC/DC converter

Rated auxiliary voltage V_{aux} / permissible variations	24, 48 V DC/± 20 % 60, 110/125 V DC/± 20 % 220, 250 V DC/± 20 % 115 V AC/–20 % +15 % 230 V AC/–20 % +15 %
Superimposed AC voltage, peak-to-peak	
at rated voltage	≤ 12 %
at limits of admissible voltage	≤ 6 %
Power consumption	
Quiescent	Approx. 2 W
Energized	Approx. 4 W
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms at V_{aux} ≥ 110 V DC ≥ 20 ms at V_{aux} ≥ 24 V DC

Binary inputs

Number	3 (marshallable)
Operating voltage	24 to 250 V DC
Current consumption, independent of operating voltage	Approx. 2.5 mA
Pickup threshold, reconnectable by solder bridges	
Rated aux. voltage	
24/48/60 V DC V_{pickup}	≥ 17 V DC
$V_{\text{drop-out}}$	< 8 V DC
110/125/220/250 V DC	
V_{pickup}	≥ 74 V DC
$V_{\text{drop-out}}$	< 45 V DC

Signal contacts

Signal/alarm relays	2 (marshallable)
Contacts per relay	1 CO
Switching capacity	
Make	1000 W / VA
Break	30 W / VA
Switching voltage	250 V
Permissible current	5 A

Heavy-duty (command) contacts

Trip relays, number	2 (marshallable)
Contacts per relay	2 NO
Switching capacity	
Make	1000 W / VA
Break	30 W / VA
Switching voltage	250 V
Permissible current	
Continuous	5 A
For 0.5 s	30 A

Design

Housing 7XP20	Refer to part 15 for dimension drawings
Weight	
Flush mounting /cubicle mounting	Approx. 4 kg
Surface mounting	Approx. 4.5 kg
Degree of protection acc. to EN 60529	
Housing	IP51
Terminals	IP21

Serial interface

Interface, serial; isolated

Standard	RS485
Test voltage	2.8 kV DC for 1 min
Connection	Data cable at housing terminals, two data wires, one frame reference, for connection of a personal computer or similar; core pairs with individual and common screening, screen must be earthed (grounded), communication possible via modem
Transmission speed	As delivered 9600 baud min. 1200 baud, max. 19200 baud

Electrical tests

Specifications

Standards	IEC 60255-5; ANSI/IEEE C37.90.0

Insulation test

Standards	IEC 60255-5, ANSI/IEEE C37.90.0
High-voltage test (routine test)	
Except DC voltage supply input and RS485	2 kV (r.m.s.), 50 Hz
Only DC voltage supply input and RS485	2.8 kV DC
High-voltage test (type test)	
Between open contacts of trip relays	1.5 kV (r.m.s.), 50 Hz
Between open contacts of alarm relays	1 kV (r.m.s.), 50 Hz
Impulse voltage test (type test) all circuits, class III	5 kV (peak), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s

Technical data

EMC tests for interference immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic standard), DIN VDE 0435 Part 303
High-frequency test IEC 60255-22-1, class III	2.5 kV (peak), 1 MHz, $\tau = 15$ µs, 400 surges/s, duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge, 8 kV air discharge, both polarities, 150 pF, R_i=330 Ω
Irradiation with radio-frequency field	
Non-modulated, IEC 60255-22-3 (report) class III	10 V/m, 27 to 500 MHz
Amplitude modulated, IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, 80 % AM, 1 kHz
Pulse modulated, IEC 61000-4-3, class III	10 V/m, 900 MHz, repetition frequency, 200 Hz, duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV, 5/50 ns, 5 kHz, burst length 15 ms, repetition rate 300 ms, both polarities, $R_i = 50$ Ω, duration 1 min
Conducted disturbances induced by radio-frequency fields, amplitude modulated IEC 601000-4-6, class III	10 V, 150 kHz to 80 MHz, 80 % AM, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous, 50 Hz 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak), 1 MHz to 1.5 MHz, decaying oscillation, 50 shots per s, duration 2 s, $R_i = 150$ Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (commom mode)	4 to 5 kV, 10/150 ns, 50 surges per s, both polarities, duration 2 s, $R_i = 80$ Ω
Radiated electromagnetic interference, ANSI/IEEE C37.90.2	10 to 20 V/m, 25 to 1000 MHz, amplitude and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity), 100 kHz, 1 MHz, 10 MHz and 50 MHz, decaying oscillation, $R_i = 50$ Ω

EMC tests for interference emission; type tests

Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage CISPR 22, EN 55022, DIN VDE 0878 Part 22, limit value class B	150 kHz to 30 MHz
Interference field strength CISPR 11, EN 55011, DIN VDE 0875 Part 11, limit value class A	30 to 1000 MHz

Mechanical stress tests

Vibration, shock and seismic vibration

<u>During operation</u>	
Standards	Acc. to IEC 60255-2-1 and IEC 60068-2
Vibration IEC 60255-21-1, class1 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude, 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1	Half-sine, acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class 1, IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sine, acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sine, acceleration 10 g duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests

Temperatures	
Recommended temperature during operation	–5 °C to +55 °C / +23 °F to +131 °F > 55 °C decreased display contrast
Permissible temperature	
during operation	–20 °C to +70 °C / –4 °F to +158 °F
during storage	–25 °C to +55 °C / –13 °F to +131 °F
during transport (Storage and transport with standard works packaging)	–25 °C to +70 °C / –13 °F to +158 °F
Humidity	Mean value per year ≤ 75 % relative humidity, on 30 days per year 95 % relative humidity, condensation not permissible

Technical data

Functions

Definite-time overcurrent protection (ANSI 50, 50N)

Setting range/steps	
Overcurrent pickup phase $I>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
earth $I_E>$	= 0.05 to 25 (steps 0.01), or ∞
phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
earth $I_E>>$	= 0.05 to 25 (steps 0.01), or ∞
phase $I>>>$	I/I_N = 0.3 to 12.5 (steps 0.1), or ∞
Delay times T for $I>$, $I_E>$, $I>>$ and $I_E>>$	0 s to 60 s (steps 0.01 s)
The set times are pure delay times	
Pickup times $I>$, $I>>$, $I_E>$, $I_E>>$	
At 2 x setting value, without meas. repetition	Approx. 35 ms
At 2 x setting value, with meas. repetition	Approx. 50 ms
Pickup times for $I>>>$ at 2 x setting value	Approx. 20 ms
Reset times $I>$, $I>>$, $I_E>$, $I_E>$	Approx. 35 ms
$I>>>$	Approx. 65 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 25 ms
Tolerances	
Pickup values $I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$	5 % of setting value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $0\ °C \leq \Theta_{amb} \leq 40\ °C$	≤ 0.5 %/10 K
Frequency, range: $0.98 \leq f/f_N \leq 1.02$	≤ 1.5 %
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 2.5 %
Harmonics	
Up to 10 % of 3rd harmonic	≤ 1 %
Up to 10 % of 5th harmonic	≤ 1 %

Inverse-time overcurrent protection (ANSI 51/51N)

Setting range/steps	
Overcurrent pickup phase I_p	I/I_N = 0.1 to 4 (steps 0.1)
earth I_{Ep}	= 0.05 to 4 (steps 0.01)
Time multiplier for I_p, I_{Ep} T_p	(IEC charac.) 0.05 to 3.2 s (steps 0.01 s) (ANSI charac.) 0.5 to 15 s (steps 0.1 s)
Overcurrent pickup phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
phase $I>>>$	= 0.3 to 12.5 (steps 0.1), or ∞
earth $I_E>>$	= 0.05 to 25 (steps 0.01), or ∞
Delay time T for $I>>$, $I_E>>$	0 s to 60 s (steps 0.01 s)
Tripping time characteristics acc. to IEC	
Pickup threshold	Approx. 1.1 x I_p
Drop-out threshold	Approx. 1.03 x I_p
Drop-out time	Approx. 35 ms
Tripping time characteristics acc. to ANSI / IEEE	
Pickup threshold	Approx. 1.06 x I_p
Drop-out threshold, alternatively: disk emulation	Approx. 1.03 x I_p
Tolerances	
Pickup values	5 %
Delay time for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_N \leq 24$	5 % of theoretical value ± 2 % current tolerance, at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ $+23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 % referred to theoretical time value

Negative-sequence overcurrent protection (ANSI 46)

Setting range/steps	
Tripping stage	8 % to 80 % of I_N
$I_2>$ in steps of 1 %	8 % to 80 % of I_N
$I_2>>$ in steps of 1 %	
Time delays $T(I_2>)$, $T(I_2>>)$ in steps of 0.01s	0.00 s to 60.00 s
Lower function limit	At least one phase current ≥ 0.1 x I_N

Pickup times	At f_N =	50 Hz	60 Hz
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx.	60 ms	75 ms
But with currents I/I_N>1.5 (overcurrent case) or negative-sequence current < (set value +0.1 x I_N)	Approx.	200 ms	310 ms
Reset times	At f_N =	50 Hz	60 Hz
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx.	35 ms	42 ms

Reset ratios	
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx. 0.95 to 0.01 x I_N
Tolerances	
Pickup values $I_2>$, $I_2>>$	
with current $I/I_N \leq 1.5$	± 1 % of I_N ± 5 % of set value
with current $I/I_N > 1.5$	± 5 % of I_N ± 5 % of set value
Stage delay times	± 1 % or 10 ms
Influence variables	
Auxiliary DC voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq +40\ °C$ $+23\ °F \leq \Theta_{amb} \leq +104\ °F$	≤ 0.5 %/10 K
Frequency,	
range: $0.98 \leq f/f_N \leq 1.02$	≤ 2 % of I_N
range: $0.95 \leq f/f_N \leq 1.05$	≤ 5 % of I_N

Auto-reclosure (option) (ANSI 79)

Number of possible shots	1 up to 9
Auto-reclose modes	3-pole
Dead times for 1st to 3rd shot	0.05 s to 1800 s (steps 0.01 s)
for 4th and any further shot	0.05 s to 1800 s (steps 0.01 s)
Reclaim time after successful AR	0.05 s to 320 s (steps 0.01 s)
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)
Duration of RECLOSE command	0.01s to 60 s (steps 0.01 s)
Control	
Number of devices	1
Evaluation of breaker control	None

Technical data

Thermal overload protection with memory (ANSI 49) (total memory according to IEC 60255-8)

Setting ranges	
Factor k acc. to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still k_τ	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip}	Reset below Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
Tolerances	
Referring to k · I_N	± 5 % (class 5 % acc. to IEC 60255-8)
Referring to trip time	± 5 % ± 2 s (class 5 % acc. to IEC 60255-8)
Influence variables referred to k · I_N	
Auxiliary DC voltage in the range of $0.8 \le V_{aux} / V_{auxN} \le 1.2$	≤ 1 %
Temperature, range: $-5\ °C \le \Theta_{amb} \le +40\ °C$ $+23\ °F \le \Theta_{amb} \le +104\ °F$	≤ 0.5 % / 10 K
Frequency, range: $0.95 \le f/f_N \le 1.05$	≤ 1 %
Without pickup value I_L / I_N	0.4 to 4 (steps 0.1)
Memory time multiplier T_L (= t_6 -time)	1 to 120 s (steps 0,1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold 1.1· I_L	± 5 %
Referring to trip time	± 5 % ± 2 s
Influence variables	
Auxiliary DC voltage in the range of $0.8 \le V_{aux} / V_{auxN} \le 1.2$	≤ 1 %
Temperature, range: $-5\ °C \le \Theta_{amb} \le +40\ °C$ $+23\ °F \le \Theta_{amb} \le +104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \le f/f_N \le 1.05$	≤ 1 %

Starting time supervision (motor protection)

Setting ranges	
Permissible starting current I_{Start}/I_N	0.4 to 20 (steps 0.1)
Permissible starting time t_{Start}	1 to 360 s (steps 0.1 s)
Tripping characteristic	$t = \left(\frac{I_{Start}}{I_{rms}}\right)^2 \cdot t$ for $I_{rms} > I_{Start}$
Reset ratio I_{rms} / I_{Start}	Approx. 0.94
Tolerances	
Pickup value	5 %
Delay time	5 % of setting value or 330 ms

Fault recording

Measured values	I_{L1}, I_{L2}, I_{L3}
Start signal	Trip, start release, binary input
Fault storage	Max. 8 fault records
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, incl. 35 power-fail safe selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 to 5.00 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (steps 0.01s)
Post-fault time T_{post}	0.05 to 0.50 s (steps 0.01 s)
Sampling rate	1 instantaneous value per ms at 50 Hz 1 instantaneous value per 0.83 ms at 60 Hz

Additional functions

Operational measured values

Operating currents	I_{L1}, I_{L2}, I_{L3}
Measuring range	0 % to 240 % I_N
Tolerance	3 % of rated value

Thermal overload values

Calculated temperature rise	Θ/Θ_{trip}
Measuring range	0 % to 300 %
Tolerance	5 % referred to Θ_{trip}

Fault event logging

Storage of indications of the last 8 faults

Time assignment

Resolution for operational indications	1 s
Resolution for fault event indications	1 ms
Max. time deviation	0.01 %

Trip circuit supervision

With one or two binary inputs

Circuit-breaker trip test

With live trip or trip/reclose cycle (version with auto-reclosure)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.
7SJ600 numerical overcurrent, motor and overload protection relay	*7SJ600□– □□A□0 – □D□□*
Binary input voltage 24 to 250 V DC with isolated RS485 port	
Rated current at 50/60 Hz	
1 A[1]	*1*
5 A[1]	*5*
Rated auxiliary voltage	
24, 48 V DC	*2*
60, 110, 125 V DC[2]	*4*
220, 250 V DC, 115 V AC[2]	*5*
230 V AC[3]	*6*
Unit design	
For panel surface mounting, terminals on the side	*B*
Terminal connection on top and bottom	*D*
For panel flush mounting/cubicle mounting	*E*
Languages	
English, German, Spanish, French, Russian	*0*
Auto-reclosure (option)	
Without	*0*
With	*1*
Control	
Without	*A*
With	*B*
U_L-Listing	
Without U_L-listing	*0*
With U_L-listing	*1*

Accessories

*Converter RS232 (V.24) - RS485**	
With communication cable for the 7SJ600 numerical overcurrent, motor and overload protection relay Length 1 m PC adapter	
With power supply unit 230 V AC	*7XV5700- 0□□00*[4]
With power supply unit 110 V AC	*7XV5700- 1□□00*[4]
Converter, full-duplex, fiber-optic cable RS485 with built-in power supply unit	
Auxiliary voltage 24 to 250 V DC and 110/230 V AC	*7XV5650- 0BA00*
Mounting rail for 19" rack	*C73165-A63-C200-1*
Manual for 7SJ600	
English	*C53000-G1176-C106-7*
Spanish	*C53000-G1178-C106-1*
French	*C53000-G1177-C106-3*
Sample order	
7SJ600, 1 A, 60 - 125 V, flush mounting, ARC	*7SJ6001-4EA00-1DA0*
Converter V.24 -RS485, 230 V AC	*7XV5700-0AA00*
Manual, English	*C53000-G1176-C106-7*

or visit www.siemens.com/siprotec

Mounting rail

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) Only when position 16 is not "*1*" (with U_L-listing).

4) Possible versions see part 13.

* RS485 bus system up to 115 kbaud
RS485 bus cable and adaptor 7XV5103-□AA□□;
see part 13.

Connection diagram

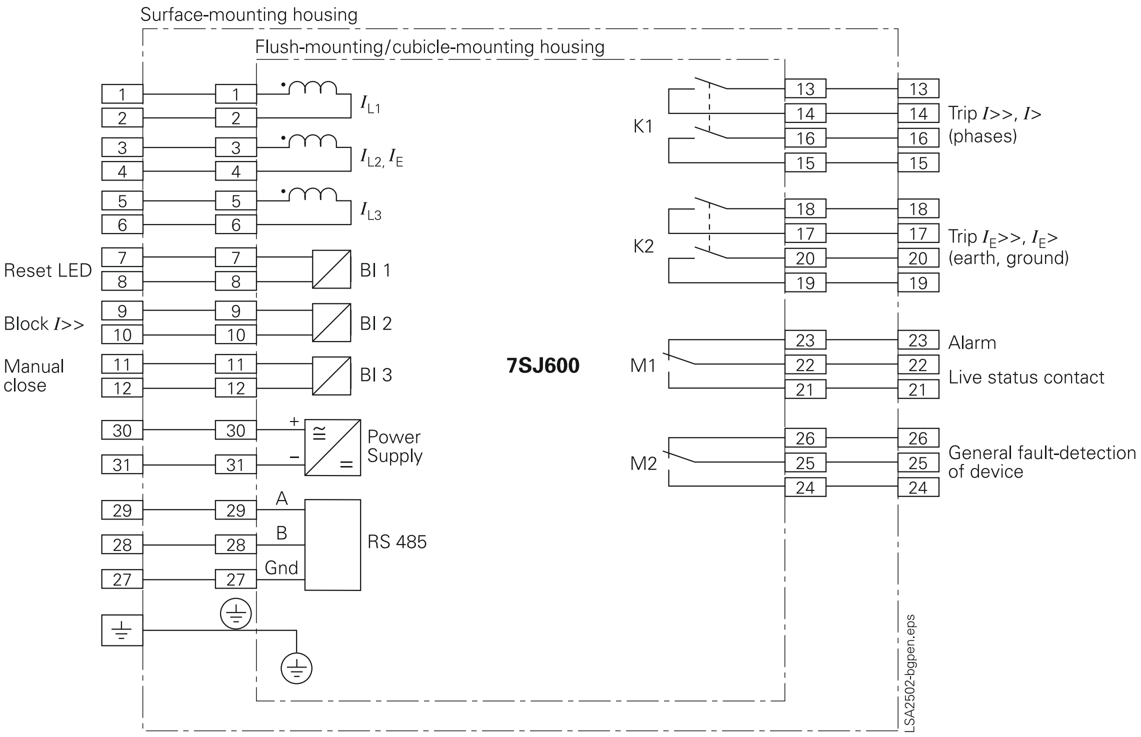


Fig. 5/32

Connection diagram according to IEC standard

SIPROTEC 7SJ602
Multifunction Overcurrent and Motor Protection Relay

Fig. 5/33 SIPROTEC 7SJ602 multifunction protection relay

Description

The SIPROTEC 7SJ602 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for line, transformer and generator differential protection. The SIPROTEC 7SJ602 provides definite-time and inverse-time overcurrent protection along with overload and unbalanced-load (negative-sequence) protection for a very comprehensive relay package.

For applications with earth-current detection two versions are available: One version with four current transformer inputs for non-directional earth (ground) fault detection and a second version with three current inputs (2 phase, 1 earth/ground) and one voltage input for directional earth (ground) fault detection.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Feeder protection

- Overcurrent-time protection
- Sensitive earth-fault detection
- Directional sensitive earth-fault detection
- Displacement voltage
- Disk emulation
- Overload protection
- Breaker failure protection
- Negative-sequence protection
- Cold load pickup
- Auto-reclosure
- Trip circuit supervision

Motor protection

- Starting time supervision
- Locked rotor
- Restart inhibit
- Undercurrent monitoring
- Temperature monitoring

Control functions

- Commands for control of a circuit-breaker
- Control via keyboard, DIGSI 4 or SCADA system

Measuring functions

- Operational measured values I, V
- Power measurement P, Q, S, W_p, W_q
- Slavepointer
- Mean values

Monitoring functions

- Fault event logging with time stamp (buffered)
- 8 oscillographic fault records
- Continuous self-monitoring

Communication interfaces

- System interface
  - IEC 60870-5-103 protocol
  - PROFIBUS-DP
  - MODBUS RTU/ASCII
- Front interface for DIGSI 4

Hardware

- 4 current transformers or
- 3 current + 1 voltage transformers
- 3 binary inputs
- 4 output relays
- 1 live status contact

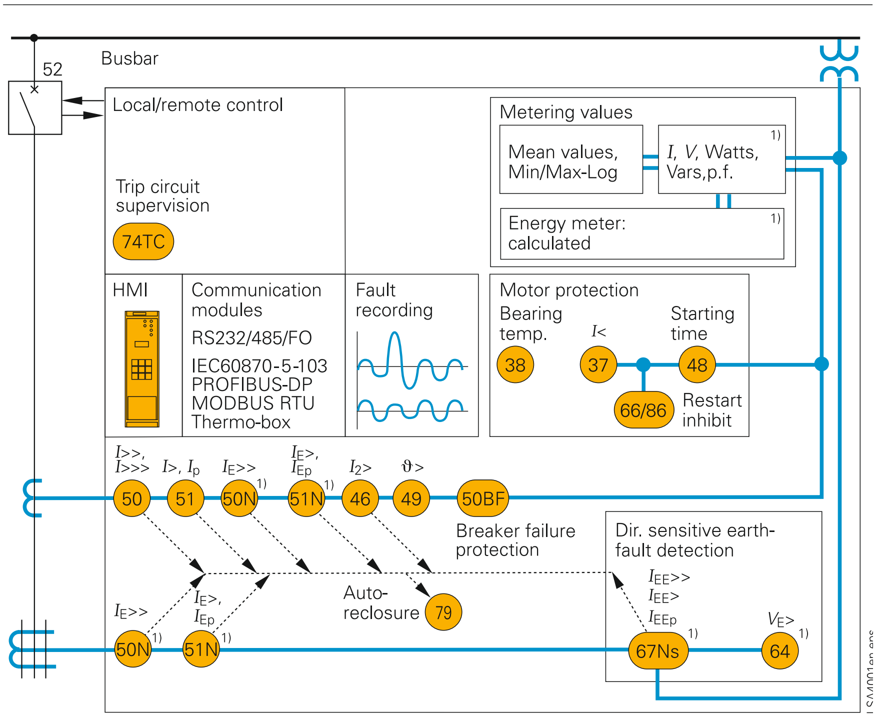
Application

Wide range of applications

The SIPROTEC 7SJ602 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ602 provides definite-time and inverse-time overcurrent protection along with overload and negative sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

The integrated control function allows simple control of a circuit-breaker or disconnector (electrically operated/motorized switch) via the integrated HMI, DIGSI or SCADA.



1) alternatively; see "Selection and ordering data" for details

Fig. 5/34 Function diagram

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
64	$V_E>$	Displacement voltage
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device, e.g. bearing temperature monitoring
74TC		Trip circuit supervision breaker control

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485, RS232, fiber-optic)
- Power supply.

The rated CT currents applied to the SIPROTEC 7SJ602 can be 1 A or 5 A. This is selectable via a jumper inside the relay.

Two different housings are available. The flush-mounting version has terminals accessible from the rear. The surface-mounting version has terminals accessible from the front. Retrofitting of a communication module, or replacement of an existing communication module with a new one are both possible.

Fig. 5/35
Rear view of flush-mounting housing

Fig. 5/36
View from below showing system interface (SCADA) with FO connection (for remote communications)

Protection functions

Definite-time characteristics

The definite-time overcurrent function is based on phase-selective evaluation of the three phase currents and earth current.

The definite-time overcurrent protection for the 3 phase currents has a low-set overcurrent element (I>), a high-set overcurrent element (I>>) and a high-set instantaneous element (I>>>). Intentional trip delays can be set from 0 to 60 seconds for all three overcurrent elements.

The definite-time overcurrent protection for the earth (ground) current has a low-set overcurrent element (I_E>) and a high-set overcurrent element (I_E>>). Intentional trip delays can be parameterized from 0 to 60 seconds.

Inverse-time characteristics

In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared.

This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

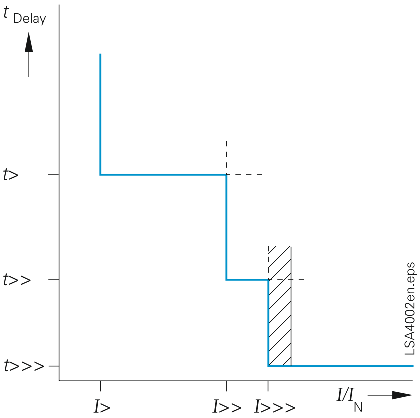


Fig. 5/37
Definite-time overcurrent characteristic

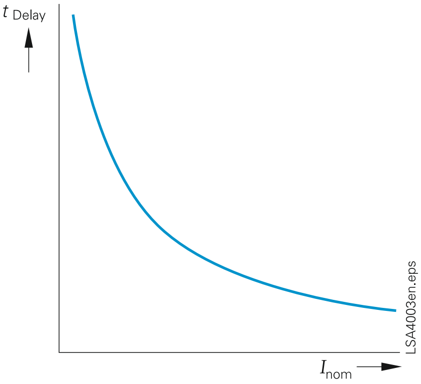


Fig. 5/38
Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	
I squared *T*	•	
RI/RD-type		

Protection functions

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns)

The direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees (cosine/sinus).

Two modes of earth-fault direction detection can be implemented: tripping or in “signalling only mode”.

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one inverse characteristic.
- Each element can be set in forward, reverse, or non-directional.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

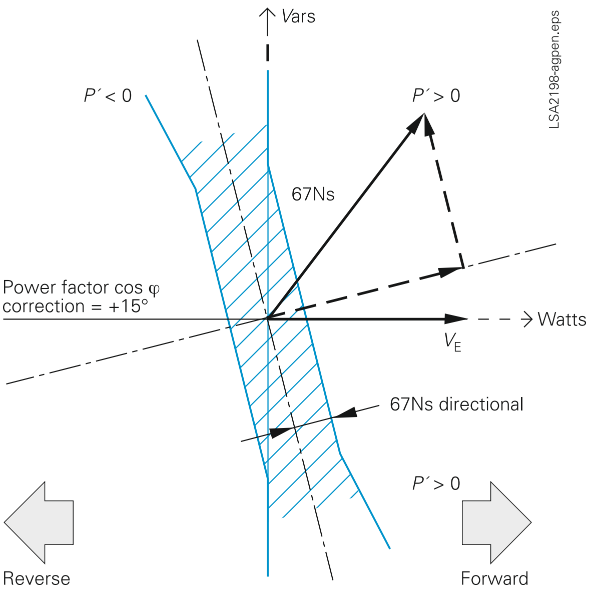


Fig. 5/39 Directional determination using cosine measurements

Thermal overload protection (ANSI 49)

The thermal overload protection function provides tripping or alarming based on a thermal model calculated from phase currents.

The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (also called thermo-box). If there is no thermo-box it is assumed that the ambient temperatures are constant.

Thermal overload protection without preload:

For thermal overload protection without consideration of the preload current, the following tripping characteristic applies only when

$I \geq 1.1 \cdot I_L$

For different thermal time constants T_L, the tripping time t is calculated in accordance with the following equation:

$$t = \frac{35}{\left(\frac{I}{I_L}\right)^2 - 1} \cdot T_L$$

I = Load current
I_L = Pickup current
T_L = Time multiplier

The reset threshold is above 1.03125 · I/I_N

Thermal overload protection with preload

The thermal overload protection with consideration of preload current constantly updates the thermal model calculation regardless of the magnitude of the phase currents. The tripping time t is calculated in accordance with the following tripping characteristic (complete memory in accordance with IEC 60255-8).

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

t = Tripping time after beginning of the thermal overload
τ = $35.5 \cdot T_L$
I_{pre} = Preload current
I = Load current
k = k factor (in accordance with IEC 60255-8)
ln = Natural logarithm
T_L = Time multiplier
I_N = Rated (nominal) current

Protection functions

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if after a trip command, current is still flowing in the faulted circuit. As an option it is possible to make use of the circuit-breaker position indication.

Negative-sequence protection (I_2>>, I_2>/ANSI 46 Unbalanced-load protection)

The negative-sequence protection (see Fig. 5/40) detects a phase failure or load unbalance due to network asymmetry. Interruptions, short-circuits or crossed connections to the current transformers are detected.

Furthermore, low level single-phase and two-phase short-circuits (such as faults beyond a transformer) as well as phase interruptions can be detected.

This function is especially useful for motors since negative-sequence currents cause impermissible overheating of the rotor.

In order to detect the unbalanced load, the ratio of negative phase-sequence current to rated current is evaluated.

I_2 = negative-sequence current
T_{12} = tripping time

Transformer protection

The high-set element permits current coordination where the overcurrent element functions as a backup for the lower-level protection relays, and the overload function protects the transformer from thermal overload. Low-current single-phase faults on the low voltage side that result in negative phase-sequence current on the high-voltage side can be detected with the negative-sequence protection.

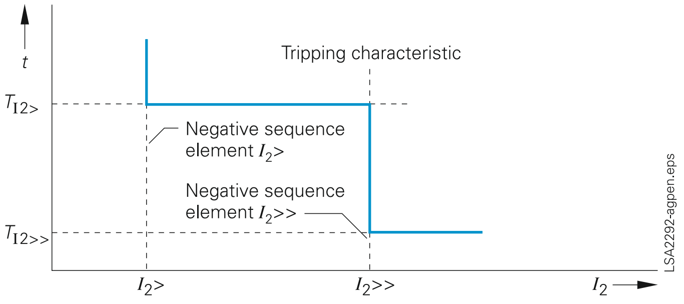


Fig. 5/40 Tripping characteristics of the negative-sequence protection function

Cold load pickup

By means of a binary input which can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable duration of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady state conditions.

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase autoreclosing of a feeder which has previously been disconnected by time-overcurrent protection.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for trip circuit monitoring.

Control

The relay permits circuit-breakers to be opened and closed without command feedback. The circuit-breaker/disconnector may be controlled by DIGSI, or by the integrated HMI, or by the LSA/SCADA equipment connected to the interface.

Protection functions

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker by-passing the internal control function, manual detection using a binary input is implemented.

Busbar protection (Reverse interlocking)

Binary inputs can be used to block any of the six current stages. Parameters are assigned to decide whether the input circuit is to operate in open-circuit or closed-circuit mode. In this case, reverse interlocking provides high-speed busbar protection in radial or ring power systems that are opened at one point. The reverse interlocking principle is used, for example, in medium-voltage power systems and in switchgear for power plants, where a high-voltage system transformer feeds a busbar section with several medium-voltage outgoing feeders.

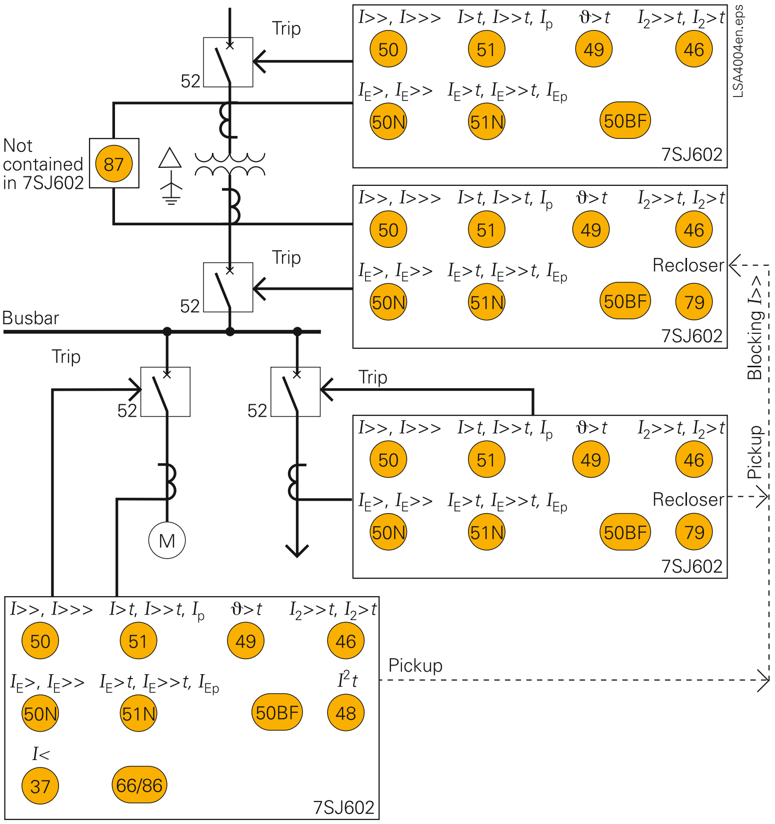


Fig. 5/41 Reserve interlocking

Motor protection

Starting time supervision (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups that might occur when excessive load torque occurs, excessive voltage drops occur within the motor or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

$$t_{\mathrm{TRIP}} = \left(\frac{I_{\mathrm{start}}}{I_{\mathrm{rms}}}\right)^2 \cdot t_{\mathrm{start\,max}}$$

for $I_{\mathrm{rms}} > I_{\mathrm{start}}$, reset ratio $\frac{I_{\mathrm{N}}}{I_{\mathrm{start}}}$ approx. 0.94

t_{TRIP} = tripping time

I_{start} = start-up current of the motor

$t_{\mathrm{start\,max}}$ = maximum permissible starting time

I_{rms} = actual current flowing

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current and the temperature characteristic is shown in a schematic diagram. The reclosing lockout only permits startup of the motor if the rotor has sufficient thermal reserves for a complete start-up.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which may occur due to a reduced motor load, is detected. This can cause shaft breakage, no-load operation of pumps or fan failure.

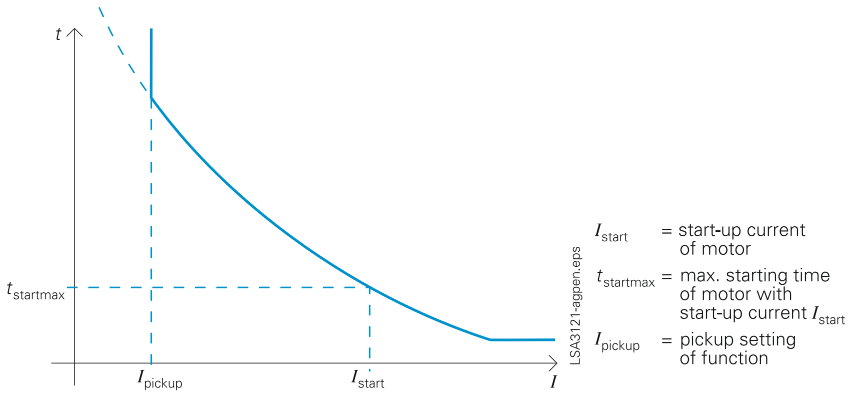


Fig. 5/42 Starting time supervision

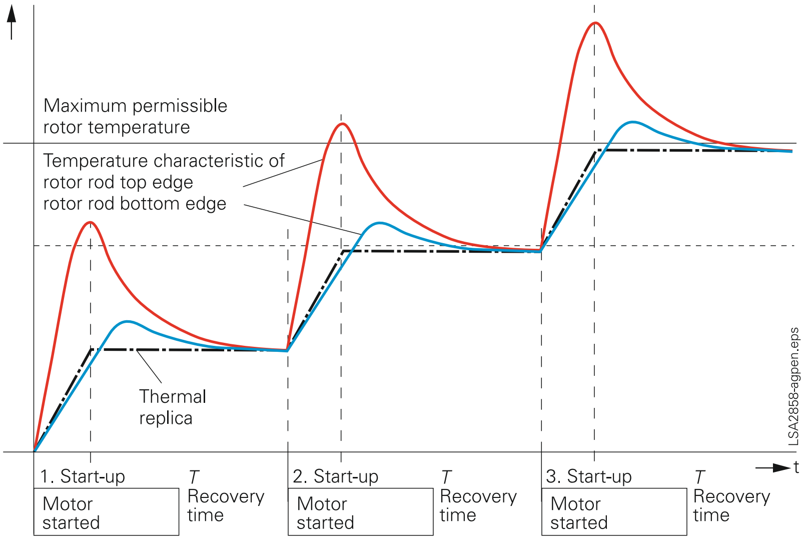


Fig. 5/43 Restart inhibit

Temperature monitoring (ANSI 38)

A temperature monitoring box with a total of 6 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via a temperature monitoring box (also called thermo-box or RTD-box) (see “Accessories”).

Additional functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_{E}, I_{EE} (67Ns)
- Voltages V_{L1}, V_{E} (67N$_{\mathrm{S}}$) if existing
- Power Watts, Vars, VA/P, Q, S
- Power factor (cos φ),
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current, voltage and power values

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability.

Local PC interface

The SIPROTEC 7SJ602 is fitted with an RS232 PC front port. A PC can be connected to ease set-up of the relay using the Windows-based program DIGSI which runs under MS-Windows. It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 events.

System interface on bottom of the unit

A communication module located on the bottom part of the unit incorporates optional equipment complements and readily permits retrofitting. It guarantees the ability to comply with the requirements of different communication interfaces.

This interface is used to carry out communication with a control or a protection system and supports a variety of communication protocols and interface designs, depending on the module connected.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area.
IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

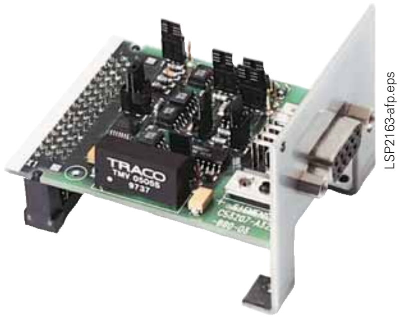


Fig. 5/44
RS232/RS485 electrical communication module

Fig. 5/45
PROFIBUS fiber-optic double ring communication module

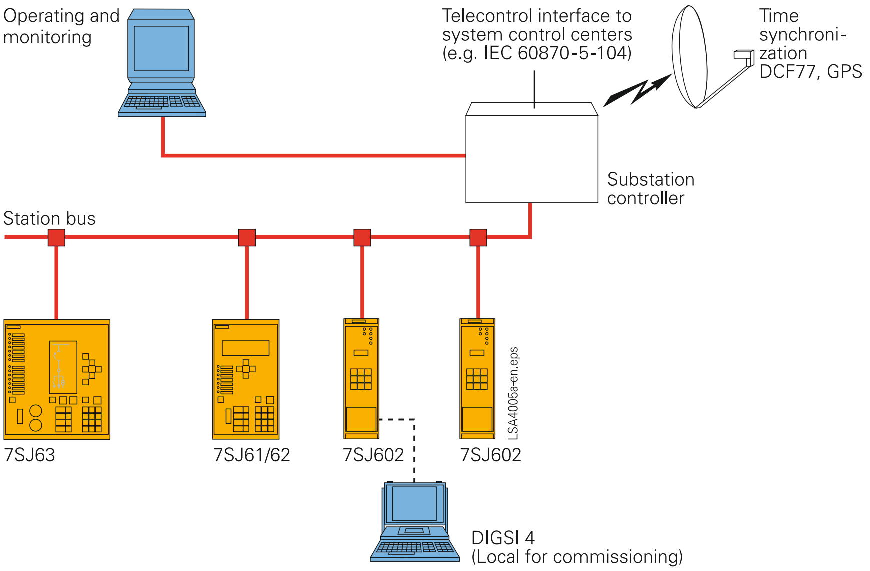


Fig. 5/46 System solution/communication

Typical connections

CT connections

Fig. 5/47	Standard • Phase current measured • Earth current measured (e. g. core balance CT)
Fig. 5/48	Standard connection • Connection of 3 CTs with residual connection for neutral fault
Fig. 5/49	• Isolated networks only

7SJ6021/7SJ6025

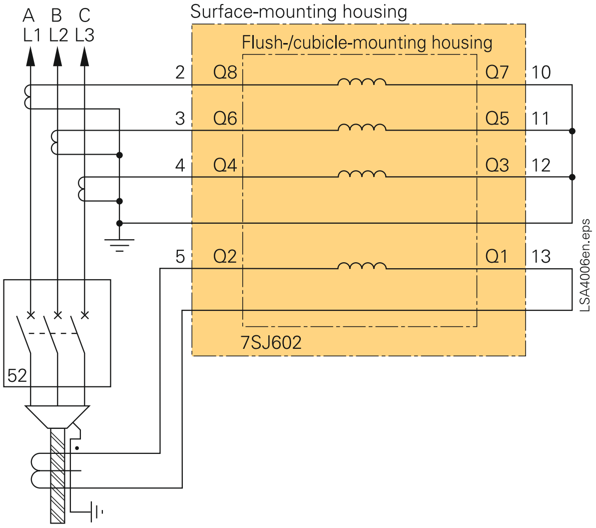


Fig. 5/47
Connection of 4 CTs with measurement of the earth (ground) current

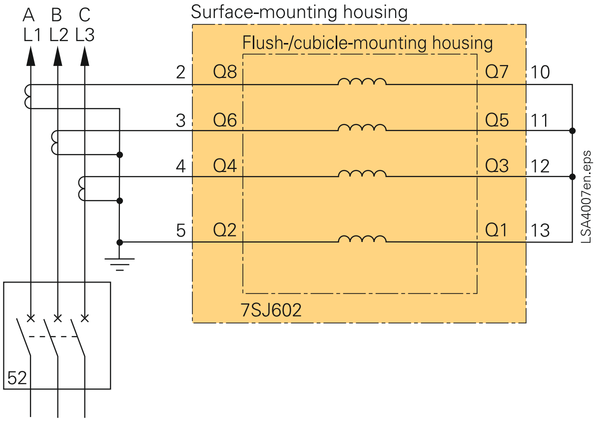


Fig. 5/48
Connection of 3 CTs with residual connection for neutral fault

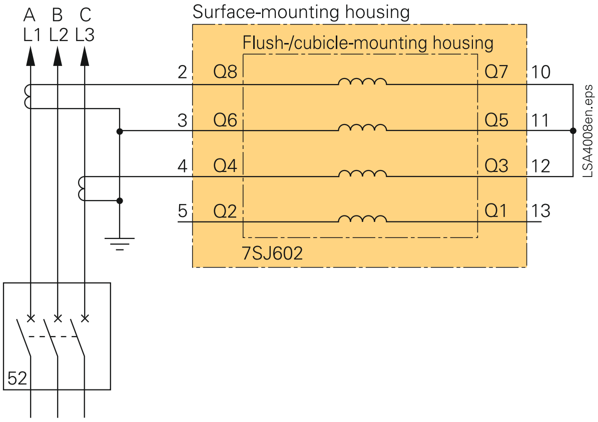


Fig. 5/49
Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

Typical connections

7SJ6022/7SJ6026

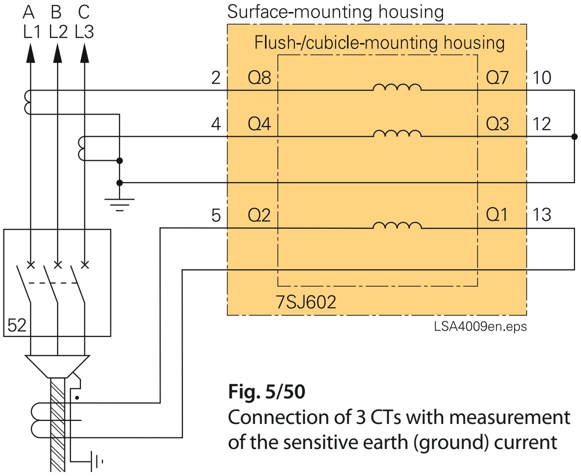


Fig. 5/50
Connection of 3 CTs with measurement of the sensitive earth (ground) current

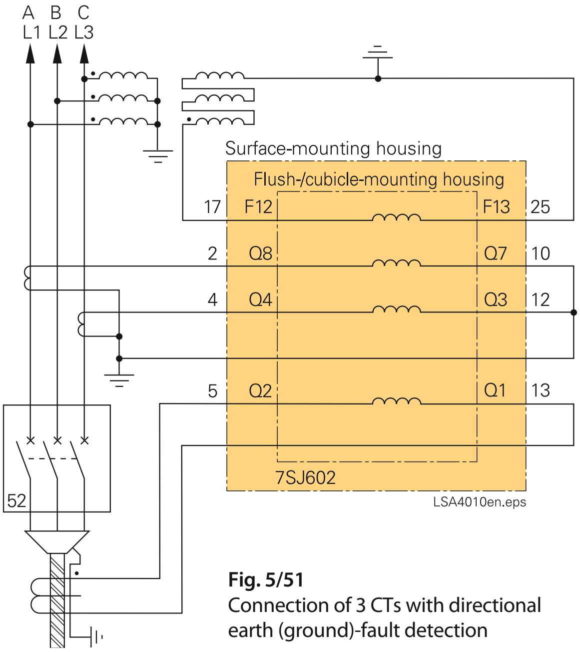


Fig. 5/51
Connection of 3 CTs with directional earth (ground)-fault detection

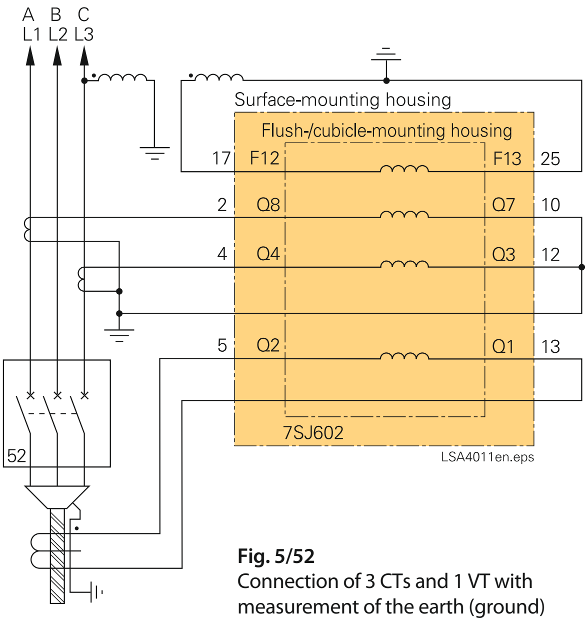


Fig. 5/52
Connection of 3 CTs and 1 VT with measurement of the earth (ground) current and one phase voltage

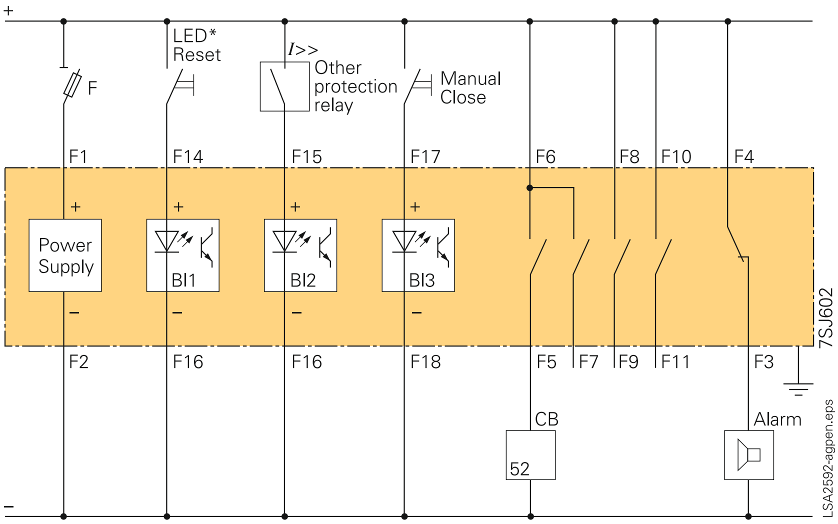


Fig. 5/53 Example of typical wiring

Technical data

General unit data

CT circuits

Rated current I_N	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A or < 8 A (settable)
Rated frequency f_N	50/60 Hz (selectable)
Power consumption	
Current input at $I_N = 1$ A	< 0.1 VA
at $I_N = 5$ A	< 0.3 VA
For sensitive earth-fault detection at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (r.m.s)	100 x I_N for 1 s 30 x I_N for 10 s 4 x I_N continuous
Dynamic (pulse current)	250 x I_N one half cycle
Overload capability if equipped with sensitive earth-fault current transformer	
Thermal (r.m.s.)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)

Voltage transformer

Rated voltage V_N	100 to 125 V
Power consumption at V_N = 100 V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage)	
Thermal (r.m.s.)	230 V continuous

Power supply

Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{aux} / permissible variations	24/48 V DC/± 20 % 60/110 V DC/± 20 % 110/125/220/250 V DC/± 20 % 115 V AC/- 20 %, + 15 % 230 V AC/- 20 %, + 15 %
Superimposed AC voltage, peak-to-peak	
At rated voltage	≤ 12 %
At limits of admissible voltage	≤ 6 %
Power consumption	Approx. 3 to 6 W, depending on operational status and selected auxiliary voltage
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms at V_{aux} ≥ 110 V AC/DC ≥ 20 ms at V_{aux} ≥ 24 V DC

Binary outputs

Trip relays	4 (configurable)
Contacts per relay	1 NO/form A (Two contacts changeable to NC/form B, via jumpers)
Switching capacity	
Make	1000 W/VA
Break	30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current	
Continuous	5 A
For 0.5 s	30 A
Permissible total current	
For common potential:	
Continuous	5 A
For 0.5 s	30 A
Alarm relays	1
Contacts per relay	1 NO/NC (form A/B)
Switching capacity	
Make	1000 W/VA
Break	30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current	5 A continuous

Binary inputs

Number	3 (configurable)
Operating voltage	24 to 250 V DC
Current consumption, independent of operating voltage	Approx. 1.8 mA
Pickup threshold, selectable via bridges	
Rated aux. voltage	
24/48/60/110 V DC V_{pickup}	≥ 19 V DC
110/125/220/250 V DC V_{pickup}	≥ 88 V DC
Permissible maximum voltage	300 V DC

Connection *(with screws)*

Current terminals	
Connection ring cable lugs	W_{max} = 11 mm, d_1 = 5 mm
Wire size	2.0 - 5.3 mm^2 (AWG 14-10)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	2.0 - 5.3 mm^2 (AWG 14-10)
Voltage terminals	
Connection ring cable lugs	W_{max} = 10 mm, d_1 = 4 mm
Wire size	0.5 - 3.3 mm^2 (AWG 20-12)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	0.5 - 3.3 mm^2 (AWG 20-12)

Unit design

Housing 7XP20	For dimensions please refer to dimension drawings, part 15
Degree of protection acc. to EN 60529	
For the device	
in surface-mounting housing	IP 51
in flush-mounting housing	
front	IP 51
rear	IP 20
For personal safety	IP 2x with closed protection cover
Weight	
Flush mounting/ cubicle mounting	Approx. 4 kg
Surface mounting	Approx. 4.5 kg

Serial interfaces

Operating interface

Connection	At front side, non-isolated, RS232, 9-pin subminiature connector
Operation	With DIGSI 4.3 or higher
Transmission speed	As delivered 19200 baud, parity: 8E1 Min. 1200 baud Max. 19200 baud
Distance	15 m

Technical data

System interface *(bottom of unit)*

IEC 60870-5-103 protocol	
Connection	Isolated interface for data transmission
Transmission rate	Min. 1200 baud, max. 19200 baud As delivered 9600 baud
RS232/RS485 acc. to ordered version	
Connection	9-pin subminiature connector on the bottom part of the housing
Test voltage	500 V AC
RS232 maximum distance	15 m
RS485 maximum distance	1000 m
Fiber-optic	
Connector type	ST connector on the bottom part of the housing
Optical wavelength	λ = 820 nm
Laser class 1 acc. to EN 60825-1/-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Bridgeable distance	Max. 1.5 km
No character position	Selectable, setting as supplied „light off"
PROFIBUS-DP	
Isolated interface for data transfer to a control center	
Transmission rate	Up to 1.5 Mbaud
Transmission reliability	Hamming distance d = 4
RS485	
Connection	9-pin subminiature connector
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
Optical wavelength	λ = 820 nm
Laser class 1 acc. to EN 60825-1-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
Idle state of interface	Settable, setting as supplied "light off"

System interface *(bottom of unit), cont'd*

MODBUS RTU / ASCII	
Isolated interface for data transfer to a control center	
Transmission rate	Up to 19200 baud
Transmission reliability	Hamming distance d = 4
RS485	
Connection	9-pin subminiature connector
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
Optical wavelength	820 nm
Laser class 1 acc. to EN 60825-1-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
Idle state of interface	"Light off"

Electrical tests

Specifications	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Insulation tests	
High-voltage tests (routine test) all circuits except for auxiliary voltage, binary inputs and communication interfaces	2.5 kV (r.m.s. value), 50 Hz
High-voltage tests (routine test) Auxiliary voltage and binary inputs	3.5 kV DC
High-voltage tests (routine test) only isolated communication interfaces	500 V (r.m.s. value); 50 Hz
Impulse voltage tests (type test) all circuits, except communication interfaces	5 kV (peak value), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for interference immunity; *type tests*	
Standards	IEC 60255-6; IEC 60255-22, (product standard) EN 50082-2 (generic standard) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz, τ = 15 µs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge, 15 kV air gap discharge, both polarities, 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report), class III	10 V/m, 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, AM 80 %; 1 kHz duration > 10 s
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m, 900 MHz, repetition frequency 200 Hz duty cycle 50 % PM

Technical data

EMC tests for interference immunity; type tests, (cont'd)

Fast transients interference/bursts
IEC 60255-22-4 and
IEC 61000-4-4, class IV
	4 kV; 5/50 ns; 5 kHz;
	burst length = 15 ms;
	repetition rate 300 ms;
	both polarities; R_i = 50 Ω;
	test duration 1 min

Surge voltage IEC 61000-4-5, class III Auxiliary voltage	Pulse: 1.2/50 µs From circuit to circuit (common mode): 2 kV, 12 Ω, 9 µF; Across contacts (diff. mode): 1 kV, 2 Ω, 18 µF
Measuring inputs, binary inputs/outputs	From circuit to circuit (common mode): 2 kV, 42 Ω, 0.5 µF; Across contacts (diff. mode): 1 kV, 42 Ω, 0.5 µF
Conducted RF amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous 300 A/m for 3 s, 50 Hz 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s R_i = 150 to 200 Ω;
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV, 10/150 ns, 50 surges per s, both polarities; duration 2 s, R_i = 80 Ω;
Radiated electromagnetic interference ANSI/IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694/ IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω;

EMC tests interference emission; type tests

Standard	EN 50081-* (generic specification)
Conducted interferences, only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz limit class B
Radio interference field strength IEC/CISPR 22	30 to 1000 MHz limit class B
Harmonic currents on incoming lines of system at 230 V AC IEC 61000-3-2	Unit belongs to class D (applies only to units with > 50 VA power consumption)
Voltage fluctuation and flicker range on incoming lines of system at 230 V AC IEC 61000-3-3	Limit values are adhered to

Mechanical stress tests

Vibration, shock and seismic vibration

During operation	
Standards	Acc. to IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude; 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine, acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transportation	
Standards	Acc. to IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine, acceleration 15 g, duration 11 ms; 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine, acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests

Temperatures

Recommended temperature During operation	–5 °C to +55 °C /23 °F to 131 °F, (> 55 °C decreased display contrast)
Limit temperature	
During operation	–20 °C to +70 °C /–4 °F to 158 °F
During storage	–25 °C to +55 °C /–13 °F to 131 °F
During transport (Storage and transport with standard works packaging)	–25 °C to +70 °C /–13 °F to 158 °F

Humidity

Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average: ≤ 75 % relative humidity, on 56 days per year 95 % relative humidity, condensation not permissible!

Technical data

Functions

Definite-time overcurrent protection *(ANSI 50, 50N)*

Setting ranges/steps	
Low-set overcurrent element	
Phase $I>$	$I/I_N = 0.1$ to 25 (steps 0.1); or ∞
Earth $I_E>$	$I/I_N = 0.05$ to 25 (steps 0.01); or ∞
High-set overcurrent element	
Phase $I>>$	$I/I_N = 0.1$ to 25 (steps 0.1); or ∞
Earth $I_E>>$	$I/I_N = 0.05$ to 25 (steps 0.01); or ∞
Instantaneous tripping	
Phase $I>>>$	$I/I_N = 0.3$ to 12.5 (steps 0.1); or ∞
Delay times T for $I>$, $I_E>$, $I>>$, $I_E>>$ and $I>>>$	0 to 60 s (steps 0.01 s)
The set times are pure delay times	
Pickup times $I>$, $I>>$, $I_E>$, $I_E>>$	
At 2 x setting value, without meas. repetition	Approx. 25 ms
At 2 x setting value, with meas. repetition	Approx. 35 ms
Pickup times for $I>>>$ at 2 x setting value	Approx. 15 ms
Reset times $I>$, $I>>$, $I_E>$, $I_E>>$	Approx. 40 ms
Reset time $I>>>$	Approx. 50 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 55 ms
Tolerances	
Pickup values $I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$	5 % of setting value or 5 % of rated value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range	
$0.98 \leq f/f_N \leq 1.02$	≤ 1.5 %
$0.95 \leq f/f_N \leq 1.05$	≤ 2.5 %
Harmonics	
Up to 10 % of 3rd harmonic	≤ 1%
Up to 10 % of 5th harmonic	≤ 1 %

Inverse-time overcurrent protection *(ANSI 51/51N)*

Setting ranges/steps	
Low-set overcurrent element	
Phase I_p	$I/I_N = 0.1$ to 4 (steps 0.1)
Earth I_{Ep}	$I/I_N = 0.05$ to 4 (steps 0.01)
Time multiplier for I_p, I_{Ep} (IEC charac.)	$T_p = 0.05$ to 3.2 s (steps 0.01 s)
Time multiplier for I_p, I_{Ep} (ANSI charac.)	$D = 0.5$ to 15 s (steps 0.1 s)
High-set overcurrent element	
Phase $I>>$	$I/I_N = 0.1$ to 25 (steps 0.1); or ∞
Earth $I_E>>$	$I/I_N = 0.05$ to 25 (steps 0.01); or ∞
Instantaneous tripping	
Phase $I>>>$	$I/I_N = 0.3$ to 12.5 (steps 0.1); or ∞
Delay time $T_I>>$	0 to 60 s (steps 0.01 s)
Tripping time characteristic acc. to IEC	See page 5/33
Pickup threshold	Approx. 1.1 x I_p
Reset threshold, alternatively disk emulation	Approx. 1.03 x I_p
Dropout time	
50 Hz	Approx. 50 ms
60 HZ	Approx. 60 ms
Tolerances	
Pickup values	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $-23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
Tripping characteristic acc. to ANSI/IEEE	See page 5/33
Pickup threshold	Approx. 1.06 x I_p
Dropout threshold, alternatively disk emulation	Approx. 1.03 x I_p
Tolerances	
Pickup threshold	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value

Technical data

(Sensitive) earth-fault protection (directional/non-directional)

Definite-time earth-fault protection *(ANSI 50Ns)*

Setting ranges/steps	
Low-set element $I_{EE}>$	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
High-set element $I_{EE}>>$	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
Delay times T for $I_{EE}>$ and $I_{EE}>>$	0 to 60 s (steps 0.01 s)
Pickup times $I_{EE}>$, $I_{EE}>>$	
At 2 x setting value without meas. repetition	Approx. 35 ms
At 2 x setting value with meas. repetition	Approx. 55 ms
Reset times $I_{EE}>$, $I_{EE}>>$	
At 50 Hz	Approx. 65 ms
At 60 Hz	Approx. 95 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 55 ms
Tolerances	
Pickup values $I_{EE}>$, $I_{EE}>>$	5 % of setting value or 5 % of rated value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, ranges: $0.98 \leq f/f_N \leq 1.02$ $0.95 \leq f/f_N \leq 1.05$	 ≤ 1.5 % ≤ 2.5 %
Harmonics Up to 10 % of 3^{rd} harmonic Up to 10 % of 5^{rd} harmonic	 ≤ 1% ≤ 1 %

Inverse-time earth-fault protection *(ANSI 51Ns)*

Setting ranges/steps	
Low-set element I_{EEp}	I/I_{EEN} = 0.003 to 1.4 (steps 0.001)
Time multiplier for I_{EEp} (IEC characteristic)	T_p = 0.05 to 3.2 s (steps 0.01 s)
Time multiplier for I_{EEp} (ANSI characteristic)	D = 0.5 to 15 s (steps 0.1 s)
High-set element $I_{EE}>>$	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
Delay time T for $I_{EE}>>$	0 to 60 s (steps 0.01 s)
<u>Tripping time characteristic acc. to IEC</u>	See page 5/33
Pickup threshold	Approx. 1.1 x I_{EEp}
Reset threshold alternatively disk emulation	Approx. 1.03 x I_{EEp}
Dropout time 50 Hz 60 Hz	 Approx. 50 ms Approx. 60 ms
Tolerances	
Pickup values	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_{EEp} \leq 20$ and $0.5 \leq I/I_{EEN} \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %

Inverse-time earth-fault protection *(ANSI 51Ns), cont'd*

Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
<u>Tripping characteristic acc. to ANSI/IEEE</u>	See page 5/33
Pickup threshold	Approx. 1.06 x I_{EEp}
Dropout threshold, alternatively disk emulation	Approx. 1.03 x I_{EEp}
Tolerances	
Pickup threshold	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_{EEp} \leq 20$ and $0.5 \leq I/I_{EEN} \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value

Direction detection *(ANSI 67Ns)*

Direction measurement	I_E, V_E (measured)
Measuring principle	Active/reactive measurement
Measuring enable	
For sensitive input	I/I_{EEN} = 0.003 to 1.2 (in steps of 0.001 I/I_{EEN})
Reset ratio	Approx. 0.8
Measuring method	cos φ and sin φ
Direction vector	-45 ° to +45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ Delay}$	1 to 60 s (steps 1 s)
Angle correction for cable converter (for resonant-earthed system)	In 2 operating points F1 and F2
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current values I_1, I_2	
For sensitive input	I/I_{EEN} = 0.003 to 1.6 (in steps of 0.001 I/I_{EEN})
Measuring tolerance acc. to DIN 57435	2 % of the setting value or 1 mA
Angle tolerance	3 °

Displacement voltage (ANSI 64)

Displacement voltage, measured	$V_E>/V_N$ = 0.02 to 1.3 (steps 0.001)
Measuring time	Approx. 60 ms
Pickup delay time	0.04 to 320 s or ∞ (steps 0.01 s)
Time delay	0.1 to 40000 s or ∞ (steps 0.01 s)
Dropout ratio	0.95 or (pickup value -0.6 V)
Measuring tolerance	
V_E (measured)	3 % of setting value, or 0.3 V
Operating time tolerances	1 % of setting value, or 10 ms
The set times are pure delay times	

Technical data

Thermal overload protection with memory (ANSI 49) with preload

Setting ranges	
Factor k according to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal warning stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still $k\tau$	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip}	Reset below 0.99 Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
Tolerances	
Referring to $k \cdot I_N$	± 5 % (class 5 % acc. to IEC 60255-8)
Referring to trip time	± 5 % ± 2 s (class 5 % acc. to IEC 60255-8)
Influencing variables	
Auxiliary DC voltage, range $0.8 \le V_{aux}/V_{auxN} \le 1.2$	≤ 1 %
Temperature, range $-5\ °C \le \Theta_{amb} \le +40\ °C$ / $23\ °F \le \Theta_{amb} \le 104\ °F$	≤ 0.5 %/10 K
Frequency, range $0.95 \le f/f_N \le 1.05$	≤ 1 %

Thermal overload protection without memory (ANSI 49) without preload

Setting ranges	
Pickup value	I_L/I_N = 0.4 to 4 (steps 0.1)
Time multiplier t_L (= t_6 -time)	1 to 120 s (steps 0.1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold 1.1 I_L	± 5 % of setting value or 5 % of rated value
Referring to trip time	± 5 % ± 2 s
Influencing variables	
Auxiliary DC voltage, range $0.8 \le V_{aux}/V_{auxN} \le 1.2$	≤ 1 %
Temperature, range $-5\ °C \le \Theta_{amb} \le +40\ °C$ / $23\ °F \le \Theta_{amb} \le 104\ °F$	≤ 0.5 %/10 K
Frequency, range $0.95 \le f/f_N \le 1.05$	≤ 1 %

Breaker failure protection

Setting ranges/steps	
Pickup of current element	CB $I>/I_N$ = 0.04 to 1.0 (steps 0.01)
Delay time	0.06 to 60 s or ∞ (steps 0.01 s)
Pickup times (with internal start) (via control) (with external start)	is contained in the delay time is contained in the delay time is contained in the delay time
Dropout time	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value
Delay time	1 % or 20 ms

Negative-sequence protection (ANSI 46)

Setting ranges/steps		
Tripping stages $I_2>$ and $I_2>>$	8 to 80 % to I_N (steps 1 %)	
Delay times $T(I_2>)$, $T(I_2>>)$	0 to 60 s (steps 0.01 s)	
Lower function limit	At least one phase current ≥ 0.1 x I_N	
Pickup times	at f_N = 50 Hz	at f_N = 60 Hz
Tripping stages $I_2>$ and $I_2>>$	Approx. 60 ms	Approx. 75 ms
But with currents $I/I_N > 1.5$ (overcurrent case) or negative-sequence current < (set value +0.1 x I_N)	Approx. 200 ms	Approx. 310 ms
Reset times		
Tripping stages $I_2>$ and $I_2>>$	Approx. 35 ms	Approx. 42 ms
Reset ratios		
Tripping stages $I_2>$ and $I_2>>$	Approx. 0.9 to 0.01 x I_N	
Tolerances		
Pickup values $I_2>$, $I_2>>$		
Current $I/I_N \le 1.5$ Current $I/I_N > 1.5$	± 1 % of I_N ± 5 % of set value ± 5 % of I_N ± 5 % of set value	
Delay times $T(I_2>)$ and $T(I_2>>)$	± 1 % but min. 10 ms	
Influencing variables		
Auxiliary DC voltage, range $0.8 \le V_{aux}/V_{auxN} \le 1.2$	≤ 1 %	
Temperature, range $-5\ °C \le \Theta_{amb}\ +40\ °C$ / $23\ °F \le \Theta_{amb} \le 104\ °F$	≤ 0.5 %/10 K	
Frequency, range $0.98 \le f/f_N \le 1.02$ $0.95 \le f/f_N \le 1.05$	≤ 1 % of I_N ≤ 5 % of I_N	

Auto-reclosure (ANSI 79)

Number of possible shots	1 to 9, configurable
Auto-reclosure modes	3-pole
Dead times for 1^{st} and any further shot	0.05 s to 1800 s (steps 0.01 s)
Blocking time after successful AR	0.05 s to 320 s (steps 0.01 s)
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)
Duration of reclose command	0.01 s to 60 s (steps 0.01 s)

Trip circuit supervision (ANSI 74TC)

Trip circuit supervision	With one or two binary inputs
Circuit-breaker trip test	Trip/reclosure cycle

Control

Number of devices	1
Evaluation of breaker contact	None

Technical data

Motor protection

Setting ranges/steps Rated motor current/ transformer rated current	I_{motor}/I_N = 0.2 to 1.2 (in steps of 0.1)
Start-up current of the motor	$I_{\text{start}}/I_{\text{motor}}$ = 0.4 to 20 (in steps of 0.1)
Permissible start-up time $t_{\text{start max}}$	1 to 360 s (in steps of 0.1 s)

Starting time supervision (ANSI 48)

Setting ranges/steps Pickup threshold	$I_{\text{pickup}}/I_{\text{motor}}$ = 0.4 to 20 (in steps of 0.1)
Tripping time characteristic	$t_{\text{TRIP}} = \left(\frac{I_{\text{start}}}{I_{\text{rms}}}\right)^2 \cdot t_{\text{start max}}$ For $I_{\text{rms}} > I_{\text{pickup}}$ I_{start} = Start-up current of the motor I_{rms} = Current actually flowing I_{pickup} = Pickup threshold, from which the motor start-up is detected $t_{\text{start max}}$ = Maximum permissible starting time t_{TRIP} = Tripping time
Reset ratio $I_{\text{rms}}/I_{\text{pickup}}$	Approx. 0.94
Tolerances Pickup values	5 % of setting value or 5 % rated value
Delay time	5 % or 330 ms

Restart inhibit for motors (ANSI 66/86)

Setting ranges/steps Rotor temperature compensation time T_{COMP}	0 to 60 min (in steps of 0.1min)
Minimum restart inhibit time T_{restart}	0.2 to 120 min (in steps of 0.1 min)
Maximum permissible number of warm starts n_w	1 to 4 (in steps of 1)
Difference between cold and warm start n_c - n_w	1 to 2 (in steps of 1)
Extension factor for cooling simulation of the rotor (running and stop)	1 to 10 (in steps of 0.1)
Restarting limit	$\Theta_{\text{restart}} = \Theta_{\text{rot max perm}} \cdot \frac{n_c - 1}{n_c}$ Θ_{restart} = Temperature limit below which restarting is possible $\Theta_{\text{rot max perm}}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{\text{rot}}/\Theta_{\text{rot trip}}$) n_c = Number of permissible start-ups from cold state

Undercurrent monitoring (ANSI 37)

Threshold	$I_L < /I_N$ = 0.1 to 4 (in steps of 0.01)
Delay time for I_L<	0 to 320 s (in steps of 0.1 s)

Thermo-box (instead of system interface) (ANSI 38)

Number of temperature sensors	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Installation drawing	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Limit values for indications For each measuring detector Warning temperature (stage 1)	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Alarm temperature (stage 2)	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Additional functions

Operational measured values

For currents	I_{L1}, I_{L2}, I_{L3}, I_E in A (Amps) primary or in % I_N
Range	10 to 240 % I_N
Tolerance	3 % of measured value
For voltages	$V_{L1\text{-}E}$, in kV primary or in %
Range	10 to 120 % of V_N
Tolerance	≤ 3 % of measured value
For sensitive earth-current detection	I_{EE}, I_{EEac}, I_{EEreac} (r.m.s., active and reactive current) in A (kA) primary, or in %
Range	0 to 160 % I_{EEN}
Tolerance	≤ 3 % of measured value

Power/work

S Apparent power	in kVA, MVA, GVA
S/VA (apparent power)	For V/V_N, I/I_N = 50 to 120 % typically < 6 %
P Active power,	in kW, MW, GW
P/Watts (active power)	For $\lvert\cos\varphi\rvert$ = 0.707 to 1, typically < 6 %, for V/V_N, I/I_N = 50 to 120 %
Q Reactive power,	In kvar, Mvar, Gvar
Q/Var (reactive power)	For $\lvert\sin\varphi\rvert$ = 0.707 to 1, typically < 6 %, for V/V_N, I/I_N = 50 to 120 %
cos φ, total and phase-selective	-1 to +1
Power factor cos φ	For $\lvert\cos\varphi\rvert$ = 0.707 to 1, typically < 5 %

Metering

+ W_p kWh	In kWh, MWh, GWh forward
- W_p kWh	In kWh reverse
+ W_q kvarh	In kvarh inductive
- W_q kvarh	In kvarh, Mvarh, Gvarh capacitive

Long-term mean values

Mean values		15, 30, 60 minutes mean values	
$I_{L1\,dmd}$	in A, kA	P_{dmd}	in kW
$I_{L2\,dmd}$	in A, kA	Q_{dmd}	in kvar
$I_{L3\,dmd}$	in A, kA	S_{dmd}	in kVA

Technical data

Min/max. LOG (memory)

Measured values	With date and time
Reset automatic	Time of day (settable in minutes) Time range (settable in days; 1 to 365, ∞)
Reset manual	Via binary input Via keyboard Via communication
Min./max. values of primary currents	I_{L1}; I_{L2}; I_{L3}
Min./max. values of primary voltages	$V_{L1\text{-}E}$
Min./max. values of power	S Apparent Power P Active power Q Reactive power Power factor cos φ
Min./max. values of primary currents mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}
Min./max. values of power mean value	P_{dmd}, Q_{dmd}, S_{dmd}

Fault event log

Storage	Storage of the last 8 faults
Time assignment	
Resolution for operational indications	1 s
Resolution for fault event indications	1 ms
Max. time deviation	0.01 %

Fault recording

Storage	Storage of max. 8 fault events
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 s to 5 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 s to 0.50 s (steps 0.01 s)
Post-fault time T_{post}	0.05 s to 0.50 s (steps 0.01 s)
Sampling rate at 50 Hz	1 instantaneous value per ms
Sampling rate at 60 Hz	1 instantaneous value per 0.83 ms
Backup battery	Lithium battery 3 V/1 Ah, type CR ½ AA Self-discharge time > 5 years “Battery fault” battery charge warning

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

c UL US
LISTED

Selection and ordering data

Description	Order No.	Order code
7SJ602 multifunction overcurrent and motor protection relay	*7SJ602☐ – ☐☐☐☐☐ – ☐☐☐☐ – ☐☐☐*	
	See next page	
Measuring inputs (4 x I), default settings		
$I_{\mathrm{N}} = 1$ A1), 15th position only with A	1	
$I_{\mathrm{N}} = 5$ A1), 15th position only with A	5	
Measuring inputs (1 x V, 3 x I), default settings		
$I_{\mathrm{ph}} = 1$ A1), I_{e} = sensitive ($I_{\mathrm{EE}} = 0.003$ to 1.5 A), 15th position only with B and J	2	
$I_{\mathrm{ph}} = 5$ A1), I_{e} = sensitive ($I_{\mathrm{EE}} = 0.015$ to 7.5 A), 15th position only with B and J	6	
Auxiliary voltage		
24/48 V DC, binary input threshold 19 V	2	
60/110 V DC2), binary input threshold 19 V3)	4	
110/125/220/250 V DC, 115/230 V AC2) binary input threshold 88 V3)	5	
Unit design		
Surface-mounting housing, terminals on top and bottom	B	
Flush-mounting housing, screw-type terminals	E	
Region-specific default and language settings		
Region World, 50/60 Hz, ANSI/IEC characteristic, languages: English, German, French, Spanish, Russian	B	
System port (on bottom of unit)		
No system port	0	
IEC 60870-5-103, electrical RS232	1	
IEC 60870-5-103, electrical RS485	2	
IEC 60870-5-103, optical 820 nm, ST connector	3	
Temperature monitoring box, electrical RS4854)	8	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector	9	L 0 E
Command (without process check back signal)		
Without command	0	
With command	1	
Measuring / fault recording		
Oscillographic fault recording	1	
Oscillographic fault recording, slave pointer, mean values, min./max. values	3	

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected in two stages by means of jumpers.

4) Temperature monitoring box 7XV5662-☐AD10, refer to part 13.

Selection and ordering data

Description	Order No.
7SJ602 multifunction overcurrent and motor protection relay	*7SJ602□-□□□□□-□□□□*

ANSI No.	Description	
	Basic version	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50N/51N	Ground/earth-fault protection TOC ground/earth $I_E>$, $I_E>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	*F A* 1)
	Basic version + directional ground/earth-fault detection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
67Ns	Directional sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
64	Displacement voltage	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	*F B* 2)
	Basic version + sensitive ground/earth-fault detection + measuring	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50Ns/51Ns	Sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
	Voltage and power measuring	*F J* 2)
	Basic version + motor protection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50N/51N	Ground/earth-fault protection TOC ground/earth $I_E>$, $I_E>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
48	Starting time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	*H A* 1)
	Basic version + directional ground/earth fault protection + motor protection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
67Ns	Directional sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
64	Displacement voltage	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
48	Starting time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	*H B* 2)
	Basic version + sensitive ground/earth-fault detection + measuring + motor protection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50Ns/51Ns	Sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
	Voltage and power measuring	
48	Starting time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	*H J* 2)
	Auto-reclosure (ARC)	
	Without auto-reclosure ARC	*0*
79	With auto-reclosure ARC	*1*

1) Only with position 7 = 1 or 5
2) Only with position 7 = 2 or 6

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition, device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows. Incl. templates, electronic manual with license for 10 PCs on CD-ROM. Authorization by serial number.	*7XS5410-0AA00*
Temperature monitoring box	
24 to 60 V AC/DC	*7XV5662-2AD10*
90 to 240 V AC/DC	*7XV5662-5AD10*
Connecting cable (contained in DIGSI 4, but can be ordered additionally) Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector)	*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit	
- length 5 m / 16.4 ft	*7XV5103-7AA05*
- length 25 m / 82 ft	*7XV5103-7AA25*
- length 50 m / 164 ft	*7XV5103-7AA50*
Manual for 7SJ602	
English please visit	*www.siemens.com/siprotec*
Spanish please visit	*www.siemens.com/siprotec*

Short-circuit links
for current terminals

Mounting rail

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole	*C73334-A1-C31-1*	1	Siemens
Voltage/current terminal 8-pole	*C73334-A1-C32-1*	1	Siemens
Short-circuit links			
For current terminals	*C73334-A1-C33-1*	1	Siemens
For other terminals	*C73334-A1-C34-1*	1	Siemens
Mounting rail for 19" rack	*C73165-A63-D200-1*	1	Siemens

Your local Siemens representative
can inform you on local suppliers.

Connection diagram

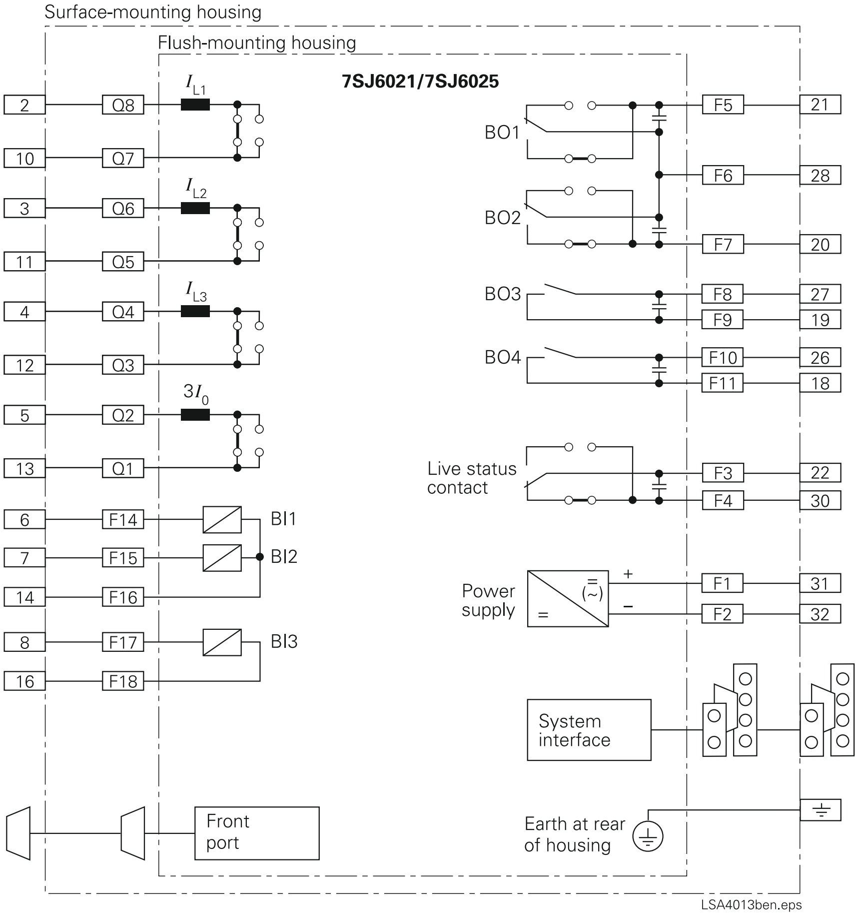


Fig. 5/54
Connection diagram according to IEC standard

Connection diagram

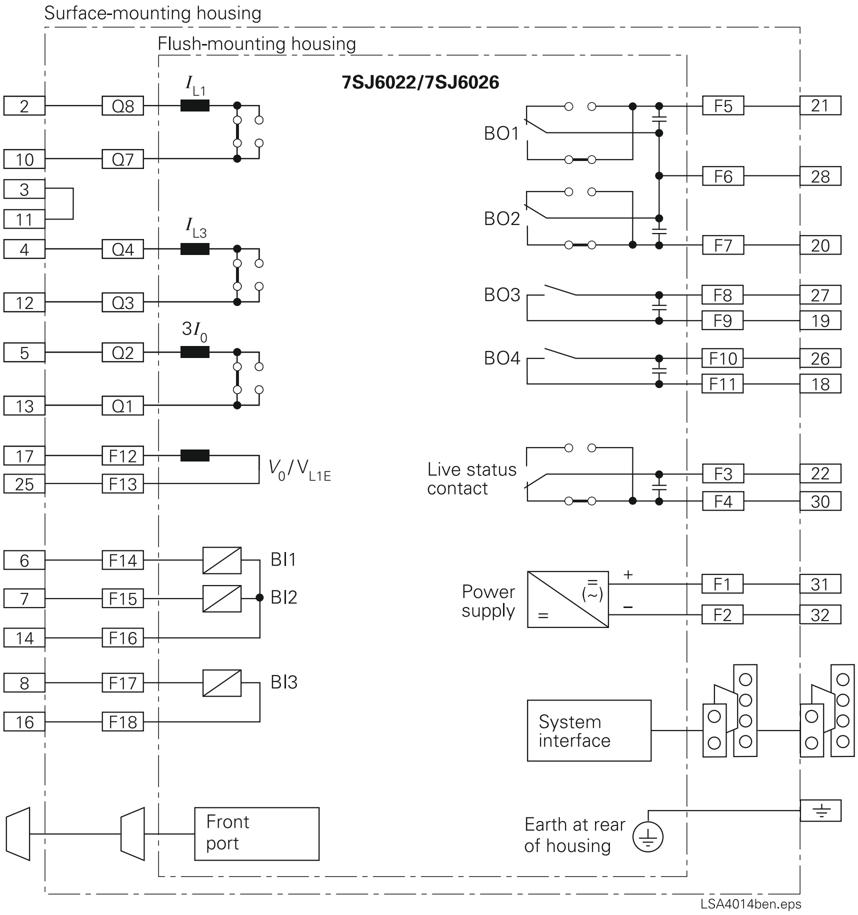


Fig. 5/55
Connection diagram according to IEC standard

SIPROTEC 4 7SJ61 Multifunction Protection Relay

Fig. 5/56 SIPROTEC 4 7SJ61 multifunction protection relay with text (left) and graphic display

Description

The SIPROTEC 4 7SJ61 relays can be used for line protection of high and medium voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point. When protecting motors, the SIPROTEC 4 7SJ61 is suitable for asynchronous machines of all sizes. The relay performs all functions of backup protection supplementary to transformer differential protection.

The relay provides control of the circuit-breaker, further switching devices and automation functions. The integrated programmable logic (CFC) allows the user to implement their own functions, e. g. for the automation of switchgear (interlocking). The user is also allowed to generate user-defined messages.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Time-overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive earth-fault detection
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
  - Undercurrent monitoring
  - Starting time supervision
  - Restart inhibit
  - Locked rotor
  - Load jam protection
- Overload protection
- Temperature monitoring
- Breaker failure protection
- Negative-sequence protection
- Auto-reclosure
- Lockout

Control functions/programmable logic

- Commands for control of a circuit-breaker and of isolators
- Position of switching elements is shown on the graphic display
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values *I*
- Circuit-breaker wear monitoring
- Slave pointer
- Time metering of operating hours
- Trip circuit supervision
- 8 oscillographic fault records
- Motor statistics

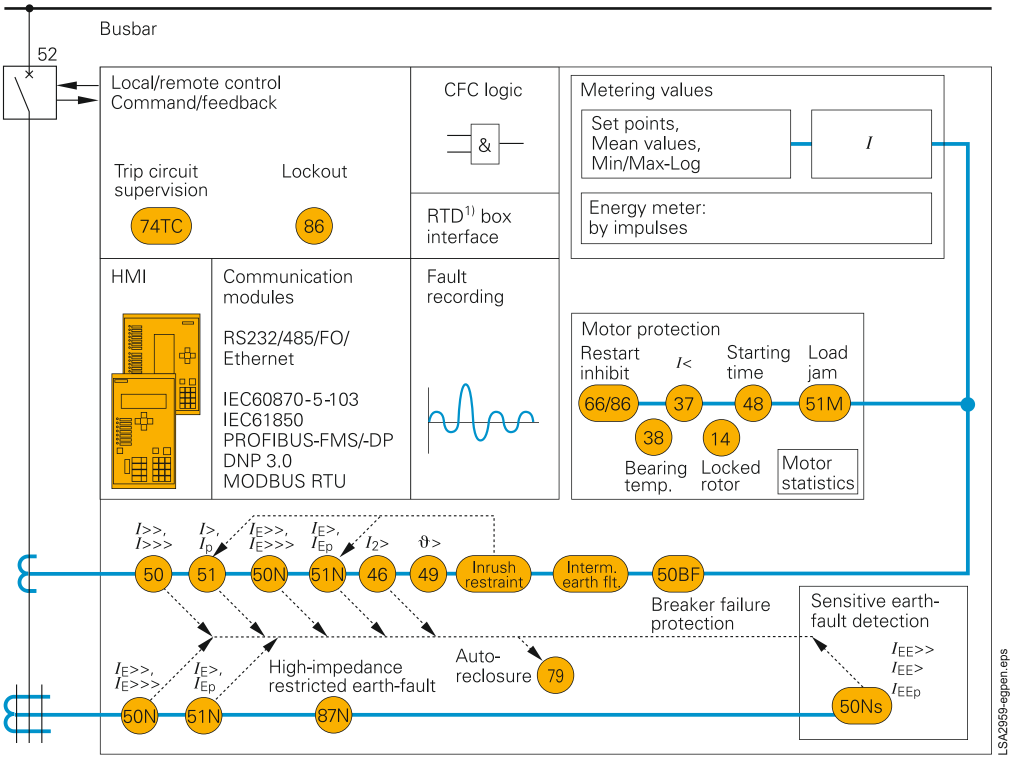
Communication interfaces

- System interface
  - IEC 60870-5-103, IEC 61850
  - PROFIBUS-FMS/-DP
  - DNP 3.0/MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Hardware

- 4 current transformers
- 3/8/11 binary inputs
- 4/8/6 output relays

Application



$^{1)}$ RTD = resistance temperature detector

Fig. 5/58 Function diagram

The SIPROTEC 4 7SJ61 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

The integrated control function permits control of disconnect devices, earthing switches or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed, in case of devices with graphic display. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The relay is a non-directional overcurrent relay which can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ61 relay is suitable for asynchronous machines of all sizes.

Transformer protection

The relay performs all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The 7SJ61can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$, $I_E>>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
50Ns, 51Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Sensitive earth-fault protection
–		Cold load pick-up (dynamic setting change)
–	$I_E>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring

Construction

Connection techniques and housing with many advantages

1/3-rack size (text display variants) and 1/2-rack size (graphic display variants) are the available housing widths of the 7SJ61 relays referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housing. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

LSP2099-afpen.eps

Fig. 5/59 Rear view with screw-type, 1/3-rack size

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set within a wide range.
In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

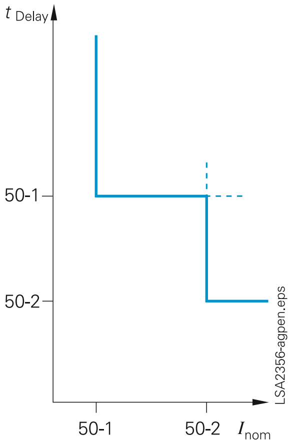


Fig. 5/60
Definite-time overcurrent protection

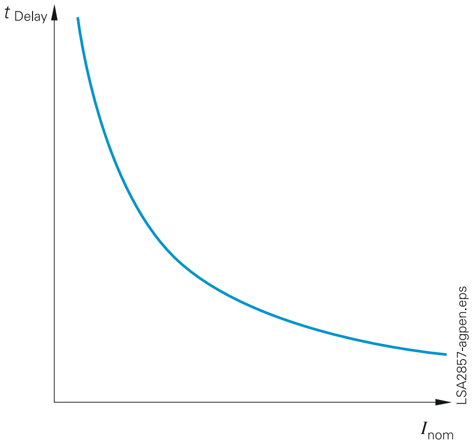


Fig. 5/61
Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	●	●
Short inverse	●	
Long inverse	●	●
Moderately inverse	●	
Very inverse	●	●
Extremely inverse	●	●

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional normal elements ($I>$, I_p) are blocked.

Cold load pickup/dynamic setting change

For time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Flexible protection functions

The 7SJ61 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current quantities can be three-phase or single-phase. The quantities can be operated as greater than or less than stages. All stages operate with protection priority. Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
$I>$, $I_E>$	50, 50N
$3I_0>$, $I_1>$, $I_2>$, $I_2/I_1>$	50N, 46
Binary input	

Protection functions

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns/50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short- circuit protection.

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if after a trip command, current is still flowing in the faulted circuit. As an option it is possible to make use of the circuit-breaker position indication.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The overcurrent elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the overcurrent elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD-box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

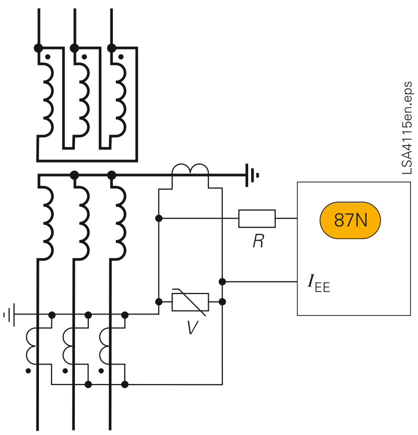


Fig. 5/62 High-impedance restricted earth-fault protection

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/61). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}. The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Protection functions/Functions

Motor protection

Starting time supervision (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups that might occur when excessive load torque occurs, excessive voltage drops occur within the motor or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\text{MOTOR START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current (2 times, for warm and cold motor)

The characteristic (equation) can be adapted optimally to the state of the motor by applying different tripping times T_A in dependence of either cold or warm motor state. For differentiation of the motor state the thermal model of the rotor is applied.

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Temperature monitoring (ANSI 38)

Up to 2 temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see “Accessories”, page 5/78).

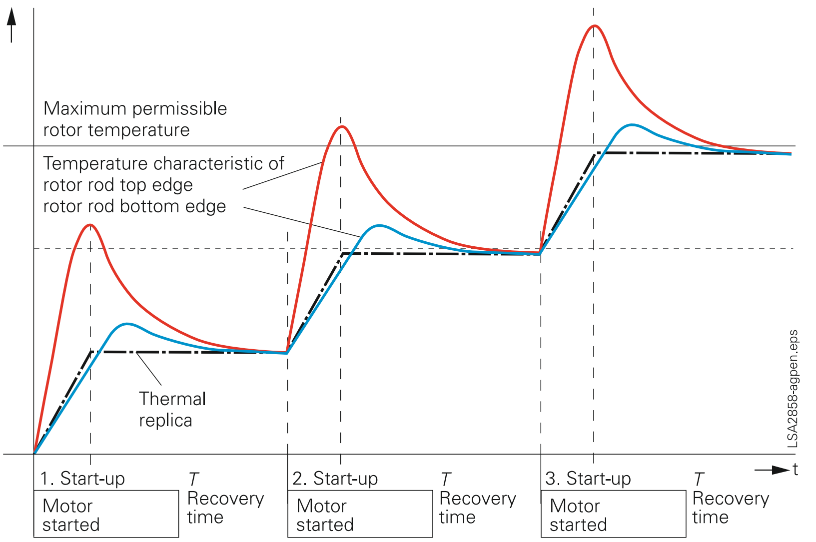


Fig. 5/63

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping). The overload protection function is too slow and therefore not suitable under these circumstances.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start- up (see Fig. 5/62).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, that can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Motor statistics

Essential information on start-up of the motor (duration, current, voltage) and general information on number of starts, total operating time, total down time, etc. are saved as statistics in the device.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- $\Sigma i^2 t$

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

Protection functions/Functions

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/63) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values.

To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ61 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters and communication.

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

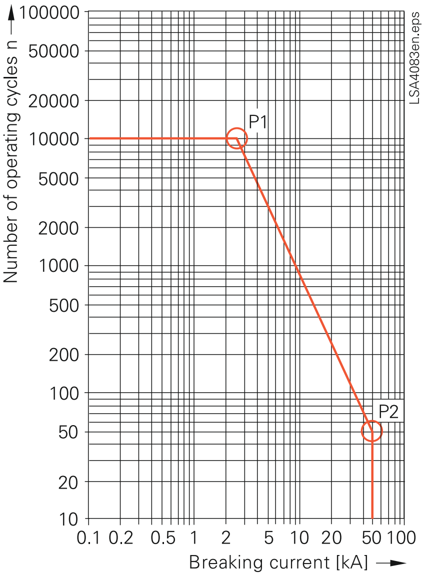


Fig. 5/64 CB switching cycle diagram

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Functions

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Measured values

The r.m.s. values are calculated from the acquired current. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (50Ns)
- Symmetrical components
  I_1, I_2, $3I_0$
- Mean as well as minimum and maximum current values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
- Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments or additional control components are necessary.

LSP2077f.eps

Fig. 5/65
NXAIR panel (air-insulated)

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user. The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.
Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it.
A time-stamped event list is available.

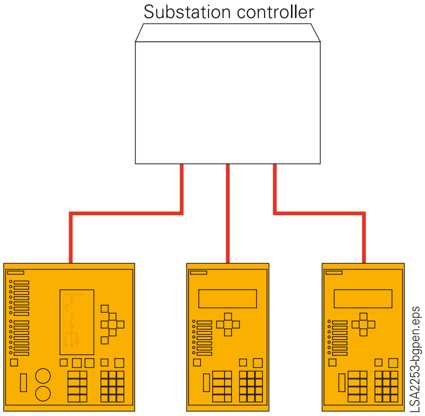


Fig. 5/66
IEC 60870-5-103: Radial fiber-optic connection

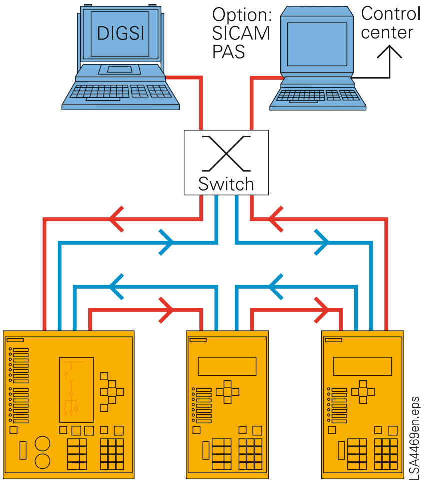


Fig. 5/67
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

---

1) For units in panel surface-mounting housings please refer to note on page 5/77.

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/65).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/66).

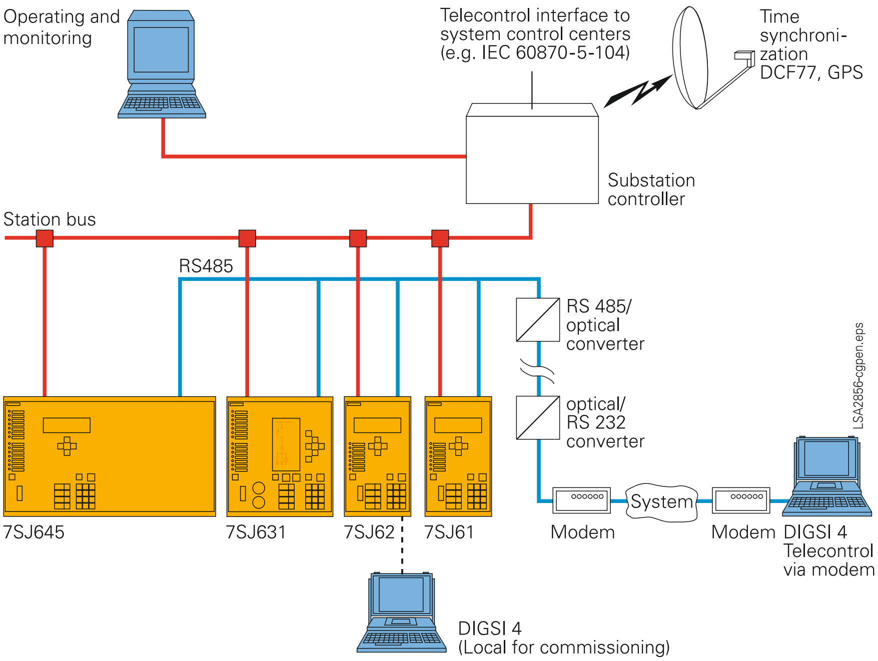


Fig. 5/67
System solution/communication

Fig. 5/68
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

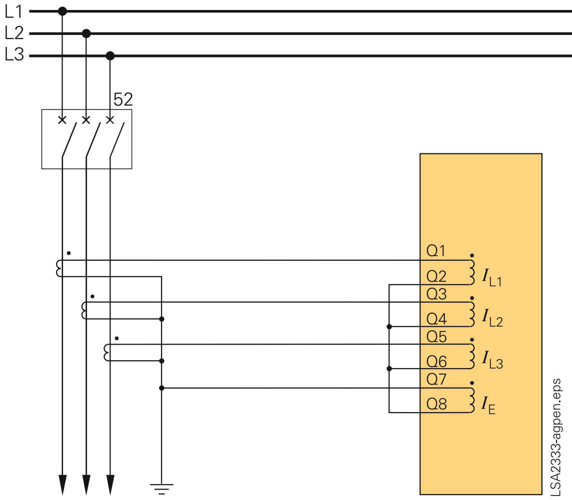


Fig. 5/69
Residual current circuit

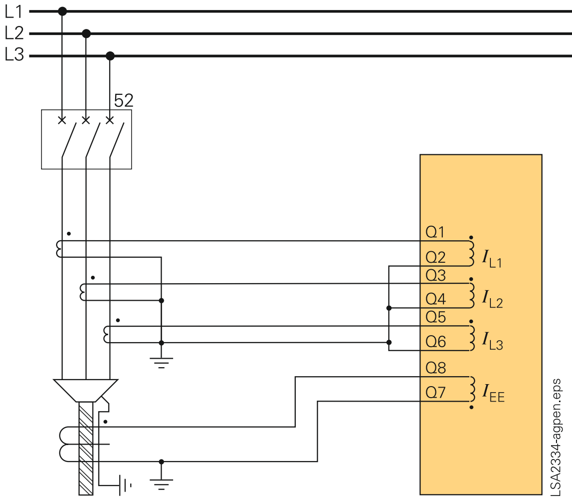


Fig. 5/70
Sensitive earth current detection

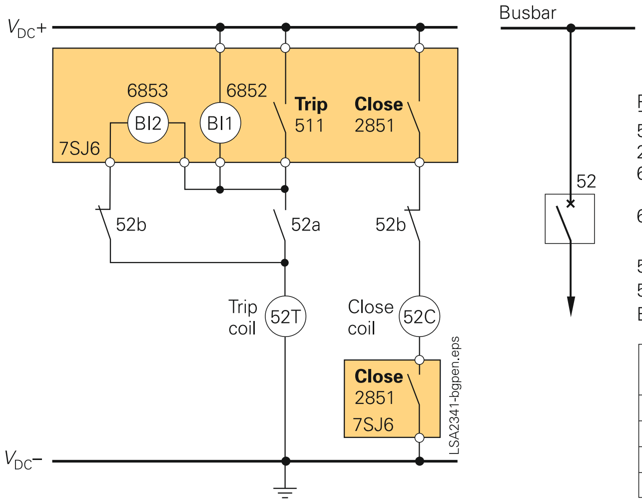
Typical applications

Overview of connection types

Type of network	Function	Current connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible
Isolated networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required
Compensated networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.



Protection indications

511*	General trip
2851*	CB close command
6852*	Trip circuit supervision: Trip relay
6853*	Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/71 Trip circuit supervision with 2 binary inputs

Technical data

General unit data

Measuring circuits

System frequency	50 / 60 Hz (settable)

Current transformer

Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	$I_{EE} < 1.6$ A
Power consumption at $I_{nom} = 1$ A at $I_{nom} = 5$ A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT Thermal (effective)	 300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)

Auxiliary voltage (via integrated converter)

Rated auxiliary voltage V_{aux}	DC	24/48 V	60/125 V	110/250 V	
	AC			115/230 V	
Permissible tolerance	DC	19–58 V	48–150 V	88–330 V	
	AC			92–138 V	184–265 V

Ripple voltage, peak-to-peak	≤ 12 %
Power consumption Quiescent Energized	 Approx. 3 W Approx. 7 W
Backup time during loss/short-circuit of auxiliary voltage	≥ 50 ms at V ≥ 110 V DC ≥ 20 ms at V ≥ 24 V DC ≥ 200 ms at 115 V/230 V AC

Binary inputs/indication inputs

Type	7SJ610	7SJ611, 7SJ613	7SJ612, 7SJ614
Number	3	8	11
Voltage range	24–250 V DC		
Pickup threshold	Modifiable by plug-in jumpers		
Pickup threshold	DC 19 V		88 V
For rated control voltage	DC 24/48/60/110/125 V		110/220/250 V
Response time/drop-out time	Approx. 3.5 ms		
Power consumption energized	1.8 mA (independent of operating voltage)		

Binary outputs/command outputs

Type		7SJ610	7SJ611, 7SJ613	7SJ612, 7SJ614
Number command/indication relay		4	8	6
Contacts per command/ indication relay		1 NO / form A (2 contacts changeable to NC/form B, via jumpers)		
Live status contact		1 NO / NC (jumper) / form A / B		
Switching capacity	Make	1000 W / VA		
	Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms		
Switching voltage	≤ 250 V DC			
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles			

Electrical tests

Specification

Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508

Insulation tests

Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; $R_i = 330$ Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50$ Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, $R_i = 150$ to 200 Ω

Technical data

EMC tests for interference immunity; type tests (cont'd)

Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200\ \Omega$

EMC tests for interference emission; type tests

Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C /-13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C /-4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C /+131 °F)	-5 °C to +55 °C /+25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C /-13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C /-13 °F to +158 °F

Humidity

Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design

Housing	7XP20
Dimensions	See dimension drawings, part 15
Weight	
1/3 19”, surface-mounting housing	4.5 kg
1/3 19”, flush-mounting housing	4.0 kg
1/2 19”, surface-mounting housing	7.5 kg
1/2 19”, flush-mounting housing	6.5 kg
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	Front: IP 51, rear: IP 20;
Operator safety	IP 2x with cover

Serial interfaces

Operating interface (front of unit)

Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud

Service/modem interface (rear of unit)

Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

Technical data

System interface (rear of unit)

IEC 60870-5-103 protocol

Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud

RS232/RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

Fiber optic

Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

IEC 60870-5-103 protocol, redundant

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

IEC 61850 protocol

Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit

Ethernet, electrical

Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth

Ethernet, optical

Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Integr. LC connector for FO connection Mounting location "B"
Optical wavelength	1300 nm
Distance	1.5 km/0.9 miles

PROFIBUS-FMS/DP

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth

Fiber optic

Connection fiber-optic cable	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/99
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles

MODBUS RTU, ASCII, DNP 3.0

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth

Fiber-optic

Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/77
Optical wavelength	820 nm
Permissible path attenuaion	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

Technical data

Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions

Definite-time overcurrent protection (ANSI 50, 50N)

Operating mode phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Number of elements (stages)	I>, I>>, I>>> (phases) I_E>, I_E>>, I_E>>> (earth)
Setting ranges	
Pickup phase elements	0.5 to 175 A or ∞ 1) (in steps of 0.01 A)
Pickup earth elements	0.25 to 175 A or ∞ 1) (in steps of 0.01 A)
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
With twice the setting value	Approx. 30 ms
With five times the setting value	Approx. 20 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$
Tolerances	
Pickup	2 % of setting value or 50 mA 1)
Delay times T, T_{DO}	1 % or 10 ms

Inverse-time overcurrent protection (ANSI 51, 51N)

Operating mode phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞ 1) (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞ 1) (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA 1)
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

1) For I_{nom} = 1 A, all limits divided by 5.

Inrush blocking

Influenced functions	Time-overcurrent elements, I>, I_E>, I_p, I_{Ep}
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA 1)
Lower function limit earth	Earth current (50 Hz and 100 Hz) ≥ 125 mA 1)
Upper function limit (setting range)	1.5 to 125 A 1) (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF

Dynamic setting change

Controllable function	Pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) earth-fault detection (ANSI 50 Ns, 51Ns)

Earth-fault pickup for all types of earth faults

Definite-time characteristic (ANSI 50Ns)

Setting ranges	
Pickup threshold I_{EE}>, I_{EE}>>	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A 1) (in steps of 0.01 A)
Delay times T for I_{EE}>, I_{EE}>>	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold I_{EE}>, I_{EE}>>	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms

Earth-fault pickup for all types of earth faults

Inverse-time characteristic (ANSI 51Ns)

User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A 1) (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA 1)
Dropout times in linear range	7 % of reference value for $2 \leq I/I_{EEp} \leq 20$ + 2 % current tolerance, or 70 ms
Logarithmic inverse	Refer to the manual
Logarithmic inverse with knee point	Refer to the manual

Technical data

***High-impedance restricted earth-fault protection** (ANSI 87N) / single-phase overcurrent protection*

Setting ranges	
Pickup thresholds I>, I>>	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A 1) or ∞ (in steps of 0.01 A)
Delay times T_I>, T_I>>	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

Intermittent earth-fault protection

Setting ranges		
Pickup threshold		
For I_E	I_{IE}>	0.25 to 175 A 1) (in steps of 0.01 A)
For $3I_0$	I_{IE}>	0.25 to 175 A 1) (in steps of 0.01 A)
For I_{EE}	I_{IE}>	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)
Times		
Pickup times		
Current = 1.25 · pickup value		Approx. 30 ms
Current ≥ 2 · pickup value		Approx. 22 ms
Dropout time		Approx. 22 ms
Tolerances		
Pickup threshold I_{IE}>		3 % of setting value, or 50 mA 1)
Times T_V, T_{sum}, T_{res}		1 % of setting value or 10 ms

***Thermal overload protection** (ANSI 49)*

Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

***Auto-reclosure** (ANSI 79)*

Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements, negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements, sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4
(setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
I>>>, I>>, I>, I_p,
I_E>>>, I_E>>, I_E>, I_{Ep}

---

1) For I_{nom} = 1 A, all limits divided by 5.

Technical data

Auto-reclosure *(ANSI 79) (cont'd)*

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection *(ANSI 50 BF)*

Setting ranges	
Pickup thresholds	0.2 to 5 A 1) (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA) 1)
Delay time	1 % or 20 ms

Flexible protection functions *(ANSI 47, 50, 50N)*

Operating modes/measuring quantities	
3-phase	$I, I_1, I_2, I_2/I_1, 3I_0$
1-phase	I, I_E, I_E sens.
Without fixed phase relation	Binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current $I, I_1, I_2, 3I_0, I_E$	0.15 to 200 A 1) (in steps of 0.01 A)
Current ratio I_2 / I_1	15 to 100 % (in steps of 1 %)
Sensitive earth current $I_{E\,sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times, phase quantities	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Pickup times, symmetrical components	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Binary input	Approx. 20 ms
Dropout times	
Phase quantities	< 20 ms
Symmetrical components	< 30 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Phase quantities	1 % of setting value or 50 mA 1)
Symmetrical components	2 % of setting value or 100 mA 1)
Times	1 % of setting value or 10 ms

Negative-sequence current detection *(ANSI 46)*

Definite-time characteristic *(ANSI 46-1 and 46-2)*

Setting ranges	
Pickup current $I_2>$, $I_2>>$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A 1)
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA 1)
Delay times	1 % or 10 ms

Inverse-time characteristic *(ANSI 46-TOC)*

Setting ranges	
Pickup current	0.5 to 10 A 1) (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A 1)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA 1)
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors *(ANSI 48)*

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A 1) (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A 1) (in steps of 0.01)
Permissible starting time $T_{STARTUP}$, cold motor	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP}$, warm motor	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I >$ $I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA 1)
Delay time	5 % or 30 ms

Load jam protection for motors *(ANSI 51M)*

Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A 1) (in steps of 0.01 A)
Delay times	0 to 600 s (in steps of 0.01 s)
Blocking duration after close signal detection	0 to 600 s (in steps of 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA 1)
Delay time	1 % of setting value or 10 ms

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Restart inhibit for motors (ANSI 66)

Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A 1) (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state

Undercurrent monitoring (ANSI 37)

Signal from the operational measured values	Predefined with programmable logic

Temperature monitoring box (ANSI 38)

Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Additional functions

Operational measured values

Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range Tolerance 1)	10 to 200 % I_{nom} 1 % of measured value or 0.5 % I_{nom}
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance 1)	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\ Trip}$	In %
Range Tolerance 1)	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\ Trip}$	In %
Reclose time $T_{Reclose}$	In min
Current of sensitive ground fault detection I_{EE}	In A (kA) primary and in mA secondary
Range Tolerance 1)	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"

Long-term averages

Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages of currents	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA)

Max. / Min. report

Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3} I_1 (positive-sequence component)
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	$I_{L1dmd}, I_{L2dmd}, I_{L3dmd}$ I_1 (positive-sequence component)

Local measured values monitoring

Current asymmetry	I_{max}/I_{min} > balance factor, for $I > I_{balance\ limit}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC

Fault recording

Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

---

1) At rated frequency.

5

Technical data

Time stamping

Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge

Oscillographic fault recording

Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 samples/cycle) 1 sample/1.04 ms (16 samples/cycle)

Statistics

Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits

Circuit-breaker wear

Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication

Motor statistics

Total number of motor start-ups	0 to 9999	(resolution 1)
Total operating time	0 to 99999 h	(resolution 1 h)
Total down-time	0 to 99999 h	(resolution 1 h)
Ratio operating time/down-time	0 to 100 %	(resolution 0.1 %)
Motor start-up data:	of the last 5 start-ups	
– start-up time	0.30 s to 9999.99 s	(resolution 10 ms)
– start-up current (primary)	0 A to 1000 kA	(resolution 1 A)

Operating hours counter

Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})

Trip circuit monitoring

With one or two binary inputs

Commissioning aids

Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report

Clock

Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication

Setting group switchover of the function parameters

Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

Control

Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

c UL us
LISTED

Selection and ordering data

Description	Order No.
7SJ61 multifunction protection relay	*7SJ61*☐☐ – ☐☐☐☐☐ – ☐☐☐☐
Housing, binary inputs (BI) and outputs (BO)	
Housing 1/3 19”, 4 line text display, 3 BI, 4 BO, 1 live status contact	*0*
Housing 1/3 19”, 4 line text display, 8 BI, 8 BO, 1 live status contact	*1*
Housing 1/3 19”, 4 line text display, 11 BI, 6 BO, 1 live status contact	*2*
Housing 1/2 19”, graphic display, 8 BI, 8 BO, 1 live status contact 7)	*3*
Housing 1/2 19”, graphic display, 11 BI, 6 BO, 1 live status contact 7)	*4*
Measuring inputs (4 x I)	
$I_{ph} = 1$ A1), $I_e = 1$ A1) (min. = 0.05 A) Position 15 only with *A*	*1*
$I_{ph} = 1$ A1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B*	*2*
$I_{ph} = 5$ A1), $I_e = 5$ A1) (min. = 0.25 A) Position 15 only with *A*	*5*
$I_{ph} = 5$ A1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B*	*6*
$I_{ph} = 5$ A1), $I_e = 1$ A1) (min. = 0.05 A) Position 15 only with *A*	*7*
Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 DC3)	*2*
60 to 125 V DC2), threshold binary input 19 DC3)	*4*
110 to 250 V DC2), 115 to 230 V4) AC, threshold binary input 88 V DC3)	*5*
110 to 250 V DC2), 115 to 230 V4) AC, threshold binary input 176 V DC3)	*6*
Unit version	
For panel surface mounting, 2 tier terminal top/bottom	*B*
For panel flush mounting, plug-in terminal (2/3 pin connector)	*D*
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	*E*
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	*A*
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	*B*
Region US, 60 Hz, ANSI, language: English (US), selectable	*C*
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	*D*
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	*E*
Region IT, 50/60 Hz, IEC/ANSI, language: Italian, selectable	*F*
System interface (Port B): Refer to page 5/77	
No system interface	*0*
Protocols see page 5/77	
Service interface (Port C)	
No interface at rear side	*0*
DIGSI 4/modem, electrical RS232	*1*
DIGSI 4/modem/RTD-box5), electrical RS485	*2*
DIGSI 4/modem/RTD-box5)6), optical 820 nm wavelength, ST connector	*3*
Measuring/fault recording	
Fault recording	*1*
Slave pointer, mean values, min/max values, fault recording	*3*

see
next
page

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected per binary input by means of jumpers.

4) 230 V AC, starting from device version …/EE.

5) Temperature monitoring box 7XV5662-☐AD10, refer to “Accessories”.

6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0☐A00 is required.

7) starting from device version .../GG and FW-Version V4.82

Selection and ordering data

Description			Order No.	Order code
7SJ61 multifunction protection relay			*7SJ61□□ – □□□□□ – □□□□–□□□□*	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}		
	50N/51N	Earth-fault protection via insensitive IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp}[1]		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	50BF	Breaker failure protection		
	37	Undercurrent monitoring		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout	*F A*	
■ IEF		Intermittent earth fault	*P A*	
■	50Ns/51Ns	Sensitive earth-fault detection (non-directional)		
	87N	High-impedance restricted earth fault	*F B*[2]	
■ IEF	50Ns/51Ns	Sensitive earth-fault detection (non-directional)		
	87N	High-impedance restricted earth fault		
		Intermittent earth fault	*P B*[2]	
■ Motor IEF	50Ns/51Ns	Sensitive earth-fault detection (non-directional)		
	87N	High-impedance restricted earth fault		
		Intermittent earth fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics	*R B*[2]	
■ Motor	50Ns/51Ns	Sensitive earth-fault detection (non-directional)		
	87N	High-impedance restricted earth fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics	*H B*[2]	
■ Motor	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics	*H A*	
ARC		Without	*0*	
	79	With auto-reclosure	*1*	
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection “e”)				*Z X 9 9*[3]

■ Basic version included

IEF = Intermittent earth fault

1) 50N/51N only with insensitive earth-current transformer when position 7 = *1*, *5*, *7*.

2) Sensitive earth-current transformer only when position 7 = *2*, *6*.

3) This variant will be supplied with a previous firmware version.

Order numbers for system port B

Description	Order No.	Order code
7SJ61 multifunction protection relay	*7SJ61□□ – □□□□□ – □□□□–□□□*	
System interface (on rear of unit, Port B)		
No system interface	*0*	
IEC 60870-5-103 protocol, RS232	*1*	
IEC 60870-5-103 protocol, RS485	*2*	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	*3*	
PROFIBUS-FMS Slave, RS485	*4*	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector ¹)	*5*	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector ¹)	*6*	
PROFIBUS-DP Slave, RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector ¹)	*9*	*L 0 B*
MODBUS, RS485	*9*	*L 0 D*
MODBUS, 820 nm wavelength, ST connector ²)	*9*	*L 0 E*
DNP 3.0, RS485	*9*	*L 0 G*
DNP 3.0, 820 nm wavelength, ST connector ²)	*9*	*L 0 H*
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector ²)	*9*	*L 0 P*
IEC 61850, 100 Mbit Ethernet, electrical, double, RSJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)²)	*9*	*L 0 S*

1) Not with position 9 = “*B*”; if 9 = “*B*”, please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-3AB10, not available with position 9 = “*B*”.
For double ring, please order converter 6GK1502-4AB10, not available with position 9 = “*B*”.
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).
2) Not available with position 9 = “*B*”.

Sample order

Position		Order No. + Order code
		7SJ6125-5EC91-3FA1+L0G
6	I/O’s: 11 BI/6 BO, 1 live status contact	*2*
7	Current transformer: 5 A	*5*
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	*5*
9	Unit version: Flush-mounting housing, screw-type terminals	*E*
10	Region: US, English language (US); 60 Hz, ANSI	*C*
11	Communication: System interface: DNP 3.0, RS485	*9* *L0G*
12	Communication: DIGSI 4, electric RS232	*1*
13	Measuring/fault recording: Extended measuring and fault records	*3*
14/15	Protection function package: Basic version	*F A*
16	With auto-reclosure	*1*

Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		*7XS5460-0AA00*
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		*7XS5410-0AA00*
Temperature monitoring box		
24 to 60 V AC/DC		*7XV5662-2AD10*
90 to 240 V AC/DC		*7XV5662-5AD10*
Varistor/Voltage Arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088		*C53207-A401-D77-1*
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		*7XV5103-7AA05*
- length 25 m /82 ft		*7XV5103-7AA25*
- length 50 m /164 ft		*7XV5103-7AA50*
Manual for 7SJ61		
English		*C53000-G1140-C118-x* 1)

---

1) x = please inquire for latest edition (exact Order No.).

Accessories

Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

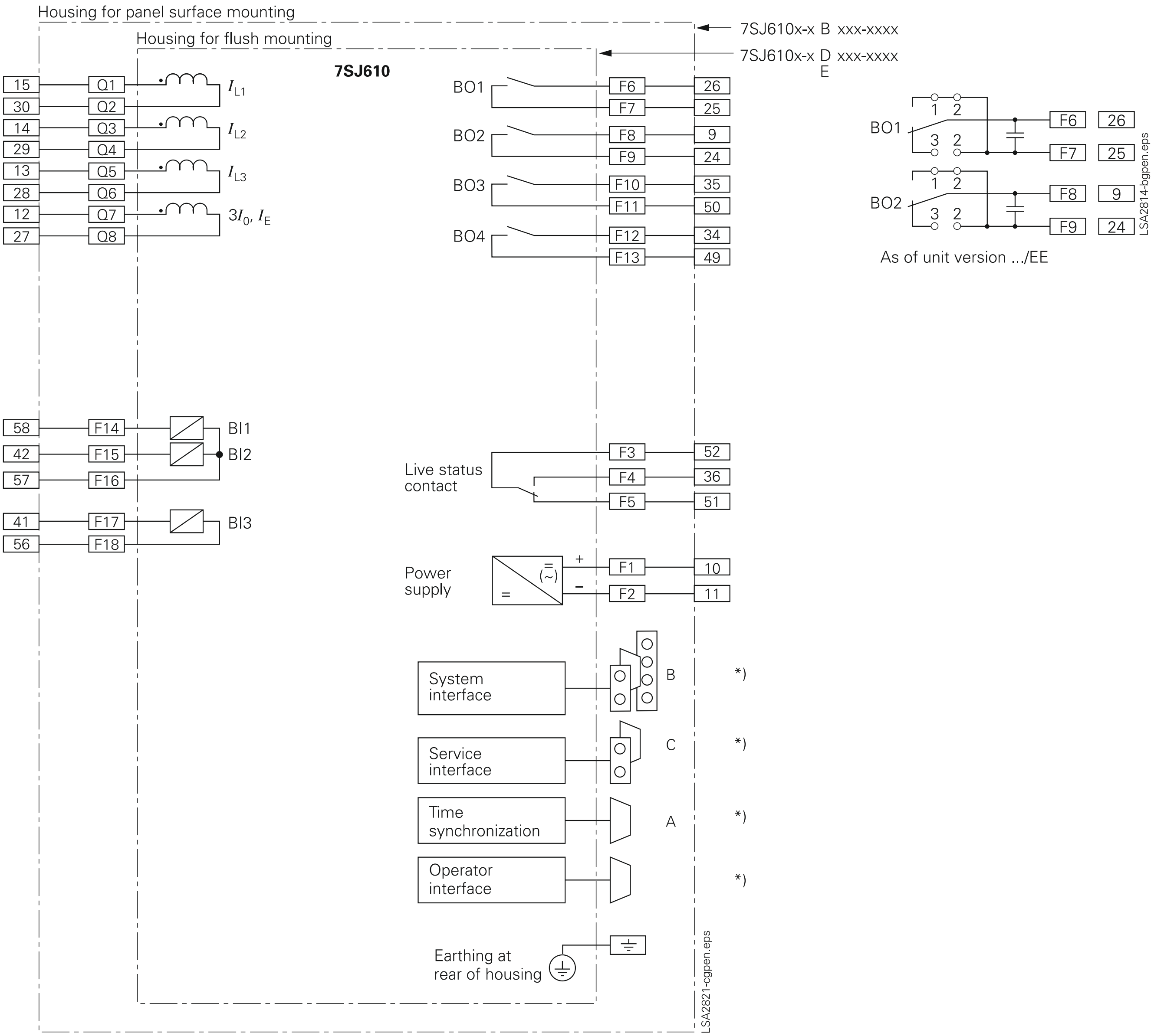
Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	*C73334-A1-C31-1*	1	Siemens
Voltage/current terminal 12-pole/8-pole	*C73334-A1-C32-1*	1	Siemens
Connector 2-pin	*C73334-A1-C35-1*	1	Siemens
Connector 3-pin	*C73334-A1-C36-1*	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	*0-827039-1*	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	*0-827396-1*	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	*0-163084-2*	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000 taped on reel	AMP 1)
Crimping tool for Type III+	*0-539635-1*	1	AMP 1)
and matching female	*0-539668-2*	1	AMP 1)
Crimping tool for CI2	*0-734372-1*	1	AMP 1)
and matching female	*1-734387-1*	1	AMP 1)
Short-circuit links			
for current terminals	*C73334-A1-C33-1*	1	Siemens
for other terminals	*C73334-A1-C34-1*	1	Siemens
Mounting rail for 19" rack	*C73165-A63-D200-1*	1	Siemens

---

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram



As of unit version .../EE

Fig. 5/72
7SJ610 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

Connection diagram

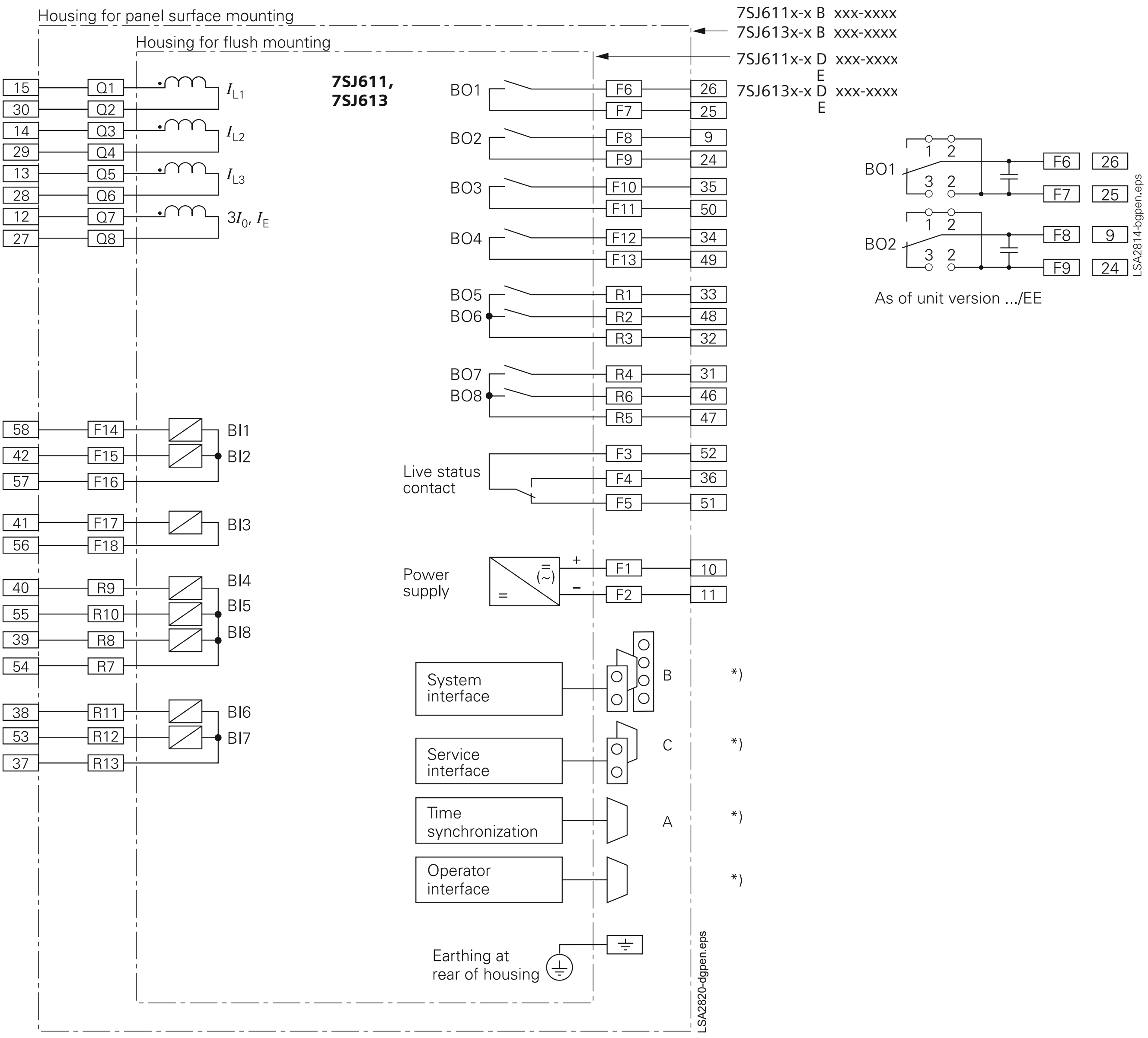


Fig. 5/73
7SJ611, 7SJ613 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

Connection diagram

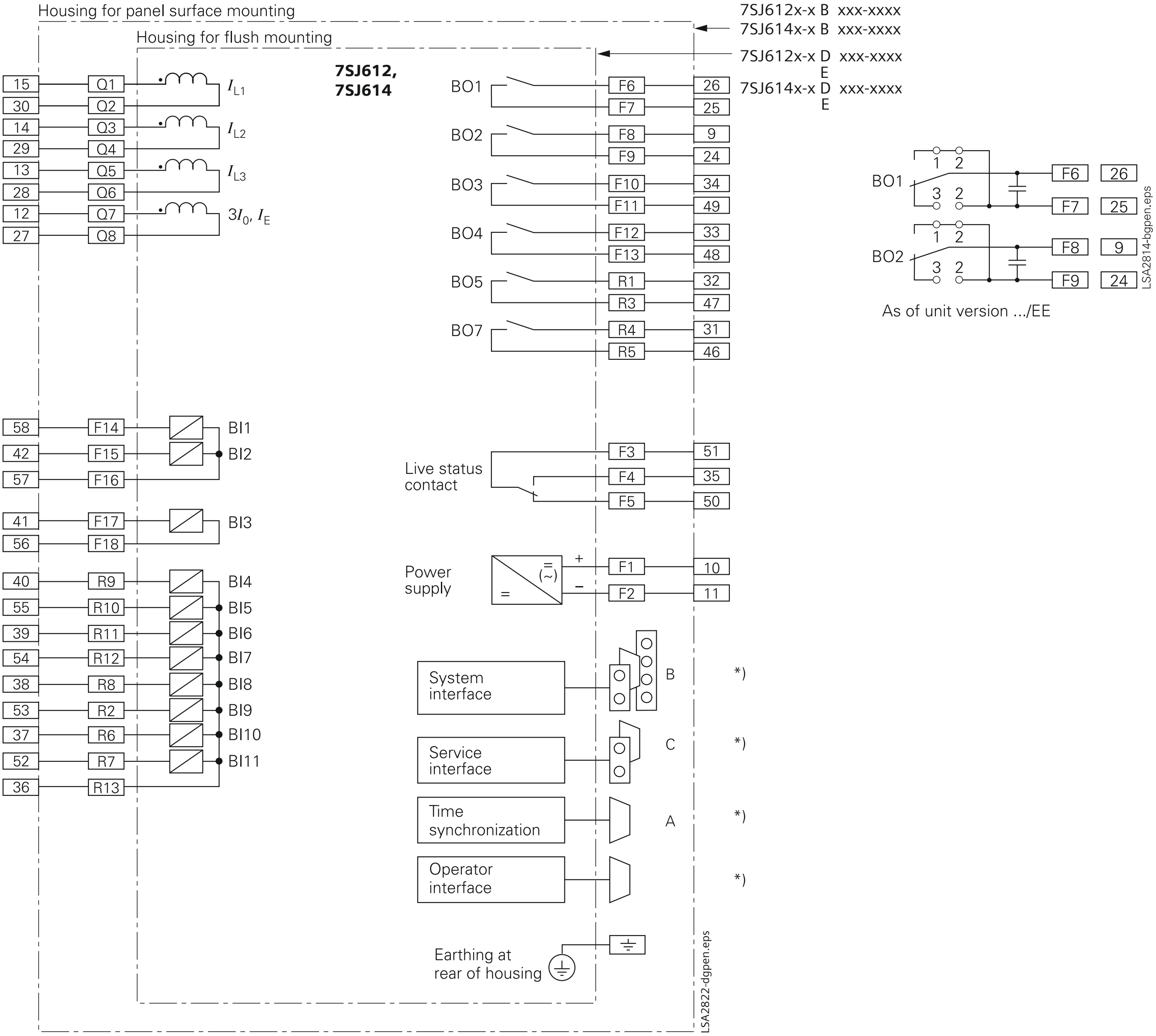


Fig. 5/74
7SJ612, 7SJ614 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

SIPROTEC 4 7SJ62 Multifunction Protection Relay

Fig. 5/75 SIPROTEC 4 7SJ62 multifunction protection relay with text (left) and graphic display

Description

The SIPROTEC 4 7SJ62 relays can be used for line protection of high and medium voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point. With regard to motor protection, the SIPROTEC 4 7SJ62 is suitable for asynchronous machines of all sizes. The relay performs all functions of backup protection supplementary to transformer differential protection.

7SJ62 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, a rate-of-frequency-change protection or reverse power protection can be implemented.

The relay provides control of the circuit-breaker, further switching devices and automation functions. The integrated programmable logic (CFC) allows the user to implement their own functions, e. g. for the automation of switchgear (interlocking). The user is also allowed to generate user-defined messages.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Time-overcurrent protection
- Directional time-overcurrent protection
- Sensitive dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
  - Undercurrent monitoring
  - Starting time supervision
  - Restart inhibit
  - Locked rotor
  - Load jam protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchro-check
- Fault locator
- Lockout
- Auto-reclosure

Control functions/programmable logic

- Commands f. ctrl of CB and of isolators
- Position of switching elements is shown on the graphic display
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V, I, f
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics

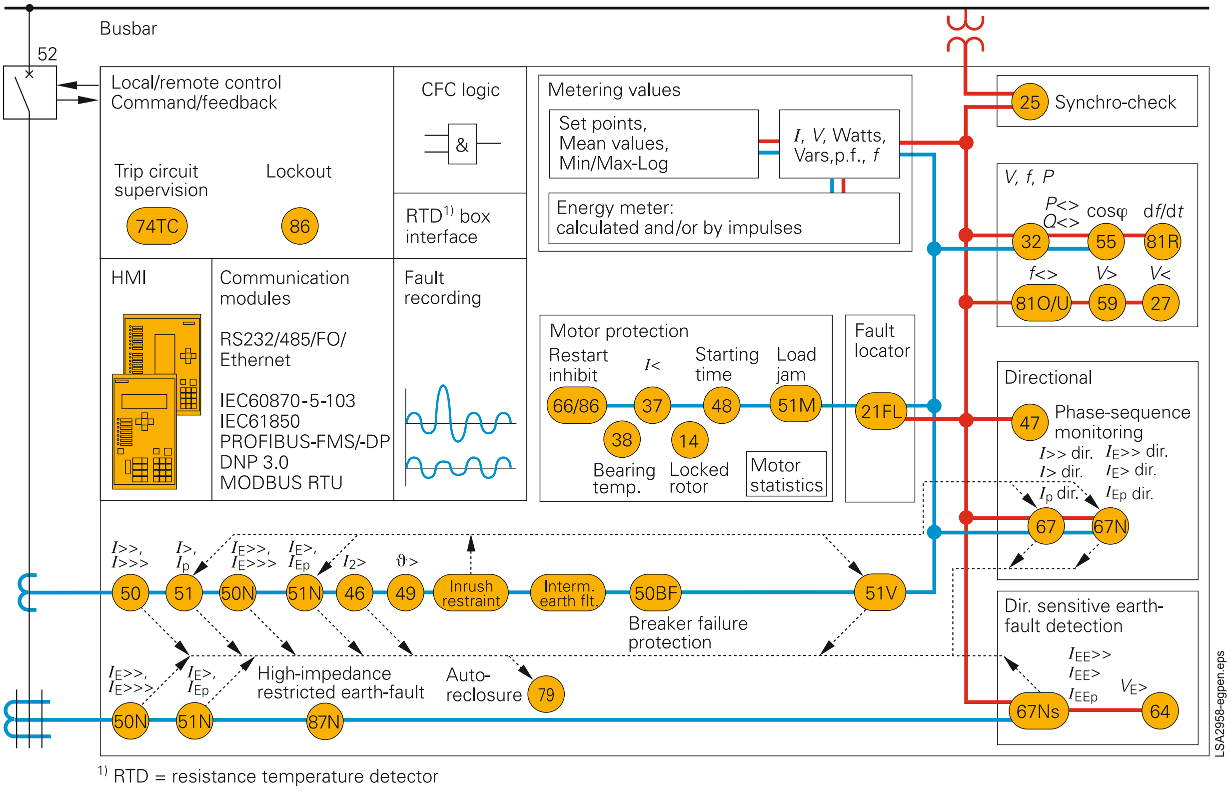
Communication interfaces

- System interface
  - IEC 60870-5-103/ IEC 61850
  - PROFIBUS-FMS/-DP
  - DNP 3.0/MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Hardware

- 4 current transformers
- 3/4 voltage transformers
- 8/11 binary inputs
- 8/6 output relays

Application



[1] RTD = resistance temperature detector

Fig. 5/76 Function diagram

The SIPROTEC 4 7SJ62 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

The integrated control function permits control of disconnect devices, earthing switches or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed, in case of devices with graphic display. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The 7SJ62 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Synchro-check

In order to connect two components of a power system, the relay provides a synchro-check function which verifies that switching ON does not endanger the stability of the power system.

Motor protection

When protecting motors, the 7SJ62 relay is suitable for asynchronous machines of all sizes.

Transformer protection

The relay performs all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The 7SJ62can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>, I>>, I>>>, I_E>, I_E>>, I_E>>>$	Definite time-overcurrent protection (phase/neutral)
51, 51V, 51N	I_p, I_{Ep}	Inverse time-overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir}>, I_{dir}>>, I_{p\ dir}$ $I_{Edir}>, I_{Edir}>>, I_{Ep\ dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>, I_{EE}>>, I_{EEp}$	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	$V_E, V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
25		Synchro-check
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase-sequence	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<, V>$	Undervoltage/overvoltage protection
59R	$\mathrm{d}V/\mathrm{d}t$	Rate-of-voltage-change protection
32	$P<>, Q<>$	Reverse-power, forward-power protection
55	$\cos \varphi$	Power factor protection
81O/U	$f>, f<$	Overfrequency/underfrequency protection
81R	$\mathrm{d}f/\mathrm{d}t$	Rate-of-frequency-change protection
21FL		Fault locator

Construction

Connection techniques and housing with many advantages

1/3-rack size (text display variants) and 1/2-rack size (graphic display variants) are the available housing widths of the 7SJ62 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housing. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Fig. 5/79 Rear view with screw-type terminals, 1/3-rack size

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51V, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.
The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes.

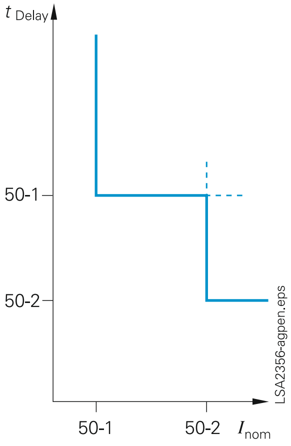


Fig. 5/77
Definite-time overcurrent protection

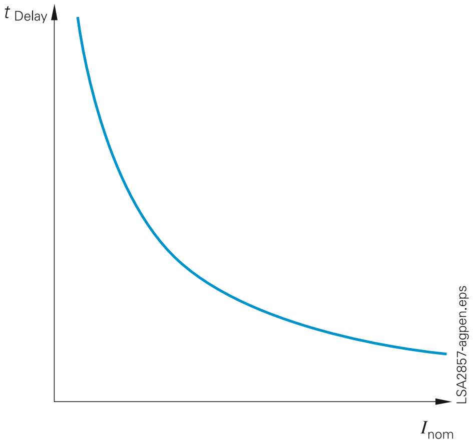


Fig. 5/78
Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	●	●
Short inverse	●	
Long inverse	●	●
Moderately inverse	●	
Very inverse	●	●
Extremely inverse	●	●

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 /BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and non-directional time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristics are offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0.

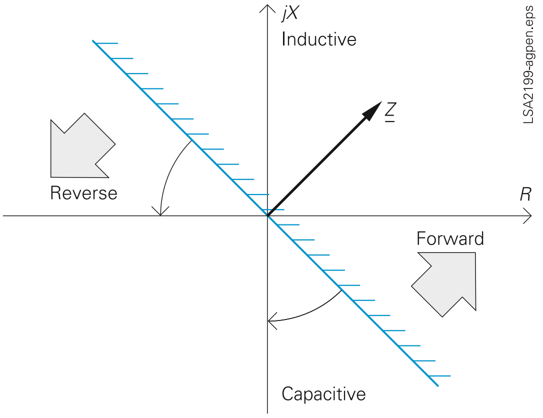


Fig. 5/80
Directional characteristic of the directional time-overcurrent protection

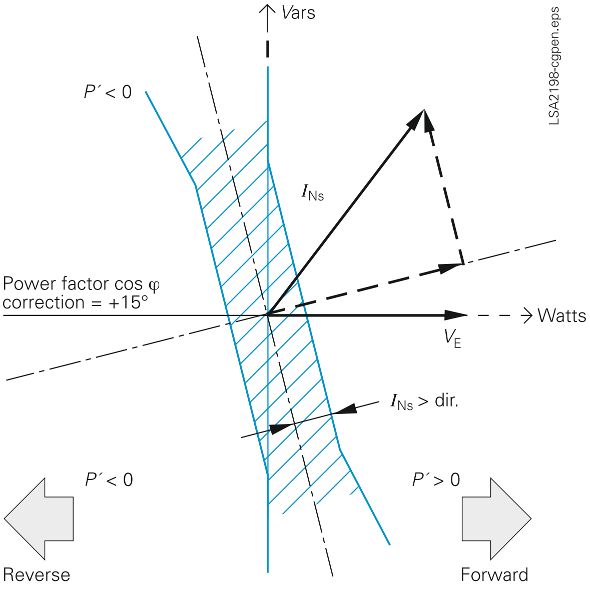


Fig. 5/81
Directional determination using cosine measurements for compensated networks

For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of earth-fault direction detection can be implemented: tripping or "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/82). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}. The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

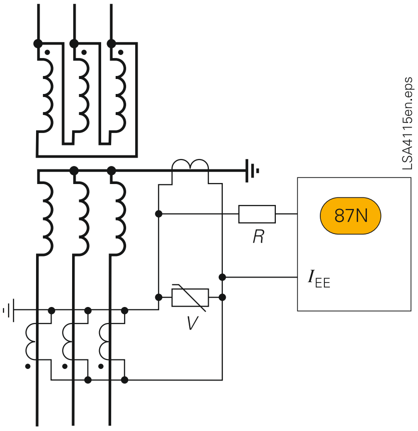


Fig. 5/82 High-impedance restricted earth-fault protection

Protection functions

Flexible protection functions

The 7SJ62 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/80). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
$I>$, $I_E>$	50, 50N
$V<$, $V>$, $V_E>$, dV/dt	27, 59, 59R, 64
$3I_0>$, $I_1>$, $I_2>$, I_2/I_1 $3V_0>$, $V_1><$, $V_2><$	50N, 46 59N, 47
$P><$, $Q><$	32
cos φ (p.f.)><	55
$f><$	81O, 81U
df/dt><	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)

Synchro-check (ANSI 25)

In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized. Voltage-, frequency- and phase-angle-differences are being checked to determine whether synchronous conditions are existent.

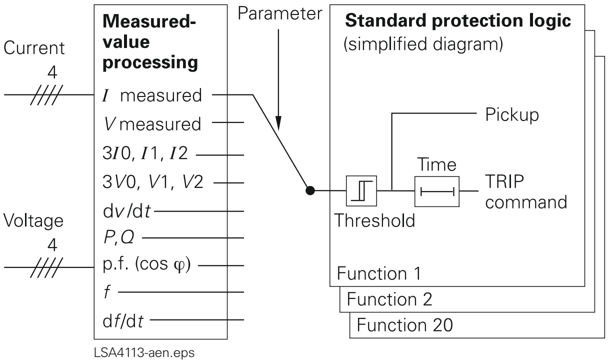


Fig. 5/83 Flexible protection functions

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD- box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

Protection functions

■ Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/84).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see “Accessories”, page 5/115).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\text{MOTOR START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current (2 times, for warm and cold motor)

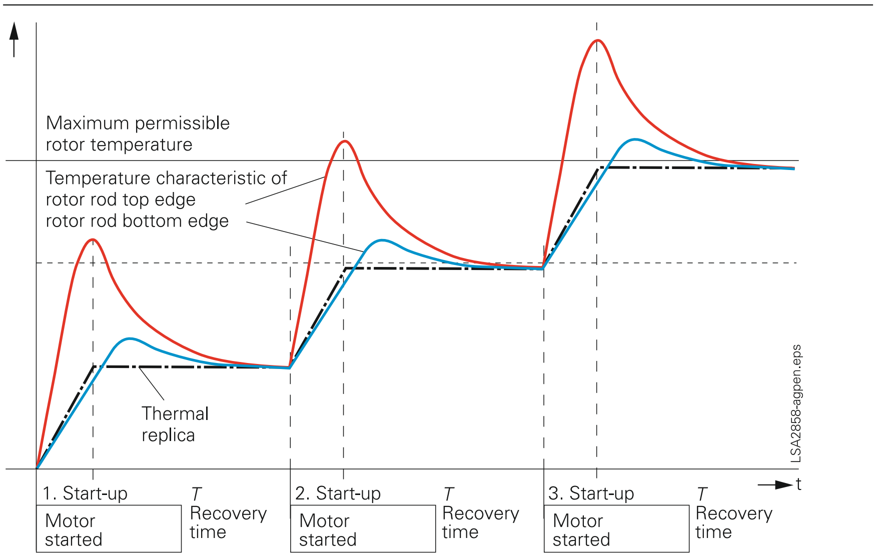


Fig. 5/84

The characteristic (equation) can be adapted optimally to the state of the motor by applying different tripping times T_A in dependence of either cold or warm motor state. For differentiation of the motor state the thermal model of the rotor is applied.

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping).

The overload protection function is too slow and therefore not suitable under these circumstances.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Motor statistics

Essential information on start-up of the motor (duration, current, voltage) and general information on number of starts, total operating time, total down time, etc. are saved as statistics in the device.

■ Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-earth, positive phase-sequence or negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)1). Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

Protection functions/Functions

The function can operate either with phase-to-phase, phase-to-earth or positive phase-sequence voltage and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting.

Frequency protection can be used over a wide frequency range (40 to 60, 50 to 70 Hz)[1]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in Ω, kilometers (miles) and in percent of the line length.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- $\Sigma i^2 t$

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/107) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

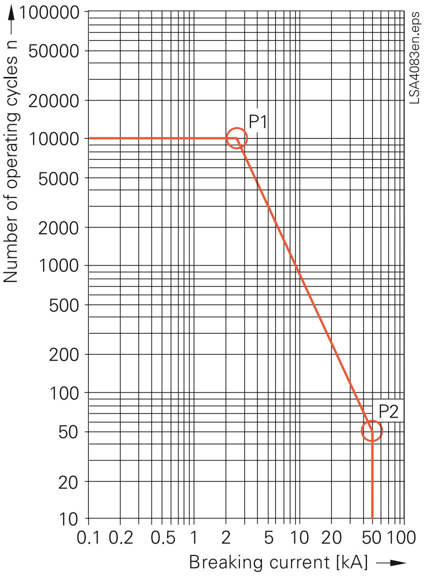


Fig. 5/85 CB switching cycle diagram

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ62 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- – integrated operator panel
- – binary inputs
- – substation control and protection system
- – DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters and communication.

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime

---

[1] The 40 to 60, 50 to 70 Hz range is available for f_N= 50/60 Hz

Functions

monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g., for current, voltage, frequency, …) or additional control components are necessary.

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase selective)
- Power factor (cos φ), (total and phase selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Fig. 5/86
NXAIR panel (air-insulated)

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user. The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.
Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

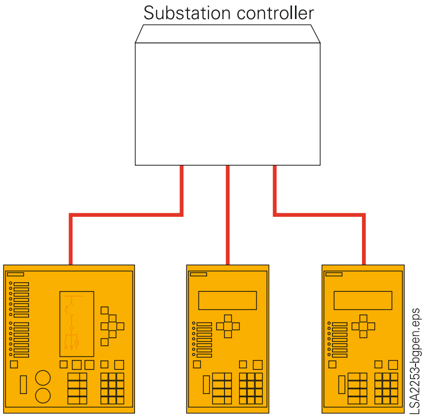


Fig. 5/87
IEC 60870-5-103: Radial fiber-optic connection

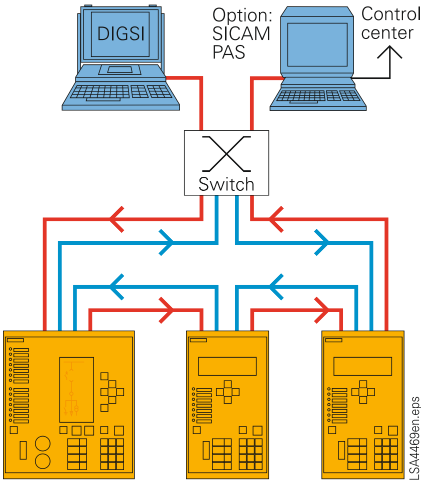


Fig. 5/88
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

---

1) For units in panel surface-mounting housings please refer to note on page 5/114.

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/87).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/88).

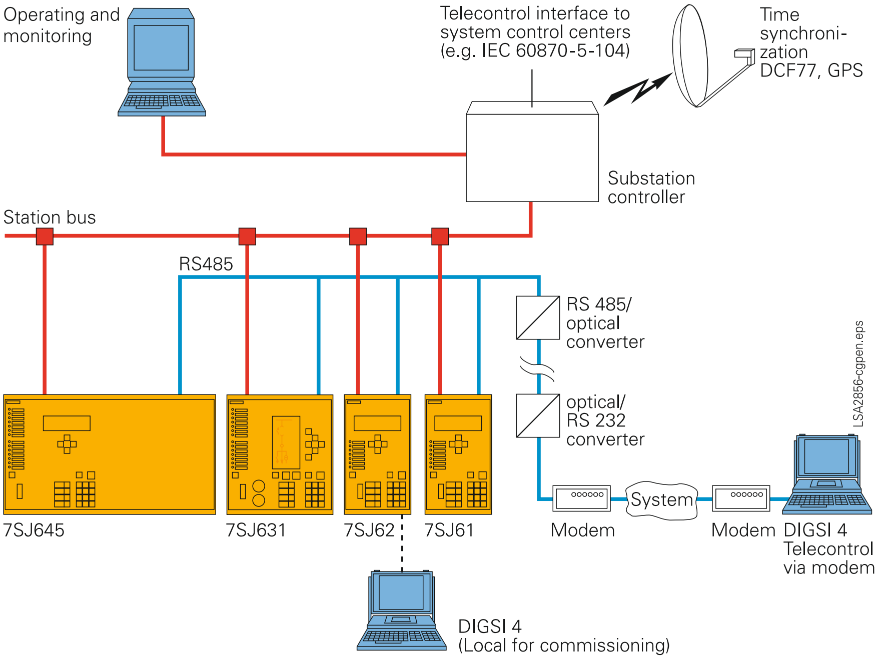


Fig. 5/90
System solution/communication

Fig. 5/89
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

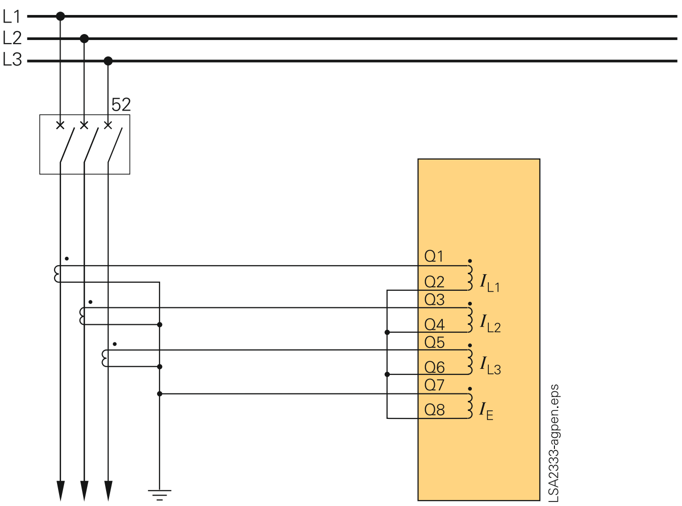


Fig. 5/91
Residual current circuit without directional element

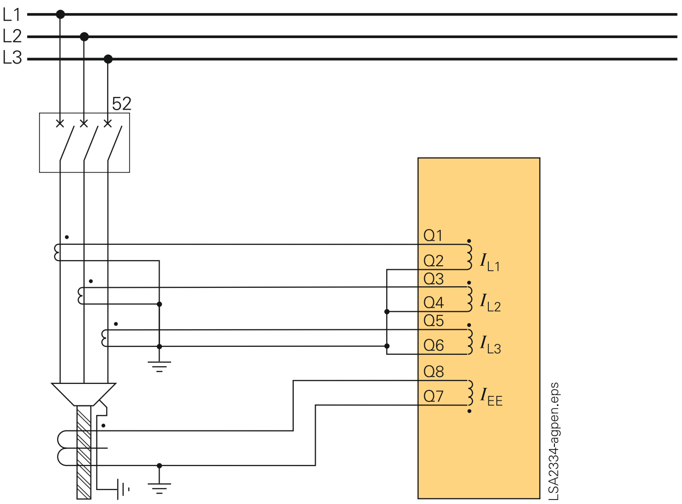


Fig. 5/92
Sensitive earth-current detection without directional element

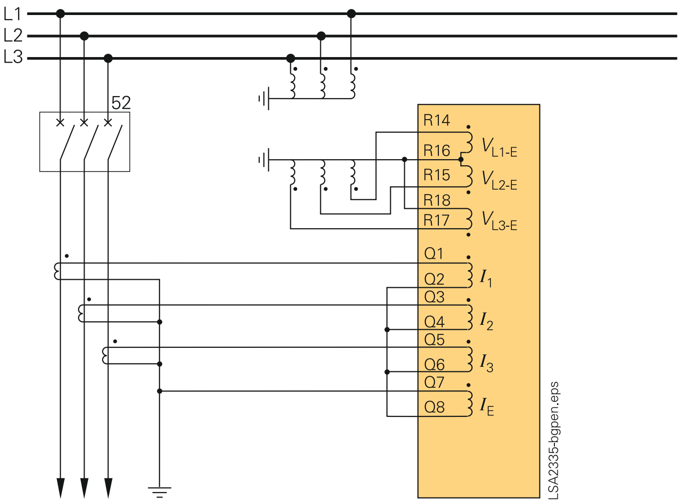


Fig. 5/93
Residual current circuit with directional element

Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the earth current. This connection maintains maximum precision for directional earth-fault detection and must be used in compensated networks.
Fig. 5/94 shows sensitive directional earth-fault detection.

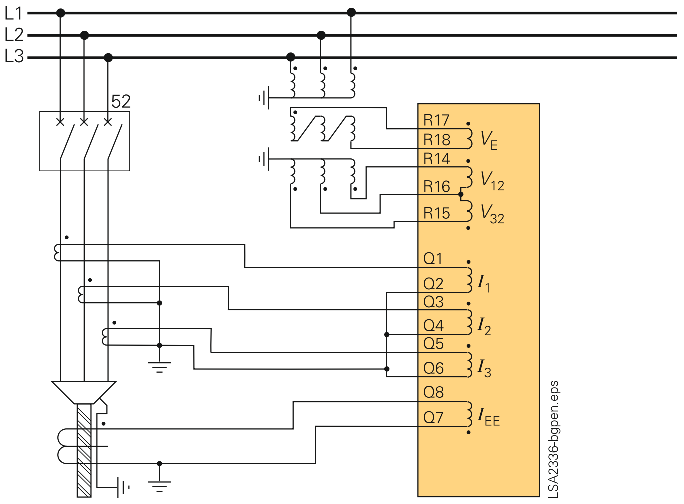


Fig. 5/94
Sensitive directional earth-fault detection with directional element for phases

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

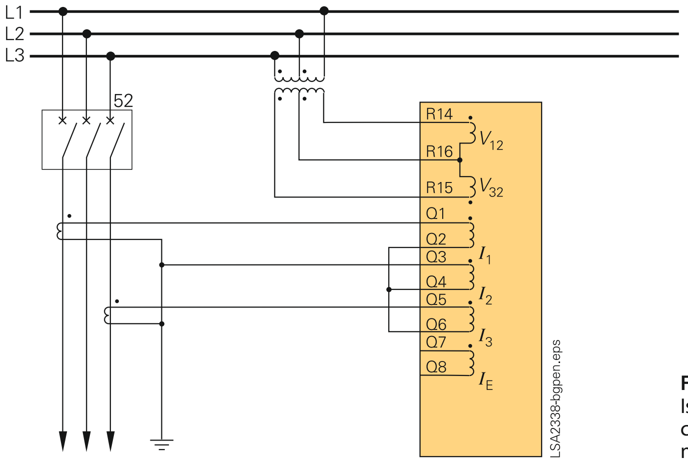


Fig. 5/95
Isolated-neutral or compensated networks

Connection for the synchro-check function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be checked for synchronism.

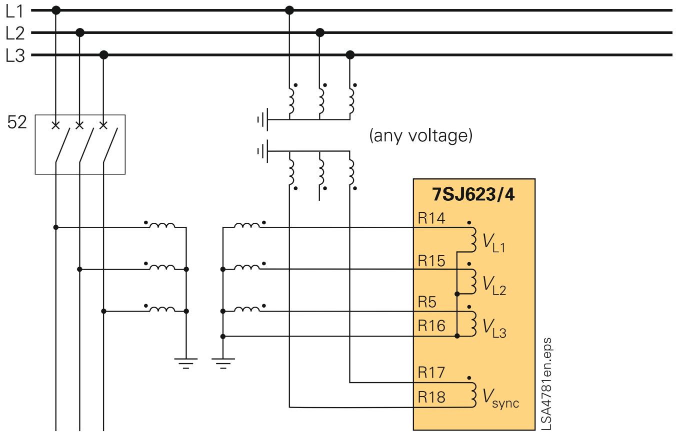


Fig. 5/96
Measuring of the busbar voltage and the outgoing feeder voltage for the synchro-check

Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current $> 0.05\ I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

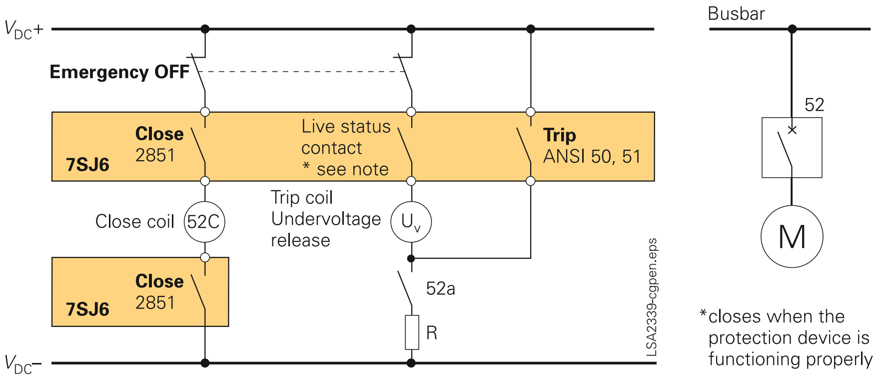
■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/97, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of network fault.



*closes when the protection device is functioning properly

Fig. 5/97 Undervoltage release with make contact (50, 51)

In Fig. 5/98 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

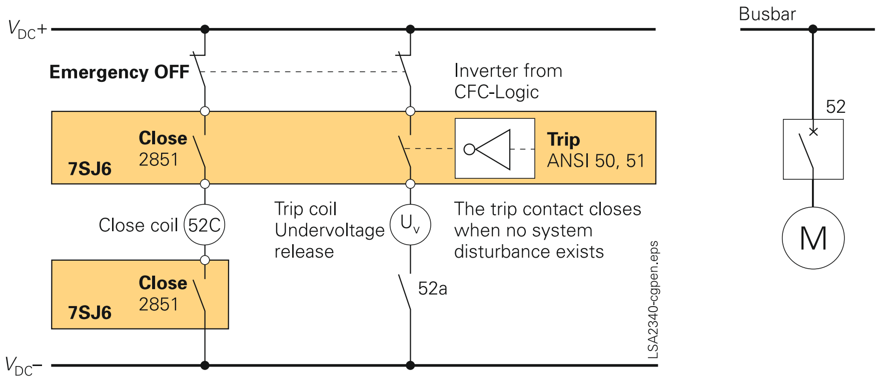


Fig. 5/98 Undervoltage trip with locking contact (trip signal 50 is inverted)

Typical applications

Trip circuit supervision (ANSI 74TC)

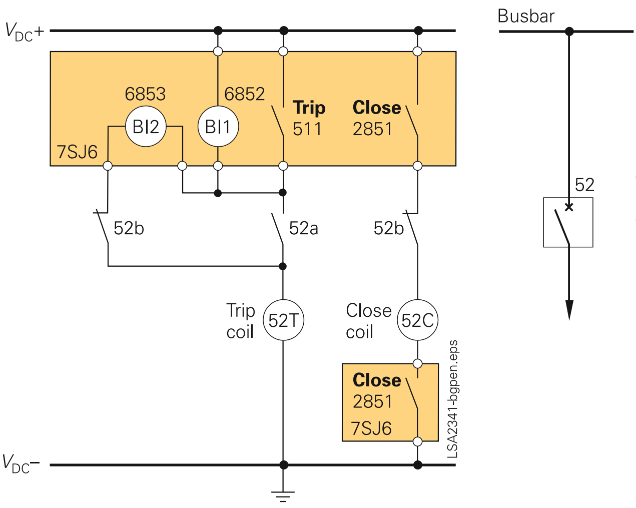
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional time-overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current. Reverse-power protection is performed via the "flexible protection functions" of the 7SJ62.



Protection indications

511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/99 Trip circuit supervision with 2 binary inputs

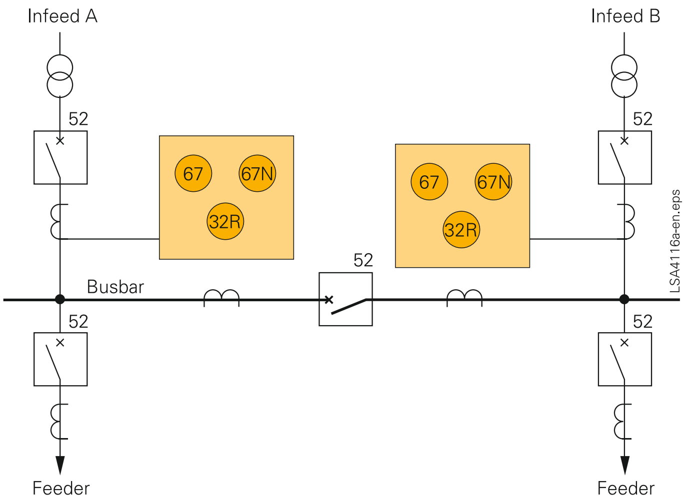


Fig. 5/100 Reverse-power protection for dual supply

Technical data

General unit data

Measuring circuits

System frequency	50 / 60 Hz (settable)

Current transformer

Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	$I_{EE} < 1.6$ A
Power consumption	
at $I_{nom} = 1$ A	Approx. 0.05 VA per phase
at $I_{nom} = 5$ A	Approx. 0.3 VA per phase
for sensitive earth-fault CT at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (effective)	100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT	
Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)

Voltage transformer

Type	7SJ621, 7SJ622	7SJ623, 7SJ622	7SJ625, 7SJ626
Number	3	4	4
Rated voltage V_{nom}	100 V to 225 V		
Measuring range	0 V to 170 V		
Power consumption at $V_{nom} = 100$ V	< 0.3 VA per phase		
Overload capability in voltage path (phase-neutral voltage)			
Thermal (effective)	230 V continuous		

Auxiliary voltage

Rated auxiliary voltage V_{aux}	DC AC	24/48 V	60/125 V	110/250 V 115/230 V	
Permissible tolerance	DC AC	19–58 V	48–150 V	88–300 V 92-138 V	 184–265 V
Ripple voltage, peak-to-peak	≤ 12 %				
Power consumption					
Quiescent	Approx. 4 W				
Energized	Approx. 7 W				
Backup time during loss/short circuit of auxiliary voltage	≥ 50 ms at V ≥ 110 V DC ≥ 20 ms at V ≥ 24 V DC ≥ 200 ms at 115 V/230 V AC				

Binary inputs/indication inputs

Type	7SJ621, 7SJ623, 7SJ625	7SJ622, 7SJ624, 7SJ626
Number	8	11
Voltage range	24–250 V DC	
Pickup threshold modifiable by plug-in jumpers		
Pickup threshold	19 V DC	88 V DC
For rated control voltage	24/48/60/ 110/125 V	110/125/ 220/250 V DC
Response time/drop-out time	Approx. 3.5	
Power consumption energized	1.8 mA (independent of operating voltage)	

Binary outputs/command outputs

Type	7SJ621, 7SJ623, 7SJ625	7SJ622 7SJ624 7SJ626
Command/indication relay	8	6
Contacts per command/ indication relay	1 NO / form A (Two contacts changeable to NC/form B, via jumpers)	
Live status contact	1 NO / NC (jumper) / form A/B	
Switching capacity		
Make	1000 W / VA	
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms	
Switching voltage	≤ 250 V DC	
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles	

Electrical tests

Specification

Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508

Insulation tests

Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min

Technical data

EMC tests for interference immunity; *type tests (cont'd)*

High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

EMC tests for interference emission; *type tests*

Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 g, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes

During transportation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 g acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 g, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 g, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C /-13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C /-4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C /+131 °F)	-5 °C to +55 °C /+25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C /-13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C /-13 °F to +158 °F

Humidity

Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design

Housing	7XP20
Dimensions	See dimension drawings, part 15
Weight	
Surface-mounting housing	4.5 kg
Flush-mounting housing	4.0 kg
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	Front: IP 51, rear: IP 20;
Operator safety	IP 2x with cover

Technical data

Serial interfaces

Operating interface (front of unit)

Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud

Service/modem interface (rear of unit)

Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

System interface (rear of unit)

IEC 60870-5-103 protocol

Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

IEC 60870-5-103 protocol, redundant

RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

IEC 61850 protocol

Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection	Two RJ45 connectors
For flush-mounting housing/ surface-mounting housing with detached operator panel	mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Intergr. LC connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles

PROFIBUS-FMS/DP

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/136
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles

MODBUS RTU, ASCII, DNP 3.0

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud

Technical data

System interface (rear of unit) (cont'd)

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Test voltage	500 V AC against earth

Fiber-optic

Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/136
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions

Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)

Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)	
Number of elements (stages)	$I>$, $I>>$, $I>>>$ (phases) $I_E>$, $I_E>>$, $I_E>>>$ (earth)	
Setting ranges		
Pickup phase elements	0.5 to 175 A or ∞ 1) (in steps of 0.01 A)	
Pickup earth elements	0.25 to 175 A or ∞ 1) (in steps of 0.01 A)	
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)	
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)	
Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)		
	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$	
Tolerances		
Pickup	2 % of setting value or 50 mA 1)	
Delay times T, T_{DO}	1 % or 10 ms	

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)

Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞ 1) (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞ 1) (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Undervoltage threshold $V<$ for release I_p	10.0 to 125.0 V (in steps of 0.1 V)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA 1)
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

Direction detection

For phase faults

Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase

For earth faults

Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative-sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current 1)
Tolerances (phase angle error under reference conditions)	
For phase and earth faults	± 3 ° electrical

---

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Inrush blocking

Influenced functions	Time-overcurrent elements, $I>$, $I_E>$, I_p, I_{Ep} (directional, non-directional)
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA[1]
Lower function limit earth	Earth current (50 Hz and 100 Hz) ≥ 125 mA[1]
Upper function limit (setting range)	1.5 to 125 A[1] (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF

Dynamic setting change

Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) earth-fault detection (ANSI 64, 50 Ns, 51Ns, 67Ns)

Displacement voltage starting for all types of earth fault (ANSI 64)

Setting ranges	
Pickup threshold $V_E>$ (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_0>$ (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay\ pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 50 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms

Phase detection for earth fault in an unearthed system

Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{ph\ min}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph\ max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V

Earth-fault pickup for all types of earth faults

Definite-time characteristic (ANSI 50Ns)

Setting ranges	
Pickup threshold $I_{EE}>$, $I_{EE}>>$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] (in steps of 0.01 A)
Delay times T for $I_{EE}>$, $I_{EE}>>$	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95

Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1]
Delay times	1 % of setting value or 20 ms

Earth-fault pickup for all types of earth faults

Inverse-time characteristic (ANSI 51Ns)

User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1] (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1]
Delay times in linear range	7 % of reference value for $2 \leq I/I_{EEp} \leq 20$ + 2 % current tolerance, or 70 ms
Logarithmic inverse	Refer to the manual
Logarithmic inverse with knee point	Refer to the manual

Direction detection for all types of earth-faults (ANSI 67Ns)

Measuring method "cos φ / sin φ"	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1] (in steps of 0.01 A)
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Reduction of dir. area $\alpha_{Red.dir.area}$	1 ° to 15 ° (in steps of 1 °)
Tolerances	
Pickup measuring enable	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1]
Angle tolerance	3 °
Measuring method "φ (V_0 / I_0)"	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Minimum voltage V_{min}, measured	0.4 to 50 V (in steps of 0.1 V)
Minimum voltage V_{min}, calculated	10 to 90 V (in steps of 1 V)
Phase angle φ	- 180° to 180° (in steps of 0.1°)
Delta phase angle $\Delta\varphi$	0° to 180° (in steps of 0.1°)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Angle tolerance	3 °

Angle correction for cable CT

Angle correction F1, F2	
Current value I_1, I_2	0 ° to 5 ° (in steps of 0.1 °)
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] (in steps of 0.01 A)

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

---

[1] For I_{nom} = 1 A, all limits divided by 5.

Technical data

High-impedance restricted earth-fault protection *(ANSI 87N) / single-phase overcurrent protection*

Setting ranges	
Pickup thresholds $I>$, $I>>$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times $T_I>$, $T_I>>$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

Intermittent earth-fault protection

Setting ranges		
Pickup threshold		
For I_E	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE}	$I_{IE}>$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)
Times		
Pickup times		
Current = 1.25 · pickup value		Approx. 30 ms
Current ≥ 2 · pickup value		Approx. 22 ms
Dropout time		Approx. 22 ms
Tolerances		
Pickup threshold $I_{IE}>$		3 % of setting value, or 50 mA[1]
Times T_V, T_{sum}, T_{res}		1 % of setting value or 10 ms

Thermal overload protection *(ANSI 49)*

Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$

t = Tripping time
τ_{th} = Temperature rise time constant

I = Load current
I_{pre} = Preload current
k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8
I_{nom} = Rated (nominal) current of the protection relay

Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

Auto-reclosure *(ANSI 79)*

Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
$I>>>$, $I>>$, $I>$, I_p, $I_{dir}>>$, $I_{dir}>$, I_{pdir}
$I_E>>>$, $I_E>>$, $I_E>$, I_{Ep}, $I_{Edir}>>$, $I_{Edir}>$, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

---

1) For I_{nom} = 1 A, all limits divided by 5.

Technical data

Breaker failure protection (ANSI 50 BF)

Setting ranges	
Pickup thresholds	0.2 to 5 A$^{1)}$ (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)$^{1)}$
Delay time	1 % or 20 ms

Synchro- and voltage check (ANSI 25)

Operating mode	• Synchro-check
Additional release conditions	• Live-bus / dead line • Dead-bus / live-line • Dead-bus and dead-line • Bypassing
Voltages	
Max. operating voltage V_{max}	20 to 140 V (phase-to-phase) (in steps of 1 V)
Min. operating voltage V_{min}	20 to 125 V (phase-to-phase) (in steps of 1 V)
V< for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)
V> for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)
Primary rated voltage of transformer $V2_{nom}$	0.1 to 800 kV (in steps of 0.01 kV)
Tolerances	2 % of pickup value or 2 V
Drop-off to pickup ratios	approx. 0.9 (V>) or 1.1 (V<)
ΔV-measurement	
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)
Tolerance	1 V
Δf-measurement	
Δf-measurement ($f2$>$f1$; $f2$<$f1$)	0.01 to 2 Hz (in steps of 0.01 Hz)
Tolerance	15 mHz
$\Delta\alpha$-measurement	
$\Delta\alpha$-measurement ($\alpha2$>$\alpha1$; $\alpha2$>$\alpha1$)	2 ° to 80 ° (in steps of 1 °)
Tolerance	2 °
Max. phase displacement	5 ° for $\Delta f \leq$ 1 Hz 10 ° for Δf > 1 Hz
Adaptation	
Vector group adaptation by angle	0 ° to 360 ° (in steps of 1 °)
Different voltage transformers V_1/V_2	0.5 to 2 (in steps of 0.01)
Times	
Minimum measuring time	Approx. 80 ms
Max. duration $T_{SYN\ DURATION}$	0.01 to 1200 s; ∞ (in steps of 0.01 s)
Supervision time $T_{SUP\ VOLTAGE}$	0 to 60 s (in steps of 0.01 s)
Closing time of CB $T_{CB\ close}$	0 to 60 s (in steps of 0.01 s)
Tolerance of all timers	1 % of setting value or 10 ms
Measuring values of synchro-check function	
Reference voltage $V1$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Voltage to be synchronized $V2$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Frequency of $V1$ and $V2$	$f1$, $f2$ in Hz
Range	f_N ± 5 Hz
Tolerance*)	20 mHz
Voltage difference ($V2 - V1$)	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Frequency difference ($f2 - f1$)	In mHz
Range	f_N ± 5 Hz
Tolerance*)	20 mHz
Angle difference ($\alpha2 - \alpha1$)	In °
Range	0 to 180 °
Tolerance*)	0.5 °

Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R)

Operating modes / measuring quantities	
3-phase	I, I_1, I_2, I_2/I_1, $3I_0$, V, V_1, V_2, $3V_0$, dV/dt, P, Q, cos φ
1-phase	I, I_E, $I_{E\ sens.}$, V, V_E, P, Q, cos φ
Without fixed phase relation	f, df/dt, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current I, I_1, I_2, $3I_0$, I_E	0.15 to 200 A$^{1)}$ (in steps of 0.01 A)
Current ratio I_2/I_1	15 to 100 % (in steps of 1 %)
Sens. earth curr. $I_{E\ sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
Voltages V, V_1, V_2, $3V_0$	2 to 260 V (in steps of 0.1 V)
Displacement voltage V_E	2 to 200 V (in steps of 0.1 V)
Power P, Q	0.5 to 10000 W (in steps of 0.1 W)
Power factor (cos φ)	- 0.99 to + 0.99 (in steps of 0.01)
Frequency f_N = 50 Hz	40 to 60 Hz (in steps of 0.01 Hz)
f_N = 60 Hz	50 to 70 Hz (in steps of 0.01 Hz)
Rate-of-frequency change df/dt	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
Voltage change dV/dt	4 V/s to 100 V/s (in steps of 1 V/s)
Dropout ratio >- stage	1.01 to 3 (insteps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Dropout differential f	0.02 to 1.00 Hz (in steps of 0.01 Hz)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	
Current, voltage (phase quantities)	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Current, voltages (symmetrical components)	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Power	
Typical	Approx. 120 ms
Maximum (low signals and thresholds)	Approx. 350 ms
Power factor	300 to 600 ms
Frequency	Approx. 100 ms
Rate-of-frequency change	
With 1.25 times the setting value	Approx. 220 ms
Voltage change dV/dt	
For 2 times pickup value	Approx. 220 ms
Binary input	Approx. 20 ms

*) With rated frequency.

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R) (cont'd)

Dropout times	
Current, voltage (phase quantities)	< 20 ms
Current, voltages (symmetrical components)	< 30 ms
Power	
Typical	< 50 ms
Maximum	< 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Rate-of-frequency change	< 200 ms
Voltage change	< 220 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Current	0.5 % of setting value or 50 mA 1)
Current (symmetrical components)	1 % of setting value or 100 mA 1)
Voltage	0.5 % of setting value or 0.1 V
Voltage (symmetrical components)	1 % of setting value or 0.2 V
Power	1 % of setting value or 0.3 W
Power factor	2 degrees
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Rate-of-frequency change	5 % of setting value or 0.05 Hz/s
Voltage change dV/dt	5 % of setting value or 1.5 V/s
Times	1 % of setting value or 10 ms

Negative-sequence current detection (ANSI 46)

Definite-time characteristic (ANSI 46-1 and 46-2)

Setting ranges	
Pickup current $I_2>$, $I_2>>$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A 1)
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA 1)
Delay times	1 % or 10 ms

Inverse-time characteristic (ANSI 46-TOC)

Setting ranges	
Pickup current	0.5 to 10 A 1) (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A 1)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA 1)
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A 1) (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A 1) (in steps of 0.01)
Permissible starting time $T_{STARTUP}$, cold motor	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP}$, warm motor	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I >$ $I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA 1)
Delay time	5 % or 30 ms

Load jam protection for motors (ANSI 51M)

Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A 1) (in steps 0.01 A)
Delay times	0 to 600 s (in steps 0.01 s)
Blocking duration after CLOSE signal detection	0 to 600 s (in steps 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA 1)
Delay time	1 % of setting value or 10 ms

Restart inhibit for motors (ANSI 66)

Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A 1) (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k\tau$ RUNNING	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state

---

1) For I_{nom} = 1 A, all limits divided by 5.

Technical data

Undercurrent monitoring (ANSI 37)

Signal from the operational measured values	Predefined with programmable logic

Temperature monitoring box (ANSI 38)

Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Undervoltage protection (ANSI 27)

Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$ dependent on voltage connection and chosen measuring quantity	10 to 120 V (in steps of 1 V) 10 to 210 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A[1] (in steps of 0.01 A)
Times	
Pickup times	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overvoltage protection (ANSI 59)

Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or negative phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$ dependent on voltage connection and chosen measuring quantity	40 to 260 V (in steps of 1 V) 40 to 150 V (in steps of 1 V) 2 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times V	Approx. 50 ms
Pickup times V_1, V_2	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Frequency protection (ANSI 81)

Number of frequency elements	4
Setting ranges	
Pickup thresholds for $f_{nom} = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
Pickup thresholds for $f_{nom} = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Dropout differential = |pickup threshold - dropout threshold|	0.02 Hz to 1.00 Hz (in steps of 0.01 Hz)
Delay times	
Undervoltage blocking, with positive-sequence voltage V_1	0 to 100 s or ∞ (in steps of 0.01 s) 10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 150 ms
Dropout times	Approx. 150 ms
Dropout	
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms

Fault locator (ANSI 21FL)

Output of the fault distance	in Ω primary and secondary, in km or miles line length, in % of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km[1] (in steps of 0.0001) 0.001 to 3 Ω/mile[1] (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for $30° \leq \varphi K \leq 90°$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions

Operational measured values

Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range	10 to 200 % I_{nom}
Tolerance[2]	1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages V_{L1-E}, V_{L2-E}, V_{L3-E} Phase-to-phase voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance[2]	1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range	0 to 120 % S_{nom}
Tolerance[2]	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %
P, active power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}

---

1) For I_{nom} = 1 A, all limits divided by 5.

2) At rated frequency.

Technical data

Operational measured values (cont'd)

Range Tolerance2)	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert \cos\varphi \rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range Tolerance2)	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert \sin\varphi \rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
cos φ, power factor (p.f.)	Total and phase segregated
Range Tolerance2)	- 1 to + 1 2 % for $\lvert \cos\varphi \rvert \geq 0.707$
Frequency f	In Hz
Range Tolerance2)	f_{nom} ± 5 Hz 20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance2)	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\ Trip}$	In %
Range Tolerance2)	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\ Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\ real}$, $I_{EE\ reactive}$	In A (kA) primary and in mA secondary
Range Tolerance2)	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"

Long-term averages

Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages of currents of real power of reactive power of apparent power	 I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAr (kVAr, MVAr) S_{dmd} in VAr (kVAr, MVAr)

Max. / Min. report

Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	$V_{L1\text{-}E}$, $V_{L2\text{-}E}$, $V_{L3\text{-}E}$ V_1 (positive-sequence component) $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$
Min./Max. values for power	S, P, Q, cos φ, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}

Local measured values monitoring

Current asymmetry	I_{max}/I_{min} > balance factor, for I>$I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for V>V_{lim}
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC

Fuse failure monitor

For all network types	With the option of blocking affected protection functions

Fault recording

Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

Time stamping

Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge

Oscillographic fault recording

Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 samples/cycle) 1 sample/1.04 ms (16 samples/cycle)

Energy/power

Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance1)	≤ 2 % for $I > 0.1\ I_{nom}$, $V > 0.1\ V_{nom}$ and $\lvert \cos\varphi \rvert$ (p.f.) ≥ 0.707

Statistics

Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits

1) At I_{nom} = 1 A, all limits multiplied with 5.

2) At rated frequency.

Technical data

Circuit-breaker wear

Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication

Motor statistics

Total number of motor start-ups	0 to 9999	(resolution 1)
Total operating time	0 to 99999 h	(resolution 1 h)
Total down-time	0 to 99999 h	(resolution 1 h)
Ratio operating time/down-time	0 to 100 %	(resolution 0.1 %)
Active energy and reactive energy	See operational measured values	
Motor start-up data:	Of the last 5 start-ups	
– Start-up time	0.30 s to 9999.99 s	(resolution 10 ms)
– Start-up current (primary)	0 A to 1000 kA	(resolution 1 A)
– Start-up voltage (primary)	0 V to 100 kV	(resolution 1 V)

Operating hours counter

Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})

Trip circuit monitoring

With one or two binary inputs

Commissioning aids

Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report

Clock

Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication

Setting group switchover of the function parameters

Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

Control

Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

c UL us
LISTED

Selection and ordering data

Description	Order No.
7SJ62 multifunction protection relay	*7SJ62☐☐ – ☐☐☐☐☐ – ☐☐☐☐*
Housing, inputs, outputs	
Housing 1/3 19”, 4 line text display, 3 x *U*, 4 x *I*, 8 BI, 8 BO, 1 live status-contact	*1*
Housing 1/3 19”, 4 line text display, 3 x *U*, 4 x *I*, 11 BI, 6 BO, 1 live status-contact	*2*
Housing 1/3 19”, 4 line text display, 4 x *U*, 4 x *I*, 8 BI, 8 BO, 1 live status-contact	*3*
Housing 1/3 19”, 4 line text display, 4 x *U*, 4 x *I*, 11 BI, 6 BO, 1 live status-contact	*4*
Housing 1/2 19”, graphic display, 4 x *U*, 4 x *I*, 8 BI, 8 BO, 1 live status contact 7)	*5*
Housing 1/2 19”, graphic display, 4 x *U*, 4 x *I*, 11 BI, 6 BO, 1 live status contact 7)	*6*
Measuring inputs (3 x V / 4 x V, 4 x I)	
I_{ph} = 1 A 1), I_e = 1 A 1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	*1*
I_{ph} = 1 A 1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*2*
I_{ph} = 5 A 1), I_e = 5 A 1) (min. = 0.25 A) Position 15 only with *A, C, E, G*	*5*
I_{ph} = 5 A 1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*6*
I_{ph} = 5 A 1), I_e = 1 A 1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	*7*
Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 DC 3)	*2*
60 to 125 V DC 2), threshold binary input 19 DC 3)	*4*
110 to 250 V DC 2), 115 to 230 V 4) AC, threshold binary input 88 V DC 3)	*5*
110 to 250 V DC 2), 115 to 230 V 4) AC, threshold binary input 176 V DC 3)	*6*
Unit version	
For panel surface mounting, two-tier terminal top/bottom	*B*
For panel flush mounting, plug-in terminal, (2/3 pin connector)	*D*
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	*E*
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	*A*
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	*B*
Region US, 60 Hz, ANSI, language: English (US), selectable	*C*
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	*D*
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	*E*
Region IT, 50/60 Hz, IEC/ANSI, language: Italian (language selectable)	*F*
Region RU, 50/60 Hz, IEC/ANSI, language: Russian(language can be changed)	*G*
System interface (Port B): Refer to page 5/114	
No system interface	*0*
Protocols see page 5/114	
Service interface (Port C)	
No interface at rear side	*0*
DIGSI 4/modem, electrical RS232	*1*
DIGSI 4/modem/RTD-box 5), electrical RS485	*2*
DIGSI 4/modem/RTD-box 5)6), optical 820 nm wave length, ST connector	*3*
Measuring/fault recording	
Fault recording	*1*
Slave pointer, mean values, min/max values, fault recording	*3*

see next page

---

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected per binary input by means of jumpers.

4) 230 V AC, starting from device version …/EE.

5) Temperature monitoring box 7XV5662-☐AD10, refer to “Accessories”.

6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0☐A00 is required.

7) starting from device version .../GG and FW-Version V4.82

Selection and ordering data

Description	Order No.
7SJ62 multifunction protection relay	*7SJ62*□□ – □□□□□ – □□□□

Designation				ANSI No.	Description			
Basic version					Control			
				50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p			
				50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}			
				50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)			
				50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$			
				51 V	Voltage-dependent inverse-time overcurrent protection			
				49	Overload protection (with 2 time constants)			
				46	Phase balance current protection (negative-sequence protection)			
				37	Undercurrent monitoring			
				47	Phase sequence			
				59N/64	Displacement voltage			
				50BF	Breaker failure protection			
				74TC	Trip circuit supervision			
					4 setting groups, cold-load pickup			
					Inrush blocking			
				86	Lockout			
■			V, P, f	27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency			
				27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F*	*E*	
■		IEF	V, P, f	27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency			
				27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection			
					Intermittent earth fault	*P*	*E*	
■	Dir			67/67N	Direction determination for overcurrent, phases and earth	*F*	*C*	
■	Dir		V, P, f	67/67N	Direction determination for overcurrent, phases and earth			
				27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency			
				27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F*	*G*	
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth			
					Intermittent earth fault	*P*	*C*	
Directional earth-fault detection ■	Dir			67/67N	Direction determination for overcurrent, phases and earth			
				67Ns	Directional sensitive earth-fault detection			
				87N	High-impedance restricted earth fault	*F*	*D*	*2)*
Directional earth-fault detection ■			V, P, f	67Ns	Directional sensitive earth-fault detection			
				87N	High-impedance restricted earth fault			
				27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency			
				27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F*	*F*	*2)*
Directional earth-fault detection ■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth			
				67Ns	Directional sensitive earth-fault detection			
				87N	High-impedance restricted earth fault			
					Intermittent earth fault	*P*	*D*	*2)*

Continued on next page

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Selection and ordering data

Description	Order No.	Order code
7SJ62 multifunction protection relay	*7SJ62□□ – □□□□□ – □□□□–□□□□*	

Designation	ANSI No.	Description	
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
	50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
	51 V	Voltage-dependent inverse-time overcurrent protection	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	37	Undercurrent monitoring	
	47	Phase sequence	
	59N/64	Displacement voltage	
	50BF	Breaker failure protection	
	74TC	Trip circuit supervision	
		4 setting groups, cold-load pickup	
		Inrush blocking	
	86	Lockout	
Directional earth-fault detection ■	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	*F B* 2)
Directional earth-fault detection ■ Motor V, P, f	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H F* 2)
Directional earth-fault detection Motor Dir V, P, f	67/67N	Direction determination for overcurrent, phases and earth	
	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H H* 2)
Directional earth-fault detection ■ Motor IEF Dir V, P, f	67/67N	Direction determination for overcurrent, phases and earth	
	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	
		Intermittent earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	
	27/59	Undervoltage/overvoltage	
	81O/U	Underfrequency/overfrequency	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*R H* 2)

Continued on next page

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Selection and ordering data

Description	Order No.	Order code
7SJ62 multifunction protection relay	*7SJ62□□ – □□□□□ – □□□□–□□□□*	

Designation		ANSI No.	Description	
Basic version			Control	
		50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
		50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
		50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
		50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
		51 V	Voltage-dependent inverse-time overcurrent protection	
		49	Overload protection (with 2 time constants)	
		46	Phase balance current protection (negative-sequence protection)	
		37	Undercurrent monitoring	
		47	Phase sequence	
		59N/64	Displacement voltage	
		50BF	Breaker failure protection	
		74TC	Trip circuit supervision	
			4 setting groups, cold-load pickup	
			Inrush blocking	
		86	Lockout	
■	Motor Dir V, P, f	67/67N	Direction determination for overcurrent, phases and earth	
		48/14	Starting time supervision, locked rotor	
		66/86	Restart inhibit	
		51M	Load jam protection, motor statistics	
		27/59	Under-/overvoltage	
		81O/U	Under-/overfrequency	
		27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H G*
■	Motor	48/14	Starting time supervision, locked rotor	
		66/86	Restart inhibit	
		51M	Load jam protection, motor statistics	*H A*
ARC, fault locator, synchro-check			Without	*0*
		79	With auto-reclosure	*1*
		21FL	With fault locator	*2*
		79, 21FL	With auto-reclosure, with fault locator	*3*
		25	With synchro-check 4)	*4* 5)
		25, 79, 21FL	With synchro-check 4), auto-reclosure, fault locator	*7* 5)
ATEX100 Certification For protection of explosion-protected motos (increased-safety type of protection "e"				*Z X 9 9* 3)

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

3) This variant will be supplied with a previous firmware version.

4) Synchro-check (no asynchronous switching), one function group; available only with devices 7SJ623 and 7SJ624

5) Ordering option only available for devices 7SJ623 and 7SJ624

Order number for system port B

Description	Order No.	Order code
7SJ62 multifunction protection relay	*7SJ62□□ – □□□□□ – □□□□–□□□*	
System interface (on rear of unit, Port B)		
No system interface	*0*	
IEC 60870-5-103 protocol, RS232	*1*	
IEC 60870-5-103 protocol, RS485	*2*	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	*3*	
PROFIBUS-FMS Slave, RS485	*4*	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector 1)	*5*	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector 1)	*6*	
PROFIBUS-DP Slave, RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector 1)	*9*	*L 0 B*
MODBUS, RS485	*9*	*L 0 D*
MODBUS, 820 nm wavelength, ST connector 2)	*9*	*L 0 E*
DNP 3.0, RS485	*9*	*L 0 G*
DNP 3.0, 820 nm wavelength, ST connector 2)	*9*	*L 0 H*
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector 2)	*9*	*L 0 P*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) 2)	*9*	*L 0 S*

1) Not with position 9 = "*B*"; if 9 = "*B*", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "*B*".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "*B*".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00)

2) Not available with position 9 = "*B*"

Sample order

Position		Order No. + Order code
		7SJ6225-5EC91-3FC1+L0G
6	I/O's: 11 BI/6 BO, 1 live status contact	*2*
7	Current transformer: 5 A	*5*
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	*5*
9	Unit version: Flush-mounting housing, screw-type terminals	*E*
10	Region: US, English language (US); 60 Hz, ANSI	*C*
11	Communication: System interface: DNP 3.0, RS485	*9* *L0G*
12	Communication: DIGSI 4, electric RS232	*1*
13	Measuring/fault recording: Extended measuring and fault records	*3*
14/15	Protection function package: Basic version plus directional TOC	*FC*
16	With auto-reclosure	*1*

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition	
Basis: Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850: Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator	
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4	
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Temperature monitoring box	
24 to 60 V AC/DC	*7XV5662-2AD10*
90 to 240 V AC/DC	*7XV5662-5AD10*
Varistor/Voltage arrester	
Voltage arrester for high-impedance REF protection	
125 Vrms; 600 A; 1S/S 256	*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088	*C53207-A401-D77-1*
Connecting cable	
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit	
- length 5 m /16.4 ft	*7XV5103-7AA05*
- length 25 m /82 ft	*7XV5103-7AA25*
- length 50 m /164 ft	*7XV5103-7AA50*
Manual for 7SJ62	
English	*C53000-G1140-C207-x* 1)

---

1) x = please inquire for latest edition (exact Order No.).

Accessories

Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

---

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

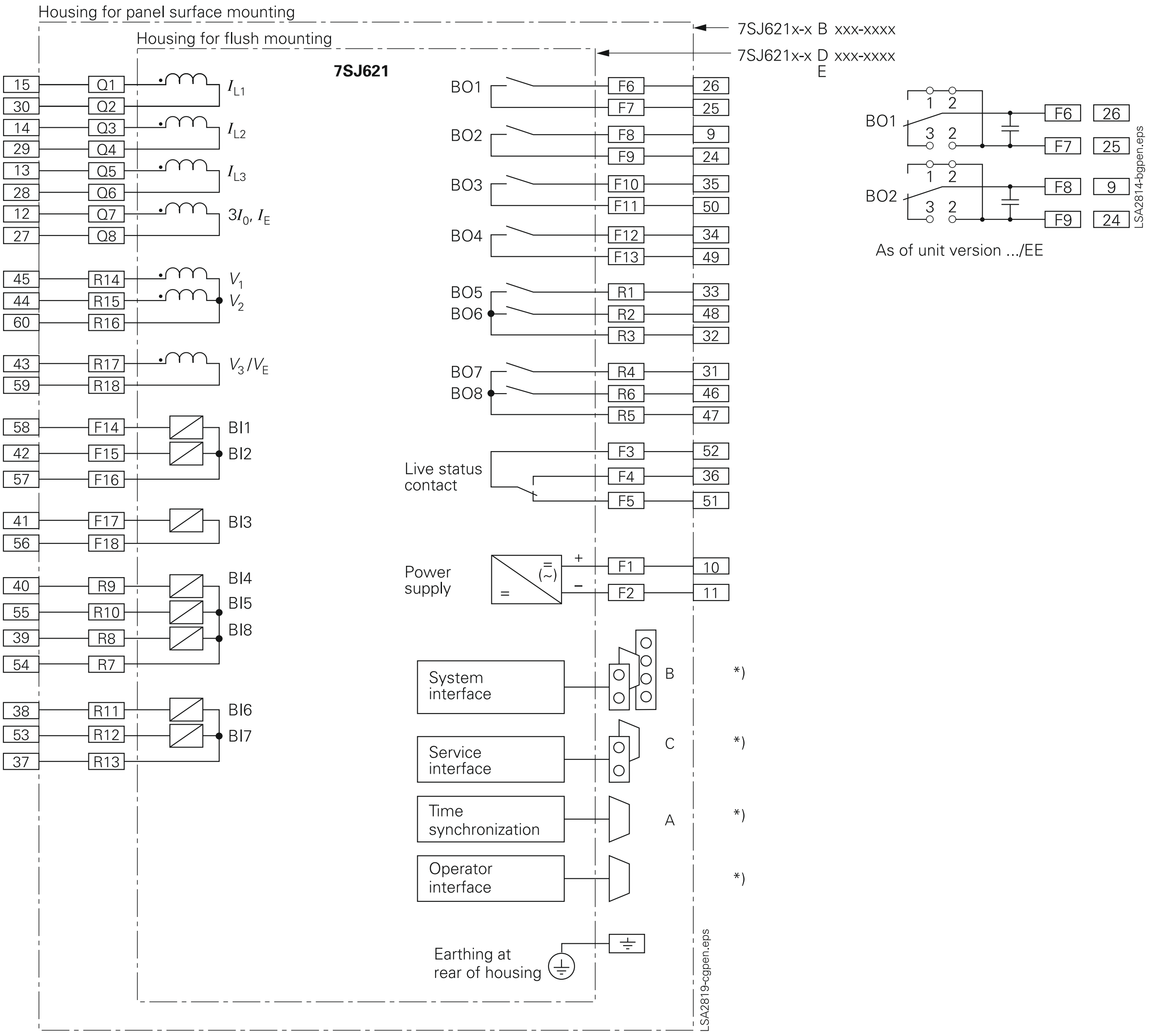
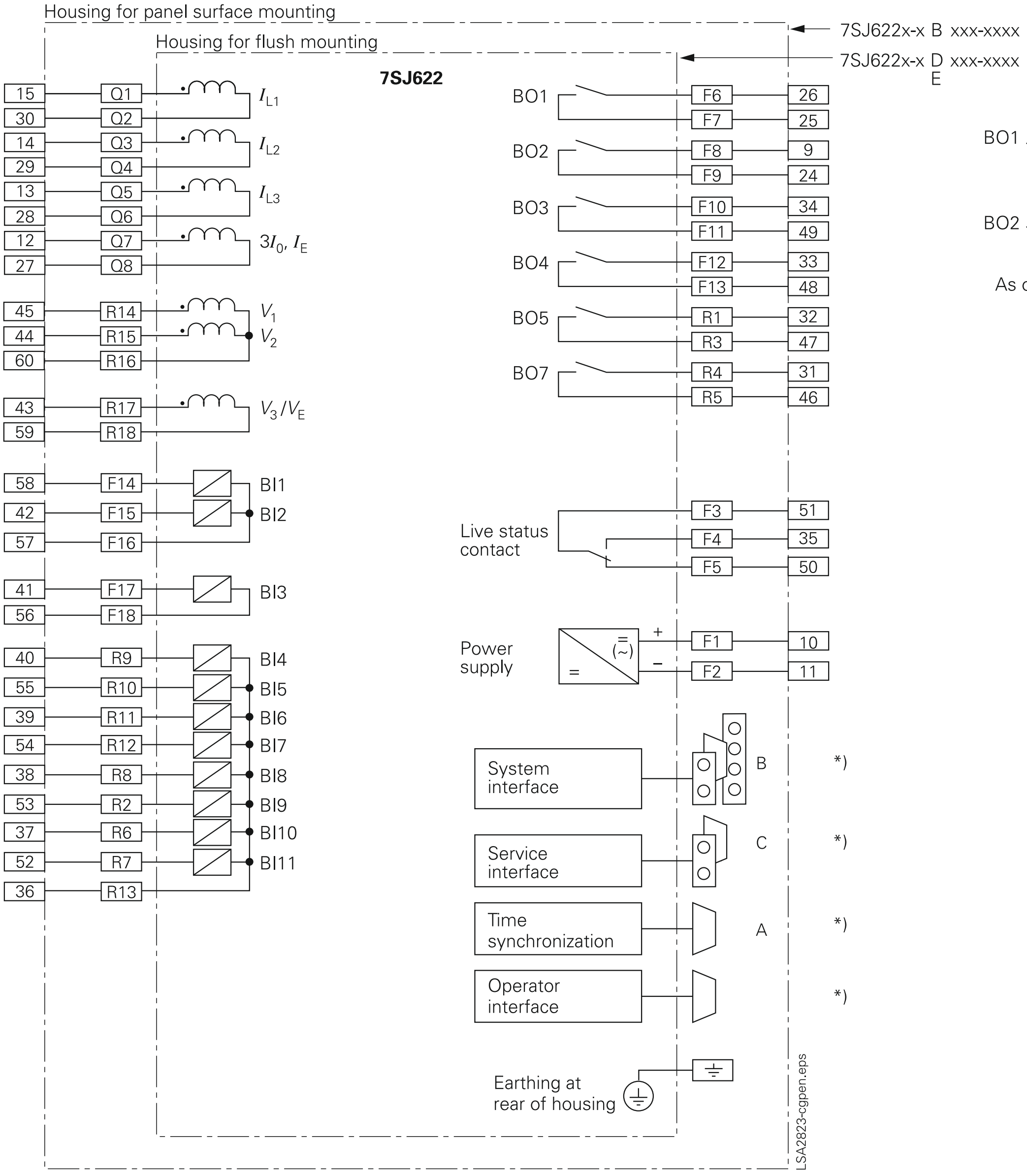


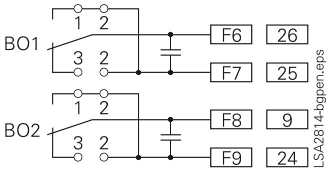
Fig. 5/101 7SJ621 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

Connection diagram





As of unit version .../EE

Fig. 5/102 7SJ622 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

Connection diagram

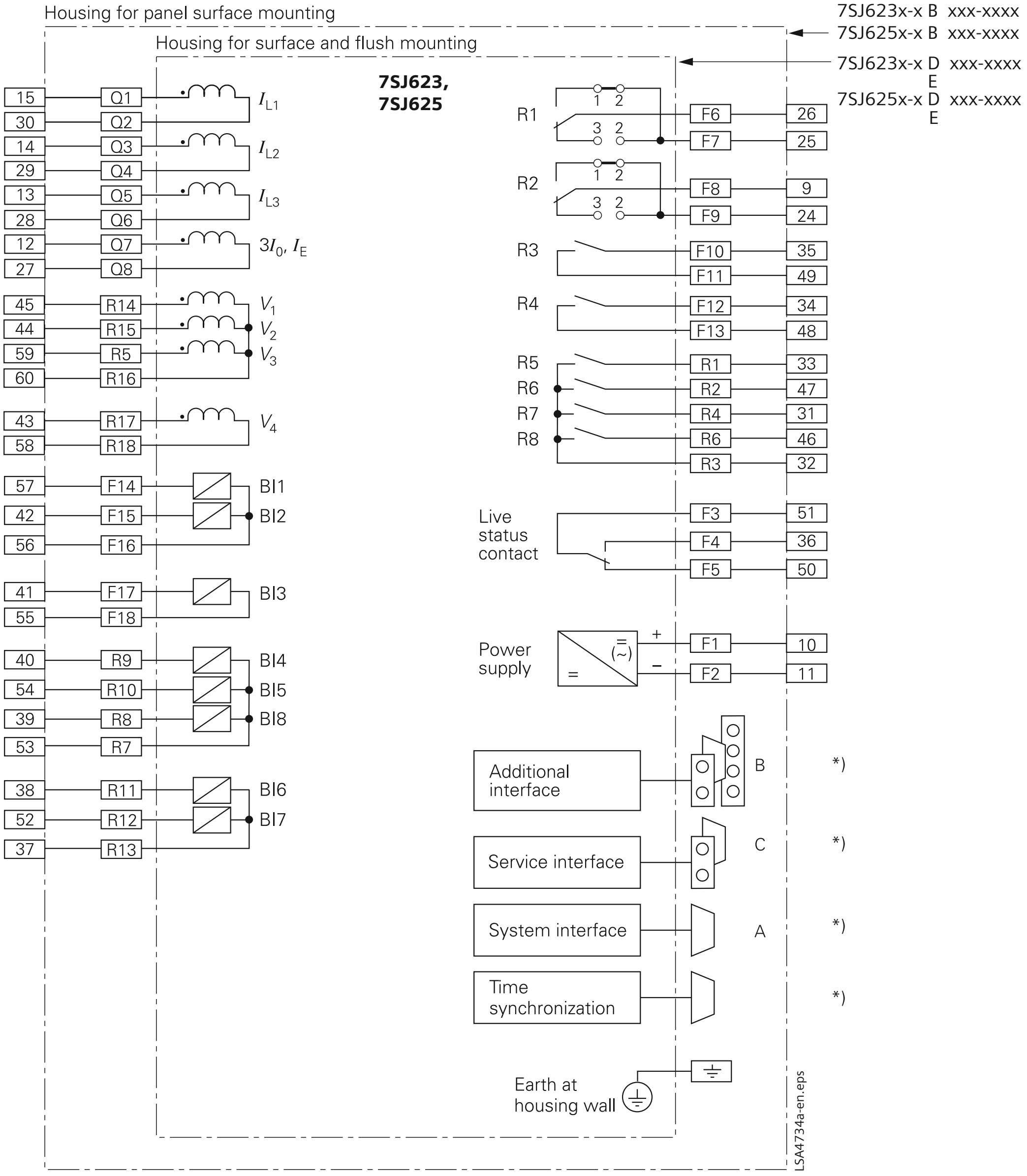


Fig. 5/103 7SJ623, 7SJ625 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version
refer to the manual (http://www.siemens.com/siprotec).

Connection diagram

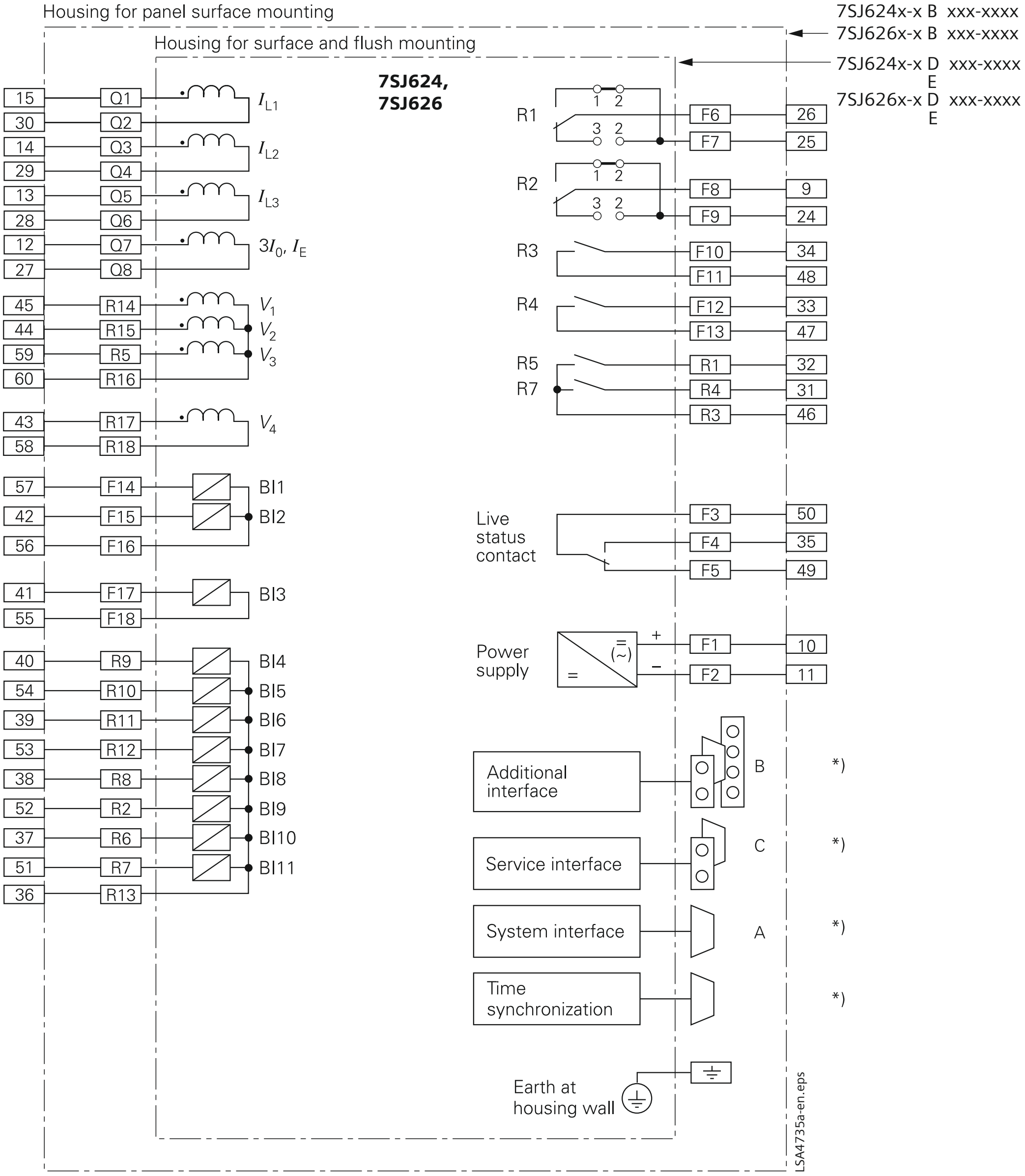


Fig. 5/104 7SJ624, 7SJ626 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

SIPROTEC 4 7SJ63 Multifunction Protection Relay

LSP2316-afpen.tif

Fig. 5/105
SIPROTEC 4 7SJ63 multifunction protection relay

Description

The SIPROTEC 4 7SJ63 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance earthed, unearthed, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. Regarding the time-overcurrent/directional time-overcurrent protection the characteristics can be either definite time, inverse time or user-defined.

The SIPROTEC 4 7SJ63 is equipped with motor protection applicable for asynchronous machines of all sizes. Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). The user is able to generate user-defined messages as well.

Function overview

Protection functions

- Time-overcurrent protection (definite-time/inverse-time/user-def.)
- Directional time-overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive dir./non-dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

Monitoring functions

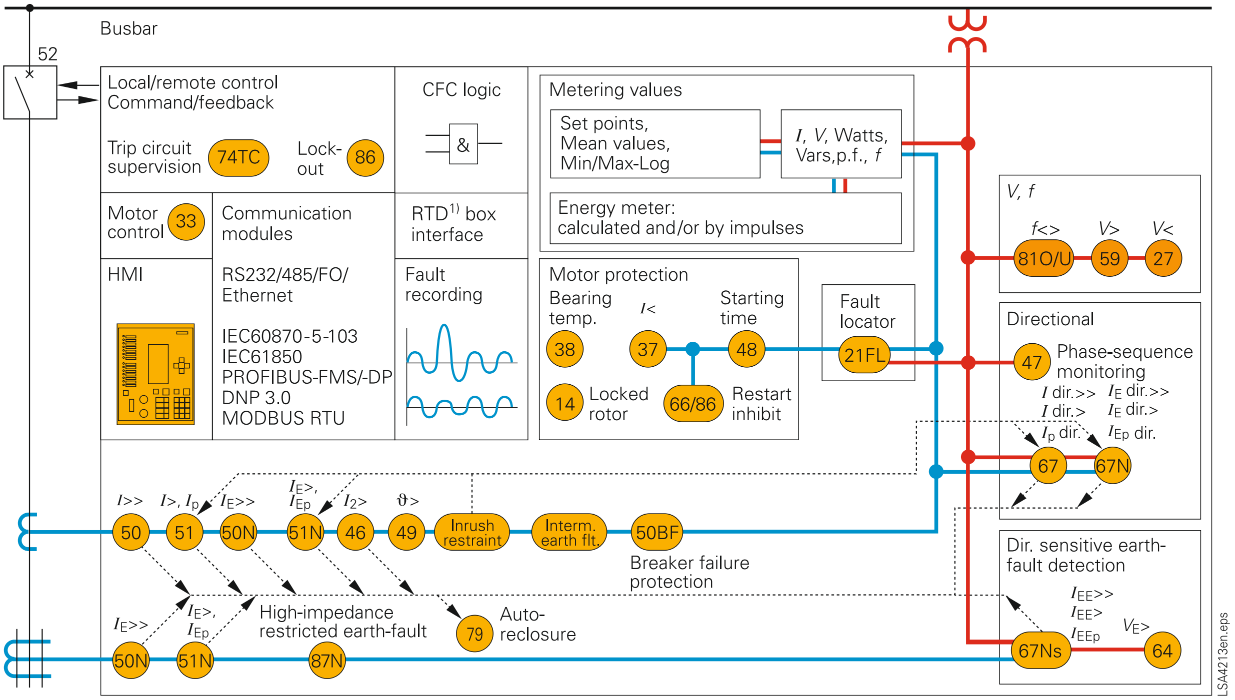
- Operational measured values V, I, f,...
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records

Communication interfaces

- System interface
  – IEC 60870-5-103, IEC 61850
  – PROFIBUS-FMS /-DP
  – DNP 3.0 / MODBUS RTU

- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG-B/DCF77

Application



¹⁾ RTD = resistance temperature detector

Fig. 5/106 Function diagram

The SIPROTEC 4 7SJ63 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ63 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The 7SJ63 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ63 relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ63 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The relays can be used universally for backup protection.

Metering values

Extensive measured values, limit values and metering values permit improved systems management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$ $I_\mathrm{E}>$, $I_\mathrm{E}>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	$I\mathrm{p}$, I_Ep	Inverse-time overcurrent protection (phase/neutral)
67, 67N	$I_\mathrm{dir}>$, $I_\mathrm{dir}>>$, $I_\mathrm{p\ dir}$ $I_\mathrm{Edir}>$, $I_\mathrm{Edir}>>$, $I_\mathrm{Ep\ dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_\mathrm{EE}>$, $I_\mathrm{EE}>>$, I_EEp	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	$V_\mathrm{E}/V_0>$	Displacement voltage, zero-sequence voltage
–	$I_\mathrm{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box) e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
21FL		Fault locator

Construction

Connection techniques and housing with many advantages

1/2 and 1/1-rack sizes

These are the available housing widths of the 7SJ63 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.
It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/109), or without operator panel, in order to allow optimum operation for all types of applications.


LSP2174-afp.tif

Fig. 5/107
Flush-mounting housing with screw-type terminals


LSP2166-afp.tif

Fig. 5/108
Rear view of flush-mounting housing with covered connection terminals and wirings

LSP2196-afp.eps

Fig. 5/109
Housing with plug-in terminals and detached operator panel

LSP2219-afpen.eps

Fig. 5/110
Surface-mounting housing with screw-type terminals


LSP2237-afp.tif

Fig. 5/111
Communication interfaces in a sloped case in a surface-mounting housing

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Two definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

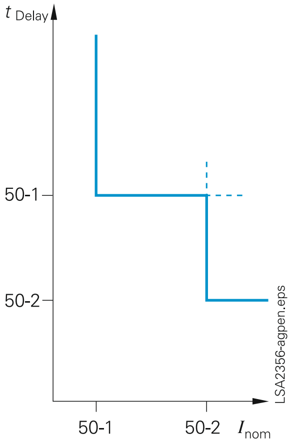


Fig. 5/112
Definite-time overcurrent protection

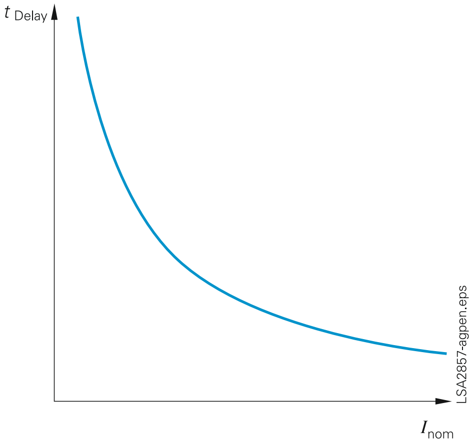


Fig. 5/113
Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	●	●
Short inverse	●	
Long inverse	●	●
Moderately inverse	●	
Very inverse	●	●
Extremely inverse	●	●

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and non-directional time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Protection functions

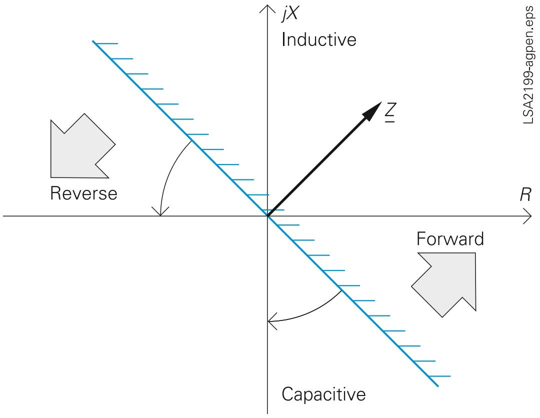


Fig. 5/114
Directional characteristic of the directional time-overcurrent protection

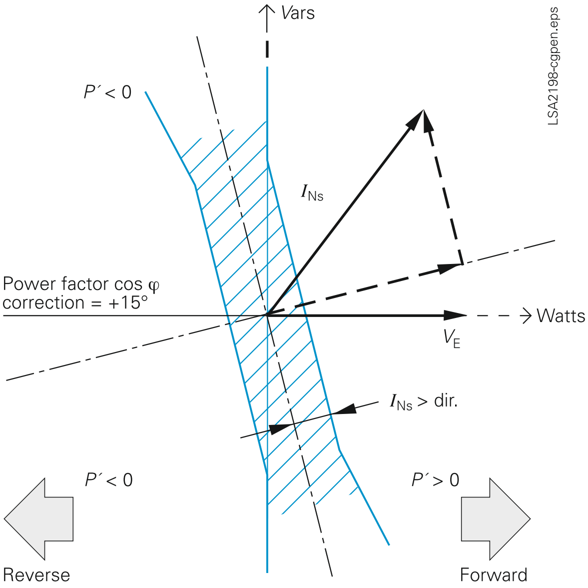


Fig. 5/115
Directional determination using cosine measurements for compensated networks

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directio- nality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of earth-fault direction detection can be implemented: tripping or “signalling only mode”.

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold $I_{IE}>$ evaluates the r.m.s. value, referred to one systems period.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/116). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}. The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value.
If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

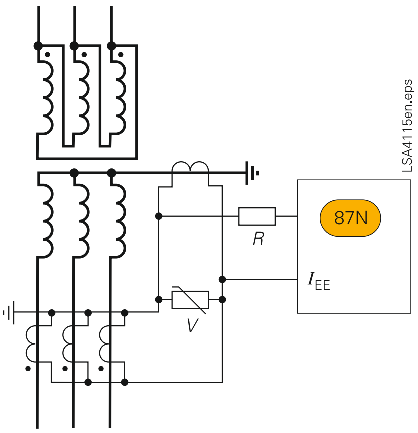


Fig. 5/116 High-impedance restricted earth-fault protection

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD- box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

Protection functions

■ Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/117).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see “Accessories”, page 5/153).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\text{MOTOR START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current

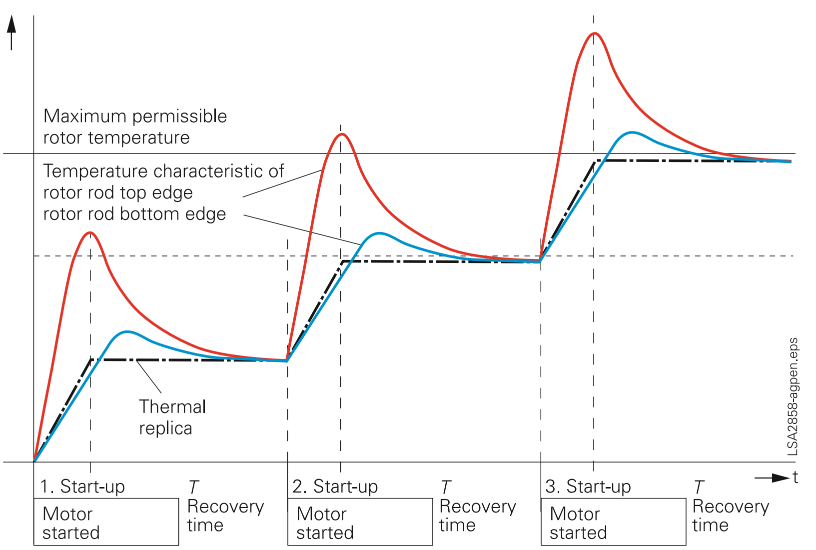


Fig. 5/117

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

■ Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase voltage (default) or with the negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with the positive phase-sequence system voltage (default) or with the phase-to-phase voltages, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

1) The 45 to 55, 55 to 65 Hz range is available for $f_N = 50/60$ Hz.

Protection functions/Functions

Fault locator (ANSI 21FL)

The fault locator specifies the distance to a fault location in kilometers or miles or the reactance of a second fault operation.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/118) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ63 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

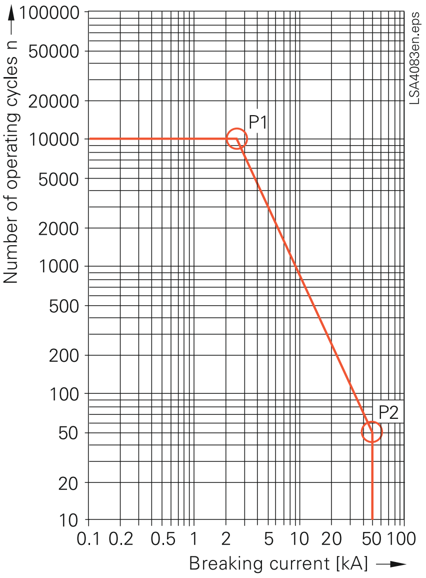


Fig. 5/118 CB switching cycle diagram

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).
If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Key-operated switch

7SJ63 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

---

1) The 45 to 55, 55 to 65 Hz range is available for f_N= 50/60 Hz

Functions

Motor control

The SIPROTEC 4 7SJ63 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and earthing switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

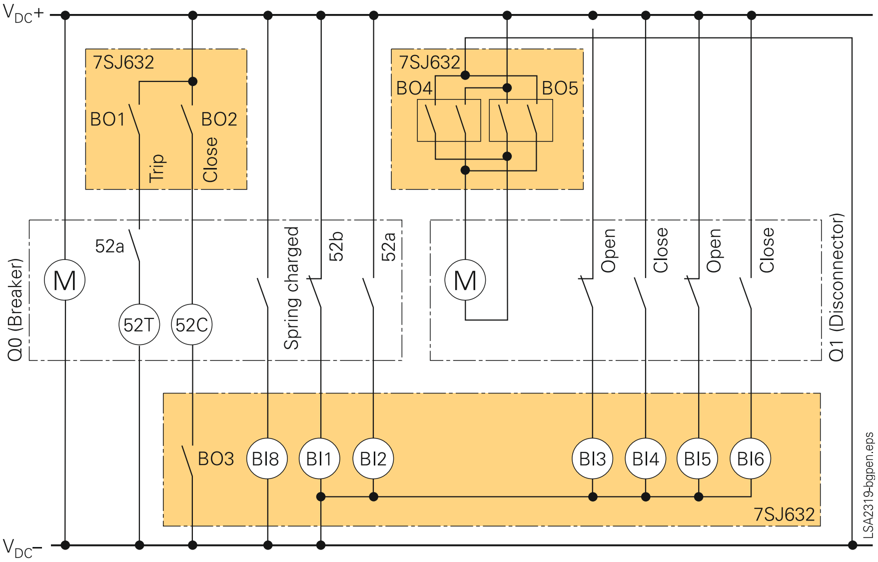


Fig. 5/119
Typical wiring for 7SJ632 motor direct control (simplified representation without fuses)
Binary output BO4 and BO5 are interlocked so that only one set of contacts are closed at a time.

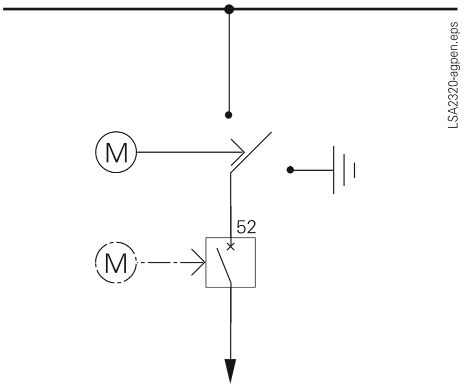


Fig. 5/120 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

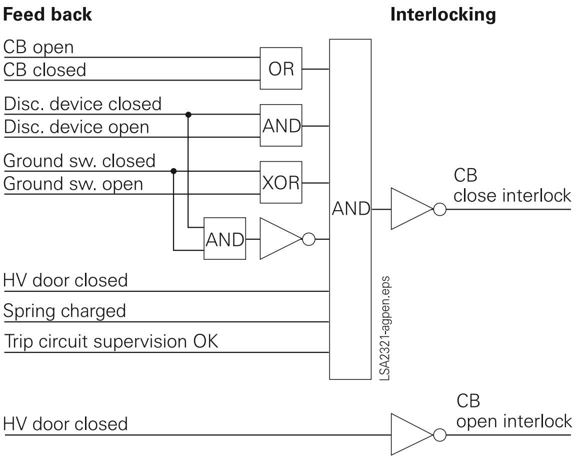


Fig. 5/121 Example: Circuit-breaker interlocking

Functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}
- Symmetrical components
  I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S
  (P, Q: total and phase-selective)
- Power factor (cos φ)
  (total and phase-selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Measuring transducers

- Characteristic with knee
  For measuring transducers it sometimes makes sense to extend a small range of the input value, e.g. for the frequency that is only relevant in the range 45 to 55, 55 to 65 Hz. This can be achieved by using a knee characteristic.
- Live-zero monitoring
  4 - 20 mA circuits are monitored for open-circuit detection.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.

LSP2078-afp.eps

Fig. 5/122
NX PLUS panel (gas-insulated)

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.
The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

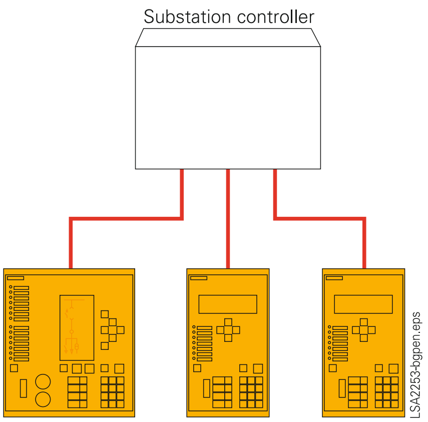


Fig. 5/123
IEC 60870-5-103: Radial fiber-optic connection

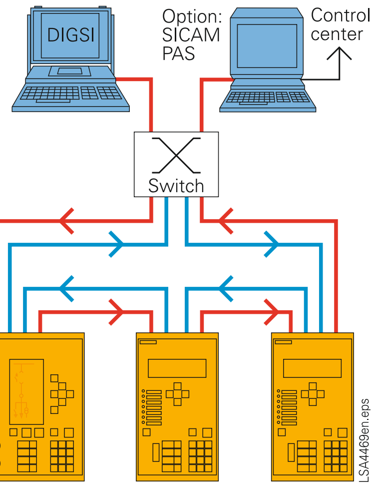


Fig. 5/124
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

---

[1)] For units in panel surface-mounting housings please refer to note on page 5/130.

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/123).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/124).

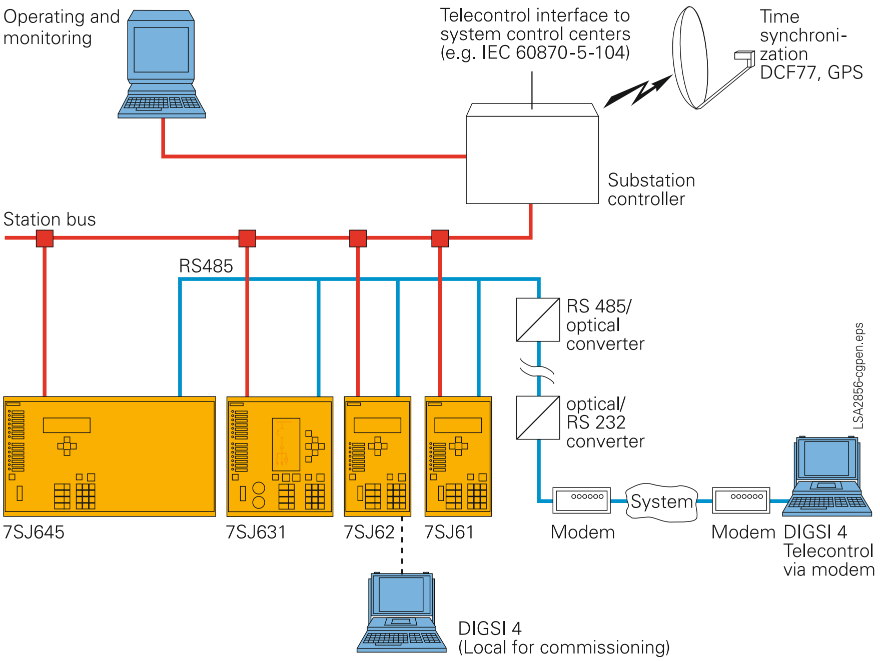


Fig. 5/125
System solution/communication

Fig. 5/126
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

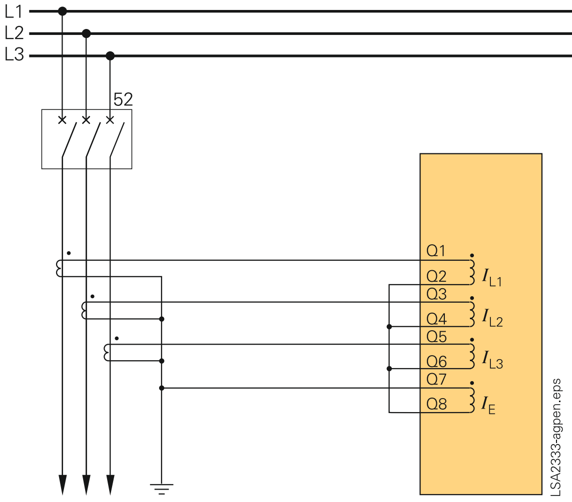


Fig. 5/127
Residual current circuit without directional element

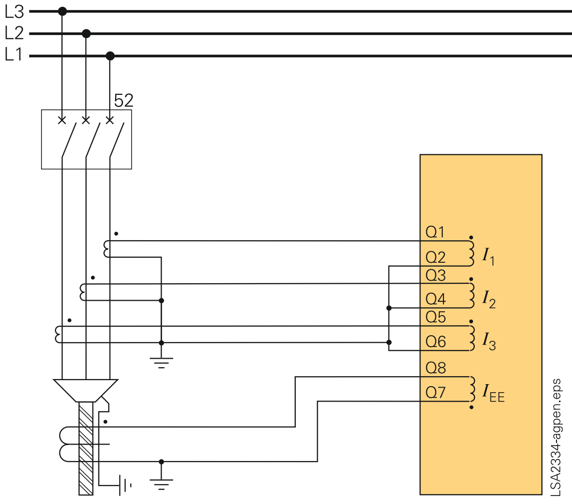


Fig. 5/128
Sensitive earth current detection without directional element

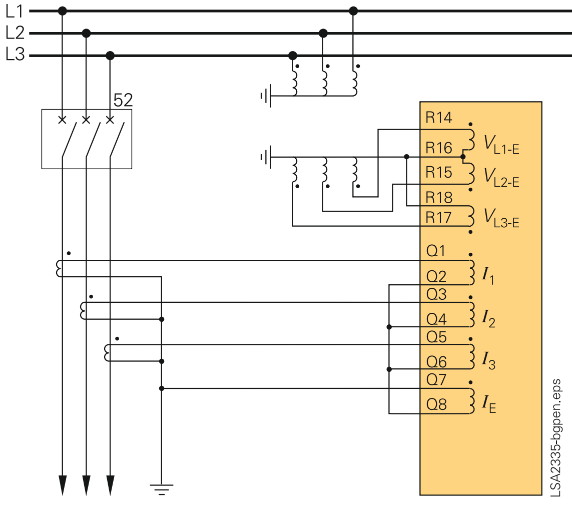


Fig. 5/129
Residual current circuit with directional element

Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the earth current. This connection maintains maximum precision for directional earth-fault detection and must be used in compensated networks.
Figure 5/130 shows sensitive directional earth-fault detection.

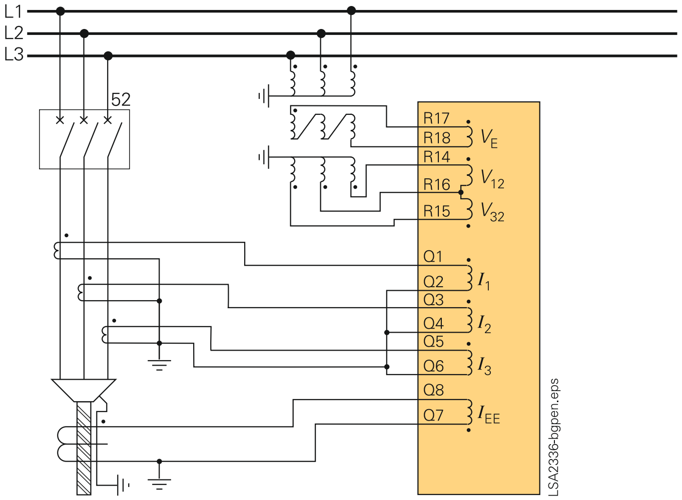


Fig. 5/130
Sensitive directional earth-fault detection with directional element for phases

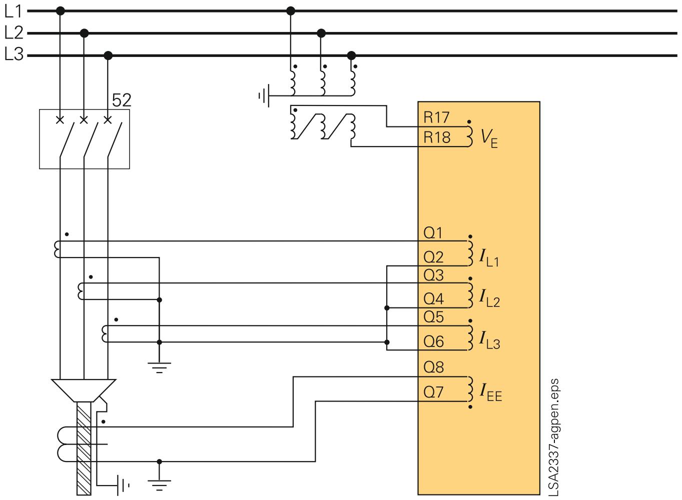


Fig. 5/131
Sensitive directional earth-fault detection

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

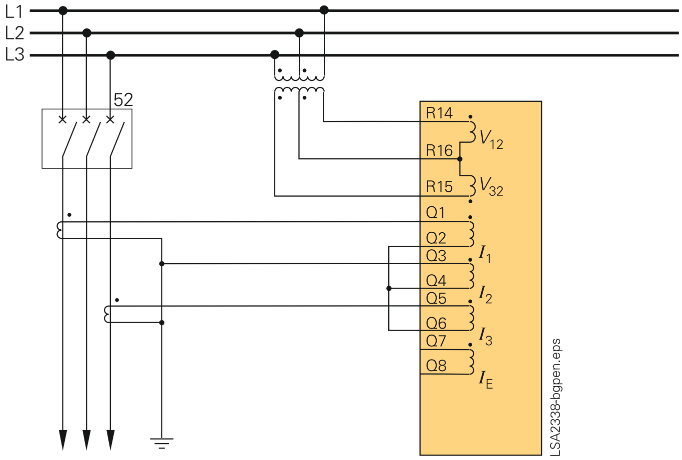


Fig. 5/132
Isolated-neutral or compensated networks

Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current $> 0.05\ I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/133, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault.

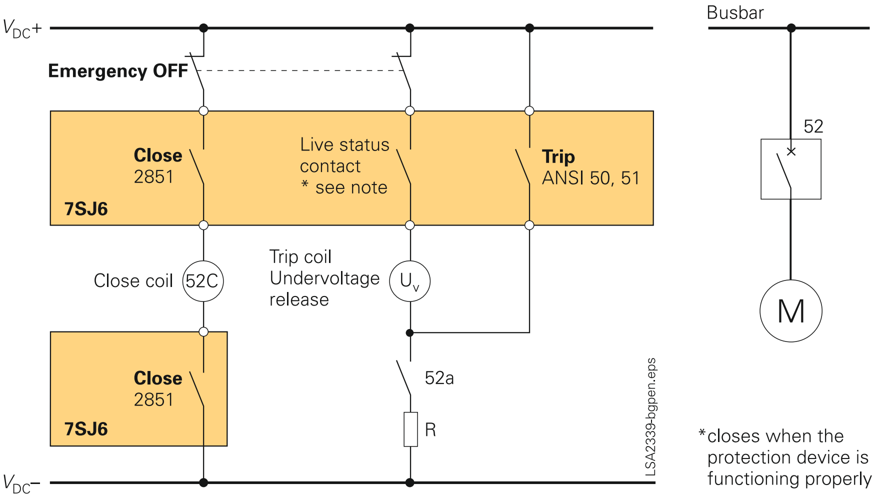


Fig. 5/133 Undervoltage release with make contact (50, 51)

Typical applications

In Fig. 5/134 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

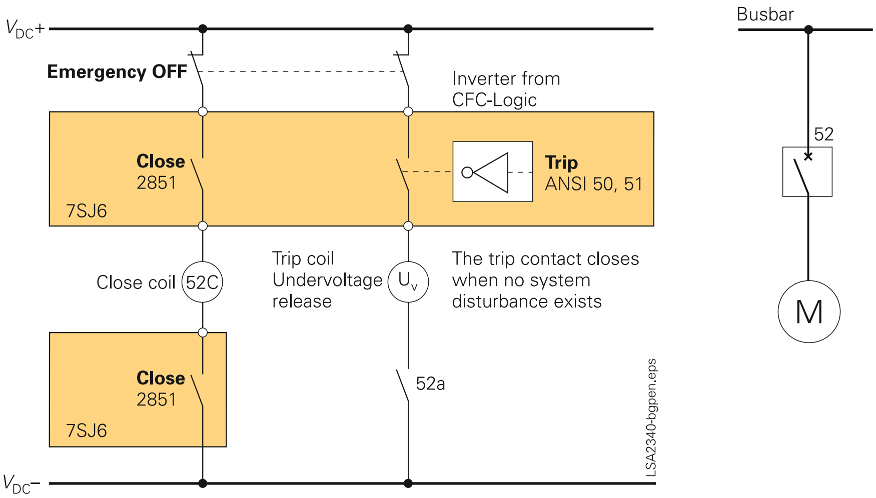
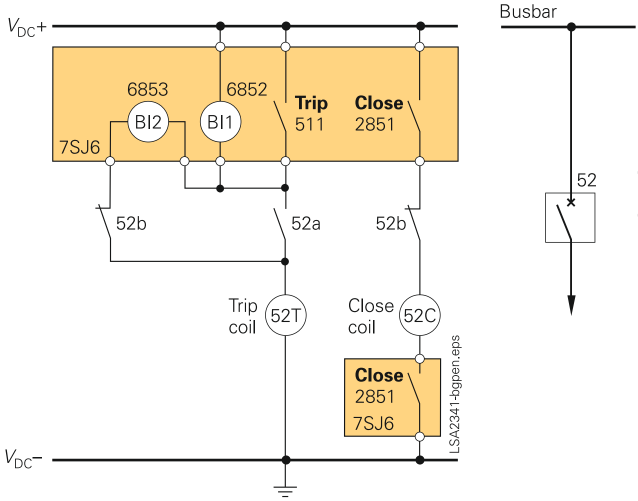


Fig. 5/134 Undervoltage release with locking contact (trip signal 50 is inverted)

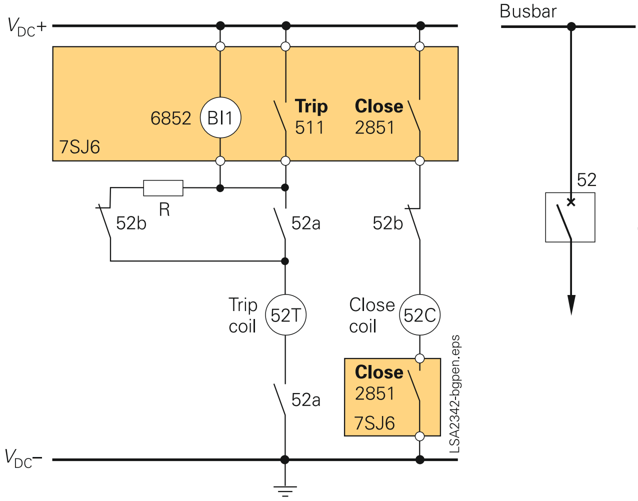


Protection indications
511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/135 Trip circuit supervision with 2 binary inputs



Protection indications
511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1
open	closed	H
open	open	H
closed	closed	L
closed	open	L

Fig. 5/136 Trip circuit supervision with 1 binary input

Technical data

General unit data

Measuring circuits

System frequency	50 / 60 Hz (settable)

Current transformer

Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	$I_{EE} < 1.6$ A
Power consumption	
at $I_{nom} = 1$ A	Approx. 0.05 VA per phase
at $I_{nom} = 5$ A	Approx. 0.3 VA per phase
for sensitive earth-fault CT at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (effective)	100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT	
Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)

Voltage transformer

Rated voltage V_{nom}	100 V to 225 V
Power consumption at $V_{nom} = 100$ V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage)	
Thermal (effective)	230 V continuous

Measuring transducer inputs

Type	7SJ633	7SJ636
Number	2	2
Input current	DC 0 - 20 mA	
Input resistance	10 Ω	
Power consumption	5.8 mW at 24 mA	

Auxiliary voltage *(via integrated converter)*

Rated auxiliary voltage V_{aux}	DC	24/48 V	60/125 V	110/250 V
Permissible tolerance	DC	19 - 58 V	48 - 150 V	88 - 300 V
Ripple voltage, peak-to-peak		≤ 12 % of rated auxiliary voltage		
Power consumption		7SJ631	7SJ632 7SJ633	7SJ635 7SJ636
Quiescent	Approx.	4 W	5.5 W	7 W
Energized	Approx.	10 W	16 W	20 W
Backup time during loss/short-circuit of auxiliary direct voltage		≥ 50 ms at V > 110 V DC ≥ 20 ms at V > 24 V DC		
Rated auxiliary voltage V_{aux}	AC	115 V	230 V	
Permissible tolerance	AC	92 - 132 V	184 - 265 V	
Power consumption		7SJ631	7SJ632 7SJ633	7SJ635 7SJ636
Quiescent	Approx.	3 W	5 W	7 W
Energized	Approx.	12 W	18 W	23 W
Backup time during loss/short-circuit of auxiliary alternating voltage		≥ 200 ms		

Binary inputs/indication inputs

Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Number (marshallable)	11	24	20	37	33
Voltage range	24 - 250 V DC				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	19 V DC		88 V DC		
For rated control voltage DC	24/48/60/110/ 125 V DC		110/125/220/250 V DC		
Power consumption energized	0.9 mA (independent of operating voltage) for BI 1…6 / 8…19 / 25…36; 1.8 mA for BI 7 / 20…24 / 37				

Binary outputs/command outputs

Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Command/indication relay	8	11	11	14	14
Contacts per command/ indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper) / form A / B				
Switching capacity Make	1000 W / VA				
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms				
Switching voltage	≤ 250 V DC				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				

Power relay (for motor control)

Type	7SJ631	7SJ632 7SJ633 7SJ636	7SJ635
Number	0	2 (4)	4 (8)
Number of contacts/relay		2 NO / form A	
Switching capacity Make	1000 W / VA at 48 V … 250 V / 500 W at 24 V		
Break	1000 W / VA at 48 V … 250 V / 500 W at 24 V		
Switching voltage	≤ 250 V DC		
Permissible current	5 A continuous, 30 A for 0.5 s		

Technical data

Electrical tests

Specification

Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508

Insulation tests

Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

EMC tests for interference emission; type tests

Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes

During transportation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Technical data

Climatic stress tests

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C /-13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C /-4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C /+131 °F)	-5 °C to +55 °C /+25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C /-13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C /-13 °F to +158 °F

Humidity

Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design

Housing	7XP20
Dimensions	See dimension drawings, part 15 of this catalog

Weight in kg	Housing width 1/2	Housing width 1/1
Surface-mounting housing	7.5	15
Flush-mounting housing	6.5	13
Housing for detached operator panel	8.0	15
Detached operator panel	2.5	2.5

Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	Front: IP 51, rear: IP 20;
Operator safety	IP 2x with cover

Serial interfaces

Operating interface *(front of unit)*

Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	min. 4800 baud, max. 115200 baud

Service/modem interface *(rear of unit)*

Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

System interface *(rear of unit)*

IEC 60870-5-103 protocol

Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting: 9600 baud, min. 9600 baud, max. 19200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

IEC 61850 protocol

Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection	Two RJ45 connectors
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Intergr. LC connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles

PROFIBUS-FMS/DP

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud

Technical data

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth

Fiber optic

Connection fiber-optic cable	Integr. ST connector for FO connection, mounting location “B”
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/174
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles

MODBUS RTU, ASCII, DNP 3.0

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth

Fiber-optic

Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/174
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions

Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)

Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase elements $I>$, $I>>$	0.5 to 175 A or ∞ 1) (in steps of 0.01 A)
Pickup earth elements $I_E>$, $I_E>>$	0.25 to 175 A or ∞ 1) (in steps of 0.01 A)
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)

Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)		
	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$	
Tolerances		
Pickup	2 % of setting value or 50 mA 1)	
Delay times T, T_{DO}	1 % or 10 ms	

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)

Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞ 1) (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞ 1) (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA 1)
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Direction detection

For phase faults

Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase

For earth faults

Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current 1)
Tolerances (phase angle error under reference conditions)	
For phase and earth faults	± 3 ° electrical

Inrush blocking

Influenced functions	Time-overcurrent elements, $I>$, $I_E>$, I_p, I_{Ep} (directional, non-directional)
Lower function limit	1.25 A 1)
Upper function limit (setting range)	1.5 to 125 A 1) (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF

Dynamic setting change

Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) earth-fault detection *(ANSI 64, 50 Ns, 51Ns, 67Ns)*

Displacement voltage starting *for all types of earth fault (ANSI 64)*

Setting ranges	
Pickup threshold $V_E>$ (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_0>$ (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay\ pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 60 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms

Phase detection for earth fault in an unearthed system

Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{ph\ min}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph\ max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V

Earth-fault pickup *for all types of earth faults*

Definite-time characteristic *(ANSI 50Ns)*

Setting ranges	
Pickup threshold $I_{EE}>$, $I_{EE}>>$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A 1) (in steps of 0.01 A)
Delay times T for $I_{EE}>$, $I_{EE}>>$	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 60 ms (non-directional) Approx. 80 ms (directional
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold $I_{EE}>$, $I_{EE}>>$	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms

Earth-fault pickup *for all types of earth faults*

Inverse-time characteristic *(ANSI 51Ns)*

User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Logarithmic inverse	$t = T_{IEEpmax} - T_{IEEp} \cdot \ln \frac{I}{I_{EEp}}$
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A 1) (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Logarithmic inverse	
Time multiplier $T_{IEEp\ mul}$	0.05 to 15 s or ∞ (in steps of 0.01 s)
Delay time T_{IEEp}	0.1 to 4 s or ∞ (in steps of 0.01 s)
Min time delay $T_{IEEpmin}$	0 to 32 s (in steps of 0.01 s)
Max. time delay $T_{IEEpmax}$	0 to 32 s (in steps of 0.01 s)

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

1) For $I_{nom} = 1$ A, all limits divided by 5.

Technical data

Times	
Pickup times	Approx. 60 ms (non-directional) Approx 80 ms (directional)
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold I_{EEp}	2 % of setting value or 1 mA
Delay times in linear range	7 % of reference value for $2 \leq I/I_{EEp}$ ≤ 20 + 2 % current tolerance, or 70 ms

Direction detection *for all types of earth-faults (ANSI 67Ns)*

Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A1) (in steps of 0.01 A)
Measuring method	cos φ and sin φ
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Angle correction for cable CT	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current value $I1$, $I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A1) (in steps of 0.01 A)
Tolerances	
Pickup measuring enable	2 % of the setting value or 1 mA
Angle tolerance	3 °

High-impedance restricted earth-fault protection *(ANSI 87N) / single-phase overcurrent protection*

Setting ranges	
Pickup thresholds $I>$, $I>>$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A1) or ∞ (in steps of 0.01 A)
Delay times $T_I>$, $T_I>>$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

Intermittent earth-fault protection

Setting ranges		
Pickup threshold		
For I_E	$I_{IE}>$	0.25 to 175 A1) (in steps of 0.01 A)
For $3I_0$	$I_{IE}>$	0.25 to 175 A1) (in steps of 0.01 A)
For I_{EE}	$I_{IE}>$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)

1) At I_{nom} = 1 A, all limits divided by 5.

Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{IE}>$	3 % of setting value, or 50 mA1)
Times T_V, T_{sum}, T_{res}	1 % of setting value or 10 ms

Thermal overload protection *(ANSI 49)*

Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \dfrac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

Auto-reclosure *(ANSI 79)*

Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command

Technical data

Auto-reclosure *(ANSI 79) (cont'd)*

Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
$I{>>}, I{>}, I_p, I_{dir}{>>}, I_{dir}{>}, I_{pdir}$
$I_E{>>}, I_E{>}, I_{Ep}, I_{Edir}{>>}, I_{Edir}{>}, I_{Edir}$

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection *(ANSI 50 BF)*

Setting ranges	
Pickup threshold CB $I>$	0.2 to 5 A[1] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
start via control	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1]
Delay time	1 % or 20 ms

Negative-sequence current detection *(ANSI 46)*

Definite-time characteristic *(ANSI 46-1 and 46-2)*

Setting ranges	
Pickup current $I_2>$, $I_2>>$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1]
Delay times	1 % or 10 ms

Inverse-time characteristic *(ANSI 46-TOC)*

Setting ranges	
Pickup current	0.5 to 10 A[1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors *(ANSI 48)*

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$	1 to 180 s (in steps of 0.1 s)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I >$ $I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1]
Delay time	5 % or 30 ms

---

[1] At I_{nom} = 1 A, all limits divided by 5.

Technical data

Restart inhibit for motors (ANSI 66)

Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A1) (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	3 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	

$$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$$

$\Theta_{restart}$ = Temperature limit below which restarting is possible

$\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$)

n_c = Number of permissible start-ups from cold state

Undercurrent monitoring (ANSI 37)

Signal from the operational measured values	Predefined with programmable logic

Temperature monitoring box (ANSI 38)

Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Undervoltage protection (ANSI 27)

Operating modes/measuring quantities	
3-phase	Positive-sequence component or smallest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$	
3-phase, phase-earth connection	10 to 210 V (in steps of 1 V)
3-phase, phase-phase connection	10 to 120 V (in steps of 1 V)
1-phase connection	10 to 120 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A1) (in steps of 0.01 A)
Dropout threshold $r \cdot V<(<)$	Max. 130 V for phase-phase voltages Max. 225 V phase-earth voltages
Times	
Pickup times $V<$, $V<<$, $V_1<$, $V_1<<$	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overvoltage protection (ANSI 59)

Operating modes/measuring quantities	
3-phase	Negative-sequence component or largest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$	
3-phase, phase-earth connection, largest phase-phase voltage	40 to 260 V (in steps of 1 V)
3-phase, phase-phase connection, largest phase-phase voltage	40 to 150 V (in steps of 1 V)
3-phase, negative-sequence voltage	2 to 150 V (in steps of 1 V)
1-phase connection	40 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Pickup times $V_2>$, $V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

---

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Frequency protection (ANSI 81)

Number of frequency elements	4
Setting ranges	
Pickup thresholds for f_{nom} = 50 Hz	45.5 to 54.5 Hz (in steps of 0.01 Hz)
Pickup thresholds for f_{nom} = 60 Hz	55.5 to 64.5 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 150 ms
Dropout times	Approx. 150 ms
Dropout	
Δf = pickup value - dropout value	Approx. 20 mHz
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	10 mHz
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms

Fault locator (ANSI 21FL)

Output of the fault distance	In Ω secondary, in km / mile of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km1) (in steps of 0.0001) 0.001 to 3 Ω/mile1) (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for 30 ° ≤ φK ≤ 90 ° and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions

Operational measured values

Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range	10 to 200 % I_{nom}
Tolerance2)	1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages $V_{L1\text{-}E}$, $V_{L2\text{-}E}$, $V_{L3\text{-}E}$ Phase-to-phase voltages $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance2)	1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range	0 to 120 % S_{nom}
Tolerance2)	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %
P, active power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}
Range	0 to 120 % S_{nom}
Tolerance2)	2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\vert\cos\varphi\vert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range	0 to 120 % S_{nom}
Tolerance2)	2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\vert\sin\varphi\vert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
cos φ, power factor (p.f.)	Total and phase segregated
Range	- 1 to + 1
Tolerance2)	3 % for $\vert\cos\varphi\vert \geq 0.707$
Frequency f	In Hz
Range	f_{nom} ± 5 Hz
Tolerance2)	20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range	0 to 400 %
Tolerance2)	5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\ Trip}$	In %
Range	0 to 400 %
Tolerance2)	5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\ Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\ real}$, $I_{EE\ reactive}$	In A (kA) primary and in mA secondary
Range	0 mA to 1600 mA
Tolerance2)	2 % of measured value or 1 mA
Measuring transducer	
Operating range	0 to 24 mA
Accuracy range	1 to 20 mA
Tolerance2)	1.5 %, relative to rated value of 20 mA
For standard usage of the measurement transducer for pressure and temperature monitoring	
Operating measured value	Pressure in hPa
Operating range (presetting)	0 hPa to 1200 hPa
Operating measured value temperature	Temp in °C / °F
Operating range (presetting)	0 °C to 240 °C or 32 °F to 464 °F
RTD-box	See section "Temperature monitoring box"

Long-term averages

Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages	
of currents	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA)
of real power	P_{dmd} in W (kW, MW)
of reactive power	Q_{dmd} in VAr (kVAr, MVAr)
of apparent power	S_{dmd} in VAr (kVAr, MVAr)

---

1) At I_{nom} = 1 A, all limits multiplied with 5.

1) At rated frequency.

Technical data

Max. / Min. report

Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	$V_{L1\text{-}E}$, $V_{L2\text{-}E}$, $V_{L3\text{-}E}$ V_1 (positive-sequence component) $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$
Min./Max. values for power	S, P, Q, $\cos\varphi$, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}

Local measured values monitoring

Current asymmetry	I_{max}/I_{min} > balance factor, for $I > I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V > V_{lim}$
Current sum	$\lvert i_{L1} + i_{L2} + i_{L3} + k_{iE} \cdot i_E \rvert$ > limit value, with $k_{iE} = \frac{I_{earth}\ \text{CT PRIM} / I_{earth}\ \text{CT SEC}}{\text{CT PRIM} \ / \text{CT SEC}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC

Fault recording

Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

Time stamping

Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge

Oscillographic fault recording

Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 5 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 samples/cycle) 1 sample/1.04 ms (16 samples/cycle)

Energy/power

Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1]	≤ 5 % for $I > 0.5\ I_{nom}$, $V > 0.5\ V_{nom}$ and $\lvert \cos\varphi \rvert$ (p.f.) ≥ 0.707

Statistics

Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits

Circuit-breaker wear

Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life)
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication

Operating hours counter

Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})

Trip circuit monitoring

With one or two binary inputs

Commissioning aids

Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report	

Clock

Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication

Control

Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

---

[1] At rated frequency.

Technical data

Setting group switchover of the function parameters

Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

c UL us
LISTED

Selection and ordering data

Description	Order No.
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□*
Housing, binary inputs (BI) and outputs (BO), measuring transducer	
Housing $^1/_2$ 19”, 11 BI, 8 BO, 1 live status contact	1
Housing $^1/_2$ 19”, 24 BI, 11 BO, 4 (2) power relays, 1 live status contact	2
Housing $^1/_2$ 19”, 20 BI, 11 BO, 2 measuring transducer inputs, 4 power relays, 1 live status contact	3
Housing $^1/_1$ 19”, 37 BI, 14 BO, 8 (4) power relays, 1 live status contact	5
Housing $^1/_1$ 19”, 33 BI, 14 BO, 2 measuring transducer inputs, 8 (4) power relays, 1 live status contact	6
Measuring inputs (3 x V, 4 x I)	
I_{ph} = 1 A1), I_e = 1 A1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	1
I_{ph} = 1 A1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	2
I_{ph} = 5 A1), I_e = 5 A1) (min. = 0.25 A) Position 15 only with *A, C, E, G*	5
I_{ph} = 5 A1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	6
I_{ph} = 5 A1), I_e = 1 A1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	7
Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 V DC3)	2
60 to 125 V DC2), threshold binary input 19 V DC3)	4
110 to 250 V DC2), 115 to 230 V4) AC, threshold binary input 88 V DC3)	5
Unit version	
For panel surface mounting, plug-in terminals, detached operator panel	A
For panel surface mounting, 2-tier terminals top/bottom	B
For panel surface mounting, screw-type terminals, detached operator panel	C
For panel flush mounting, plug-in terminals (2/3 pin connector)	D
For panel flush mounting , screw-type terminals (direct connection/ring-type cable lugs)	E
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), without operator panel, panel mounting in low-voltage housing	F
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	G
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	B
Region US, 60 Hz, ANSI, language: English (US), selectable	C
Region FR, IEC/ANSI language: French, selectable	D
Region World, IEC/ANSI language: Spanish, selectable	E
System interface (Port B): Refer to page 5/152	
No system interface	0
Protocols see page 5/152	
Service interface (Port C)	
No interface at rear side	0
DIGSI 4/modem, electrical RS232	1
DIGSI 4/modem/RTD-box5), electrical RS485	2
DIGSI 4/modem/RTD-box5)6), optical 820 nm wavelength, ST connector	3
Measuring/fault recording	
Slave pointer, mean values, min/max values, fault recording	3

see
next
page

---

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected per binary input by means of jumpers.

4) 230 V AC, starting from unit version .../EE

5) Temperature monitoring box 7XV5662-□AD10, refer to “Accessories”.

6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

Selection and ordering data

Description	Order No.
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□*

Designation				ANSI No.	Description			
Basic version					Control			
				50/51	Time-overcurrent protection			
					$I>$, $I>>$, I_p, reverse interlocking			
				50N/51N	Earth-fault protection			
					$I_E>$, $I_E>>$, I_{Ep}			
				50N/51N	Insensitive earth-fault protection via			
					IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)			
				49	Overload protection (with 2 time constants)			
				46	Phase balance current protection			
					(negative-sequence protection)			
				37	Undercurrent monitoring			
				47	Phase sequence			
				59N/64	Displacement voltage			
				50BF	Breaker failure protection			
				74TC	Trip circuit supervision			
					4 setting groups, cold-load pickup			
					Inrush blocking			
				86	Lockout	F	A	
■			V, f	27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency	F	E	
■		IEF	V, f	27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency			
					Intermittent earth fault	P	E	
■	Dir			67/67N	Direction determination for overcurrent, phases and earth			
				47	Phase sequence	F	C	
■	Dir		V, f	67/67N	Direction determination for overcurrent, phases and earth			
				27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency	F	G	
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth			
					Intermittent earth fault	P	C	
Directional	Dir			67/67N	Direction determination for overcurrent, phases and earth			
earth-fault				67Ns	Directional sensitive earth-fault detection			
detection				87N	High-impedance restricted earth fault			
■						F	D	2)
Directional	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth			
earth-fault				67Ns	Directional sensitive earth-fault detection			
detection				87N	High-impedance restricted earth fault			
■					Intermittent earth fault	P	D	2)
Directional				67Ns	Directional sensitive earth-fault detection			
earth-fault				87N	High-impedance restricted earth fault			
detection								
■						F	B	2)
Directional	Motor		V, f	67Ns	Directional sensitive earth-fault detection			
earth-fault				87N	High-impedance restricted earth fault			
detection				48/14	Starting time supervision, locked rotor			
■				66/86	Restart inhibit			
				27/59	Under-/overvoltage			
				81O/U	Under-/overfrequency	H	F	2)

continued on next page

■ Basic version included

V, f = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Selection and ordering data

Description	Order No.	Order code
7SJ63 multifunction protection relay	*7SJ63*□□ – □□□□□ – □□□□–□□□□	

Designation	ANSI No.	Description	Order No.
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, I_p, reverse interlocking	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, I_{Ep}	
	50N/51N	Earth-fault protection via insensitive IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	37	Undercurrent monitoring	
	47	Phase sequence	
	59N/64	Displacement voltage	
	50BF	Breaker failure protection	
	74TC	Trip circuit supervision	
		4 setting groups, cold-load pickup	
		Inrush blocking	
	86	Lockout	
Directional earth-fault detection ■ Motor Dir V, f	67/67N	Direction determination for overcurrent, phases and earth	
	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	*H H* 2)
Directional earth-fault detection ■ Motor Dir IEF V, f	67/67N	Direction determination for overcurrent, phases and earth	
	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault Intermittent earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	*R H* 2)
■ Motor Dir V, f	67/67N	Direction determination for overcurrent, phases and earth	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	*H G*
■ Motor	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	*H A*
ARC, fault locator		Without	*0*
	79	With auto-reclosure	*1*
	21FL	With fault locator	*2*
	79, 21FL	With auto-reclosure, with fault locator	*3*
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection "e")			*Z X 9 9* 3)

■ Basic version included

V, *f* = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

---

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

3) This variant might be supplied with a previous firmware version.

Order number for system port B

Description	Order No.	Order code
7SJ63 multifunction protection relay	*7SJ63☐☐ – ☐☐☐☐☐ – ☐☐☐☐–☐☐☐*	
System interface (on rear of unit, Port B)		
No system interface	*0*	
IEC 60870-5-103 protocol, RS232	*1*	
IEC 60870-5-103 protocol, RS485	*2*	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	*3*	
PROFIBUS-FMS Slave, RS485	*4*	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector ¹)	*5*	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector ¹)	*6*	
PROFIBUS-DP Slave, RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector ¹)	*9*	*L 0 B*
MODBUS, RS485	*9*	*L 0 D*
MODBUS, 820 nm wavelength, ST connector ²)	*9*	*L 0 E*
DNP 3.0, RS485	*9*	*L 0 G*
DNP 3.0, 820 nm wavelength, ST connector ²)	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)²)	*9*	*L 0 S*

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "B".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "B".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "B".

Sample order

Order No. + Order code: *7SJ6325-5EC91-3FC1+L0G*

Position		Order No. + Order code
6	I/O's: 24 BI/11 BO, 1 live status contact	*2*
7	Current transformer: 5 A	*5*
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	*5*
9	Unit version: Flush-mounting housing, screw-type terminals	*E*
10	Region: US, English language (US); 60 Hz, ANSI	*C*
11	Communication: System interface: DNP 3.0, RS485	*9* *L 0 G*
12	Communication: DIGSI 4, electrical RS232	*1*
13	Measuring/fault recording: Extended measuring and fault records	*3*
14/15	Protection function package: Basic version plus directional TOC	*F C*
16	With auto-reclosure	*1*

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator	
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional	
License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4	
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Temperature monitoring box	
24 to 60 V AC/DC	*7XV5662-2AD10*
90 to 240 V AC/DC	*7XV5662-5AD10*
Varistor/Voltage Arrester	
Voltage arrester for high-impedance REF protection	
125 Vrms; 600 A; 1S/S 256	*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088	*C53207-A401-D77-1*
Connecting cable	
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit	
- length 5 m /16.4 ft	*7XV5103-7AA05*
- length 25 m /82 ft	*7XV5103-7AA25*
- length 50 m /164 ft	*7XV5103-7AA50*
Manual for 7SJ63	
English	*C53000-G1140-C147-x* 1)

---

1) x = please inquire for latest edition (exact Order No.).

Accessories

Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

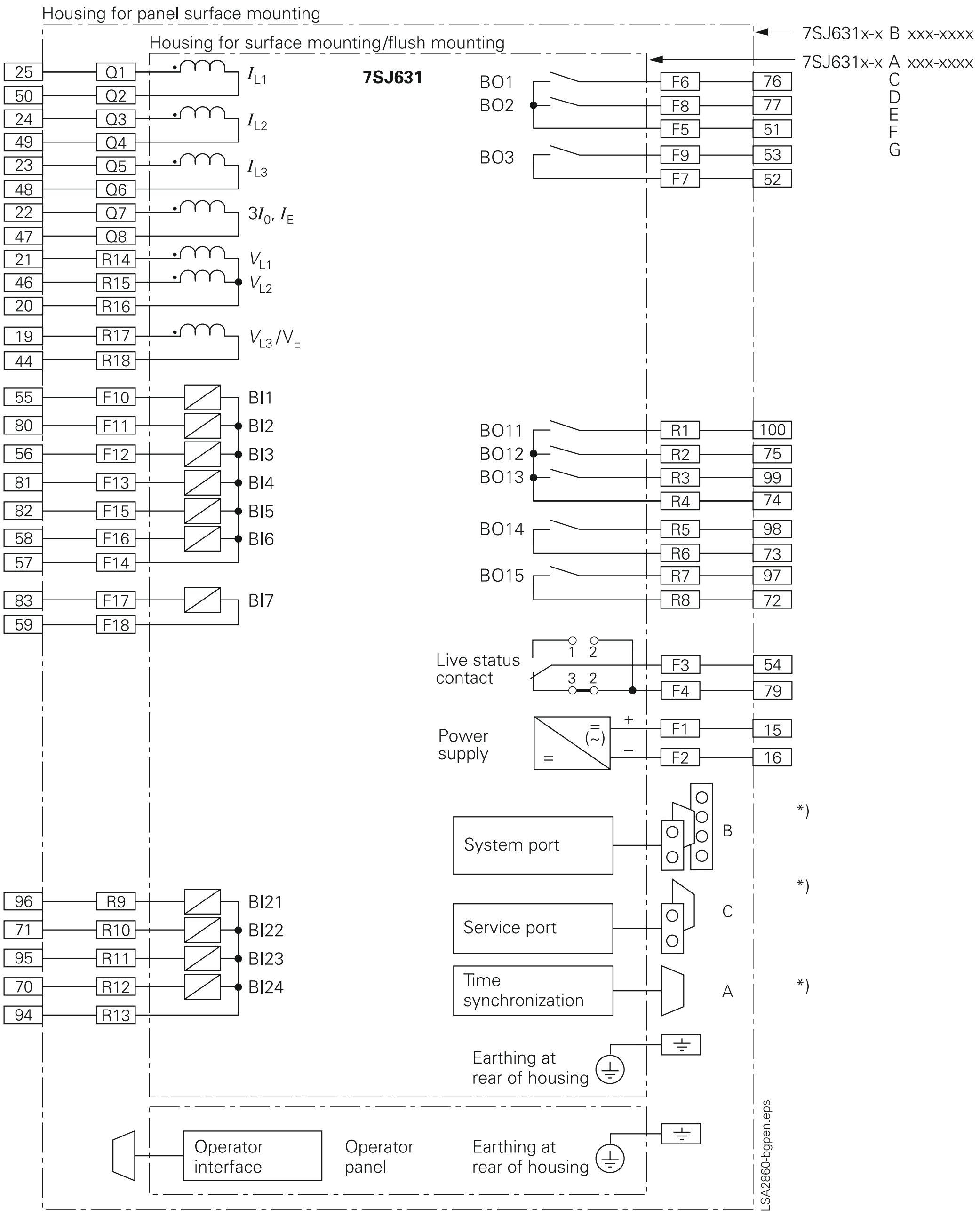


Fig. 5/137
7SJ631 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

Connection diagram

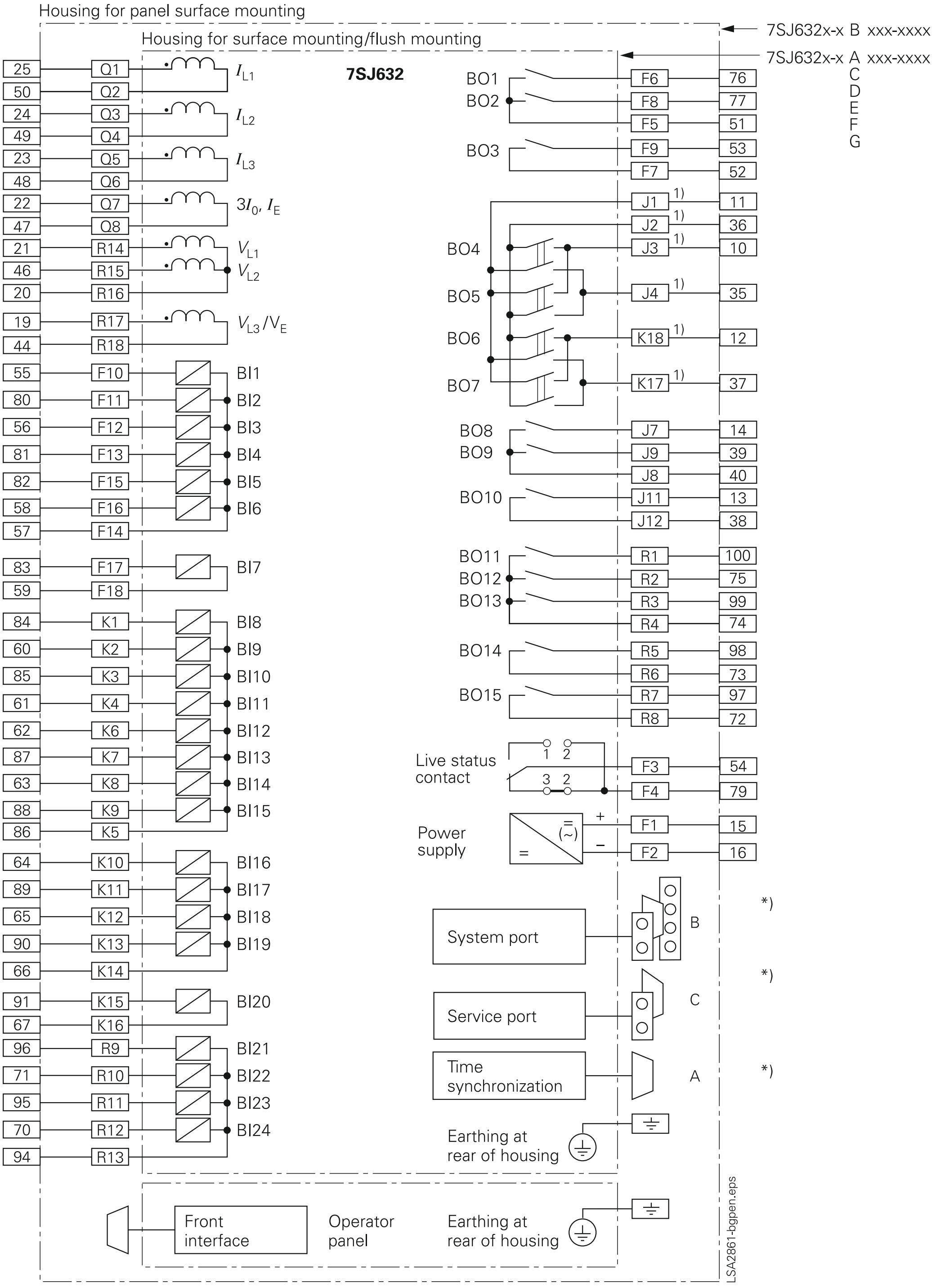


Fig. 5/138
7SJ632 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

Connection diagram

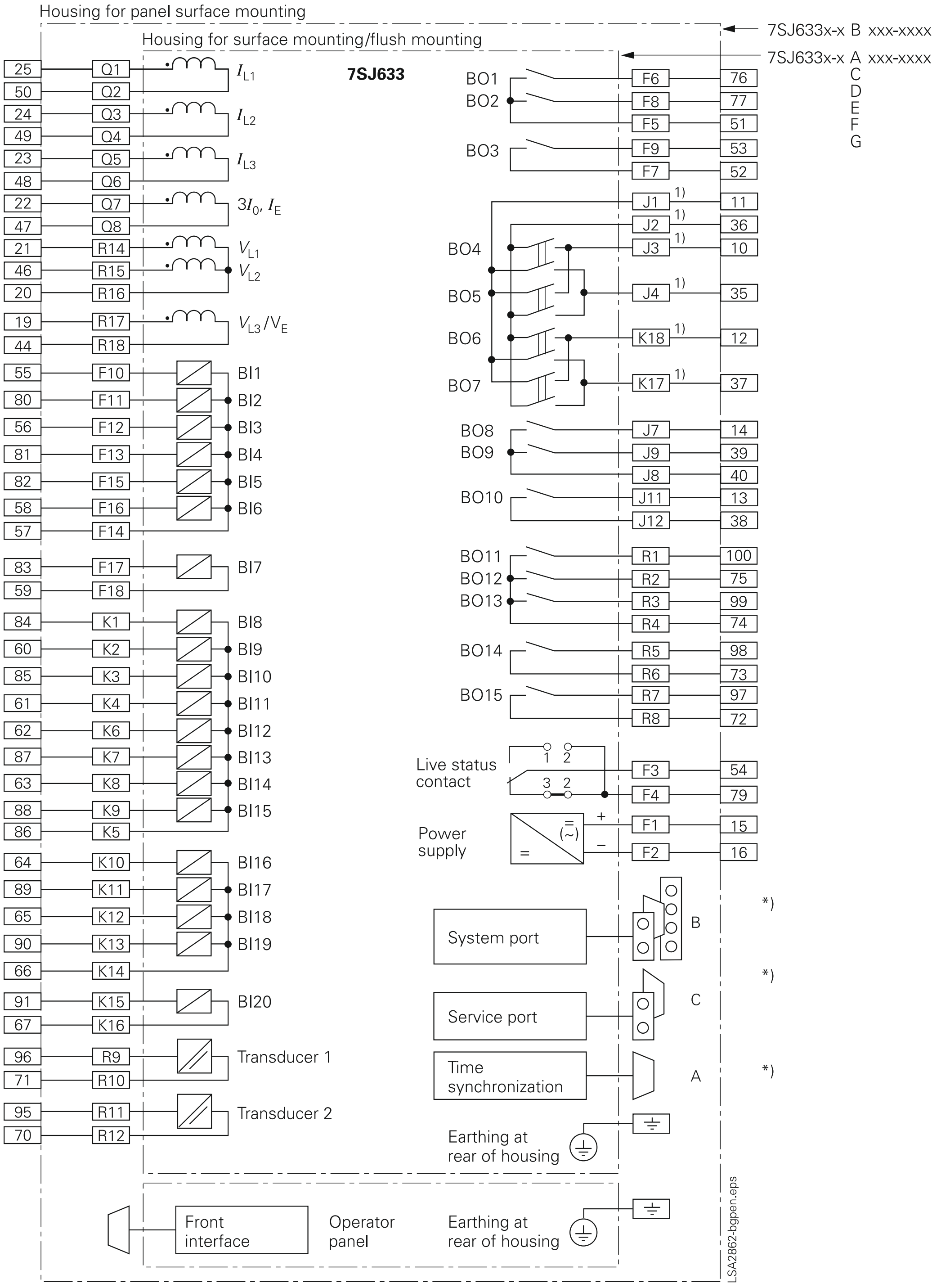


Fig. 5/139
7SJ633 connection diagram

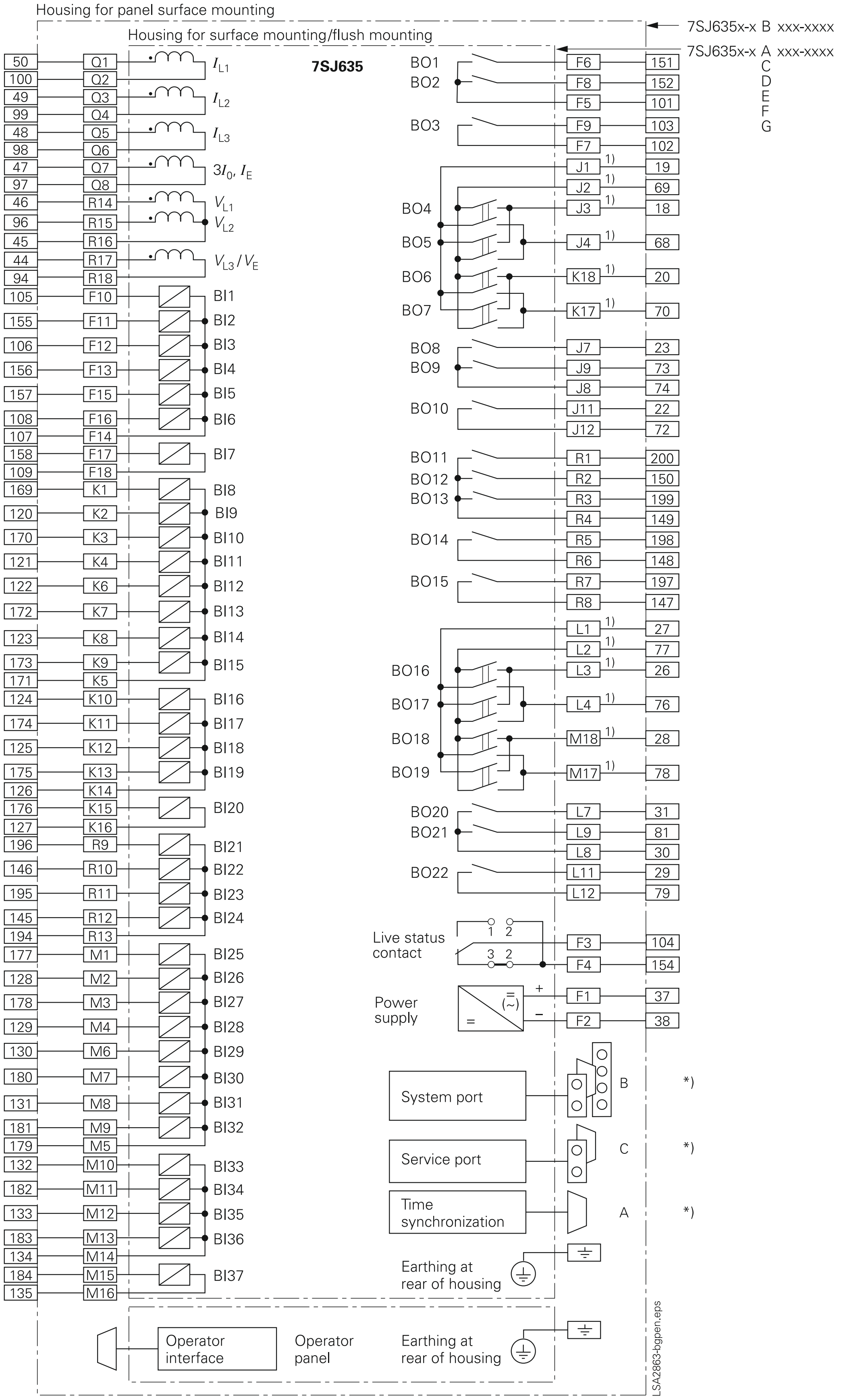
---

*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

Connection diagram



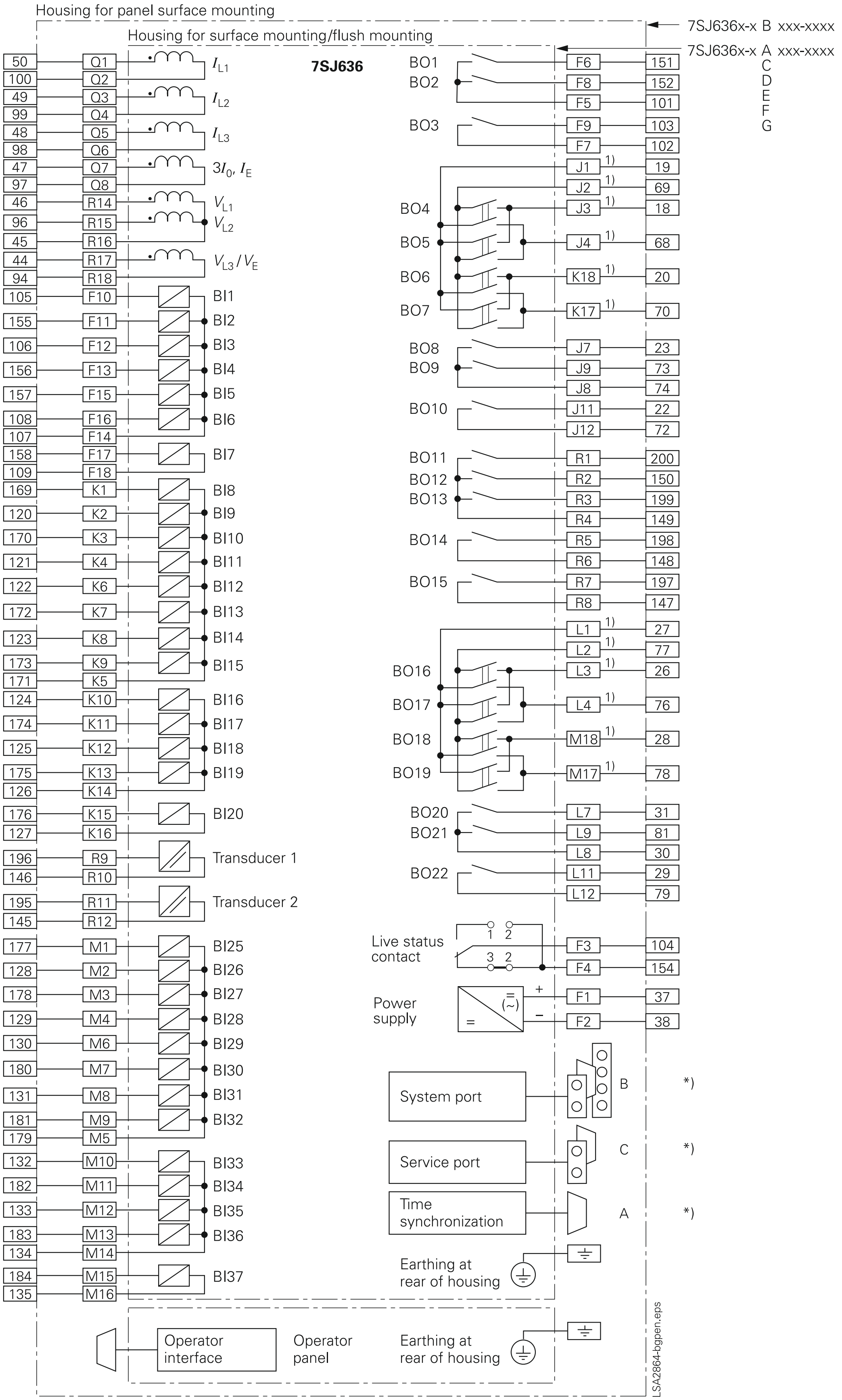
*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7, BO16/BO17 and BO18/BO19. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/140
7SJ635 connection diagram

Connection diagram



*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7, BO16/BO17 and BO18/BO19. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/141
7SJ636 connection diagram

SIPROTEC 4 7SJ64
Multifunction Protection Relay with Synchronization

LSP2316-afpen.tif

Fig. 5/142
SIPROTEC 4 7SJ64 multifunction protection relay

Description

The SIPROTEC 4 7SJ64 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance earthed, unearthed, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. The SIPROTEC 4 7SJ64 is equipped with a synchronization function which provides the operation modes 'synchronization check' (classical) and 'synchronous/asynchronous switching' (which takes the CB mechanical delay into consideration). Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor, load jam protection as well as motor statistics.

The 7SJ64 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, rate-of-frequency-change protection or reverse power protection can be implemented.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). CFC capacity is much larger compared to 7SJ63 due to extended CPU power. The user is able to generate user-defined messages as well.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Time-overcurrent protection
- Directional time-overcurrent protection
- Sensitive dir./non-dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Rate-of-frequency-change protection
- Power protection (e.g. reverse, factor)
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchronization
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

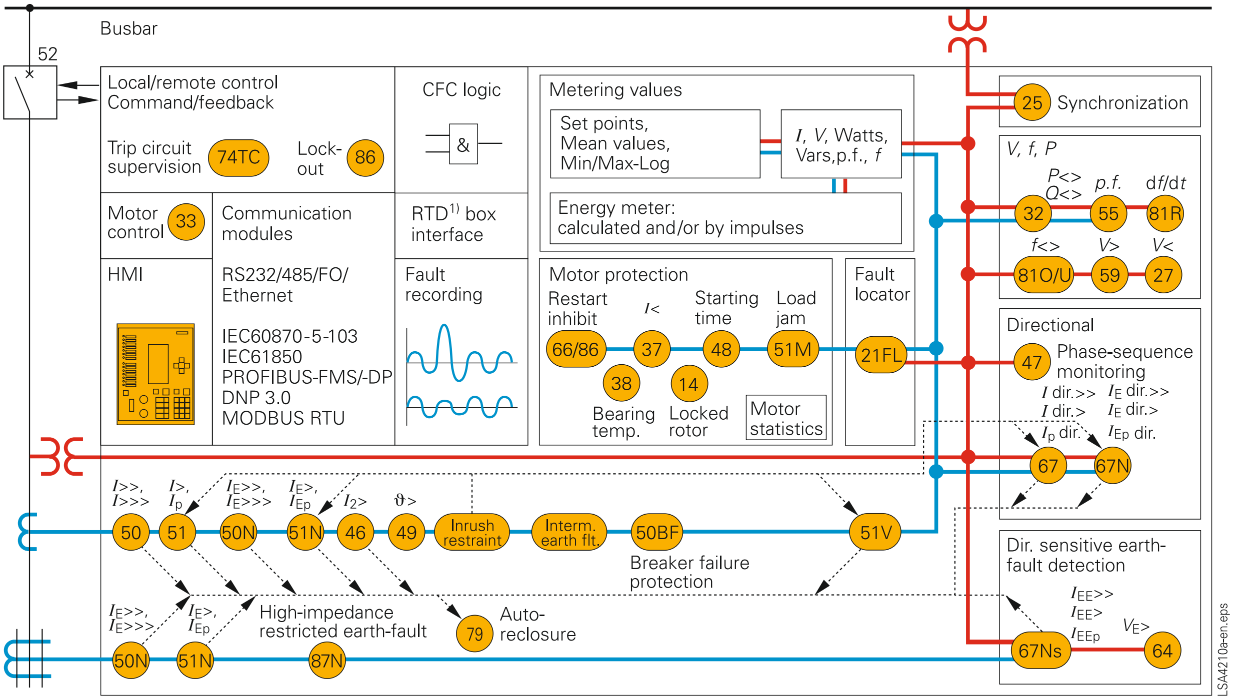
Monitoring functions

- Operational measured values V, I, f,...
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics

Communication interfaces

- System interface
  - IEC 60870-5-103, IEC 61850
  - PROFIBUS-FMS / DP
  - DNP 3.0 / MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Additional interface for temperature detection (RTD-box)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Application



[1] RTD = resistance temperature detector

Fig. 5/143 Function diagram

The SIPROTEC 4 7SJ64 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ64 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow users to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. Due to extended CPU power, the programmable logic capacity is much larger compared to 7SJ63. The user can also generate user-defined messages.

Line protection

The 7SJ64 units can be used for line protection of high and medium-voltage networks with earthed, low-resistance earthed, isolated or compensated neutral point.

Synchronization

In order to connect two components of a power system, the relay provides a synchronization function which verifies that switching ON does not endanger the stability of the power system.

The synchronization function provides the operation modes ‘synchro-check’ (classical) and ‘synchronous/asynchronous switching’ (which takes the c.-b. mechanical delay into consideration).

Motor protection

When protecting motors, the relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ64 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults of the transformer.

Backup protection

The relays can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$, $I_E>>>$	Definite-time overcurrent protection (phase/neutral)
50, 50N	$I>>>>$, $I_2>$ $I_E>>>>$	Additional definite-time overcurrent protection stages (phase/neutral) via flexible protection functions
51, 51V, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\ dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral) Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	V_E, $V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79M		Auto-reclosure
25		Synchronization
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device, e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
59R	dV/dt	Rate-of-voltage-change protection
32	$P<>$, $Q<>$	Reverse-power, forward-power protection
55	$\cos\varphi$	Power factor protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

Construction

Connection techniques and housing with many advantages

1/3, 1/2 and 1/1-rack sizes

These are the available housing widths of the 7SJ64 relays, referred to a 19” module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.
It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.
The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/146), or without operator panel, in order to allow optimum operation for all types of applications.


LSP2174-afp.tif

Fig. 5/144
Flush-mounting housing with screw-type terminals

LSP2299-bfpen.tif

Fig. 5/145
Front view of 7SJ64 with 1/3x19" housing

LSP2196-afp.eps

Fig. 5/146
Housing with plug-in terminals and detached operator panel

LSP2219-afpen.eps

Fig. 5/147
Surface-mounting housing with screw-type terminals


LSP2237-afp.tif

Fig. 5/148
Communication interfaces in a sloped case in a surface-mounting housing

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51,51V, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set in a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated. The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes.
With the "flexible protection functions", further definite-time overcurrent stages can be implemented in the 7SJ64 unit.

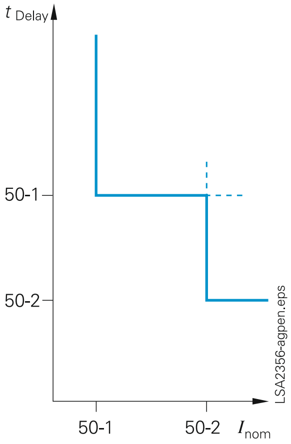


Fig. 5/149
Definite-time overcurrent protection

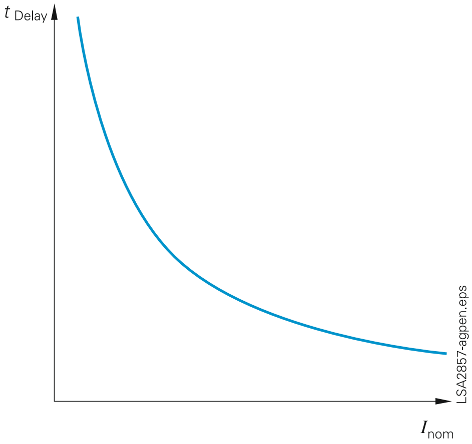


Fig. 5/150
Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	●	●
Short inverse	●	
Long inverse	●	●
Moderately inverse	●	
Very inverse	●	●
Extremely inverse	●	●
Definite inverse	●	

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/ time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and nondirectional time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable).
Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns/67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated.

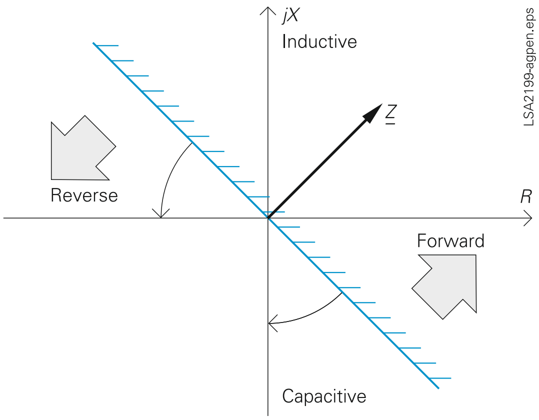


Fig. 5/151
Directional characteristic of the directional time-overcurrent protection

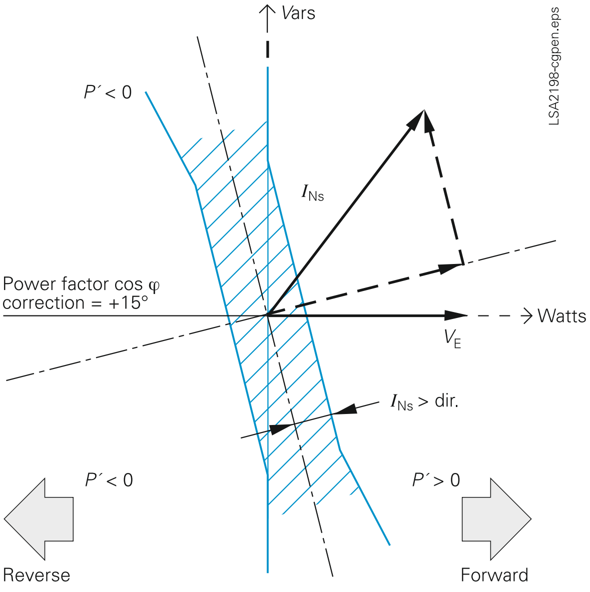


Fig. 5/152
Directional determination using cosine measurements for compensated networks

For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of earth-fault direction detection can be implemented: tripping or “signalling only mode”.

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode, as an additional short-circuit protection.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns/50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode, as an additional short-circuit protection.

Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold $I_{IE}>$ evaluates the r.m.s. value, referred to one systems period.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

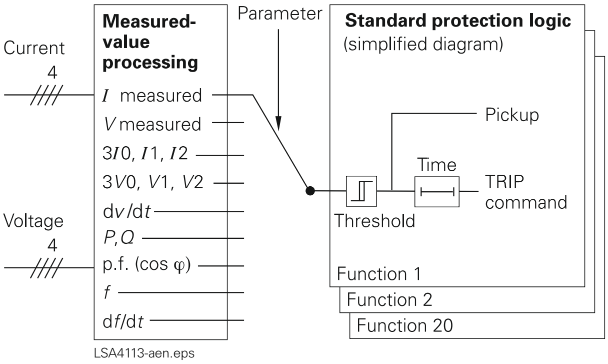
Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

Auto-reclosures (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR
- The AR CLOSE command can be given synchronous by use of the synchronization function.



LSA4113-aen.eps

Fig. 5/153 Flexible protection functions

Flexible protection functions

The 7SJ64 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/153). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
$I>$, $I_E>$	50, 50N
$V<$, $V>$, $V_E>$, dV/dt	27, 59, 59R, 64
$3I_0>$, $I_1>$, $I_2>$, I_2/I_1 $3V_0>$, $V_1><$, $V_2><$	50N, 46 59N, 47
$P><$, $Q><$	32
$\cos\varphi$ (p.f.)><	55
$f><$	81O, 81U
$df/dt><$	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)

Synchronization (ANSI 25)

- In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized (classic synchro-check). Furthermore, the synchronizing function may operate in the “Synchronous/asynchronous switching” mode. The unit then distinguishes between synchronous and asynchronous networks:
  In synchronous networks, frequency differences between the two subnetworks are almost non-existant. In this case, the circuit-breaker operating time does not need to be considered. Under asynchronous condition, however, this difference is markedly larger and the time window for switching is shorter. In this case, it is recommended to consider the operating time of the circuit-breaker.

Protection functions

The command is automatically pre-dated by the duration of the operating time of the circuit-breaker, thus ensuring that the contacts of the CB close at exactly the right time.

Up to 4 sets of parameters for the synchronizing function can be stored in the unit. This is an important feature when several circuit-breakers with different operating times are to be operated by one single relay.

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator), a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD- box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/154). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}.

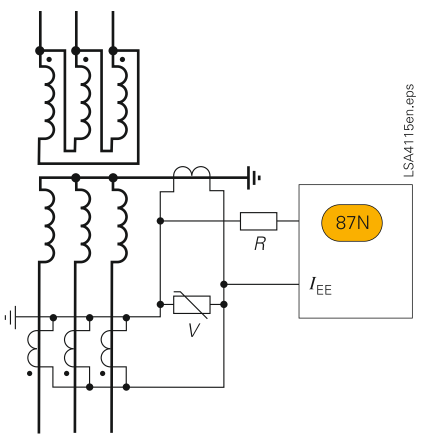


Fig. 5/154 High-impedance restricted earth- fault protection

The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

■ Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/155).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see “Accessories”, page 5/175).

Protection functions

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\mathrm{MOTOR\,START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\mathrm{MOTOR\,START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current (2 times, for warm and cold motor)

The characteristic (equation) can be adapted optimally to the state of the motor by applying different tripping times T_A in dependence of either cold or warm motor state. For differentiation of the motor state the thermal model of the rotor is applied.

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping).

The overload protection function is too slow and therefore not suitable under these circumstances.

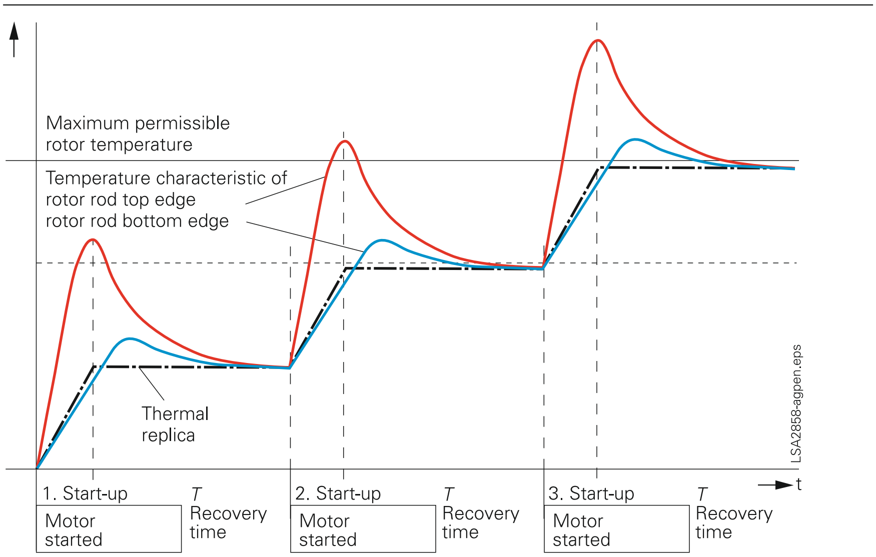


Fig. 5/155

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Motor statistics

Essential information on start-up of the motor (duration, current, voltage) and general information on number of starts, total operating time, total down time, etc. are saved as statistics in the device.

■ Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-earth, positive phase-sequence or negative phase-sequence voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)1). Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with phase-to-phase, phase-to-earth or positive phase-sequence voltage, and can be monitored with a current criterion.
Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are

---

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

Protection functions/Functions

protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (40 to 60, 50 to 70 Hz)1). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in Ω, kilometers (miles) and in percent of the line length.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- $\Sigma i^2 t$

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/181) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ64 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

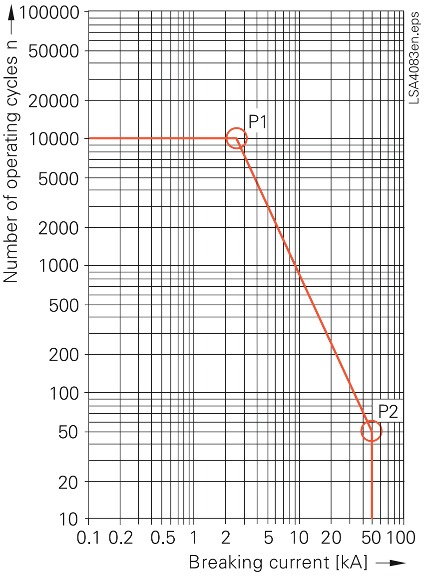


Fig. 5/156 CB switching cycle diagram

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).
If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”.

Key-operated switch

7SJ64 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

---

1) The 40 to 60, 50 to 70 Hz range is available for f_N = 50/60 Hz.

Functions

Motor control

The SIPROTEC 4 7SJ64 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and earthing switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time.

In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

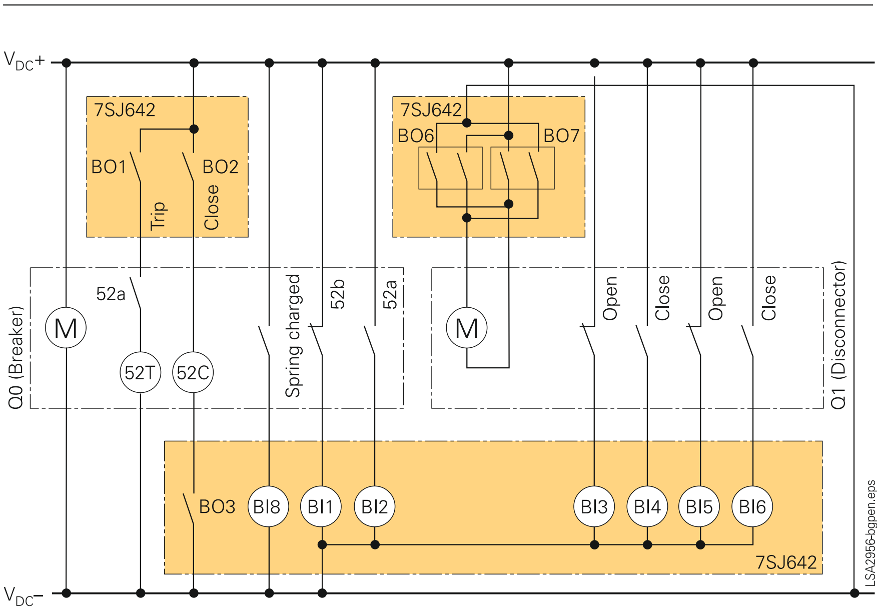


Fig. 5/157
Typical wiring for 7SJ642 motor direct control (simplified representation without fuses)
Binary output BO6 and BO7 are interlocked so that only one set of contacts are closed at a time.

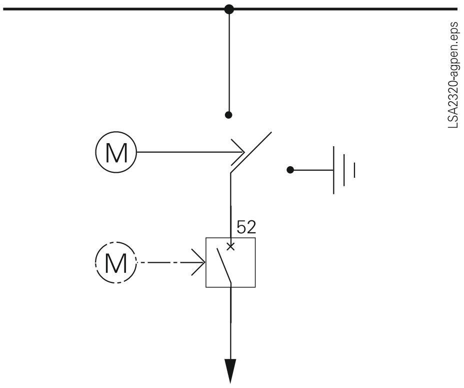


Fig. 5/158 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

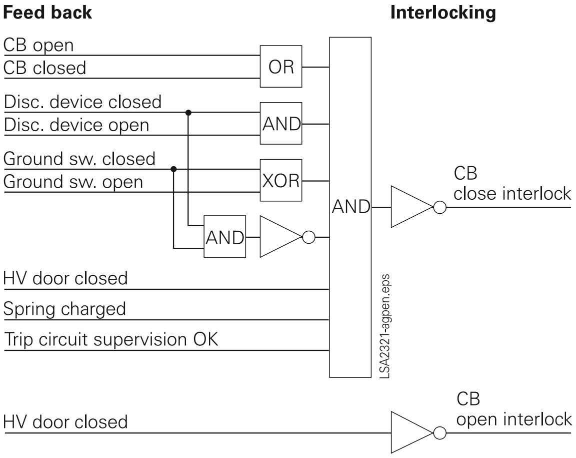


Fig. 5/159 Example: Circuit-breaker interlocking

Functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}, V_{syn}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase-selective)
- Power factor (cos φ) (total and phase-selective)
- Frequency
- Energy ± kWh, ± kVArh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
- Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.

LSP2078-afp.eps

Fig. 5/160
NX PLUS panel (gas-insulated)

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.
The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS485 interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.
- Additional interface
  Up to 2 RTD-boxes can be connected via this interface.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI. It is also possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor also provides a few items of unit-specific information in browser windows.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.
Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

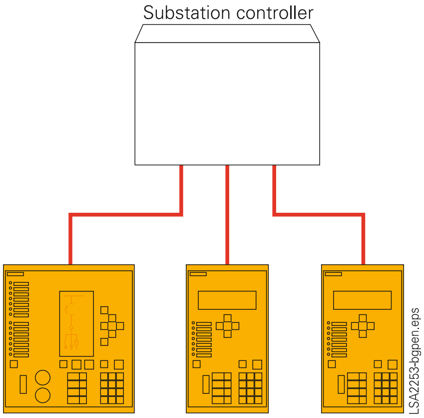


Fig. 5/161
IEC 60870-5-103: Radial fiber-optic connection

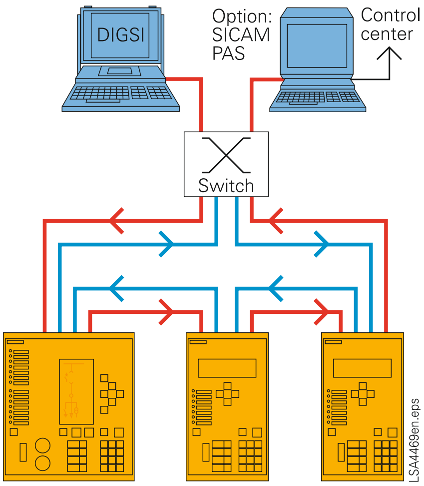


Fig. 5/162
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

---

1) For units in panel surface-mounting housings please refer to note on page 5/193.

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/161).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/162).

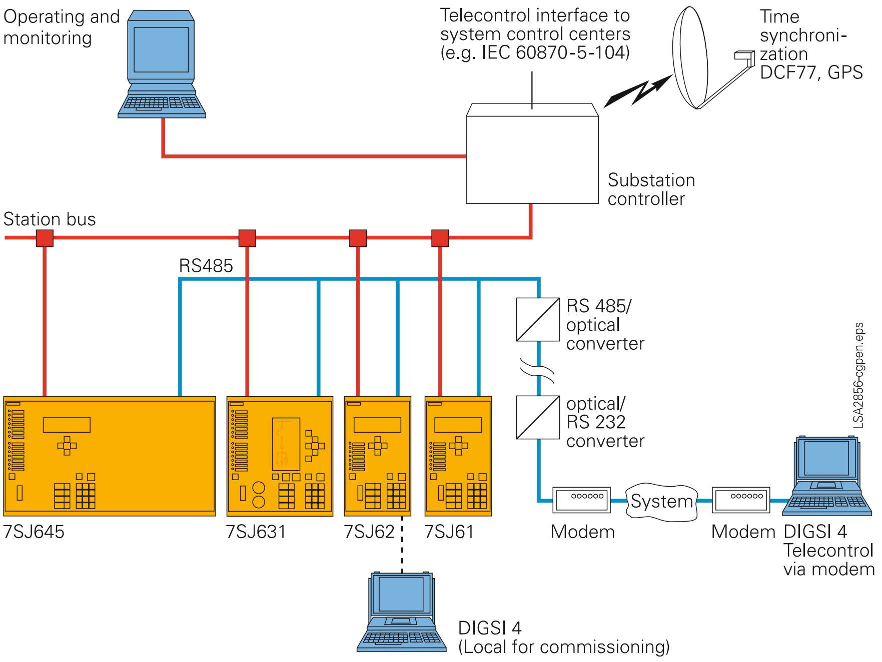


Fig. 5/163
System solution/communication

Fig. 5/164
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

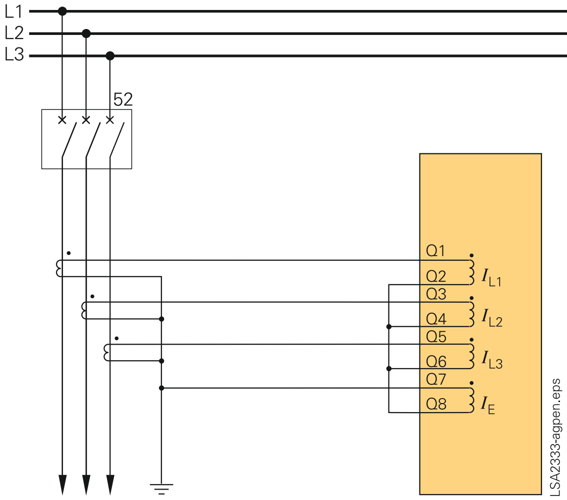


Fig. 5/165
Residual current circuit without directional element

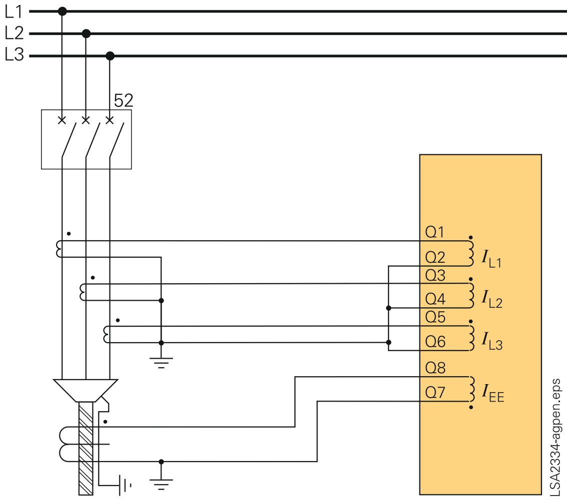


Fig. 5/166
Sensitive earth current detection without directional element

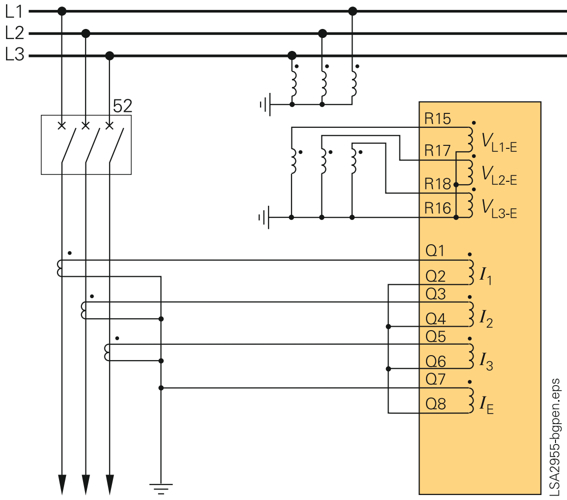


Fig. 5/167
Residual current circuit with directional element

Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-earth neutral current transformer for the earth current. This connection maintains maximum precision for directional earth- fault detection and must be used in compensated networks.
Fig. 5/168 shows sensitive directional earth-fault detection.

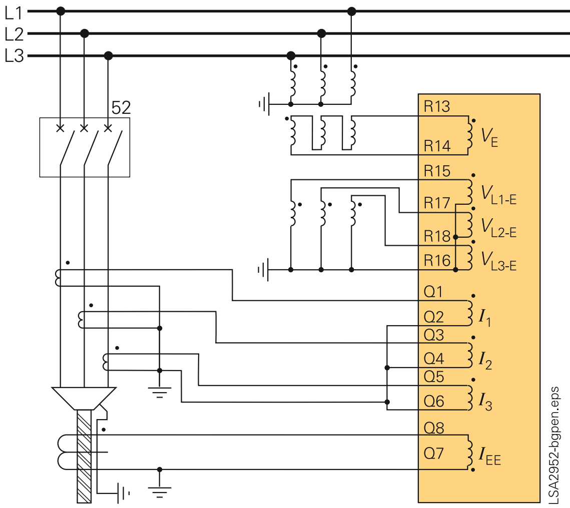


Fig. 5/168
Sensitive directional earth-fault detection with directional element for phases

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

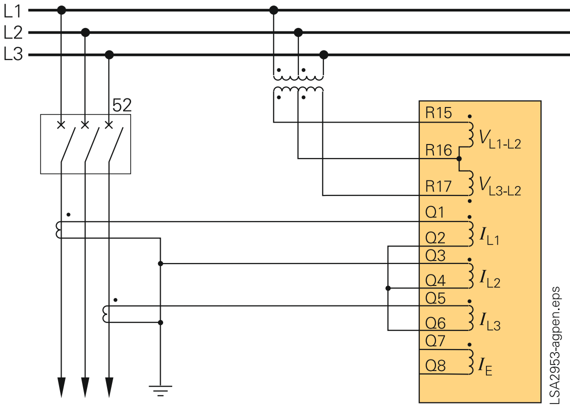


Fig. 5/169
Isolated-neutral or compensated networks

Connection for the synchronization function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be synchronized.

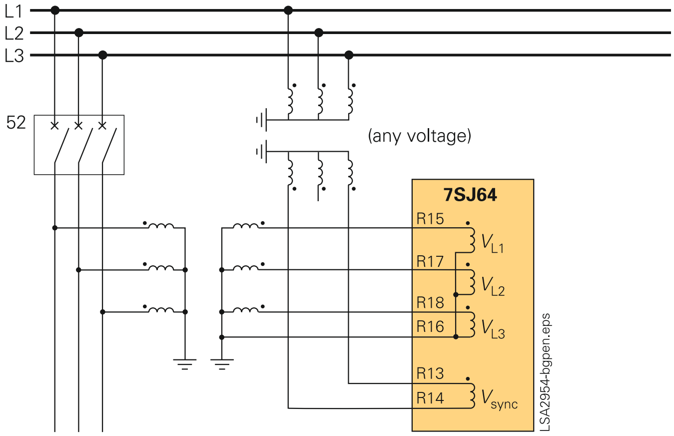


Fig. 5/170
Measuring of the busbar voltage and the outgoing feeder voltage for synchronization

Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase-current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current $> 0.05\ I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

■ Application examples

Synchronization function

When two subnetworks must be interconnected, the synchronization function monitors whether the subnetworks are synchronous and can be connected without risk of losing stability.

As shown in Fig. 5/171, load is being fed from a generator to a busbar via a transformer. It is assumed that the frequency difference of the 2 subnetworks is such that the device determines asynchronous system conditions.

The voltages of the busbar and the feeder should be the same when the contacts are made; to ensure this condition the synchronism function must run in the “synchronous/asynchronous switching” mode.
In this mode, the operating time of the CB can be set within the relay.
Differences between angle and frequency can then be calculated by the relay while taking into account the operating time of the CB. From these differences, the unit derives the exact time for issuing the CLOSE command under asynchronous conditions.
When the contacts close, the voltages will be in phase.

The vector group of the transformer can be considered by setting parameters. Thus no external circuits for vector group adaptation are required.

This synchronism function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local/remote).

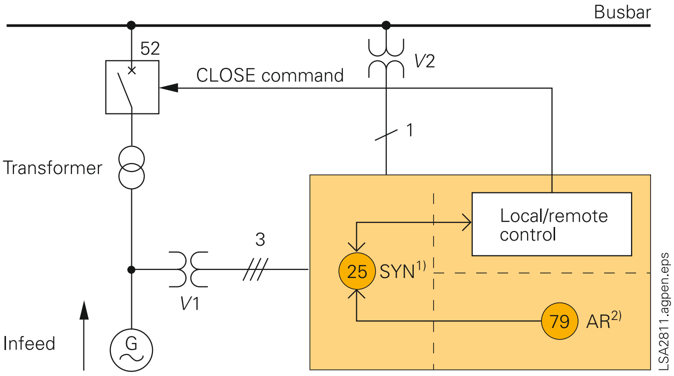


Fig. 5/171 Measuring of busbar and feeder voltages for synchronization

1) Synchronization function
2) Auto-reclosure function

Typical applications

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Figure 5/172, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault.

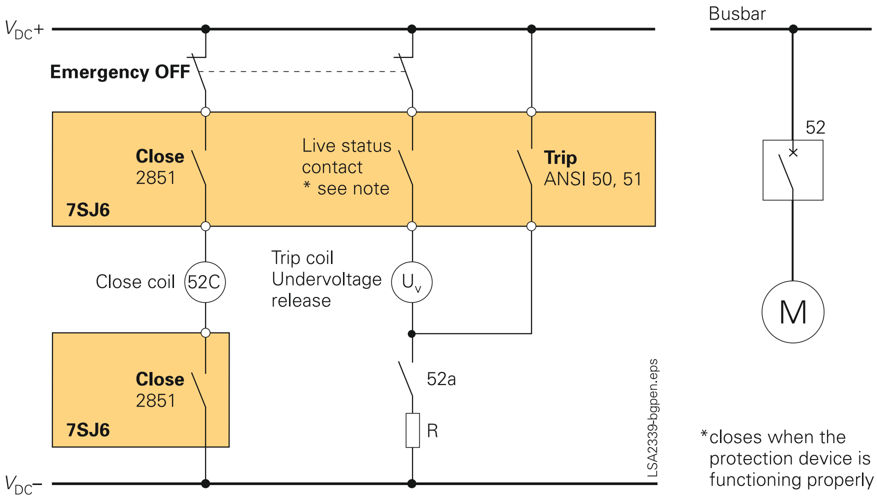


Fig. 5/172 Undervoltage release with make contact 50, 51

In Fig. 5/173 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

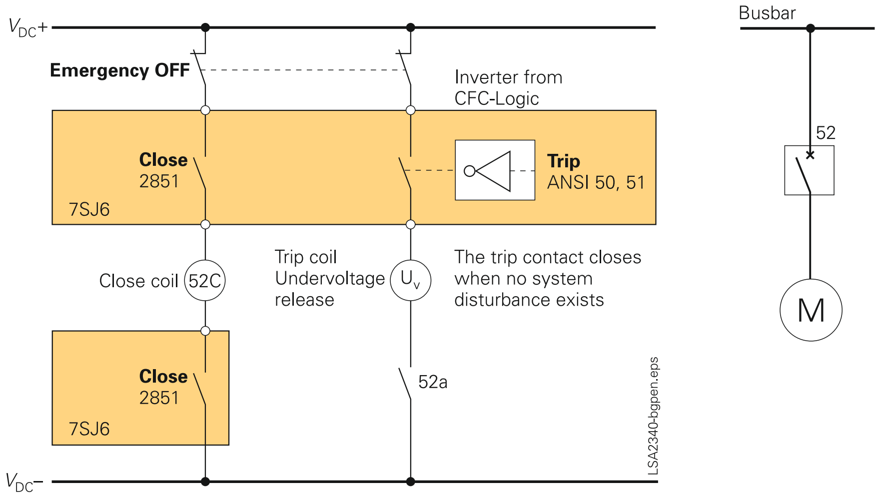


Fig. 5/173 Undervoltage release with locking contact (trip signal 50 is inverted)

Typical applications

Trip circuit supervision (ANSI 74TC)

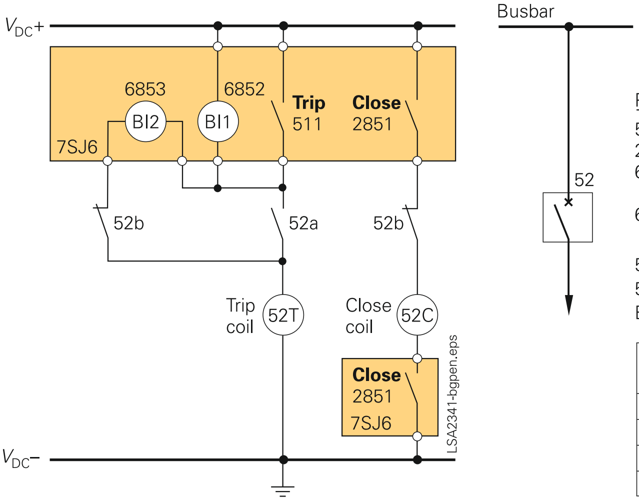
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional time-overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current. Reverse-power protection is performed via the "flexible protection functions" of the 7SJ64.



Protection indications

511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/174 Trip circuit supervision with 2 binary inputs

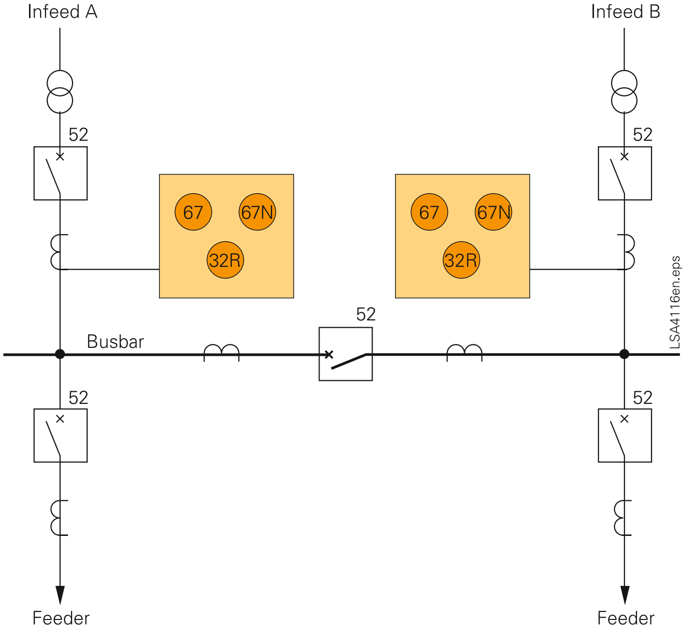


Fig. 5/175 Reverse-power protection for dual supply

Technical data

General unit data

Measuring circuits

System frequency	50 / 60 Hz (settable)

Current transformer

Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	$I_{EE} < 1.6$ A
Power consumption	
at $I_{nom} = 1$ A	Approx. 0.05 VA per phase
at $I_{nom} = 5$ A	Approx. 0.3 VA per phase
for sensitive earth-fault CT at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (effective)	100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT	
Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)

Voltage transformer

Rated voltage V_{nom}	100 V to 225 V
Measuring range	0 V to 200 V
Power consumption at $V_{nom} = 100$ V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage)	
Thermal (effective)	230 V continuous

Auxiliary voltage *(via integrated converter)*

Rated auxiliary voltage V_{aux}	DC	24/48 V	60/125 V	110/250 V	
Permissible tolerance	DC	19 - 58 V	48 - 150 V	88 - 300 V	
Ripple voltage, peak-to-peak		≤ 12 % of rated auxiliary voltage			
Power consumption		7SJ640	7SJ641 7SJ642	7SJ645	7SJ647
Quiescent	Approx.	5 W	5.5 W	6.5 W	7.5 W
Energized	Approx.	9 W	12.5 W	15 W	21 W
Backup time during loss/short-circuit of auxiliary direct voltage		≥ 50 ms at V > 110 V DC ≥ 20 ms at V > 24 V DC			
Rated auxiliary voltage V_{aux}	AC	115 / 230 V			
Permissible tolerance	AC	92 - 132 V / 184 - 265 V			
Power consumption		7SJ640	7SJ641 7SJ642	7SJ645	7SJ647
Quiescent	Approx.	7 W	9 W	12 W	16 W
Energized	Approx.	12 W	19 W	23 W	33 W
Backup time during loss/short-circuit of auxiliary alternating voltage		≥ 200 ms			

Binary inputs/indication inputs

Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Number (marshallable)	7	15	20	33	48
Voltage range	24 - 250 V DC				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	19 V DC		88 V DC		
For rated control voltage DC	24/48/60/110/ 125 V DC		110/125/220/250 V DC		
Power consumption energized	0.9 mA (independent of operating voltage) for BI 8…19 / 21…32; 1.8 mA for BI 1…7 / 20/33…48				

Binary outputs/command outputs

Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Command/indication relay	5	13	8	11	21
Contacts per command/ indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper)/form A/B				
Switching capacity Make	1000 W / VA				
Break	30 W / VA / 40 W resistive/ 25 W at L/R ≤ 50 ms				
Switching voltage	≤ 250 V DC				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				

Power relay *(for motor control)*

Type	7SJ640 7SJ641	7SJ642	7SJ645	7SJ647
Number	0	2 (4)	4 (8)	4 (8)
Number of contacts/relay		2 NO / form A		
Switching capacity Make	1000 W / VA at 48 V … 250 V / 500 W at 24 V			
Break	1000 W / VA at 48 V … 250 V / 500 W at 24 V			
Switching voltage	≤ 250 V DC			
Permissible current	5 A continuous, 30 A for 0.5 s			

Technical data

Electrical tests

Specification

Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508

Insulation tests

Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

EMC tests for interference emission; type tests

Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Technical data

Climatic stress tests

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F

Humidity

Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design

Type	7SJ640 7SJ642	7SJ641	7SJ645 7SJ647
Housing	7XP20		
Dimensions	See dimension drawings, part 15 of this catalog		
Weight in kg	Housing width 1/3	Housing width 1/2	Housing width 1/1
Surface-mounting housing	8	11	15
Flush-mounting housing	5	6	10
Housing for detached operator panel	–	8	12
Detached operator panel	–	2.5	2.5
Degree of protection acc. to EN 60529			
Surface-mounting housing	IP 51		
Flush-mounting housing	Front: IP 51, rear: IP 20;		
Operator safety	IP 2x with cover		

Serial interfaces

Operating interface *(front of unit)*

Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud

Service/modem interface *(rear of unit)*

Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud

RS232/RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

Additional interface *(rear of unit)*

Isolated interface for data transfer	Port D: RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “D”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

Fiber optic

Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “D”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

Technical data

System interface *(rear of unit)*

IEC 60870-5-103 protocol

Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

IEC 60870-5-103 protocol, redundant

RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

IEC 61850 protocol

Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors Mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Intergr. LC connector for FO connection Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles

PROFIBUS-FMS/DP

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable For flush-mounting housing/ surface-mounting housing with detached operator panel	Integr. ST connector for FO connection, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/215
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles

MODBUS RTU, ASCII, DNP 3.0

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/215
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions

Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)

Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)	
Number of elements (stages)	I>, I>>, I>>> (phases) I_E>, I_E>>, I_E>>> (earth)	
Setting ranges		
Pickup phase elements	0.5 to 175 A or ∞ 1) (in steps of 0.01 A)	
Pickup earth elements	0.25 to 175 A or ∞ 1) (in steps of 0.01 A)	
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)	
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)	
Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)		
	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for I/I_{nom} ≥ 0.3	
Tolerances		
Pickup	2 % of setting value or 50 mA 1)	
Delay times T, T_{DO}	1 % or 10 ms	

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)

Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞ 1) (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞ 1) (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Undervoltage threshold V< for release I_p	10.0 to 125.0 V (in steps of 0.1 V)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for I_p/I_{nom} ≥ 0.3, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA 1)
Pickup time for 2 ≤ I/I_p ≤ 20	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for 0.05 ≤ I/I_p ≤ 0.9	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

Direction detection

For phase faults

Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot}$ ± 86° - 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase

For earth faults

Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot}$ ± 86° - 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	V_E ≈ 2.5 V displacement voltage, measured; $3V_0$ ≈ 5 V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2$ ≈ 5 V negative-sequence voltage; $3I_2$ ≈ 225 mA negative-sequence current 1)
Tolerances (phase angle error under reference conditions)	
For phase and earth faults	± 3 ° electrical

Inrush blocking

Influenced functions	Time-overcurrent elements, I>, I_E>, I_p, I_{Ep} (directional, non-directional)
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA 1)
Lower function limit earth	Earth current (50 Hz and 100 Hz) ≥ 125 mA 1)
Upper function limit (setting range)	1.5 to 125 A 1) (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF

Dynamic setting change

Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

---

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

(Sensitive) earth-fault detection *(ANSI 64, 50 Ns, 51Ns, 67Ns)*

Displacement voltage starting *for all types of earth fault (ANSI 64)*

Setting ranges	
Pickup threshold V_E> (measured)	1.8 to 200 V (in steps of 0.1 V)
Pickup threshold 3V_0> (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay\ pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 50 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold 3V_0 (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms

Phase detection for earth fault in an unearthed system

Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{ph\ min}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph\ max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V

Earth-fault pickup *for all types of earth faults*

Definite-time characteristic *(ANSI 50Ns)*

Setting ranges	
Pickup threshold I_{EE}>, I_{EE}>>	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] (in steps of 0.01 A)
Delay times T for I_{EE}>, I_{EE}>>	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1]
Delay times	1 % of setting value or 20 ms

Earth-fault pickup *for all types of earth faults*

Inverse-time characteristic *(ANSI 51Ns)*

User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1] (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1]
Delay times in linear range	7 % of reference value for 2 ≥ I/I_{EEp} ≥ 20 + 2 % current tolerance, or 70 ms
Logarithmic inverse	Refer to the manual
Logarithmic inverse with knee point	Refer to the manual

Direction detection *for all types of earth-faults (ANSI 67Ns)*

Measuring method "cos φ/sin φ"	
Direction measurement	I_E and V_E measured or 3I_0 and 3V_0 calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1] (in steps of 0.01 A)
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Reduction of dir. area $\alpha_{Red.dir.area}$	1 ° to 15 ° (in steps of 1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Tolerances	
Pickup measuring enable	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1]
Angle tolerance	3 °
Measuring method "φ (V_0/I_0)"	
Direction measurement	I_E and V_E measured or 3I_0 and 3V_0 calculated
Minimum voltage $V_{min.}$ measured	0.4 to 50 V (in steps of 0.1 V)
Minimum voltage $V_{min.}$ calculated	10 to 90 V (in steps of 1 V)
Phase angle φ	-180° to 180° (in steps of 0.1°)
Delta phase angle Δ φ	0° to 180° (in steps of 0.1°)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold 3 V_0 (calculated)	3 % of setting value or 3 V
Angle tolerance	3 °

Angle correction for cable CT

Angle correction F1, F2	0° to 5° (in steps of 0.1°)
Current value $I1$, $I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] (in steps of 0.01 A)

High-impedance restricted earth-fault protection *(ANSI 87N) / single-phase overcurrent protection*

Setting ranges	
Pickup thresholds I>, I>>	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times T_I>, T_I>>	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for I/I_{nom} ≥ 0.5
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

---

1) For I_{nom} = 1 A, all limits divided by 5.

Technical data

Intermittent earth-fault protection

Setting ranges		
Pickup threshold		
For I_E	I_{IE}>	0.25 to 175 A 1) (in steps of 0.01 A)
For $3I_0$	I_{IE}>	0.25 to 175 A 1) (in steps of 0.01 A)
For I_{EE}	I_{IE}>	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)
Times		
Pickup times		
Current = 1.25 · pickup value		Approx. 30 ms
Current ≥ 2 · pickup value		Approx. 22 ms
Dropout time		Approx. 22 ms
Tolerances		
Pickup threshold I_{IE}>		3 % of setting value, or 50 mA 1)
Times T_V, T_{sum}, T_{res}		1 % of setting value or 10 ms

Thermal overload protection (ANSI 49)

Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \le 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

Auto-reclosure (ANSI 79)

Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault	
Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault	
Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
I>>>, I>>, I>, I_p, I_{dir}>>, I_{dir}>, I_{pdir}
I_E>>>, I_E>>, I_E>, I_{Ep}, I_{Edir}>>, I_{Edir}>, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection (ANSI 50 BF)

Setting ranges	
Pickup thresholds	0.2 to 5 A 1) (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA) 1)
Delay time	1 % or 20 ms

Synchro- and voltage check (ANSI 25)

Operating modes	• Synchro-check • Asynchronous/synchronous
Additional release conditions	• Live-bus / dead line • Dead-bus / live-line • Dead-bus and dead-line • Bypassing

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Voltages	
Max. operating voltage V_{max}	20 to 140 V (phase-to-phase) (in steps of 1 V)
Min. operating voltage V_{min}	20 to 125 V (phase-to-phase) (in steps of 1 V)
V< for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)
V> for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)
Primary rated voltage of transformer $V2_{\text{nom}}$	0.1 to 800 kV (in steps of 0.01 kV)
Tolerances	2 % of pickup value or 2 V
Drop-off to pickup ratios	approx. 0.9 (V>) or 1.1 (V<)
ΔV-measurement	
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)
Tolerance	1 V
Δf-measurement	
Δf-measurement ($f2>f1$; $f2<f1$)	0.01 to 2 Hz (in steps of 0.01 Hz)
Tolerance	15 mHz
$\Delta\alpha$-measurement	
$\Delta\alpha$-measurement ($\alpha2>\alpha1$; $\alpha2>\alpha1$)	2 ° to 80 ° (in steps of 1 °)
Tolerance	2 °
Max. phase displacement	5 ° for $\Delta f \leq 1$ Hz 10 ° for $\Delta f > 1$ Hz
Circuit-breaker operating time	
CB operating time	0.01 to 0.6 s (in steps of 0.01 s)
Threshold ASYN ⇔ SYN	
Threshold synchronous / asynchronous	0.01 to 0.04 Hz (in steps of 0.01 Hz)
Adaptation	
Vector group adaptation by angle	0 ° to 360 ° (in steps of 1 °)
Different voltage transformers V_1/V_2	0.5 to 2 (in steps of 0.01)
Times	
Minimum measuring time	Approx. 80 ms
Max. duration $T_{\text{SYN DURATION}}$	0.01 to 1200 s; ∞ (in steps of 0.01 s)
Supervision time $T_{\text{SUP VOLTAGE}}$	0 to 60 s (in steps of 0.01 s)
Closing time of CB $T_{\text{CB close}}$	0 to 60 s (in steps of 0.01 s)
Tolerance of all timers	1 % of setting value or 10 ms
Measuring values of synchro-check function	
Reference voltage $V1$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Voltage to be synchronized $V2$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Frequency of $V1$ and $V2$	$f1$, $f2$ in Hz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Voltage difference ($V2 - V1$)	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Frequency difference ($f2 - f1$)	In mHz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Angle difference ($\alpha2 - \alpha1$)	In °
Range	0 to 180 °
Tolerance*)	0.5 °

Negative-sequence current detection *(ANSI 46)*

Definite-time characteristic *(ANSI 46-1 and 46-2)*

Setting ranges	
Pickup current I_2>, I_2>>	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{\text{nom}} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1]
Delay times	1 % or 10 ms

Inverse-time characteristic *(ANSI 46-TOC)*

Setting ranges	
Pickup current	0.5 to 10 A[1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Flexible protection functions *(ANSI 27, 32, 47, 50, 55, 59, 81R)*

Operating modes / measuring quantities	
3-phase	I, I_1, I_2, I_2/I_1, $3I_0$, V, V_1, V_2, $3V_0$, dV/dt, P, Q, cos φ
1-phase	I, I_E, $I_{\text{E sens.}}$, V, V_E, P, Q, cos φ
Without fixed phase relation	f, df/dt, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current I, I_1, I_2, $3I_0$, I_E	0.15 to 200 A[1] (in steps of 0.01 A)
Current ratio I_2/I_1	15 to 100 % (in steps of 1 %)
Sens. earth curr. $I_{\text{E sens.}}$	0.001 to 1.5 A (in steps of 0.001 A)
Voltages V, V_1, V_2, $3V_0$	2 to 260 V (in steps of 0.1 V)
Displacement voltage V_E	2 to 200 V (in steps of 0.1 V)
Power P, Q	0.5 to 10000 W (in steps of 0.1 W)
Power factor (cos φ)	- 0.99 to + 0.99 (in steps of 0.01)
Frequency $f_N = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
$f_N = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Rate-of-frequency change df/dt	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
Voltage change dV/dt	4 V/s to 100 V/s (in steps of 1 V/s)
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Dropout differential f	0.02 to 1.00 Hz (in steps of 0.01 Hz)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)

*) With rated frequency.

[1] At $I_{\text{nom}} = 1$ A, all limits divided by 5.

Technical data

Flexible protection functions *(ANSI 27, 32, 47, 50, 55, 59, 81R) (cont'd)*

Times	
Pickup times	
Current, voltage (phase quantities)	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Current, voltages (symmetrical components)	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Power	
Typical	Approx. 120 ms
Maximum (low signals and thresholds)	Approx. 350 ms
Power factor	300 to 600 ms
Frequency	Approx. 100 ms
Rate-of-frequency change	
with 1.25 times the setting value	Approx. 220 ms
Voltage change dV/dt for 2 times pickup value	Approx. 220 ms
Binary input	Approx. 20 ms
Dropout times	
Current, voltage (phase quantities)	< 20 ms
Current, voltages (symmetrical components)	< 30 ms
Power	
Typical	< 50 ms
Maximum	< 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Rate-of-frequency change	< 200 ms
Voltage change	< 220 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Current	0.5 % of setting value or 50 mA 1)
Current (symmetrical components)	1 % of setting value or 100 mA 1)
Voltage	0.5 % of setting value or 0.1 V
Voltage (symmetrical components)	1 % of setting value or 0.2 V
Power	1 % of setting value or 0.3 W
Power factor	2 degrees
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Rate-of-frequency change	5 % of setting value or 0.05 Hz/s
Voltage change dV/dt	5 % of setting value or 2 V/s
Times	1 % of setting value or 10 ms

Starting time monitoring for motors *(ANSI 48)*

Setting ranges	
Motor starting current I_{STARTUP}	2.5 to 80 A 1) (in steps of 0.01)
Pickup threshold $I_{\text{MOTOR START}}$	2 to 50 A 1) (in steps of 0.01)
Permissible starting time $T_{\text{STARTUP , COLD MOTOR}}$	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{\text{STARTUP, WARM MOTOR}}$	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{\text{BLOCKED-ROTOR}}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic for $I >$ $I_{\text{MOTOR START}}$	$t = \left(\frac{I_{\text{STARTUP}}}{I}\right)^2 \cdot T_{\text{STARTUP}}$ I_{STARTUP} = Rated motor starting current I = Actual current flowing T_{STARTUP} = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{\text{MOTOR START}}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA 1)
Delay time	5 % or 30 ms

Load jam protection for motors *(ANSI 51M)*

Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A 1) (in steps of 0.01 A)
Delay times	0 to 600 s (in steps of 0.01 s)
Blocking duration after CLOSE signal detection	0 to 600 s (in steps of 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA 1)
Delay time	1 % of setting value or 10 ms

Restart inhibit for motors *(ANSI 66)*

Setting ranges	
Motor starting current relative to rated motor current $I_{\text{MOTOR START}}/I_{\text{Motor Nom}}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{\text{Motor Nom}}$	1 to 6 A 1) (in steps of 0.01 A)
Max. permissible starting time $T_{\text{Start Max}}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{\text{MIN. INHIBIT TIME}}$	0.2 to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau \text{ at STOP}}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau \text{ RUNNING}}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{\text{restart}} = \Theta_{\text{rot max perm}} \cdot \frac{n_c - 1}{n_c}$ Θ_{restart} = Temperature limit below which restarting is possible $\Theta_{\text{rot max perm}}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{\text{rot}}/\Theta_{\text{rot trip}}$) n_c = Number of permissible start-ups from cold state

Undercurrent monitoring *(ANSI 37)*

Signal from the operational measured values	Predefined with programmable logic

---

1) At $I_{\text{nom}} = 1$ A, all limits divided by 5.

Technical data

Temperature monitoring box (ANSI 38)

Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Undervoltage protection (ANSI 27)

Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$	
dependent on voltage connection and chosen measuring quantity	10 to 120 V (in steps of 1 V) 10 to 210 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A1) (in steps of 0.01 A)
Times	
Pickup times	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	0.5 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overvoltage protection (ANSI 59)

Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or negative phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$	
dependent on voltage connection and chosen measuring quantity	40 to 260 V (in steps of 1 V) 40 to 150 V (in steps of 1 V) 2 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times V	Approx. 50 ms
Pickup times V_1, V_2	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	0.5 % of setting value or 1 V
Times	1 % of setting value or 10 ms

---

1) At $I_{nom} = 1$ A, all limits divided by 5.

2) At $I_{nom} = 1$ A, all limits multiplied with 5.

3) At rated frequency.

Frequency protection (ANSI 81)

Number of frequency elements	4
Setting ranges	
Pickup thresholds for $f_{nom} = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
Pickup thresholds for $f_{nom} = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Dropout differential = |pickup threshold - dropout threshold|	0.02 Hz to 1.00 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 80 ms
Dropout times	Approx. 75 ms
Dropout	
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms

Fault locator (ANSI 21FL)

Output of the fault distance	In Ω primary or secondary, in km / miles of line length, in % of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km2) (in steps of 0.0001) 0.001 to 3 Ω/mile2) (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for 30 ° ≤ φK ≤ 90 ° and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions

Operational measured values

Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range	10 to 200 % I_{nom}
Tolerance3)	1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages V_{L1-E}, V_{L2-E}, V_{L3-E} Phase-to-phase voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_{SYN}, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance3)	1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range	0 to 120 % S_{nom}
Tolerance3)	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %

Technical data

Operational measured values *(cont'd)*	
P, active power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}
Range	0 to 120 % S_{nom}
Tolerance1)	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\cos\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range	0 to 120 % S_{nom}
Tolerance1)	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\sin\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
$\cos\varphi$, power factor (p.f.)	Total and phase segregated
Range	- 1 to + 1
Tolerance1)	2 % for $\lvert\cos\varphi\rvert \geq 0.707$
Frequency f	In Hz
Range	$f_{nom} \pm 5$ Hz
Tolerance1)	20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range	0 to 400 %
Tolerance1)	5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\,Trip}$	In %
Range	0 to 400 %
Tolerance1)	5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\,Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\,real}$, IEE reactive	In A (kA) primary and in mA secondary
Range	0 mA to 1600 mA
Tolerance1)	2 % of measured value or 1 mA
RTD-box	See section “Temperature monitoring box”
Synchronism and voltage check	See section “Synchronism and voltage check”

Long-term averages	
Time window	5, 15, 30 or 60 minutes
Frequency of updates	Adjustable
Long-term averages	
of currents	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA)
of real power	P_{dmd} in W (kW, MW)
of reactive power	Q_{dmd} in VAr (kVAr, MVAr)
of apparent power	S_{dmd} in VAr (kVAr, MVAr)

---

1) At rated frequency.

Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	$V_{L1\text{-}E}$, $V_{L2\text{-}E}$, $V_{L3\text{-}E}$ V_1 (positive-sequence component) $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$
Min./Max. values for power	S, P, Q, $\cos\varphi$, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}

Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I>I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V>V_{lim}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC

Fuse failure monitor	
For all types of networks	With the option of blocking affected protection functions

Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message “Battery Fault” for insufficient battery charge

Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz	1 sample/1.25 ms (16 samples/cycle)
Sampling rate for 60 Hz	1 sample/1.04 ms (16 samples/cycle)

Technical data

Energy/power

Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1]	≤ 2 % for $I > 0.1\ I_{nom}$, $V > 0.1\ V_{nom}$ and $\lvert \cos \varphi \rvert$ (p.f.) ≥ 0.707

Statistics

Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits

Circuit-breaker wear

Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication

Motor statistics

Total number of motor start-ups	0 to 9999	(resolution 1)
Total operating time	0 to 99999 h	(resolution 1 h)
Total down-time	0 to 99999 h	(resolution 1 h)
Ratio operating time/down-time	0 to 100 %	(resolution 0.1 %)
Active energy and reactive energy	See operational measured values	
Motor start-up data:	Of the last 5 start-ups	
– Start-up time	0.30 s to 9999.99 s	(resolution 10 ms)
– Start-up current (primary)	0 A to 1000 kA	(resolution 1 A)
– Start-up voltage (primary)	0 V to 100 kV	(resolution 1 V)

Operating hours counter

Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})

Trip circuit monitoring

With one or two binary inputs

Commissioning aids

Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report

Clock

Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication

Setting group switchover of the function parameters

Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

Control

Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	
Units with small display	Control via menu, assignment of a function key
Units with large display	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

c UL us
LISTED

---

1) At rated frequency.

Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*
Housing, binary inputs and outputs	
Housing 1/3 19”, 7 BI, 5 BO, 1 live status contact, text display 4 x 20 character (only for 7SJ640) 9th position only with: *B, D, E*	*0*
Housing 1/2 19”, 15 BI, 13 BO (1 NO/NC or 1a/b contact), 1 live status contact, graphic display	*1*
Housing 1/2 19”, 20 BI, 8 BO, 4 (2) power relays, 1 live status contact, graphic display	*2*
Housing 1/1 19”, 33 BI, 11 BO, 8 (4) power relays, 1 live status contact, graphic display	*5*
Housing 1/1 19”, 48 BI, 21 BO, 8 (4) power relays, 1 live status contact, graphic display	*7*
Measuring inputs (4 x V, 4 x I)	
$I_{\text{ph}} = 1$ A$^{1)}$, $I_{\text{e}} = 1$ A$^{1)}$ (min. = 0.05 A) Position 15 only with *A, C, E, G*	*1*
$I_{\text{ph}} = 1$ A$^{1)}$, I_{e} = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*2*
$I_{\text{ph}} = 5$ A$^{1)}$, $I_{\text{e}} = 5$ A$^{1)}$ (min. = 0.25 A) Position 15 only with *A, C, E, G*	*5*
$I_{\text{ph}} = 5$ A$^{1)}$, I_{e} = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*6*
$I_{\text{ph}} = 5$ A$^{1)}$, $I_{\text{e}} = 1$ A$^{1)}$ (min. = 0.05 A) Position 15 only with *A, C, E, G*	*7*
Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, threshold binary input 19 V DC$^{3)}$	*2*
60 to 125 V DC$^{2)}$, threshold binary input 19 V DC$^{3)}$	*4*
110 to 250 V DC$^{2)}$, 115 to 230 V AC, threshold binary input 88 V DC$^{3)}$	*5*
Unit version	
Surface-mounting housing, plug-in terminals, detached operator panel, panel mounting in low-voltage housing	*A*
Surface-mounting housing, 2-tier terminals on top/bottom	*B*
Surface-mounting housing, screw-type terminals (direct connection/ ring-type cable lugs), detached operator panel, panel mounting in low-voltage housing	*C*
Flush-mounting housing, plug-in terminals (2/3 pin connector)	*D*
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	*E*
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), without operator panel, panel mounting in low-voltage housing	*F*
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	*G*
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German (language selectable)	*A*
Region World, 50/60 Hz, IEC/ANSI, language: English (GB) (language selectable)	*B*
Region US, 60 Hz, ANSI, language: English (US) (language selectable)	*C*
Region FR, 50/60 Hz, IEC/ANSI, language: French (language selectable)	*D*
Region World, 50/60 Hz, IEC/ANSI, language: Spanish (language selectable)	*E*
Region IT, 50/60 Hz, IEC/ANSI, language: Italian (language selectable)	*F*
Region RU, 50/60 Hz, IEC/ANSI, language: Russian(language can be changed)	*G*

see next page

1) Rated current can be selected by means of jumpers

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected per binary input by means of jumpers.

Selection and ordering data

Description	Order No.	Order code
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*	*□□□*
System interface (on rear of unit, Port B)		
No system interface	*0*	see following pages
IEC 60870-5-103 protocol, RS232	*1*	
IEC 60870-5-103 protocol, RS485	*2*	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	*3*	
PROFIBUS-FMS Slave, RS485	*4*	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector 1)	*5*	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector 1)	*6*	
PROFIBUS-DP Slave, RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector 1)	*9*	*L 0 B*
MODBUS, RS485	*9*	*L 0 D*
MODBUS, 820 nm wavelength, ST connector 2)	*9*	*L 0 E*
DNP 3.0, RS485	*9*	*L 0 G*
DNP 3.0, 820 nm wavelength, ST connector 2)	*9*	*L 0 H*
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector 2)	*9*	*L 0 P*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) 2)	*9*	*L 0 S*
Only Port C (service interface)		
DIGSI 4/modem, electrical RS232	*1*	
DIGSI 4/modem/RTD-box 3), electrical RS485	*2*	
Port C and D (service and additional interface)	*9*	*M □ □*
Port C (service interface)		
DIGSI 4/modem, electrical RS232		*1*
DIGSI 4/modem/RTD-box 3), electrical RS485		*2*
Port D (additional interface)		
RTD-box 3), 820 nm fiber, ST connector 4)		*A*
RTD-box 3), electrical RS485		*F*
Measuring/fault recording		
Fault recording	*1*	
Slave pointer, mean values, min/max values, fault recording	*3*	

---

1) Not with position 9 = "*B*"; if 9 = "*B*", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "*B*".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "*B*".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "*B*".

3) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".

4) When using the RTD-box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

Selection and ordering data

Description — Order No.

7SJ64 multifunction protection relay with synchronization — *7SJ64□□ – □□□□□ – □□□□*

Designation				ANSI No.	Description		
Basic version					Control		
				50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
				50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}		
				50N/51N	Insensitive earth-fault protection through IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)		
				50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$		
				51 V	Voltage-dependent inverse-time overcurrent protection		
				49	Overload protection (with 2 time constants)		
				46	Phase balance current protection (negative-sequence protection)		
				37	Undercurrent monitoring		
				47	Phase sequence		
				59N/64	Displacement voltage		
				50BF	Breaker failure protection		
				74TC	Trip circuit supervision; 4 setting groups, cold-load pickup; inrush blocking		
				86	Lockout	*F*	*A*
■			*V*, *P*, *f*	27/59	Under-/overvoltage		
				81 O/U	Under-/overfrequency		
				27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
				32/55/81R		*F*	*E*
■		IEF	*V*, *P*, *f*	27/59	Under-/overvoltage		
				81 O/U	Under-/overfrequency		
				27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
				32/55/81R	Intermittent earth fault	*P*	*E*
■	Dir			67/67N	Direction determination for overcurrent, phases and earth	*F*	*C*
■	Dir		*V*, *P*, *f*	67/67N	Direction determination for overcurrent, phases and earth		
				27/59	Under-/overvoltage		
				81O/U	Under-/overfrequency		
				27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
				32/55/81R		*F*	*G*
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth; intermittent earth fault	*P*	*C*
Directional earth-fault detection	Dir			67/67N	Direction determination for overcurrent, phases and earth		
				67Ns	Directional sensitive earth-fault detection		
■				87N	High-impedance restricted earth fault	*F*	*D* 2)
Directional earth-fault detection			*V*, *P*, *f*	67Ns	Directional sensitive earth-fault detection		
				87N	High-impedance restricted earth fault		
				27/59	Under-/overvoltage		
■				81O/U	Under-/overfrequency		
				27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
				32/55/81R		*F*	*F* 2)
Directional earth-fault detection	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth		
				67Ns	Directional sensitive earth-fault detection		
■				87N	High-impedance restricted earth fault Intermittent earth fault	*P*	*D* 2)

■ Basic version included

V, *P*, *f* = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	*7SJ64☐☐ – ☐☐☐☐☐ – ☐☐☐☐*

Designation				ANSI No.	Description	
Basic version					Control	
				50/51	Time-overcurrent protection $I>, I>>, I>>>, I_p$	
				50N/51N	Earth-fault protection $I_E>, I_E>>, I_E>>>, I_{Ep}$	
				50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>, I_{EE}>>, I_{EEp}$ 1)	
				50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>, I>>>>, I_E>>>>$	
				51 V	Voltage-dependent inverse-time overcurrent protection	
				49	Overload protection (with 2 time constants)	
				46	Phase balance current protection (negative-sequence protection)	
				37	Undercurrent monitoring	
				47	Phase sequence	
				59N/64	Displacement voltage	
				50BF	Breaker failure protection	
				74TC	Trip circuit supervision, 4 setting groups, cold-load pickup, inrush blocking	
				86	Lockout	
Directional earth-fault detection ■				67Ns	Directional sensitive earth-fault detection,	
				87N	High-impedance restricted earth fault	F B 2)
Directional earth-fault detection ■	Motor		V, P, f	67Ns	Directional sensitive earth-fault detection,	
				87N	High-impedance restricted earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				51M	Load jam protection, motor statistics	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	
				27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	H F 2)
Directional earth-fault detection	Motor Dir		V, P, f	67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				51M	Load jam protection, motor statistics	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	
				27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	H H 2)
Directional earth-fault detection ■	Motor Dir	IEF	V, P, f	67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
					Intermittent earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				51M	Load jam protection, motor statistics	
				27/59	Undervoltage/overvoltage	
				81O/U	Underfrequency/overfrequency	
				27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	R H 2)

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

Selection and ordering data

Description			Order No.	Order code
7SJ64 multifunction protection relay with synchronization			*7SJ64□□ – □□□□□ – □□□□ – □□□□*	

Designation	ANSI No.	Description	Order code
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
	50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
	51 V	Voltage-dependent inverse-time overcurrent protection	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	37	Undercurrent monitoring	
	47	Phase sequence	
	59N/64	Displacement voltage	
	50BF	Breaker failure protection	
	74TC	Trip circuit supervision	
		4 setting groups, cold-load pickup	
		Inrush blocking	
	86	Lockout	
■ Motor Dir V, P, f	67/67N	Direction determination for overcurrent, phases and earth	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H G*
■ Motor	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	*H A*
ARC, fault locator, synchronization			
	Without		*0*
	79	With auto-reclosure	*1*
	21FL	With fault locator	*2*
	79, 21FL	With auto-reclosure, with fault locator	*3*
	25	With synchronization	*4*
	25, 79, 21FL	With synchronization, auto-reclosure, fault locator	*7*
ATEX100 Certification For protection of explosion-protected motos (increased-safety type of protection "e"			*Z X 9 9* 2)

---

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) This variant might be supplied with a previous firmware version.

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator	
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional	
License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4	
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Temperature monitoring box	
24 to 60 V AC/DC	*7XV5662-2AD10*
90 to 240 V AC/DC	*7XV5662-5AD10*
Varistor/Voltage Arrester	
Voltage arrester for high-impedance REF protection	
125 Vrms; 600 A; 1S/S 256	*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088	*C53207-A401-D77-1*
Connecting cable	
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit	
- length 5 m /16.4 ft	*7XV5103-7AA05*
- length 25 m /82 ft	*7XV5103-7AA25*
- length 50 m /164 ft	*7XV5103-7AA50*
Manual for 7SJ64	
English	*C53000-G1140-C20 7-x* 1)

---

1) x = please inquire for latest edition (exact Order No.).

Accessories

Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin		1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

---

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

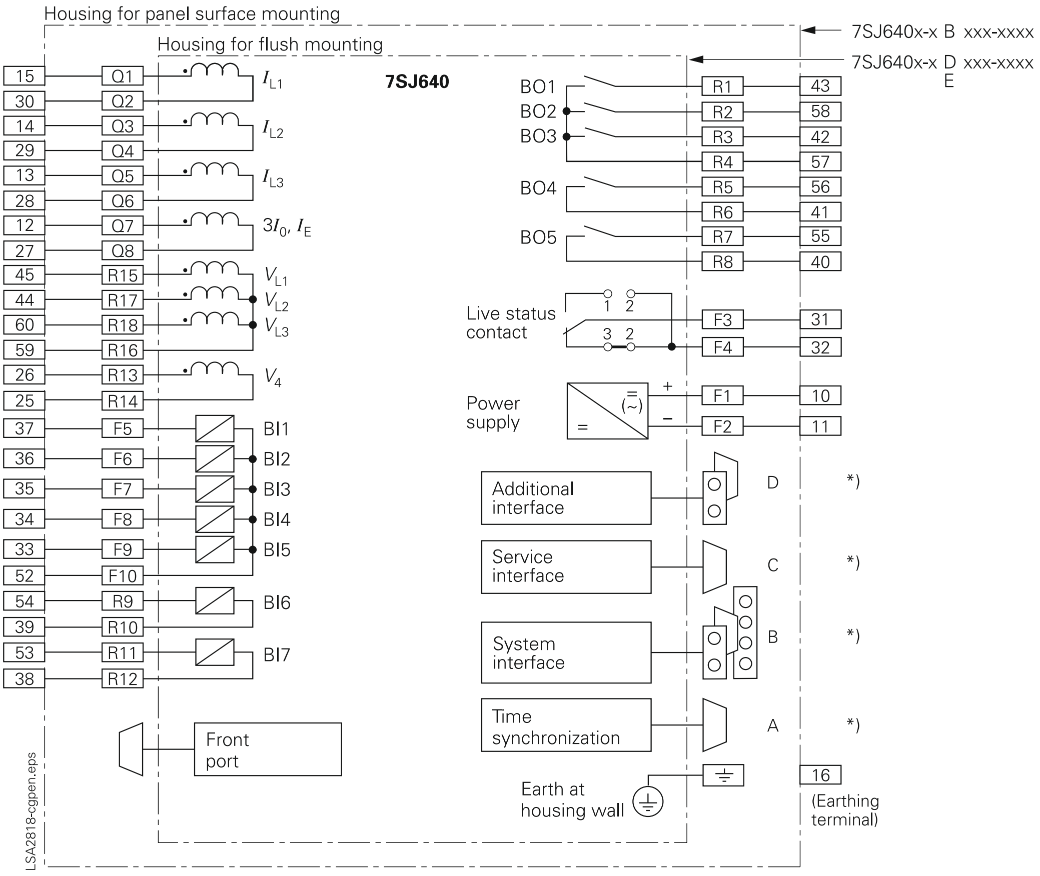


Fig. 5/176
7SJ640 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

Connection diagram

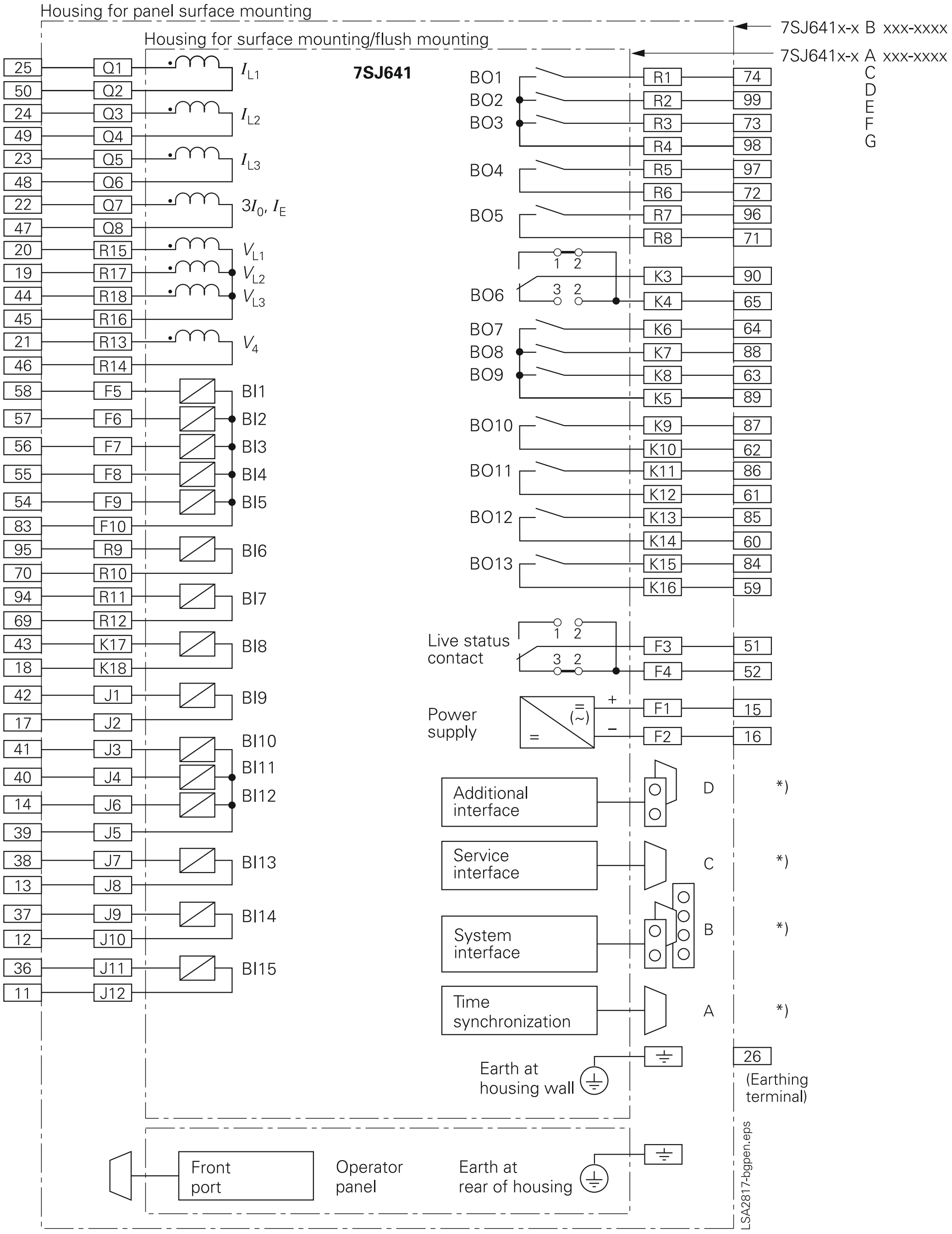


Fig. 5/177
7SJ641 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

Connection diagram

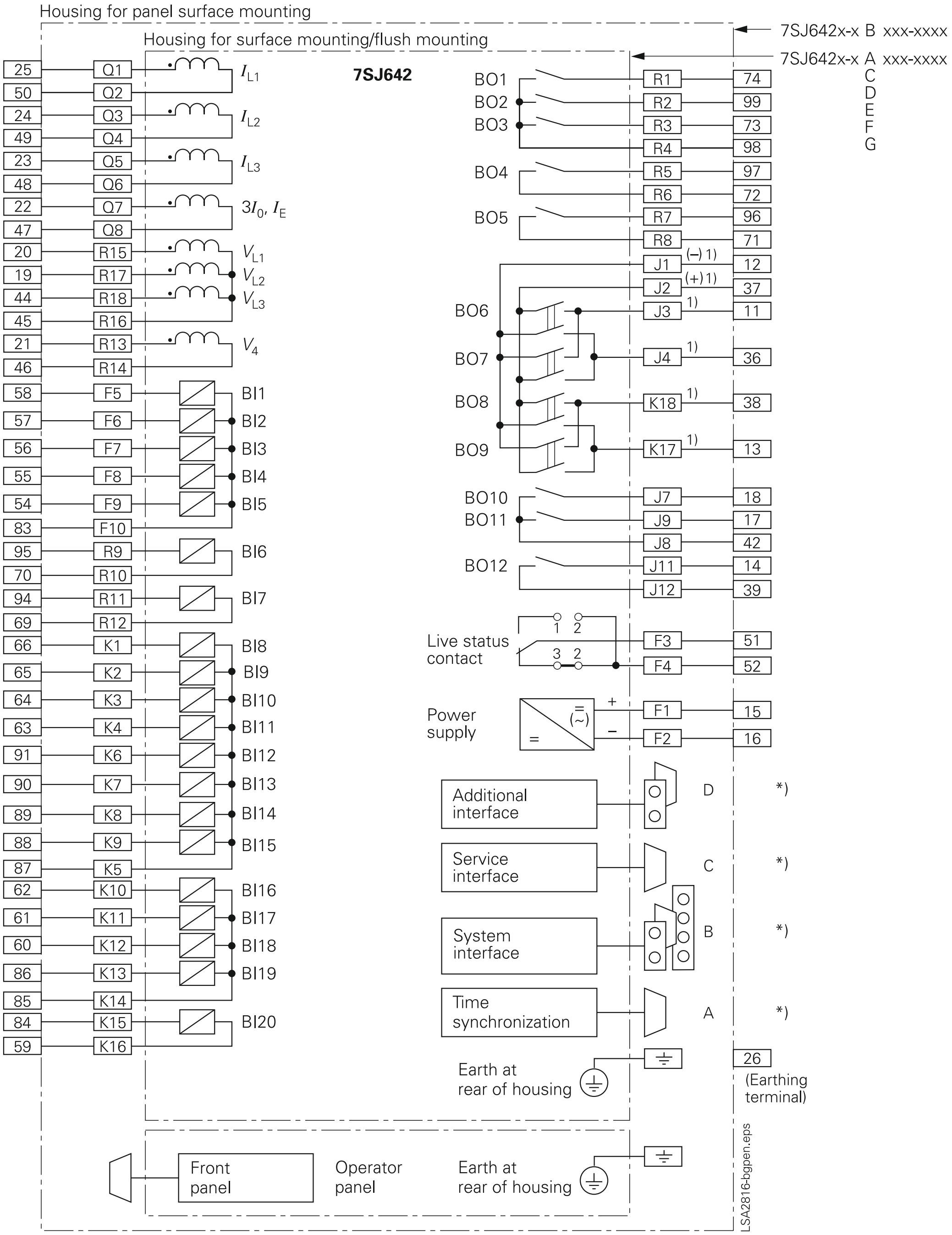


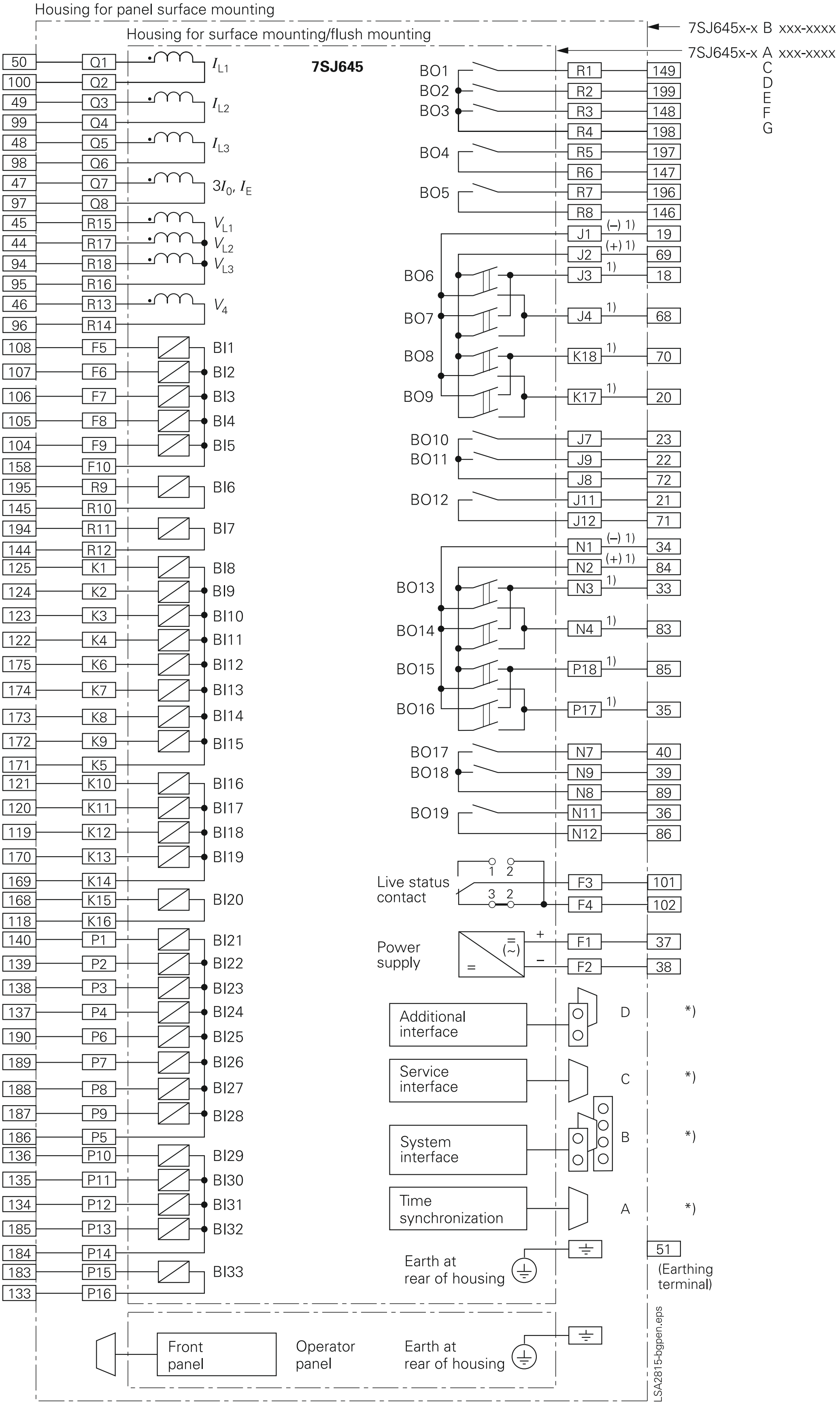
Fig. 5/178
7SJ642 connection diagram

---

*) For pinout of communication ports see part 15 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9. If used for protection purposes only one binary output of a pair can be used.

Connection diagram



*) For pinout of communication ports see part 15 of this catalog. For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/179
7SJ645 connection diagram

Connection diagram

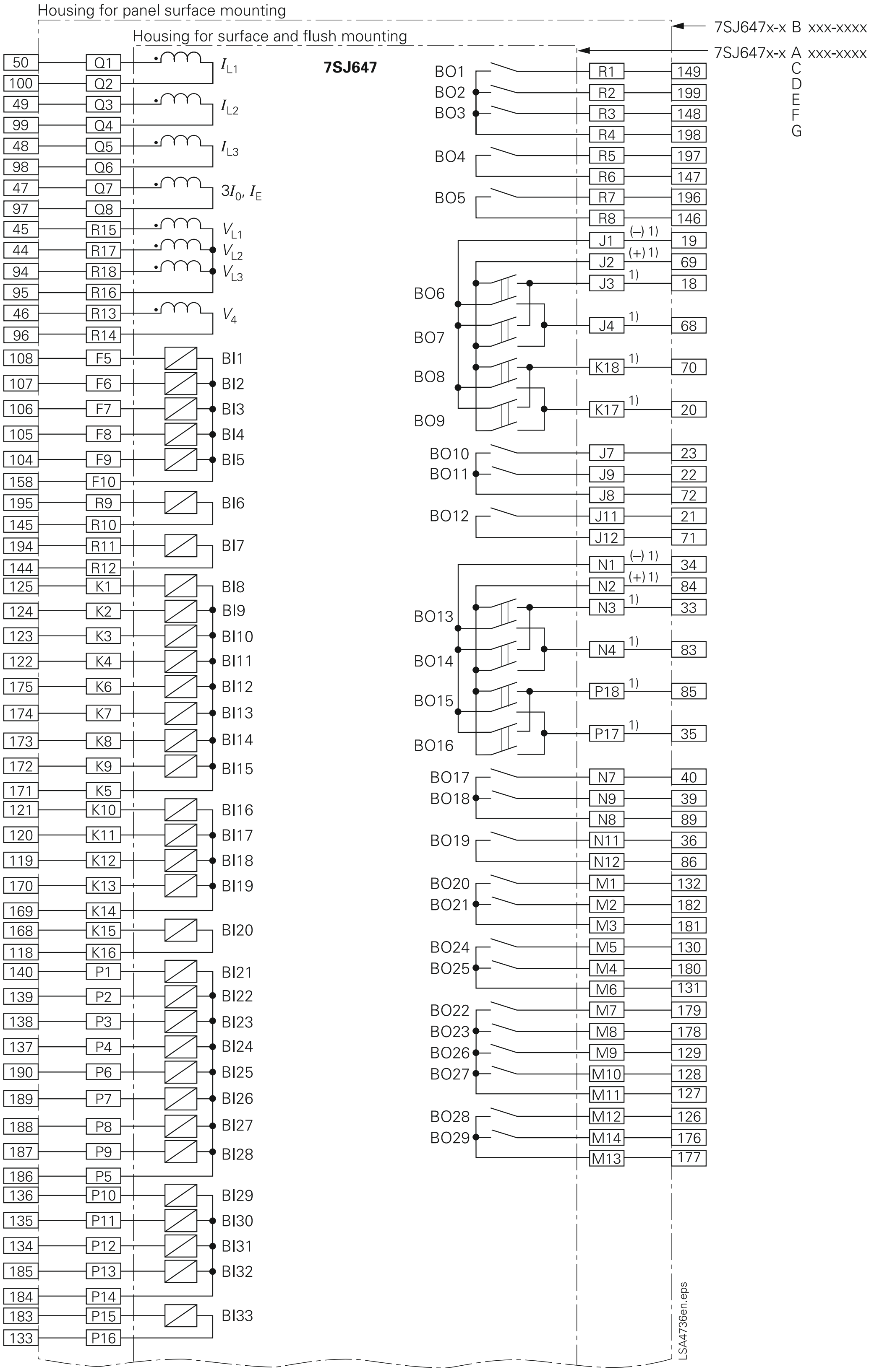


Fig. 5/180
7SJ647 connection diagram part 1;
continued on following page

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16. If used for protection purposes only one binary output of a pair can be used.

Connection diagram

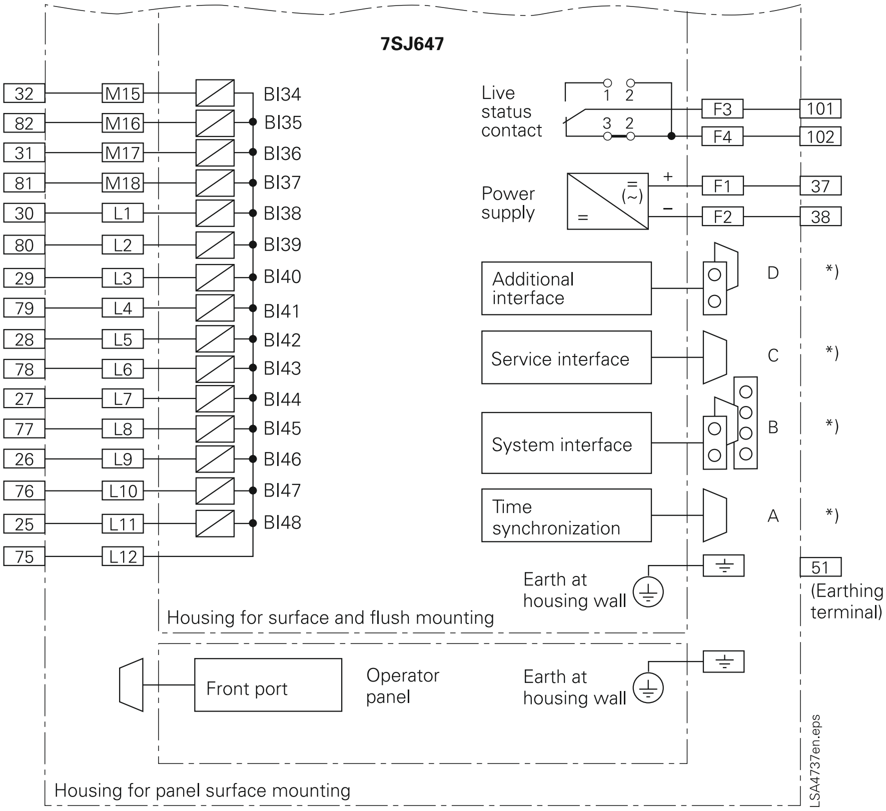


Fig. 5/181
7SJ647 connection diagram part 2

---

*) For pinout of communication ports see part 15 of this catalog. For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

Distance Protection

SIPROTEC 4 7SA6 Distance Protection Relay for all Voltage Levels

LSP2318-afp.tif

Fig. 6/1
SIPROTEC 4
7SA6 distance protection relay

Description

The SIPROTEC 4 7SA6 distance protection relay is a universal device for protection, control and automation on the basis of the SIPROTEC 4 system. Its high level of flexibility makes it suitable to be implemented at all voltage levels. With this relay you are ideally equipped for the future: it offers security of investment and also saves on operating costs.

- High-speed tripping time
- Impedance setting range allows very small settings for the protection of very short lines
- Self-setting detection for power swing frequencies up to 7 Hz
- Current transformer saturation detector prevents non-selective tripping by distance protection in the event of CT saturation.
- Phase-segregated teleprotection for improved selectivity and availability
- Digital relay-to-relay communication by means of an integrated serial protection data interface
- Adaptive auto-reclosure (ADT)

Function overview

Protection functions

- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance earth-fault protection for single and three-pole tripping (50N, 51N, 67N)
- Earth-fault detection in isolated and resonant-earthed networks
- Tele (pilot) protection (85)
- Fault locator (FL)
- Power-swing detection/tripping (68/68T)
- Phase overcurrent protection (50/51/67)
- Switch-onto-fault protection (50HS)
- STUB bus overcurrent protection (50STUB)
- Overvoltage/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79)
- Synchro-check (25)
- Breaker failure protection (50BF)
- Thermal overload protection (49)

Control function

- Commands f. ctrl. of CBs and isolators

Monitoring functions

- Trip circuit supervision (74TC)
- Self-supervision of the relay
- Measured-value supervision
- Event logging/fault logging
- Oscillographic fault recording
- Switching statistics

Front design

- Easy operation w. numeric keys
- Function keys
- LEDs for local alarm
- PC front port for convenient relay setting

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  - IEC 61850 Ethernet
  - IEC 60870-5-103 protocol
  - PROFIBUS-FMS/-DP
  - DNP 3.0
- 1 serial protection data interface for teleprotection
- Rear-side service/modem interface
- Time synchronization via
  - IRIG-B or DCF 77 or
  - system interface

Application

The distance protection relay 7SA6 is non-switched incorporating all the additional functions for protection of overhead lines and cables at all voltage levels from 5 to 765 kV.

All methods of neutral point connection (resonant earthing, isolated, solid or low-resistance earthing) are reliably dealt with. The unit can issue single or three-pole TRIP commands as well as CLOSE commands. Consequently both single-pole, three-pole and multiple auto-reclosure is possible.

Teleprotection functions as well as earth-fault protection and sensitive earth-fault detection are included. Power swings are detected reliably and non-selective tripping is prevented. The unit operates reliably and selectively even under the most difficult network conditions.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control or interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware. The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

ANSI	Protection functions
21/21N	Distance protection
FL	Fault locator
50N/51N 67N	Directional earth-fault protection
50/51/67	Backup overcurrent protection
50 STUB	STUB-bus overcurrent stage
68/68T	Power swing detection/tripping
85/21	Teleprotection for distance protection
27WI	Weak-infeed protection
85/67N	Teleprotection for earth-fault protection
50HS	Switch-onto-fault protection
50BF	Breaker-failure protection
59/27	Overvoltage/undervoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)
49	Thermal overload protection
I_{EE}	Sensitive earth-fault detection

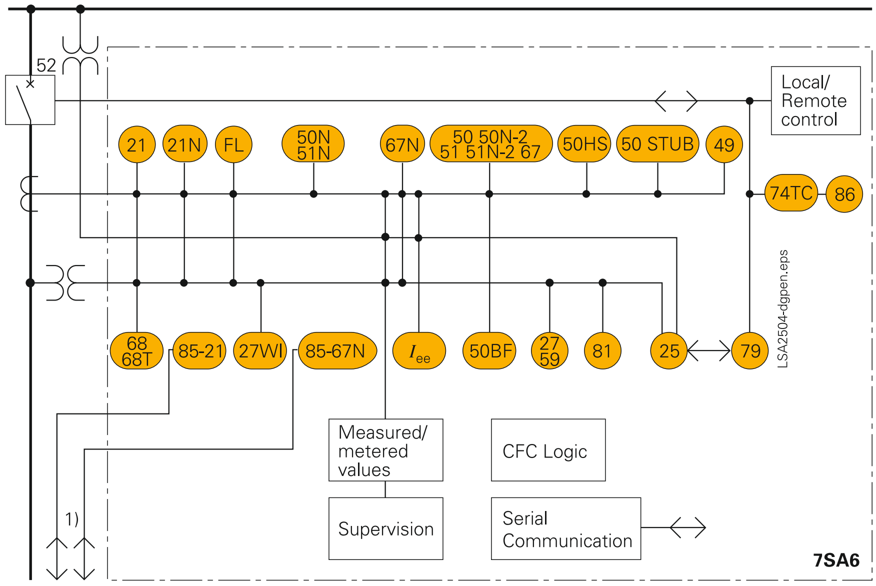


Fig. 6/2 Function diagram

1) Teleprotection schemes can use conventional signaling or serial data exchange

Construction

Connection techniques and housing with many advantages

1/3, 1/2, 2/3, and 1/1-rack sizes:
These are the available housing widths of the 7SA6 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option. It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 6/5), in order to allow optimum operation for all types of applications.


LSP2174-afp.tif

Fig. 6/3
Flush-mounting housing with screw-type terminals


LSP2166-afp.tif

Fig. 6/4
Rear view of flush-mounting housing with covered connection terminals and wirings

LSP2244-afp.eps

Fig. 6/5 Flush-mounting housing with plug-in terminals and detached operator panel

LSP2219-afp.eps

Fig. 6/6
Surface-mounting housing with screw-type terminals


LSP2237-afp.tif

Fig. 6/7
Com munication interfaces in a sloped case in a surface-mounting housing

Protection functions

Distance protection (ANSI 21, 21N)

The main function of the 7SA6 is a non-switched distance protection. By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of fault. The shortest tripping time is less than one cycle. All methods of neutral-point connection (resonant earthing, isolated, solid or low-resistance earthing) are reliably dealt with. Single-pole and three-pole tripping is possible. Overhead lines can be equipped with or without series capacitor compensation.

Four pickup methods
The following pickup methods can be employed alternatively:

- Overcurrent pickup *I*>>
- Voltage-dependent overcurrent pickup *V*/*I*
- Voltage-dependent and phase angle-dependent overcurrent pickup *V*/*I*/*φ*
- Impedance pickup *Z*<

Load zone
The pickup mode with quadrilateral impedance pickup (*Z*<) is fitted with a variable load zone. In order to guarantee a reliable discrimination between load operation and short-circuit (especially on long high loaded lines), the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity
The 7SA6 distance protection incorporates a well-proven, highly sophisticated phase selection algorithm. The pickup of unfaulted phases is reliably eliminated. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range. Interference to distance measurement caused by parallel lines can be compensated by taking the earth current of the parallel system into account.

This parallel line compensation can be taken into account both for distance measurement and for fault locating.

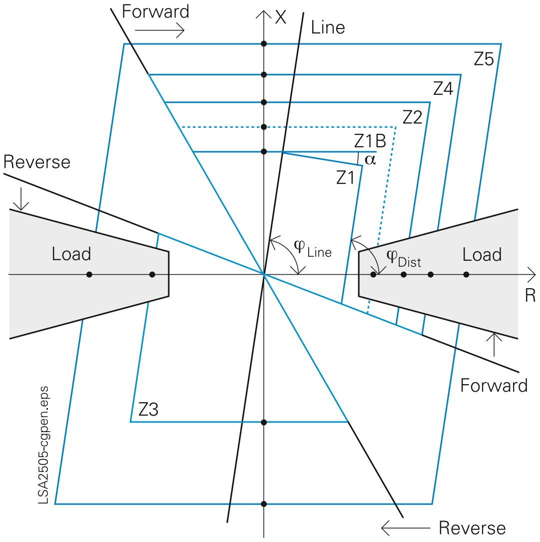


Fig. 6/8
Impedance fault detection *Z*< with quadrilateral characteristic

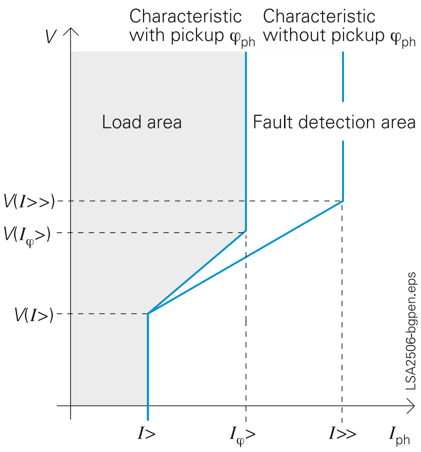


Fig. 6/9
Voltage and angle-dependent overcurrent fault detection *V* / *I* / *φ*

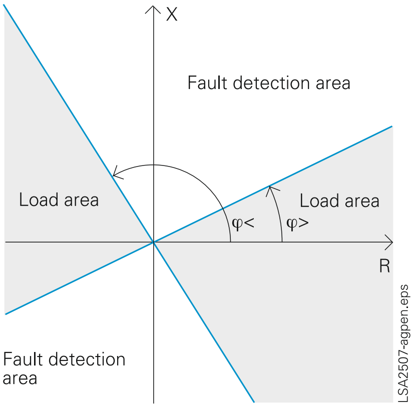


Fig. 6/10
Angle pickup for the *V* / *I* / *φ* fault detection

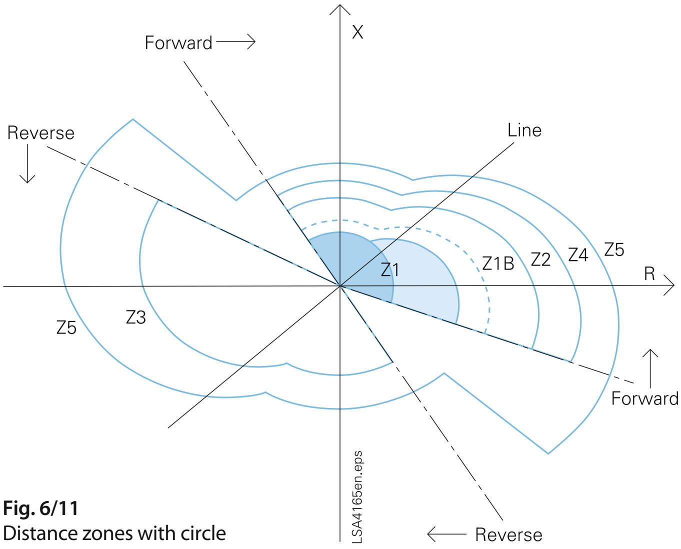


Fig. 6/11
Distance zones with circle characteristic

Protection functions

Seven distance zones

Six independant distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partially separate for single-phase and three-phase faults. Earth faults are detected by monitoring the earth current $3I_0$ and the zero-sequence voltage $3V_0$. The quadrilateral tripping characteristic allows use of separate settings for the X and the R directions. Different R settings can be employed for earth and phase faults. This characteristic offers advantages in the case of faults with fault resistance. For applications to medium-voltage cables with low line angles, it may be advantageous to select the distance zones with the optional circle characteristic.
All the distance protection zones can be set to forward, reverse or non-directional.

Optimum direction detection

Use of voltages, which are not involved with the short-circuit loop, and of voltage memories for determination of the fault direction ensure that the results are always reliable.

Elimination of interference signals

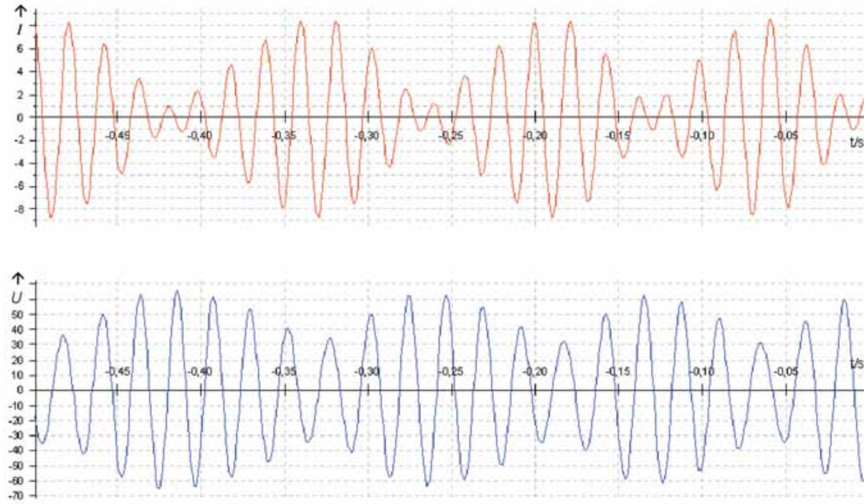
Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.
The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and in this case the EMERGENCY definite-time overcurrent protection can be activated.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in ohms, kilometers (miles) and in percent of the line length. Parallel line compensation and load current compensation for high-resistance faults is also available.



LSP2208-afp.tif

Fig. 6/12 Power swing current and voltage wave forms

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SA6 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- POTT
- Directional comparison pickup
- Unblocking
- PUTT acceleration with pickup
- PUTT acceleration with Z1B
- Blocking
- Pilot-wire comparison
- Reverse interlocking
- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function).

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are power-line carrier, microwave radio and fiber-optic links. A serial protection data interface for direct connection to a digital communication network or fiber-optic link is available.

7SA6 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines). Phase-selective transmission is also possible with multi-end application, if some user-specific linkages are implemented by way of the integrated CFC logic.

During disturbances in the signaling channel receiver or on the transmission circuit, the teleprotection function can be blocked via a binary input signal without losing the zone selectivity.

The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function.

Transient blocking (current reversal guard) is provided for all the release and blocking methods in order to suppress interference signals during tripping of parallel lines.

Protection functions

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SA6 relay is equipped with phase-selective phase-selective “external trip inputs” that can be assigned to the received inter-trip signal for this purpose.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided.
If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate phase-selective tripping at the weak-infeed end. A phase-selective single-pole or three-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-earth voltage drops correspondingly. As an option, the weak infeed logic can be equipped according to a French specification.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or that are only lightly loaded. The 7SA6 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding)
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SA6 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Directional earth-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In an earthed network it may happen that the distance protection´s sensitivity is not sufficient to detect high-resistance earth faults. The 7SA6 protection relay therefore offers protection functions for faults of this nature.

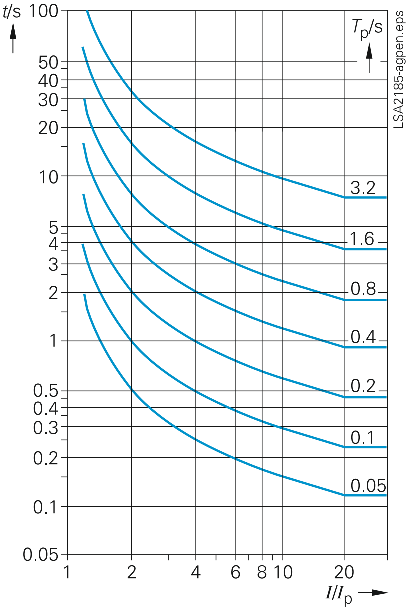
The earth-fault protection can be used with three definite-time stages and one inverse-time stage (IDMT).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”). A 4th definite-time stage can be applied instead of the 1st inverse-time stage.

An additional logarithmic inverse-time characteristic is also available.

The direction decision is determined by the earth current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2. In addition or as an alternative, the direction can be determined with the earth current of an earthed power transformer and the zero-sequence voltage. Dual polarization applications can therefore be fulfilled. Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or in both directions (non-directional).

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for small zero-sequence fault currents which usually have a high content of 3rd and 5th harmonic.



LSA2185-agpen.eps

$$t = \frac{0.14}{\left(I / I_p\right)^{0.02} - 1} T_p$$

Fig. 6/13 Normal inverse

LSP2209-afp.tif

Fig. 6/14
Transient earth-fault relay 7SN60

Protection functions

Inrush stabilization and instantaneous switch-onto-fault tripping can be activated separately for each stage as well.

Different operating modes can be selected. The earth-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional earth-fault protection (ANSI 85-67N)

The directional earth-fault protection can be combined with the available signaling methods:

- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for earth-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N, 67)

The 7SA6 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the earth current. The application can be extended to a directional overcurrent protection (ANSI 67) by taking into account the decision of the available direction detection elements. Two operating modes are selectable. The function can run in parallel to the distance protection or only during failure of the voltage in the VT secondary circuit (emergency operation).

The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”).

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is required when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast three-pole tripping.

With smaller fault currents, instantaneous tripping after switch-onto-fault is also possible with the overreach distance zone Z1B or with pickup.

The switch-onto-fault initiation can be detected via the binary input “manual close” or automatically via measurement.

Earth-fault detection in systems with a star-point that is not effectively earthed

In systems with an isolated or resonant earthed (grounded) star-point, single-phase earth faults can be detected. The following functions are integrated for this purpose:

- Detection of an earth fault by monitoring of the displacement voltage
- Determination of the faulted phase by measurement of the phase-to-earth voltage
- Determination of the earth-fault direction by highly accurate measurement of the active and reactive power components in the residual earth fault current.
- Alarm or trip output can be selected in the event of an earth-fault in the forward direction.
- Operation measurement of the active and reactive component in the residual earth current during an earth-fault.

Earth-fault direction detection can also be effected on the basis of the transient earth-fault principle by interfacing with the additional unit 7SN60 (see Fig. 6/14). Procedures for logging, time stamping and event recording for the network control system are standardized by the 7SA6.

Breaker failure protection (ANSI 50BF)

The 7SA6 relay incorporates a two-stage breaker failure protection to detect failures of tripping command execution, for example, due to a defective circuit-breaker. The current detection logic is phase-selective and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command will be generated. The breaker failure protection can be initiated by all integrated protection functions, as well as by external devices via binary input signals.

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated via a binary input signaling that the line isolator (disconnector) is open.

Separate settings are available for phase and earth faults.

Auto-reclosure (ANSI 79)

The 7SA6 relay is equipped with an auto-reclosure function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without earth, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosure for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without earth and 3-pole auto-reclosure for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the internal AR function by external protection
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Protection functions

Auto-reclosure (cont'd) (ANSI 79)

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no teleprotection method is employed: When faults within the zone extension but external to the protected line are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose a synchro-check function is provided. After verification of the network synchronism, the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g. checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Fuse failure monitoring and other supervision functions

The 7SA6 relay provides comprehensive supervision functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this supervision system.

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit, the distance protection would respond with an unwanted trip due to this loss of voltage.

This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection and switching to the backup-emergency overcurrent protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Broken-conductor supervision
- Summation of currents and voltages
- Phase-sequence supervision.

Directional power protection

The 7SA6 has a function for detecting the power direction by measuring the phase angle of the positive-sequence system's power. Fig. 6/15 shows an application example displaying negative active power. An indication is issued in the case when the measured angle *φ* (S1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φ A and φ B. Via CFC the output signal of the directional monitoring can be linked to the "Direct Transfer Trip (DTT)" function and thus, as reverse power protection, initiate tripping of the CB.

Fig. 6/16 shows another application displaying capacitive reactive power. In the case of overvoltage being detected due to long lines under no-load conditions it is possible to select the lines where capacitive reactive power is measured.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

Under certain operating conditions it is advisable to block CLOSE commands after a TRIP command of the relay has been issued. Only a manual “RESET” command unblocks the CLOSE command. The 7SA6 is equipped with such an interlocking logic.

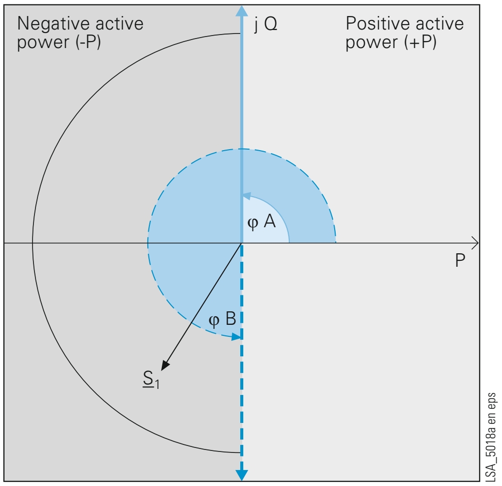


Fig. 6/15 Monitoring of active power direction

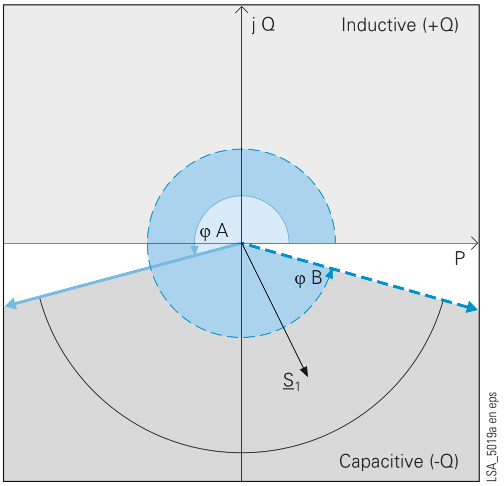


Fig. 6/16 Monitoring of reactive power

Thermal overload protection (ANSI 49)

For thermal protection of cables and transformers an overload protection with an early-warning stage is provided. The thermal replica can be generated with the maximum or mean value of the respective overtemperatures in the three phases, or with the overtemperature corresponding to the maximum phase current.

The tripping time characteristics are exponential functions according to IEC 60255-8 and they take account of heat loss due to the load current and the accompanying drop in temperature of the cooling medium. The previous load is therefore taken into account in the tripping time with overload. A settable alarm stage can output a current or temperature-dependent indication before the tripping point is reached.

Protection functions

BCD-coded output of fault location

The fault location calculated by the unit can be output for remote indication in BCD code. The output of the fault location is made in percent of the set line length with 3 decimal digits.

Analog output 0 to 20 mA

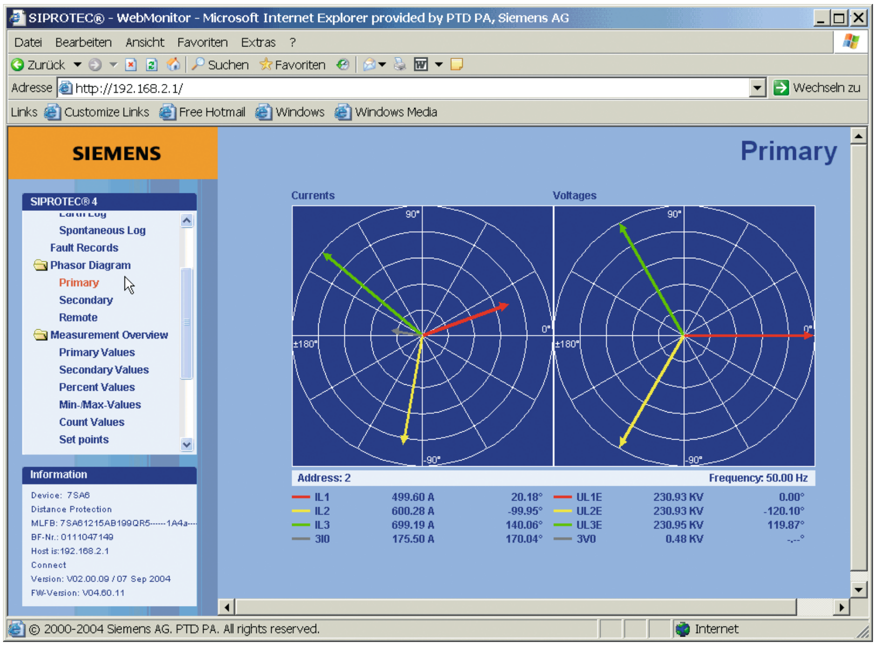
Some measured values can be output as analog values (0 to 20 mA). On a plug-in module (Fig. 6/21) two analog channels are made available. Up to two plug-in modules can be installed in the 7SA6. As an option, 2, 4 or no analog channels are available (please refer to the selection and ordering data). The measured values available for output are listed in the technical data.

Commissioning and fault event analyzing

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged. For applications with serial protection data interface, all currents, voltages and phases are available via communication link at each local unit, displayed at the front of the unit with DIGSI 4 or with WEB Monitor[1]. A common time tagging facilitates the comparison of events and fault records.

WEB Monitor - Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. Apart from numeric values, graphical displays in particular provide clear information and a high degree of operating reliability. Of course, it is also possible to call up detailed measured value displays and annunciation buffers. By emulation of the integrated unit operation on the PC it is also possible to adjust selected settings for commissioning purposes.



http://192.168.2.1/

Device: 7SA6
Distance Protection
MLFB: 7SA61215AB199QR5------1A4a---
BF-Nr.: 0111047149
Host is:192.168.2.1
Connect
Version: V02.00.09 / 07 Sep 2004
FW-Version: V04.60.11

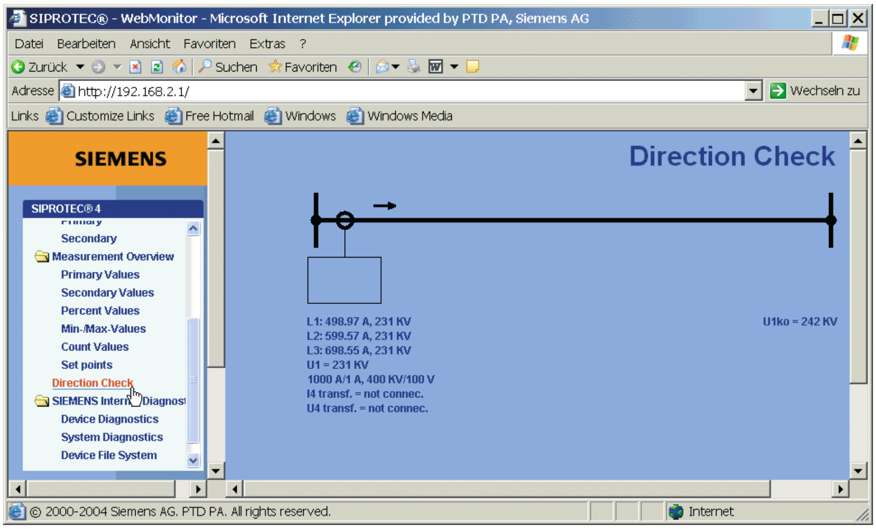
Address: 2 Frequency: 50.00 Hz

IL1	499.60 A	20.18°	UL1E	230.93 KV	0.00°
IL2	600.28 A	-99.95°	UL2E	230.93 KV	-120.10°
IL3	699.19 A	140.06°	UL3E	230.95 KV	119.87°
3I0	175.50 A	170.04°	3V0	0.48 KV	-.--°

© 2000-2004 Siemens AG. PTD PA. All rights reserved.

LSP2819.tif

Fig. 6/17 Web Monitor: Supported commissioning by phasor diagram



http://192.168.2.1/

L1: 498.97 A, 231 KV
L2: 599.57 A, 231 KV
L3: 698.55 A, 231 KV
U1 = 231 KV
1000 A/1 A, 400 KV/100 V
I4 transf. = not connec.
U4 transf. = not connec.

U1ko = 242 KV

© 2000-2004 Siemens AG. PTD PA. All rights reserved.

LSP2818.tif

Fig. 6/18 Web Monitor: Display of the protection direction

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication “circuit-breaker TRIP” to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the unit which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks which are already widely applied in the power supply sector.

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

7SA6 units are always fitted with a rear-side hardwired service interface, optionally as RS232 or RS485. In addition to the front-side operator interface, a PC can be connected here either directly or via a modem.

Time synchronization interface

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should a unit fail, there is no effect on the communication with the rest of the system.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc.) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet but is also possible with DIGSI. It is also possible to retrieve operating and fault records as well as fault recordings via a browser. This Web monitor will also provide a few items of unit-specific information in browser windows.

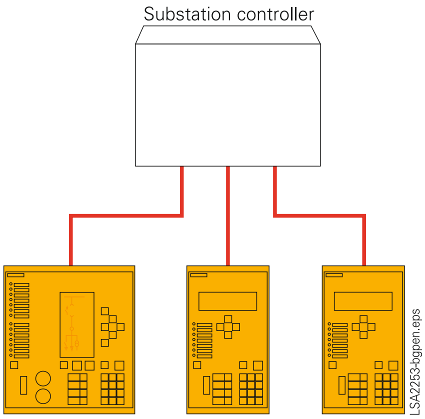


Fig. 6/19
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

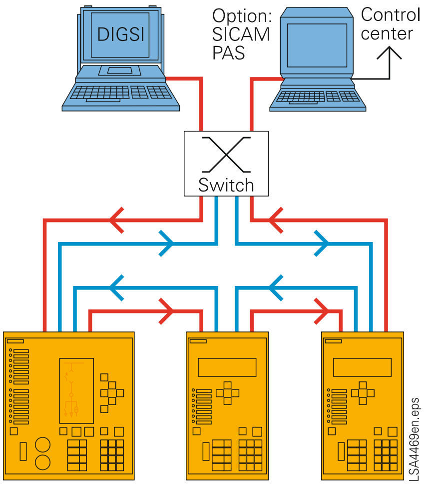


Fig. 6/20
Bus structure for station bus with Ethernet and IEC 61850

Communication

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide. Supplements for control functions are defined in the manufacturer-specific part of this standard.

PROFIBUS-DP

PROFIBUS-DP is an industrial communications standard and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

Analog outputs 0 to 20 mA

2 or 4 analog output interfaces for transmission of measured or fault location values are available for the 7SA6. Two analog output interfaces are provided in an analog output module. Up to two analog output modules can be inserted per unit.

Fig. 6/21
820 nm fiber-optic communication module

Fig. 6/22
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

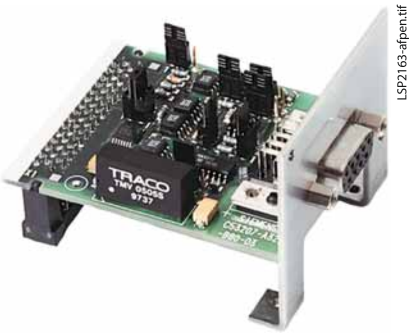


Fig. 6/23
RS232/RS485 electrical communication module

Fig. 6/24
Output module 0 to 20 mA, 2 channels

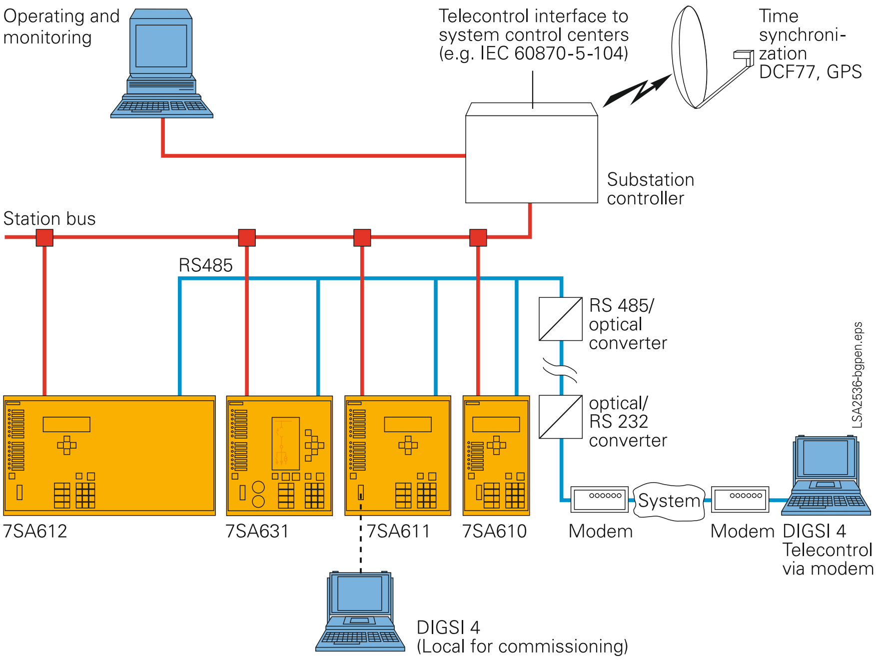


Fig. 6/25
Communication

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 6/25).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI and the Web monitor can also be used via the same station bus.

Serial protection data interface

The tele (pilot) protection schemes can be implemented using digital serial communication. The 7SA6 is capable of remote relay communication via direct links or multiplexed digital communication networks. The serial protection data interface has the following features:

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Signaling for directional earth-fault protection – directional comparison for high resistance faults in solidly earthed systems
- Echo-function
- Two and three-terminal line applications can be implemented without additional logic
- Interclose command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- 28 remote signals for fast transfer of binary signals
- Flexible utilisation of the communication channels by means of the programmable CFC logic
- Display of the operational measured values of the opposite terminal(s) with phase-angle information relative to a common reference vector
- Clock synchronization: the clock in only one of the relays must be synchronized from an external so called "Absolute Master" when using the serial protection data interface. This relay will then synchronize the clock of the other (or the two other relays in 3 terminal applications) via the protection data interface.
- 7SA522 and 7SA6 can be combined via the protection data interface.

The communication possibilities are identical to those for the line differential protection relays 7SD5 and 7SD610. The following options are available:

- FO5[1], OMA1[2] module: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for link to communication networks via communication converters or for direct FO cable connection
- FO6[1], OMA2[2] module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multi-mode FO cable
- FO17[1]: For direct connection up to 25 km[3], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1]: For direct connection up to 60 km[3] 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1]: For direct connection up to 100 km[3] 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30[1]: For transmission with the IEEE C37.94 standard.

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface. If the connection to the multiplexor supports IEEE C37.94, a direct fibre optic connection to the relay is possible using the FO30 module.

For operation via copper wire communication (pilot wires), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Communication data:

- Supported network interfaces G703.1 with 64 kBit/s; X21/RS422 with 64 or 128 or 512 kBit/s; IEEE C37.94
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC
- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.

Figure 6/26 shows four applications for the serial protection data interface on a two-terminal line.

---

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal fiber-optic module OMA1 will be delivered together with an external repeater.

Communication

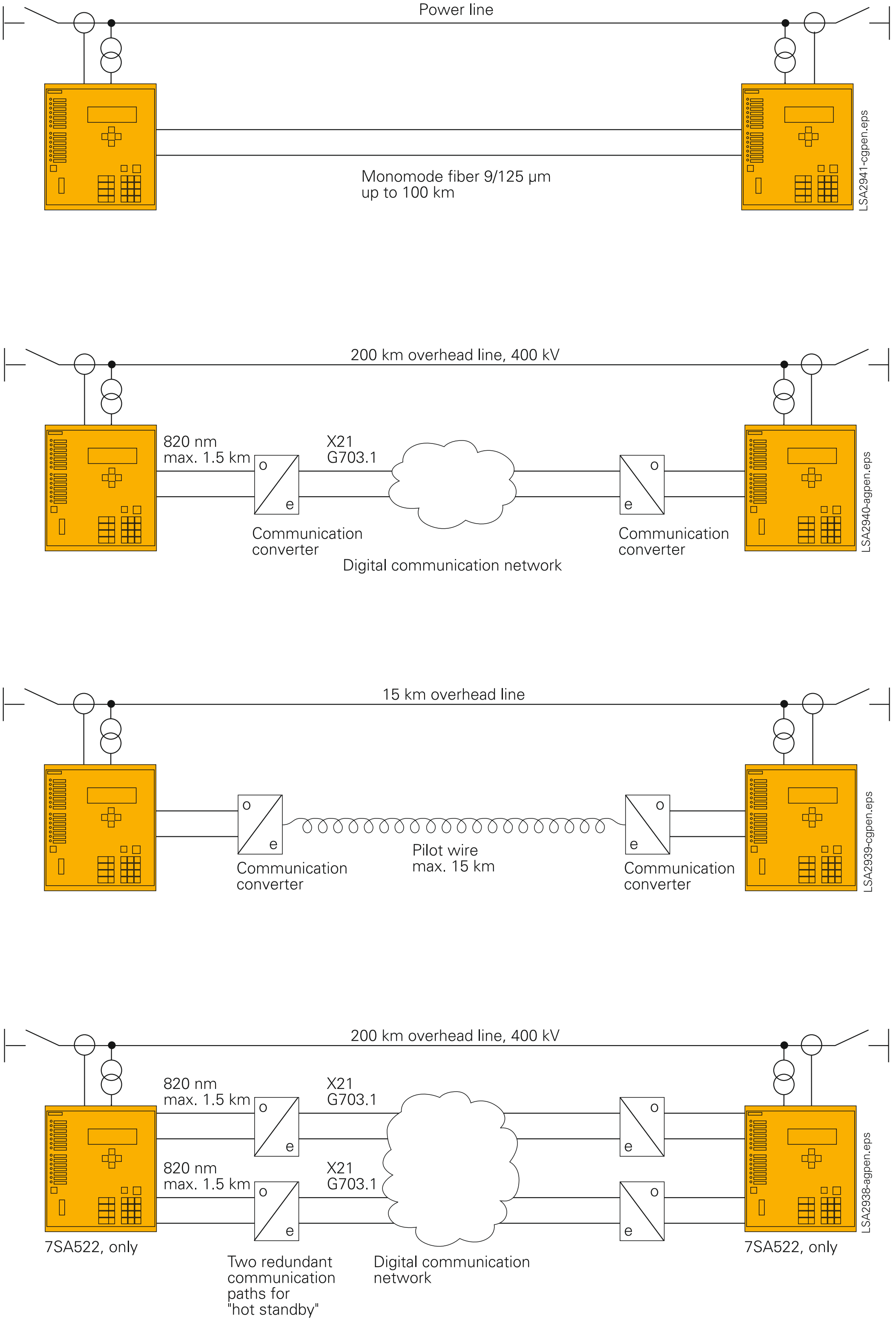


Fig. 6/26
Communication topologies for the serial protection data interface on a two-terminal line

Communication

Three-terminal lines can also be protected with a tele (pilot) protection scheme by using SIPROTEC 4 distance protection relays. The communication topology may then be a ring or a chain topology, see Fig. 6/27. In a ring topology a loss of one data connection is tolerated by the system. The topology is re-routed to become a chain topology within less than 100 ms. To reduce communication links and to save money for communications, a chain topology may be generally applied.

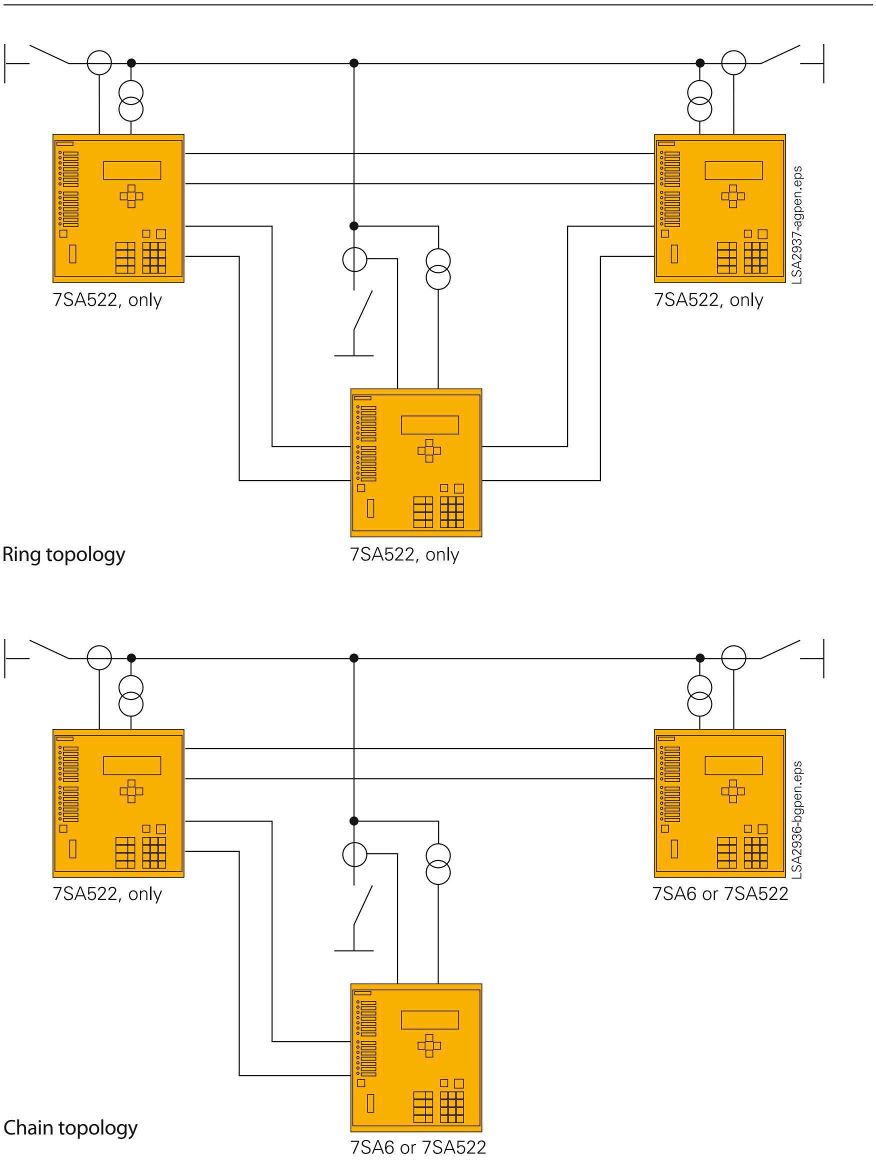


Fig. 6/27 Ring or chain communication topology

Typical connection

Connection for current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer ($=3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

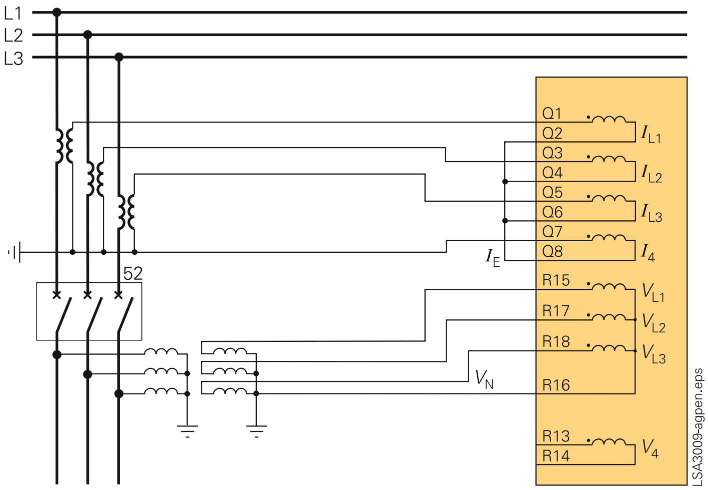


Fig. 6/28 Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 6/28, 6/32 or 6/33.

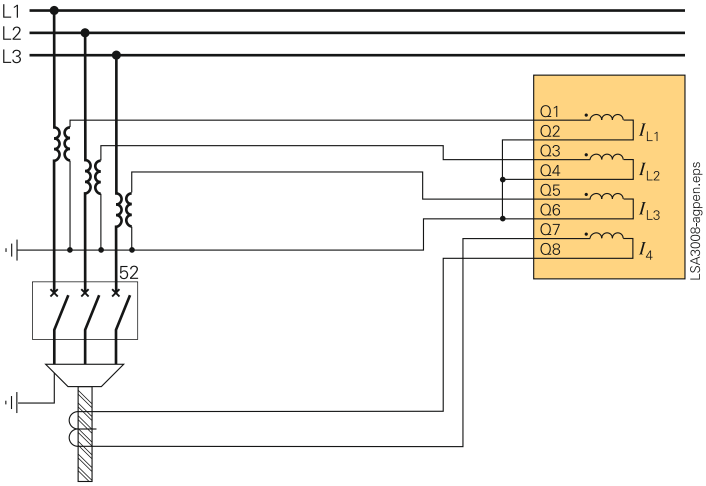


Fig. 6/29 Alternative connection of current transformers for sensitive earth-current measuring with core-balance current transformers

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of an earthed transformer for directional earth-fault protection. The voltage connection is effected in accordance with Fig. 6/28, 6/32 or 6/33.

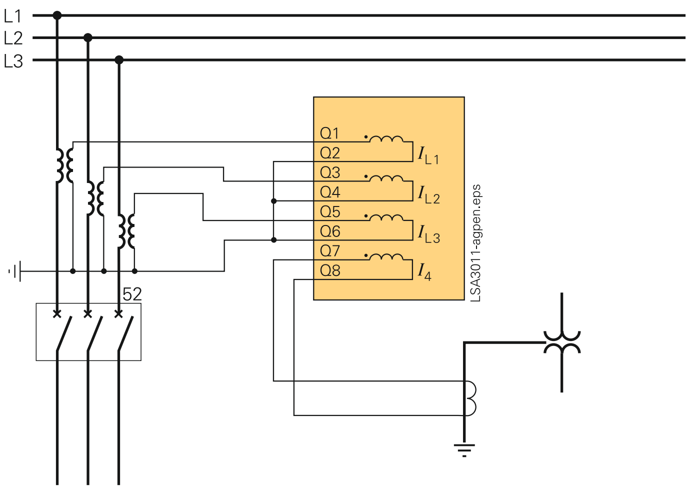


Fig. 6/30 Alternative connection of current transformers for measuring neutral current of an earthed power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 6/28, 6/32 or 6/33.

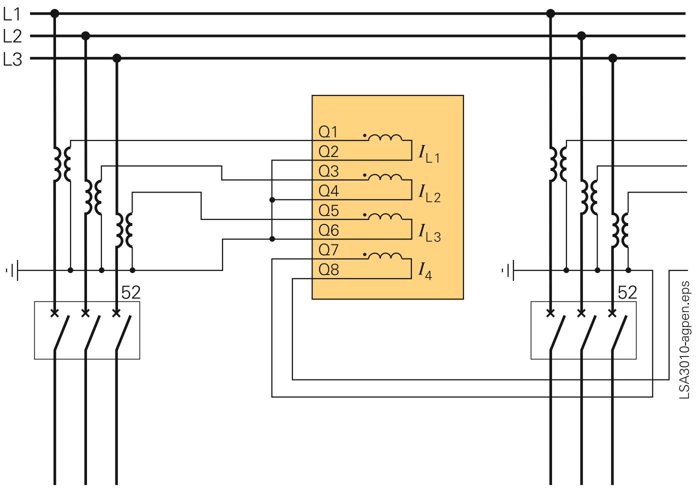


Fig. 6/31 Alternative connection of current transformers for measuring the earth current of a parallel line

Typical connection

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and earth-fault directional protection. The current connection is effected in accordance with Fig. 6/28, 6/29, 6/30 and 6/31.

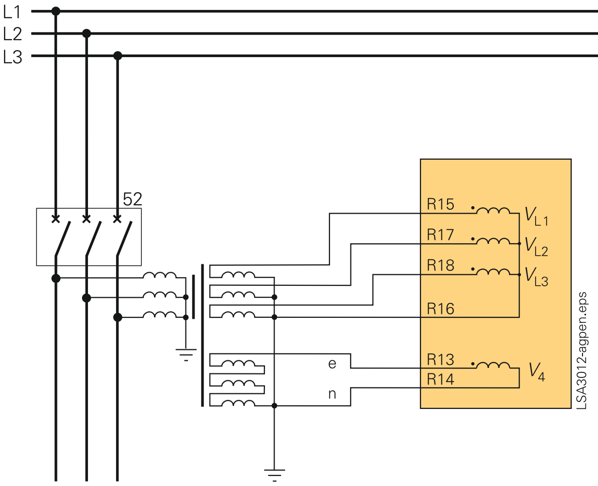


Fig. 6/32 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchro-check.

Note: Any phase-to-phase or phase-to-earth voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 6/28, 6/29, 6/30 and 6/31.

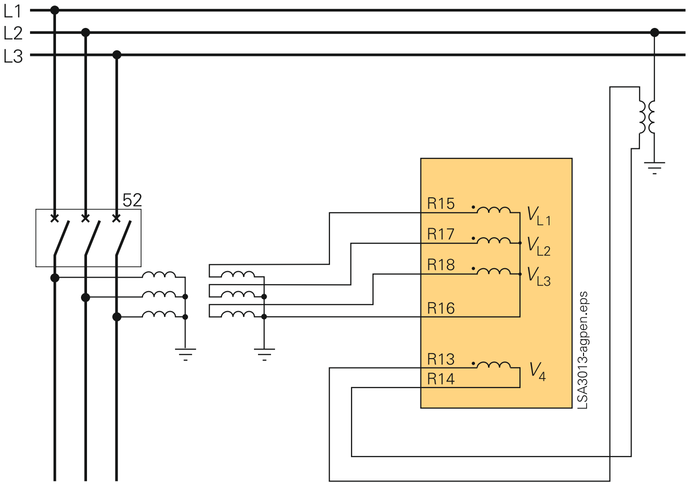


Fig. 6/33 Alternative connection of voltage transformers for measuring the busbar voltage

Technical data

General unit data

Analog inputs

Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage V_{nom}	80 to 125 V (selectable)
Power consumption	
With I_{nom} = 1 A	Approx. 0.05 VA
With I_{nom} = 5 A	Approx. 0.30 VA
For I_{E}, sensitive with 1 A	Approx. 0.05 VA
Voltage inputs	≤ 0.10 VA
Overload capacity of current circuit (r.m.s.)	
Thermal	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (peak value)	1250 A (half cycle)
Earth current	
Sensitive	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (peak value)	750 A (half cycle)
Thermal overload capacity of voltage circuit	230 V continuous

Auxiliary voltage

Rated voltages	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 to 230 V AC (50/60 Hz)
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Quiescent	Approx. 5 W
Energized	Approx. 12 W to 18 W, depending on design
Bridging time during failure of the auxiliary voltage	
For V_{aux} = 48 V and V_{aux} ≥ 110 V	≥ 50 ms
For V_{aux} = 24 V and V_{aux} = 60 V	≥ 20 ms

Binary inputs

Quantity	
7SA610*-*A/E/J	5
7SA610*-*B/F/K	7
7SA6*1*-*A/E/J	13
7SA6*1*-*B/F/K	20
7SA6*2*-*A/E/J	21
7SA6*2*-*B/F/K	29
7SA6*2*-*C/G/L	33
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	17 or 73 or 154 V DC, bipolar
Functions are freely assignable	
Pickup/reset voltage thresholds Ranges are settable by means of jumpers for each binary input	19 V DC/10 V DC or 88 V DC/44 V DC, or 176 V DC/88 V DC bipolar (3 nominal ranges 17/73/154 V DC)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time >60 ms

Output contacts

"Unit ready" contact (live status contact)	1 NC/NO contact[1]
Command/indication relay	
Quantity	
7SA610*-*A/E/J	5 NO contacts, 3 NC/NO contact[1]
7SA610*-*B/F/K	5 NO contacts,
7SA6*1*-*A/E/J	12 NO contacts, 4 NC/NO contacts[1]
7SA6*1*-*B/F/K	8 NO contacts, 4 power relays[2]
7SA6*2*-*A/E/J	19 NO contacts, 5 NC/NO contacts[1]
7SA6*2*-*B/F/K	26 NO contacts, 6 NC/NO contacts[1]
7SA6*2*-*C/G/L	11 NO contacts, 8 power relays[2]
NO/NC contact	
Switching capacity	
Make	1000 W / VA
Break, high-speed trip outputs	1000 W / VA
Break, contacts	30 VA
Break, contacts (for resistive load)	40 W
Break, contacts (for $\tau = L/R \leq 50$ ms)	25 VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx.	
NO contact	8 ms
NO/NC contact (selectable)	8 ms
Fast NO contact	5 ms
High-speed NO trip outputs	< 1 ms
Power relay for direct control of disconnector actuator motors	
Switching capacity	
Make for 48 to 250 V	1000 W/ VA
Break for 48 to 250 V	1000 W/ VA
Make for 24 V	500 W/ VA
Break for 24 V	500 W/ VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Max. operating time	30 s
Permissible relative operating time	1 %

LEDs

	Quantity
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	
7SA610	7
7SA6*1/2/3	14

---

1) Can be set via jumpers.

2) Each pair of power relays is mechanically interlocked to prevent simultaneous closing.

Technical data

Unit design

Housing	7XP20
Dimensions	Refer to part 15 f. dimension drawings
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 20 with terminal cover put on

Weight		
Flush-mounting housing	1/3 x 19"	4 kg
	1/2 x 19"	6 kg
	2/3 x 19"	8 kg
	1/1 x 19"	10 kg
Surface-mounting housing	1/3 x 19"	6 kg
	1/2 x 19"	11 kg
	1/1 x 19"	19 kg

Serial interfaces

Operating interface for DIGSI 4 (front of unit)

Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1

Time synchronization

DCF77/ IRIG-B signal (format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Service/modem interface for DIGSI 4 / modem / service

Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

System interface

	IEC 61850 Ethernet IEC 60870-5-103 protocol PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 38400 baud
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Dielectric test	500 V / 50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kBd; 100 m at 12 MBd
PROFIBUS fiber-optic	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[4]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance	500 kbit/s 1.6 km 1500 kbit/s 530 m

Protection data interface

Quantity	1
FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 8 dB
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 16 dB
FO30[1]: for direct fibre-optic connection to a multiplexor using IEEE C37.94 standard	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 8 dB
FO17[1]: for direct connection up to 24 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 13 dB
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB

Relay communication equipment

External communication converter 7XV5662-0AA00 with X21/RS422 or G703.1 interface

External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option with clock recovery) to the X21/RS422/G703.1 interface of the communication network	Electrical X21/RS422 or G703.1 interface settable by jumper Baud rate settable by jumper
FO interface with 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi- mode fiber to protection relay
Electrical X21/RS422 interface	64/128/512 kbit (settable by jumper) max. 800 m, 15-pin connector to the communication network
Electrical G703.1 interface	64 kbit/s max. 800 m, screw-type terminal to the communication network

External communication converter 7XV5662-0AC00 for pilot wires

External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option with clock recovery) to pilot wires.	Typical distance: 15 km max.
FO interface for 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode fiber to protection relay, 128 kbit
Electrical interface to pilot wires	5 kV-isolated

---

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal fiber-optic module (OMA1) will be delivered together with an external repeater.

4) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order Code L0A (DP RS485) or 9 and Order Code L0G (DNP 3.0) and additionally a suitable external repeater.

Technical data

Electrical tests

Specifications

Standards	IEC 60255 (product standards) IEEE Std C37.90.0/.1/.2; UL 508 VDE 0435 Further standards see "Individual functions"

Insulation tests

Standards	IEC 60255–5 and 60870-2-1
High-voltage test (routine test)	
All circuits except for power supply, binary inputs, high-speed outputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage, binary inputs and high-speed outputs (routine test)	3.5 kV DC
only isolated communication interfaces and time synchronization interface (routine test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s

EMC tests for noise immunity; type tests

Standards	IEC 60255-6/-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 part 301 DIN VDE 0435-110
High-frequency test IEC 60255-22-1 class III and VDE 0435 Section 303, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ µs; 400 surges per s; test duration 2 s, $R_i = 200\ \Omega$
Electrostatic discharge IEC 60255-22-2 class IV and IEC 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz
IEC 61000-4-3, class III	10 V/m; 1.4 to 2 GHz: 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-31, IEC 61000-4-3, class III amplitude/pulse modulated	10 V/m; 80, 160, 450. 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common mode: 2 kV; 12 Ω; 9 µF Differential mode:1 kV; 2 Ω; 18 µF
Analog measurement inputs, binary inputs, relays output	Common mode: 2 kV; 42 Ω; 0.5 µF Differential mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability, IEEE Std C37.90.1	2.5 kV (peak); 1 MHz $\tau = 50$ µs; 400 surges per second, test duration 2 s, $R_i = 200\ \Omega$
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repition rate 300 ms, ; both polarities; test duration 1 min; $R_i = 50\ \Omega$
Radiated electromagnetic interference IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz, amplitude and pulse-modulated
Damped oscillations IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200\ \Omega$

EMC tests for noise emission; type test

Standard	EN 61000-6-3 (generic standard)
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B
Harmonic currents on the network lead at 230 V AC, IEC 61000-3-2	Class A limits are observed
Voltage fluctuations and flicker on the network incoming feeder at 230 V AC, IEC 61000-3-3	Limits are observed

Mechanical stress test

Vibration, shock stress and seismic vibration

<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Technical data

Climatic stress tests

Standard	IEC 60255-6
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.

Functions

Distance protection *(ANSI 21, 21N)*

Types of pickup	Overcurrent pickup ($I>$); Voltage-dependent overcurrent pickup ($V< / I>$); Voltage-dependent and phase angle-dependent overcurrent pickup ($V< / I> / \varphi>$); Impedance pickup ($Z<$)
Types of tripping	Three-pole for all types of faults; Single-pole for single-phase faults / otherwise three-pole; Single-pole for single-phase faults and two-pole phase-to-phase faults / otherwise three-pole
Characteristic	Quadrilateral or circle
Distance protection zones	7, 1 of which as controlled zone All zones can be set to forward, reverse, non-directional or inactive
Timer stages for tripping delay	7 for multi-phase faults 3 for single-phase faults
Setting range	0 to 30 s or deactivated (steps 0.01 s)
Zone setting X (for distance zones and Z< starting)	0.050 to 600 Ω $_{(1A)}$ / 0.01 to 120 Ω $_{(5A)}$ (step 0.001 Ω)
Resistance setting (for quadrilateral distance zones and Z< starting)	
Phase-to-phase faults and phase-to-earth faults	0.05 to 600 Ω $_{(1A)}$ / 0.01 to 120 Ω $_{(5A)}$ (step 0.001 Ω)
Line angle	10 ° to 89 °
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Zone setting Z_r (for circle characteristic)	0.050 to 600 Ω$_{(1\,A)}$/0.010 to 120 Ω$_{(5\,A)}$ (step 0.001 Ω)
Threshold angle α for increased resistance tolerance (circle charac.)	10 to 90 ° (step 1°)
Overcurrent pickup $I>>$ (for $I>>$, $V</I>$, $V</I>/\varphi>$)	0.25 to 10 A $_{(1A)}$ / 1.25 to 50 A $_{(5A)}$ (step 0.01 A)
Minimum current pickup $I>$ (for $V</I>$, $V</I>/\varphi>$ and $Z<$)	0.05 to 4 A $_{(1A)}$ / 0.25 to 20 A $_{(5A)}$ (step 0.01 A)
Minimum current pickup $I_{\varphi}>$ (for $V</I>/\varphi>$)	0.1 to 8 A $_{(1A)}$ / 0.5 to 40 A $_{(5A)}$ (step 0.01 A)
Undervoltage pickup (for $V</I>$ and $V</I>/\varphi>$)	
$V_{\mathrm{PH\text{-}e}}<$	20 to 70 V (step 1 V)
$V_{\mathrm{PH\text{-}PH}}<$	40 to 130 V (step 1 V)
Load angle pickup (for $V</I>/\varphi>$)	
Load angle φ	30 ° to 80 °
Load angle φ	90 ° to 120 °
Load zone (for $Z<$)	Impedances within the load zone do not cause pickup in pickup mode Z<; Load zones for phase-to-phase and phase-to-earth faults can be set separately
Load angle	20 ° to 60 °
Resistance	0.1 to 600 Ω $_{(1A)}$ / 0.02 to 120 Ω $_{(5A)}$
Earth-fault detection	
Earth current $3I_0>$	0.05 to 4 A $_{(1A)}$ / 0.25 A to 20 A $_{(5A)}$ (step 0.01 A)
Zero-sequence voltage $3V_0>$	
for earthed networks	1 to 100 V (step 1 V) or deactivated
for resonant-earthed networks	10 to 200 V (step 1 V) or deactivated
Earth impedance matching	
Parameter formats	R_E/R_L and X_E/X_L or k_0 and φ (k_0)
Separately settable for	Distance protection zone Z1 and higher distance zones (Z1B, Z2 to Z6)
R_E/R_L and X_E/X_L	-0.33 to +7.00 (step 0.01)
k_0 and φ (k_0)	0 to 4 (step 0.01) and - 135 ° to 135 ° (step 0.01 °)
Parallel line matching	For parallel compensation
R_M/R_L and X_M/X_L	0 to 8 (step 0.01)
Phase preference on double earth-faults in resonant-earthed / non-earthed networks	Phase preference or no preference (selectable)
Direction decision for all types of faults	With fault-free voltages and/or voltage memory
Direction sensitivity	Dynamically unlimited

Technical data

Times	
Shortest trip time (measured at the fast relay; refer to the terminal connection diagram)	Approx. 17 ms for $f_N = 50$ Hz Approx. 15 ms for $f_N = 60$ Hz
Shortest trip time (measured at the high-speed trip outputs)	Approx. 12 ms at 50 Hz Approx. 10 ms at 60 Hz
Reset time	Approx. 30 ms
Tolerances	For sinusoidal measured variables
Response values (in conformity with DIN 57435, Part 303)	
V and I	≤ 5 % of setting value
Angle (φ)	≤ 3 °
Impedances (in conformity with DIN 57435, Part 303)	$\left\lvert\frac{\Delta X}{X}\right\rvert \leq 5\ \%$ for $30\,° \leq \varphi_{SC} \leq 90\,°$ $\left\lvert\frac{\Delta R}{R}\right\rvert \leq 5\ \%$ for $0\,° \leq \varphi_{SC} \leq 60\,°$
Time stages	1 % of setting value or 10 ms

Fault locator

Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or in % of line length
Start of calculation	With trip, with reset of pickup, with binary input
Reactance per unit length	0.005 to 6.5 $\Omega/\text{km}_{(1A)}$ / 0.001 to 1.3 $\Omega/\text{km}_{(5A)}$ (step 0.001 Ω/km)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for $30\,° \leq \varphi_{SC} \leq 90\,°$ and $V_{SC}/V_{nom} > 0.1$

BCD-coded output of fault location

Indicated value	Fault location in % of the line length
Output signals	Max. 10: d[1 %], d[2 %], d[4 %], d[8 %], d[10 %], d[20 %], d[40 %], d[80 %], d[100 %], d[release]
Indication range	0 % to 195 %

Tele (pilot) protection for distance protection (ANSI 85-21)

Modes of operation	PUTT (Z1B acceleration); DUTT; PUTT (acceleration with pickup); POTT; Directional comparison; Reverse interlocking Pilot-wire comparison; Unblocking; Blocking
Additional functions	Echo function (refer to weak-infeed function) Transient blocking for schemes with measuring range extension
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2- and 3-end-lines

Weak-infeed protection (ANSI 27-WI)

Operating modes with carrier (signal) reception and no fault detection	Echo Echo and trip with undervoltage
Undervoltage phase-earth	2 to 70 V (step 1 V)
Time delay	0 to 30 s (step 0.01 s)
Echo impulse	0 to 30 s (step 0.01 s)
Tolerances	
Voltage threshold	≤ 5 % of setting value or 0.5 V
Timer	1 % of setting value or 10 ms

Direct transfer trip (DTT)

Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0 to 30 s (step 0.01 s)
Timer tolerance	1 % of setting value or 10 ms

Power swing detection (ANSI 68, 68T)

Power swing detection principle	Measurement of the rate of change of the impedance vector and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping for out-of-step conditions
Power swing blocking programs	All zones blocked; Z1/Z1B blocked; Z2 to Z6 blocked; Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults

Backup overcurrent protection (ANSI 50 (N), 51 (N), 67)

Operating modes	Active only with loss of VT secondary circuit or always active
Characteristic	2 definite-time stages / 1 inverse-time stage, 1 definite-time Stub-protection stage
Instantaneous trip after switch-onto-fault	Selectable for every stage

Definite-time stage (ANSI 50, 50N)

Phase current pickup I_{PH}>>	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A)
Earth current pickup $3I_0$>>	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A)
Phase current pickup I_{PH}>	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A)
Earth current pickup $3I_0$>	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A)
Time delay	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % of setting value or 1 % I_N
Delay times	1 % of setting value or 10 ms
Operating time	Approx. 25 ms

Technical data

***Inverse-time stage** (ANSI 51, 51N)*

Phase current pickup I_P	0.1 to 4 A (1A) / 0.5 to 20 A (5A) (step 0.01 A)
Earth current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Tripping time characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time inverse
Tripping time characteristics acc. to ANSI/IEEE (not for DE region, see selection and ordering data 10th position)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Time multiplier for IEC charac. T	T_p = 0.05 to 3 s (step 0.01 s)
Time multiplier for ANSI charac. D	D_{IP} = 0.5 to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 I/I_p (ANSI: I/I_p = M)
Reset threshold	Approx. 1.05 x I/I_p (ANSI: I/I_p = M)
Tolerances Operating time for $2 \leq I/I_p \leq 20$	 ≤ 5 % of setpoint ± 15 ms

***Directional earth-fault overcurrent protection for high-resistance faults in systems with earthed star point** (ANSI 50N, 51N, 67N)*

Characteristic	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages or 3 definite-time stages / 1 $V_{0invers.}$ stage
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults selectable for every stage
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics Stages 1 and 2 (I>>> and I>>)	 3rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 (I> and inverse 4th stage)	2nd and higher harmonics are completely suppressed by digital filtering

***Definite-time stage** (ANSI 50N)*

Pickup value $3I_0$>>>	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>>	0.2 to 25 A (1A) / 1 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Pickup value $3I_0$, 4th stage	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Time delay for definite-time stages	0 to 30 s (step 0.01 s) or deactivated

Tolerances Current pickup Delay times	 ≤ 3 % of setting value or 1 % I_{nom} 1 % of setting value or 10 ms
Command / pickup times $3I_0$>>> and $3I_0$>>	Approx. 30 ms
Command / pickup times $3I_0$> and $3I_0$, 4th stage	Approx. 40 ms

***Inverse-time stage** (ANSI 51N)*

Earth-current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7) 0.003 to 4 A (1A) / 0.015 to 20 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Tripping characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time
ANSI/IEEE tripping characteristic (not for region DE, see selection and ordering data, position 10)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Inverse logarithmic tripping characteristics (not for regions DE and US, see selection and ordering data, position 10)	$t = T_{3I0\text{Pmax}} - T_{3I0\text{P}} \ln \frac{3I0}{3I0_{\text{p}}}$
Pickup threshold	1.1 to 4.0 x I/I_p (step 0.1 s)
Time multiplier for IEC charac. T	T_p = 0.05 to 3 s (step 0.01 s)
Time multiplier for ANSI charac. D	D_{I0P} = 0.5 to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 I/I_p (ANSI: I/I_p = M)
Inverse logarithmic pickup threshold	1.1 to 4.0 x I/I_{0P} (step 0.1)
Reset threshold	Approx. 1.05 I/I_{0P} (ANSI: I/I_p = M)
Tolerance Operating time for $2 \leq I/I_p \leq 20$	 ≤ 5 % of setpoint ± 15 ms

Zero-sequence voltage protection V

Tripping characteristic	$t = \frac{2\text{ s}}{\frac{V_0}{4} - V_{0\text{inv min}}}$

Zero-sequence power-dependent stage

Compensated zero-sequence power	$S_r = 3I_0 \cdot 3V_0 \cdot \cos(\varphi - \varphi_{\text{comp.}})$

***Direction decision** (ANSI 67N)*

Measured signals for direction decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_Y (star point current of an earthed power transformer) or $3I_2$ and $3V_2$ (negative-sequence system) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Min. current I_Y (of earthed transformers)	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)

Technical data

Inrush current blocking, capable of being activated for each stage

Component of the 2nd harmonic	10 to 45 % of the fundamental (step 1 %)
Max. current, which cancels inrush current blocking	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)

Tele (pilot) protection

For directional earth-fault protection (ANSI 85-67N)

Operating modes	Directional comparison, blocking, unblocking
Additional functions	Echo (see function “weak infeed”); transient blocking for schemes with parallel lines
Send and receive signals	Suitable for 2 and 3 end-lines

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Operating mode	Active only after CB closing; instantaneous trip after pickup
Pickup current I>>>	1 to 25 A (1A) / 5 to 125 A (5A) (step 0.01 A)
Reset ratio	Approx. 0.90
Tolerances	
Current starting	≤ 3 % of setting value or 1 % I_N
Shortest tripping time	
With reference to fast relays	Approx. 12 ms
With high-speed trip to outputs	Approx. 8 ms

Voltage protection (ANSI 59, 27)

Operating modes	Local tripping and/or carrier trip for remote end

Overvoltage protection

Pickup values $V_{\text{PH-E}}$>>, $V_{\text{PH-E}}$> (phase-earth overvoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_{\text{PH-PH}}$>>, $V_{\text{PH-PH}}$> (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_0$>>, $3V_0$> ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values V_1>>, V_1> (positive-sequence overvoltage)	2 to 220 V (step 0.1 V)
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values V_2>>, V_2> (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)

Undervoltage protection

Pickup values $V_{\text{PH-E}}$<<, $V_{\text{PH-E}}$< (phase-earth undervoltage)	1 to 100 V (step 0.1 V)
Pickup values $V_{\text{PH-PH}}$<<, $V_{\text{PH-PH}}$< (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values V_1<<, V_1< (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage prot. stages	Minimum current; binary input
Reset ratio (settable)	1.01 to 1.20 (step 0.01)

Time delays

Time delay for all stages	0 to 100 s (step 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Command/pickup time for $3V_0$ stages	Approx. 30 ms or 65 ms (settable)
Tolerances	
Voltage limit values	≤ 3 % of setting value or 1 V
Time stages	1 % of setting value or 10 ms

Frequency protection (ANSI 81)

Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-earth)
Pickup times	Approx. 80 ms
Dropout times	Approx. 80 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	15 mHz for $V_{\text{PH-PH}}$: 50 to 230 V
Delay times	1 % of the setting value or 10 ms

Thermal overload protection (ANSI 49)

Factor k acc. to IEC 60255-8	0.1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{\text{Alarm}}/\Theta_{\text{Trip}}$	50 to 100 % referred to tripping temperature (steps 1 %)
Current-based alarm stage I_{Alarm}	0.1 to 4 A (1A) / 0.5 to 20 A (5A) (steps 0.01 A)
Calculating mode for overtemperature	$\Theta_{\max}$, Θ_{mean}, Θ with $I_{\max}$
Pickup time characteristic	$t = \tau \ln \frac{I^2 - I_{\text{pre}}^2}{I^2 - (k\,I_{\text{nom}})^2}$
Reset ratio	
$\Theta/\Theta_{\text{Alarm}}$	Approx. 0.99
$\Theta/\Theta_{\text{Trip}}$	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Overload measured values	$\Theta/\Theta_{\text{Trip}}$ L1; $\Theta/\Theta_{\text{Trip}}$ L2; $\Theta/\Theta_{\text{Trip}}$ L3; $\Theta/\Theta_{\text{Trip}}$
Tolerances	Class 10 % acc. to IEC 60255-8

Breaker failure protection (ANSI 50BF)

Number of stages	2
Pickup of current element	0.05 to 20 A (1A) / 0.25 to 100 A (5A) (step 0.01 A)
Time delays $T1_{\text{1phase}}$, $T1_{\text{3phase}}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Drop-off (overshoot) time, internal	≤ 15 ms, typical; 25 ms, max.
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms

Technical data

Auto-reclosure (ANSI 79)

Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1 or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{1\text{-PH}}$, $T_{3\text{-PH}}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage $_{\text{PH-E}}$	30 to 90 V (step 1 V)
Dead line voltage $_{\text{PH-E}}$	2 to 70 V (step 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 1 V

Synchro-check (ANSI 25)

Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	
With auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1°)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Minimum measuring time	Approx. 80 ms
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 1 V

Earth-fault detection for compensated / isolated networks

Zero-sequence voltage $3V_0$	1 to 150 V (step 1 V)
Phase selection with phase voltages $V<$ and $V>$	10 to 100 V (step 1 V)
Directional determination	Active / reactive power measurements
Minimum current for directional determination	3 to 1000 mA (steps 1 mA)
Angle correction for core-balance CT	0 to 5 ° at 2 operating points (step 0.1 °)
Operating modes	Only indication; indication and trip
Delay times	0 to 320 s (step 0.01 s)
Pickup time	Approx. 50 ms
Earth-fault measured values	Active and reactive component of earth-fault current I_{EEac}, I_{EEreac}
Tolerances	
Voltage limit values	≤ 5 % of setting value or 1 V
Current limit values	≤ 10 % of setting value
Time stages	1 % of setting value or 10 ms

Trip circuit supervision (ANSI 74TC)

Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Additional functions

Operational measured values

Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; $I_{\text{E sensitve}}$; I_1; I_2; I_{Y}; $3I_{0\text{PAR}}$
Tolerances	Typ. 0.3 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{\text{Phase-Earth}}$; 3 x $V_{\text{Phase-Phase}}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}
Tolerances	Typ. 0.25 % of indicated measured value or 0.01 % V_{nom}
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert \cos \varphi \rvert = 0.7$ to 1 and V/V_{nom}, $I/I_{\text{nom}} = 50$ to 120 %	Typical ≤ 1%
Q: for $\lvert \sin \varphi \rvert = 0.7$ to 1 and V/V_{nom} , $I/I_{\text{nom}} = 50$ to 120 %	Typical ≤ 1%
S: for V/V_{nom}, $I/I_{\text{nom}} = 50$ to 120 %	Typical ≤ 1%
Frequency	f
Tolerance	≤ 10 mHz
Power factor	p.f. ($\cos \varphi$)
Tolerance for $\lvert \cos \varphi \rvert = 0.7$ to 1	Typical ≤ 0.02
Load impedances with directional indication	3 x $R_{\text{Phase-Earth}}$, $X_{\text{Phase-Earth}}$ 3 x $R_{\text{Phase-Phase}}$, $X_{\text{Phase-Phase}}$
Earth-fault measured values	Active and reactive component of earth-fault current I_{EEac}, I_{EEreac}
Overload measured values	$\Theta/\Theta_{\text{Trip}}$ L1; $\Theta/\Theta_{\text{Trip}}$ L2; $\Theta/\Theta_{\text{Trip}}$ L3; $\Theta/\Theta_{\text{Trip}}$

Long-term mean values

Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q-; S

Technical data

Minimum/maximum memory

Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values	
Min./max. of measured values	3 x I_{Phase}; I_1; 3 x $V_{\text{Phase-Earth}}$; 3 x $V_{\text{Phase-to-phase}}$; $3V_0$; V_1; P+; P-; Q+; Q-; S; f; power factor (+); power factor (–)
Min./max. of mean values	3 x $I_{\text{Phase;}}$ I_1; P; Q; S

Energy meters

Four-quadrant meters	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance for $\lvert \cos\varphi \rvert > 0.7$ and $V >$ 50 % V_{nom} and $I >$ 50 % I_{nom}	5 %

Analog measured value output 0 to 20 mA

Number of analog channels	2 per plug-in module Alternatively 1 or 2 or no plug-in module (Refer to ordering data, position 11 and Order code for position 12)
Indication range	0 to 22 mA
Selectable measured values	Fault location [%]; fault location [km]; V_{L23} [%]; I_{L2} [%]; |P| [%]; |Q| [%]; breaking current $I_{\text{max-primary}}$
Max. burden	350 Ω

Oscillographic fault recording

Analog channels	3 x I_{Phase}, $3I_0$, $3I_0$ PAR 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	> 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	100

Control

Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys, control keys (if available)
Remote control	Control protection, DIGSI, pilot wires

Further additional functions

Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Phase sequence Fuse failure monitor Power direction
Indications	
Operational indications	Buffer size 200
System disturbance indication	Storage of indications of the last 8 faults, buffer size 600
Earth-fault indication	Storage of indications of the last 8 faults, buffer size 200
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, c.-b. test, status display of binary inputs, setting of output relays, generation of indications for testing serial interfaces
Phase rotation adjustment	Clockwise or anti-clockwise

CE conformity

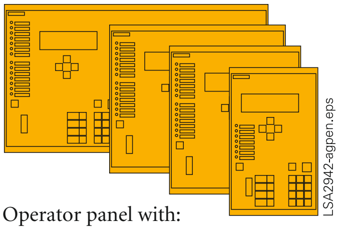
This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23/EEC).

This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directive and with the standard EN 60255-6 for the low-voltage directive.

This device is designed and produced for industrial use.

The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

Selection and ordering data



Operator panel with:
- 4-line backlit display,
- function keys,
- numerical keys,
- PC interface

Description	Order No.
7SA61 distance protection relay for all voltage levels	*7SA61□□-□□□□□-□□□□*

see pages 6/32 to 6/35

Housing, number of LEDs	
Housing width 1/3 19", 7 LEDs	*0*
Housing width 1/2 19", 14 LEDs	*1*
Housing width 1/1 19", 14 LEDs	*2*
Housing width 2/3 19", 14 LEDs	*3*

Measuring input (4 x V, 4 x I)	
I_{PH} = 1 A[1], I_e = 1 A (min. = 0.05 A)	*1*
I_{PH} = 1 A[1], I_e = sensitive (min. = 0.003 A)	*2*
I_{PH} = 5 A[1], I_e = 5 A (min. = 0.25 A)	*5*
I_{PH} = 5 A[1], I_e = sensitive (min. = 0.003 A)	*6*

Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, binary input threshold 17 V[3]	*2*
60 to 125 V DC[2], binary input threshold 17 V[3]	*4*
110 to 250 V DC[2], 115 to 230 V AC, binary input threshold 73 V[3]	*5*

Binary/ indication inputs	Indication/ command outputs incl. live status contact	Fast relay[4]	High-speed trip output	Power relay[5]	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
For 7SA610								
5	4	5			■			*A*
5	4	5					■	*E*
5	4	5				■		*J*
7	6				■			*B*
7	6						■	*F*
7	6					■		*K*
For 7SA611								
13	5	12			■			*A*
13	5	12					■	*E*
13	5	12				■		*J*
13	4	8	5		■			*M*
13	4	8	5				■	*N*
13	4	8	5			■		*P*
20	9			4	■			*B*
20	9			4			■	*F*
20	9			4		■		*K*
For 7SA612								
21	13	12			■			*A*
21	13	12					■	*E*
21	13	12				■		*J*
21	12	8	5		■			*M*
21	12	8	5				■	*P*
21	12	8	5			■		*R*
29	21	12			■			*B*
29	21	12					■	*F*
29	21	12				■		*K*
29	20	8	5		■			*N*
29	20	8	5				■	*Q*
29	20	8	5			■		*S*
33	12			8	■			*C*
33	12			8			■	*G*
33	12			8		■		*L*
For 7SA613								
21	13	12			■			*A*
21	12	8	5		■			*M*

1) Rated current can be selected by means of jumpers.

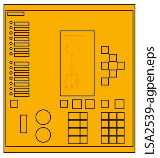
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary input thresholds.

4) Fast relays are identified in the terminal connection diagram.

5) Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

Selection and ordering data



Operator panel with:
- backlit graphic display for single-line diagram
- control keys,
- key-operated switches,
- function keys,
- numerical keys,
- PC interface

Description	Order No.
7SA63 distance protection relay for all voltage levels	*7SA63□□-□□□□□-□□□□*

see pages 6/32 to 6/35

Housing, number of LEDs	
Housing width 1/2 19", 14 LEDs	*1*
Housing width 1/1 19", 14 LEDs	*2*

Measuring input (4 x V, 4 x I)	
$I_{PH} = 1$ A$^{1)}$, $I_e = 1$ A (min. = 0.05 A)	*1*
$I_{PH} = 1$ A$^{1)}$, $I_e =$ sensitive (min. = 0.003 A)	*2*
$I_{PH} = 5$ A$^{1)}$, $I_e = 5$ A (min. = 0.25 A)	*5*
$I_{PH} = 5$ A$^{1)}$, $I_e =$ sensitive (min. = 0.003 A)	*6*

Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, binary input threshold 17 V$^{3)}$	*2*
60 to 125 V DC$^{2)}$, binary input threshold 17 V$^{3)}$	*4*
110 to 250 V DC$^{2)}$, 115 to 230 V AC, binary input threshold 73 V$^{3)}$	*5*

Binary/ indication-inputs	Indication/ command outputs incl. live status contact	Fast relay$^{4)}$	High-speed trip outputs	Power relay$^{5)}$	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
For 7SA631								
13	5	12			■			*A*
13	5	12					■	*E*
13	5	12				■		*J*
13	4	8	5		■			*M*
13	4	8	5				■	*N*
13	4	8	5			■		*P*
20	9			4	■			*B*
20	9			4			■	*F*
20	9			4		■		*K*
For 7SA632								
21	13	12			■			*A*
21	13	12					■	*E*
21	13	12				■		*J*
21	12	8	5		■			*M*
21	12	8	5				■	*P*
21	12	8	5			■		*R*
29	21	12			■			*B*
29	21	12					■	*F*
29	21	12				■		*K*
29	20	8	5		■			*N*
29	20	8	5				■	*Q*
29	20	8	5			■		*S*
33	12			8	■			*C*
33	12			8			■	*G*
33	12			8		■		*L*

1) Rated current can be selected by means of jumpers.

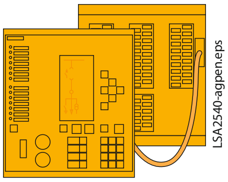
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary inputs thresholds.

4) Fast relays are identified in the terminal connection diagram.

5) Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

Selection and ordering data



Units with
detached operator panel with
- backlit graphic display
- control keys
- key-operated switches
- function keys
- numerical keys
- PC interface

Description	Order No.
7SA64 distance protection relay for all voltage levels	*7SA64□□-□□□□□-□□□□*
Housing, number of LEDs	
Housing width 1/2 19", 14 LEDs	*1*
Housing width 1/1 19", 14 LEDs	*2*
Measuring input (4 x V, 4 x I)	
I_{PH} = 1 A1), I_e = 1 A (min. = 0.05 A)	*1*
I_{PH} = 1 A1), I_e = sensitive (min. = 0.003 A)	*2*
I_{PH} = 5 A1), I_e = 5 A (min. = 0.25 A)	*5*
I_{PH} = 5 A1), I_e = sensitive (min. = 0.003 A)	*6*
Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, binary input threshold 17 V3)	*2*
60 to 125 V DC2), binary input threshold 17 V3)	*4*
110 to 250 V DC2), 115 to 230 V AC, binary input threshold 73 V3)	*5*

see pages 6/32
to 6/35

Binary/ indication-inputs	Indication/ command outputs incl. live status contact	Fast relay4)	High-speed trip outputs	Power relay5)	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	
For 7SA641							
13	5	12			■		*A*
13	5	12				■	*J*
13	4	8	5		■		*M*
13	4	8	5			■	*P*
20	9			4	■		*B*
20	9			4		■	*K*
For 7SA642							
21	13	12			■		*A*
21	13	12				■	*J*
21	12	8	5		■		*M*
21	12	8	5			■	*R*
29	21	12			■		*B*
29	21	12				■	*K*
29	20	8	5		■		*N*
29	20	8	5			■	*S*
33	12			8	■		*C*
33	12			8		■	*L*

---

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary inputs thresholds.

4) Fast relays are identified in the terminal connection diagram.

5) Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

Selection and ordering data

Description	Order No.	Order code
7SA6 distance protection relay for all voltage levels	*7SA6*□□□-□□□□□-□□□□	□□□
	see pages 6/33 to 6/35	
Region-specific default settings / language settings		
Region DE, language: German	*A*	
Region World, language: English (GB)	*B*	
Region US, language: English (US)	*C*	
Region FR, French	*D*	
Region World, Spanish	*E*	
Region World, Italian	*F*	
Region World, language: Russian	*G*	
Region World, language: Polish	*H*	
Port B		
Empty	*0*	
System interface, IEC 60870-5-103 protocol, electrical RS232	*1*	
System interface, IEC 60870-5-103 protocol, electrical RS485	*2*	
System interface, IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
System interface, PROFIBUS-FMS Slave[2], electrical RS485	*4*	
System interface, PROFIBUS-FMS Slave[2], optical [3], double ring [3], ST connector	*6*	
2 analog outputs, each 0.....20 mA	*7*	
System interface, PROFIBUS-DP, electrical RS485	*9*	*L 0 A*
System interface, PROFIBUS-DP, optical 820 nm, double ring [3], ST connector	*9*	*L 0 B*
System interface, DNP 3.0, electrical RS485	*9*	*L 0 G*
System interface, DNP 3.0, optical 820 nm, ST connector[3]	*9*	*L 0 H*
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate, RJ45 plug connectors	*9*	*L 0 R*
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, LC connector[4]	*9*	*L 0 S*

---

1) Definitions for region-specific default settings and functions:

Region DE:	preset to $f = 50$ Hz and line length in km, only IEC inverse characteristic can be selected, directional earth (ground) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r; distance protection can be selected with quadrilateral or circle characteristic.
Region US:	preset to $f = 60$ Hz and line length in miles, ANSI inverse characteristic only, directional earth (ground) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r, no U_0 inverse characteristic.
Region World:	preset to $f = 50$ Hz and line length in km, directional earth (ground) fault protection: no direction decision with zero-sequence power S_r, no U_0 inverse characteristic.
Region FR:	preset to f = 50 Hz and line length in km, directional earth (ground) fault protection: no U_0 inverse characteristic, no logarithmic inverse characteristic, weak infeed logic selectable between French specification and world specification.

2) For SICAM energy automation systems.

3) Optical double ring interfaces are not available with surface mounting housings.

4) For surface mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.

Selection and ordering data

Description	Order No.	Order code
7SA6 distance protection relay for all voltage levels	7SA6☐☐☐-☐☐☐☐☐-☐☐☐☐	☐☐☐
	see pages 6/34 and 6/35	
Port C and port D		
Port C: DIGSI/modem, electrical RS232, Port D: empty	1	
Port C: DIGSI/modem, electrical RS485, Port D: empty	2	
Port C and Port D installed	9	M ☐☐
Port C		
DIGSI/modem, electrical RS232		1
DIGSI/modem, electrical RS485		2
Port D		
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 1.5 km For direct connection via multi-mode FO cable or communication networks [1]		A
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable		B
Two analog outputs, each 0...20 mA		K
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 24 km for direct connection via mono-mode FO cable[2]		G
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable[2][3]		H
Protection data interface: optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable[2][4]		J
FO30 optical 820 nm, 2-ST-connector, length of optical fibre up to 1.5 km for multimode fibre, for communication networks with IEEEC37.94 interface or direct optical fibre connection (not available for surface mounted housing)		S

---

1) For suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire) see "Accessories".

2) For surface -mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

3) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

4) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Selection and ordering data

Description	Order No.
7SA6 distance protection relay for all voltage levels	*7SA6□□□-□□□□□-□□□□*

Functions 1

Trip mode	Thermal overload protection (ANSI 49)	BCD-coded output for fault location	
3-pole			*0*
3-pole		■	*1*
3-pole	■		*2*
3-pole	■	■	*3*
1/3-pole			*4*
1/3-pole		■	*5*
1/3-pole	■		*6*
1/3-pole	■	■	*7*

Functions 2

Distance protection pickup (ANSI 21, 21N)	Power swing detection (ANSI 68, 68T)	Parallel line compensation	
$I>$			*A*
$V< / I>$			*B*
Quadrilateral ($Z<$)			*C*
Quadrilateral ($Z<$), $V< / I> / \varphi$			*D*
Quadrilateral ($Z<$)	■		*F*
Quadrilateral ($Z<$), $V< / I> / \varphi$	■		*G*
$V< / I>$		■ 1)	*J*
Quadrilateral ($Z<$)		■ 1)	*K*
Quadrilateral ($Z<$), $V< / I> / \varphi$		■ 1)	*L*
Quadrilateral ($Z<$)	■	■ 1)	*N*
Quadrilateral ($Z<$), $V< / I> / \varphi$	■	■ 1)	*P*

Functions 3

Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	Breaker failure protection (ANSI 50BF)	Over/undervoltage protection $V>$, $V<$ (ANSI 27, 59) Over/underfrequency protection (ANSI 81)	
				A
			■	*B*
		■		*C*
		■	■	*D*
	■			*E*
	■		■	*F*
	■	■		*G*
	■	■	■	*H*
■				*J*
■			■	*K*
■		■		*L*
■		■	■	*M*
■	■			*N*
■	■		■	*P*
■	■	■		*Q*
■	■	■	■	*R*

Functions 4

Directional earth-fault protection, earthed networks (ANSI 50N, 51N, 67N)	Earth-fault detection compensated/ isolated networks	Measured values extended Min, max, mean	
			0
		■	*1*
	■ 2)		*2*
	■ 2)	■	*3*
■			*4*
■		■	*5*
■	■ 2)		*6*
■	■ 2)	■	*7*

1) Only with position 7 of Order No. = *1* or *5*.

2) Only with position 7 of Order No. = *2* or *6*.

Selection and ordering data

Description	Order No.
7SA6 distance protection relay for all voltage levels	*7SA6□□□-□□□□□-□□□□*

Preferential types

Functions 1

Trip mode, 3-pole	Trip mode 1 or 3-pole	Pickup I>	Pickup V</I>	Z< (quadrilateral) V</I>/φ	Power swing detection	Parallel line compensation	Auto-reclosure	Synchro-check	Breaker failure protection	Voltage protection Frequency protection	Earth-fault protection directional for earthed networks	Earth-fault directional for compensated isolated networks	Overload protection	Measured values, extended, min. max. mean	
Basic version															
■		■								■					*1 A B 0*
■		■								■				■	*1 A B 1*
Medium voltage, cables															
■		■	■						■	■	■	■1)	■		*3 B D 6*
■		■	■						■	■	■	■1)	■	■	*3 B D 7*
Medium voltage, overhead lines															
■		■	■				■		■	■	■	■1)	■		*3 B M 6*
■		■	■				■		■	■	■	■1)	■	■	*3 B M 7*
High voltage, cables															
■		■	■	■	■			■	■	■	■		■		*3 G H 4*
■		■	■	■	■			■	■	■	■		■	■	*3 G H 5*
High voltage, overhead lines															
■	■	■	■	■	■	■2)	■	■	■	■	■		■		*7 P R 4*
■	■	■	■	■	■	■2)	■	■	■	■	■		■	■	*7 P R 5*

---

1) Only with position 7 of Order No. = *2* or *6*.

2) Only with position 7 of Order No. = *1* or *5*.

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	*3RV1611-1AG14*
Manual for 7SA6 English, V4.61 and higher	*C53000-G1176-C156-5*

Accessories

Description	Order No.
Opto-electric communication converters	
Optical to X21/RS422 or G703.1	*7XV5662-0AA00*
Optical to pilot wires	*7XV5662-0AC00*
Additional interface modules	
Protection data interface FO 5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	*C53207-A351-D651-1*
Protection data interface FO 6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	*C53207-A351-D652-1*
Protection data interface FO 17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*C53207-A322-B115-3*
Protection data interface FO 18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*C53207-A322-B116-3*
Protection data interface FO 19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	*C53207-A322-B117-3*
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*7XV5461-0BG00*
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*7XV5461-0BH00*
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	*7XV5461-0BJ00*

Fig. 6/34 Mounting rail for 19" rack

Fig. 6/35
2-pin connector

Fig. 6/36
3-pin connector

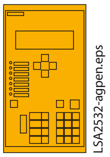
Fig. 6/37
Short-circuit link for current contacts

Fig. 6/38
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	6/35
	3-pin	*C73334-A1-C36-1*	1	Siemens	6/36
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	*0-539635-1*	1	AMP 1)	
	and matching female	*0-539668-2*		AMP 1)	
	for CI2	*0-734372-1*	1	AMP 1)	
	and matching female	*1-734387-1*		AMP 1)	
19"-mounting rail		*C73165-A63-D200-1*	1	Siemens	6/34
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	6/37
	For other terminals	*C73334-A1-C34-1*	1	Siemens	6/38
Safety cover for terminals	large	*C73334-A1-C31-1*	1	Siemens	6/4
	small	*C73334-A1-C32-1*	1	Siemens	6/4

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram



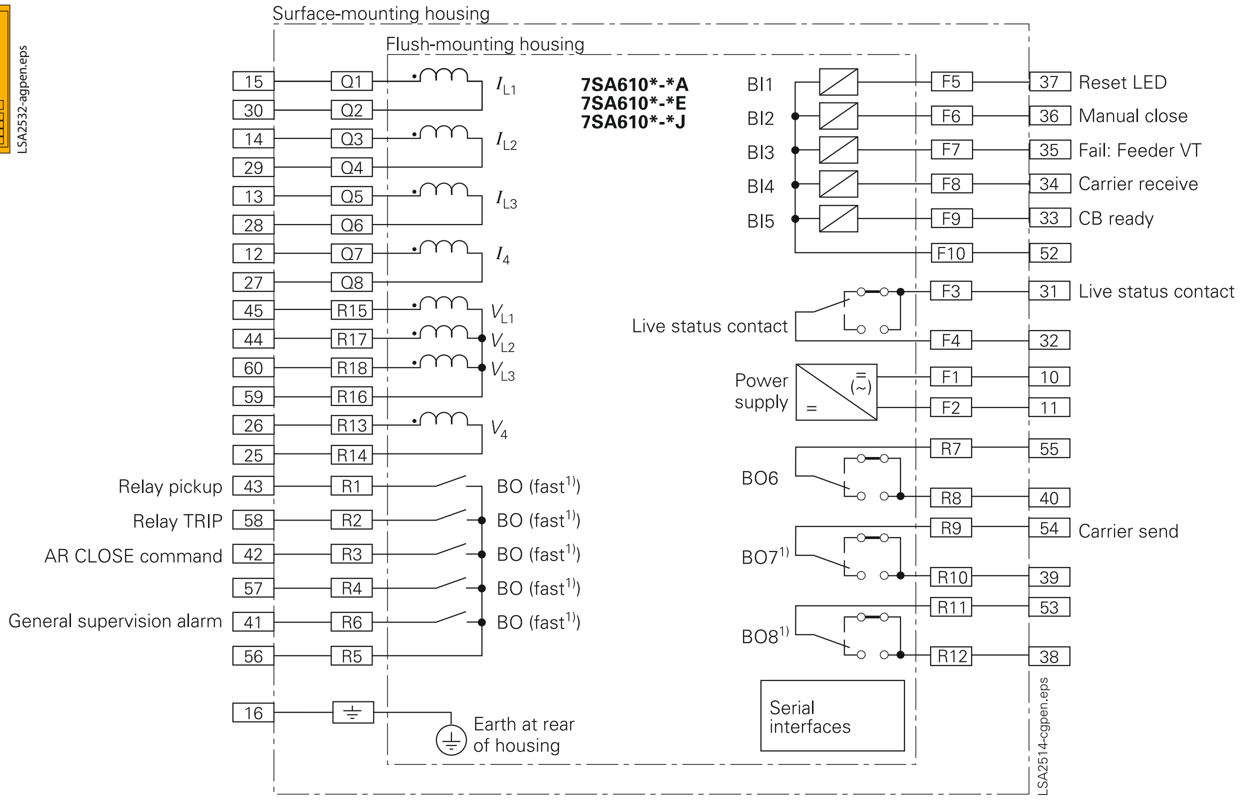


Fig. 6/39
Connection diagram

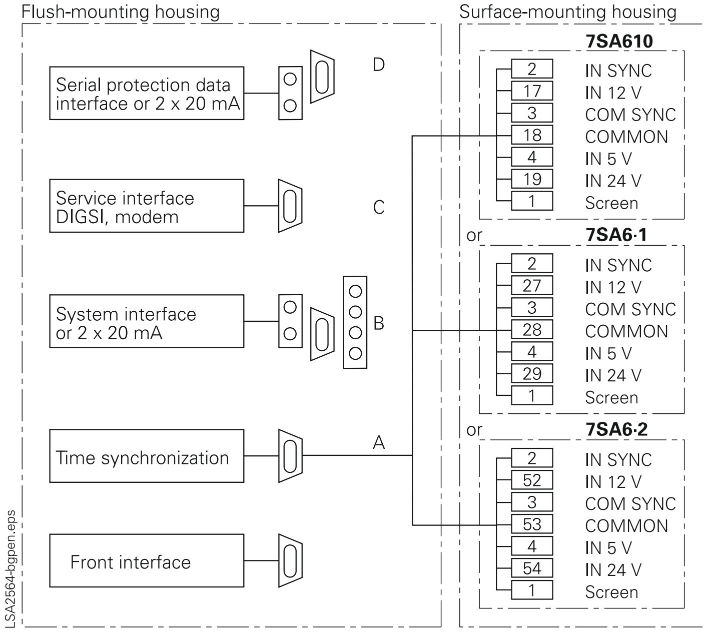
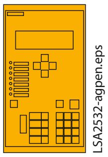


Fig. 6/40
Serial interfaces

---

1) Starting from unit version …./EE.

Connection diagram



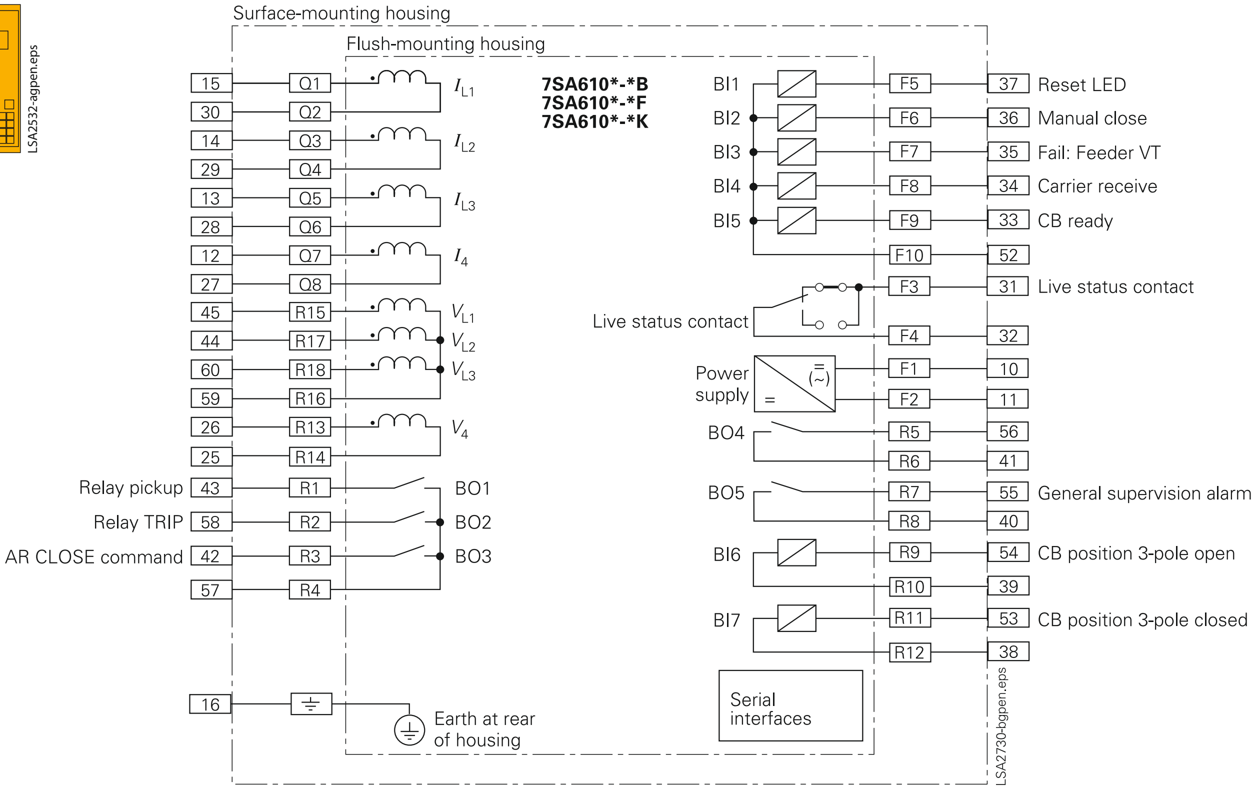


Fig. 6/41
Connection diagram

Note: For serial interfaces see Fig. 6/40.

Connection diagram

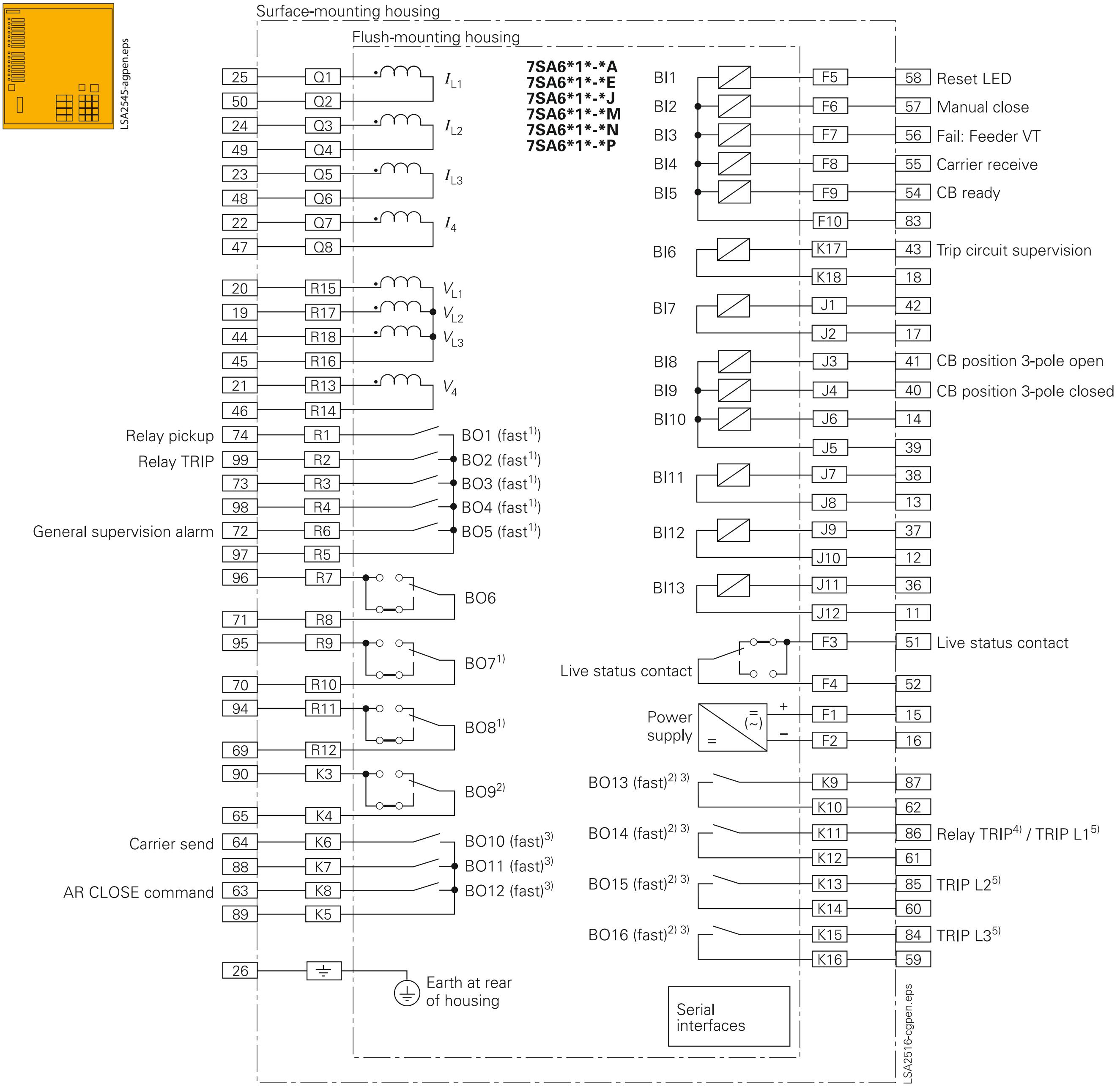


Fig. 6/42

Connection diagram

1) Starting from unit version .../EE.

2) High-speed trip outputs in versions 7SA6*1*-*M, 7SA*1*-*N, 7SA*1*-*P.
Time advantage of high-speed relays over fast relays: approx. 5 ms

3) Time advantage with fast relay approx. 3 ms.

4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

Connection diagram

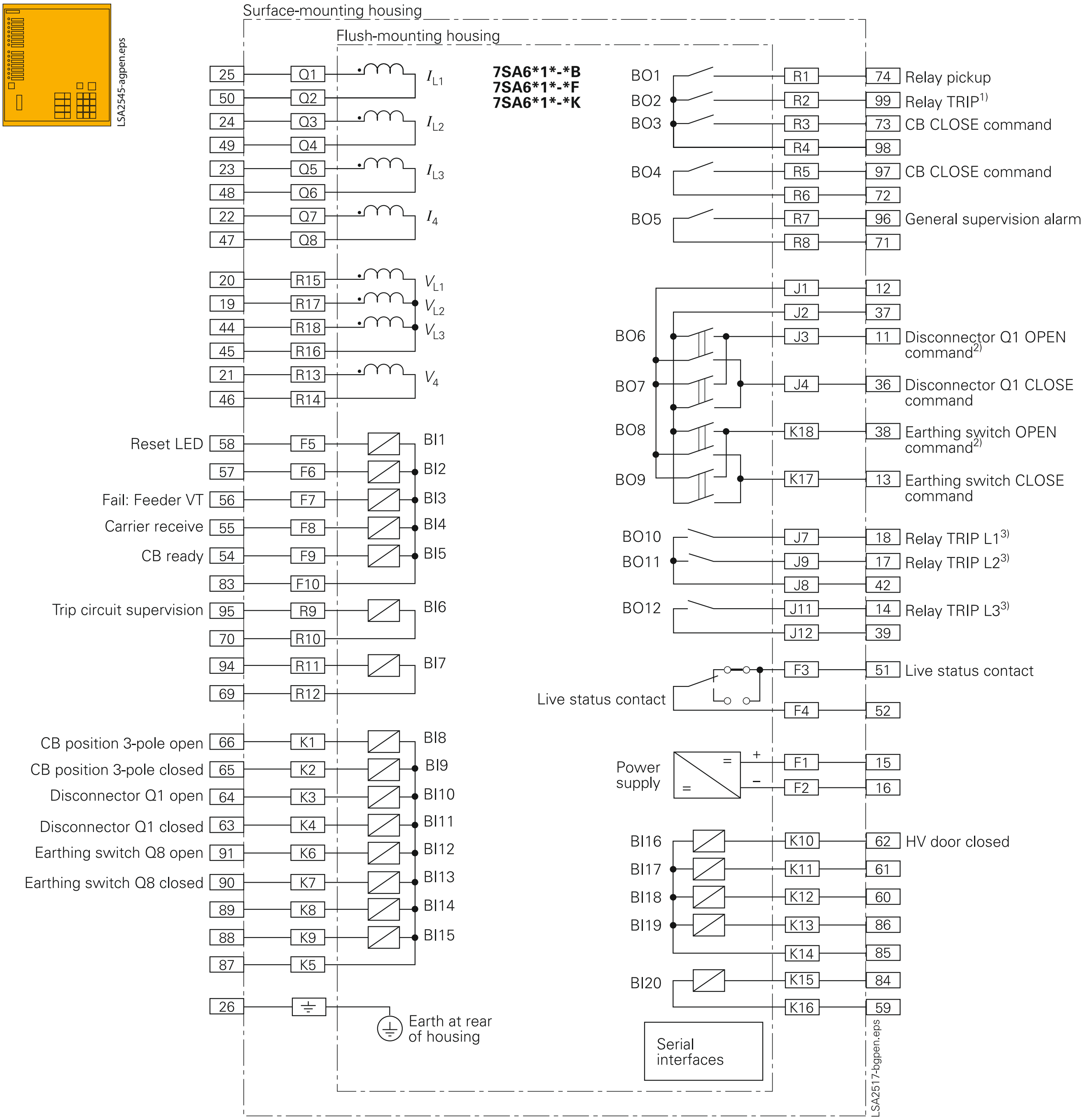


Fig. 6/43
Connection diagram

---

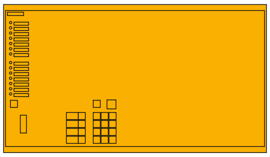
1) Version with 3-pole tripping.

2) Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

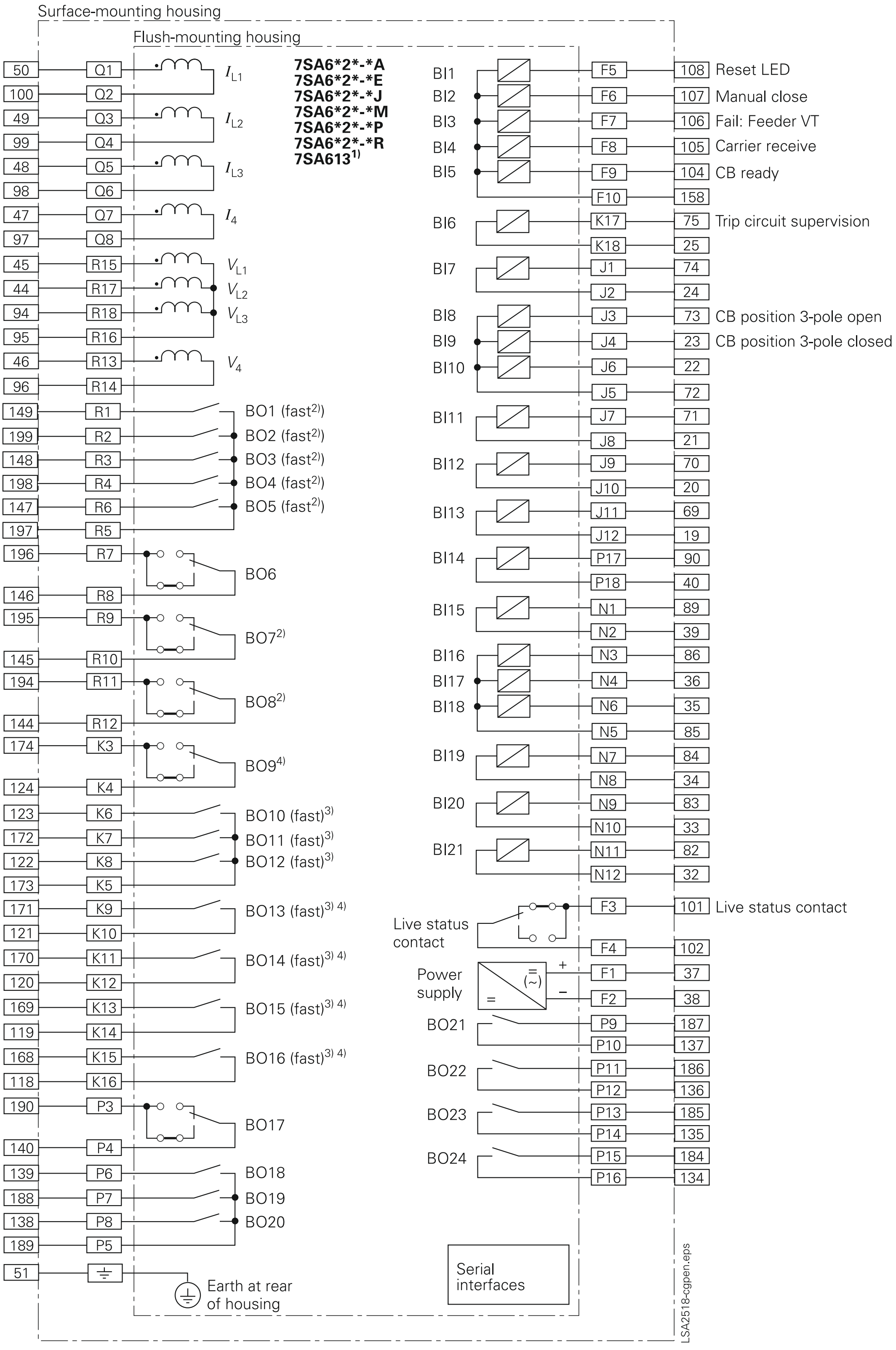
3) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

Connection diagram



LSA2546-agpen.eps



1) 7SA613 is only available in a 2/3 x 19" flush-mounting housing.

2) Starting from unit version .../EE

3) Time advantage with fast relay approx. 3 ms.

4) High-speed trip outputs in versions 7SA6*2*-*M, 7SA6*2*-*P, 7SA6*2*-*R. Time advantage of high-speed relays over fast relays: approx. 5 ms

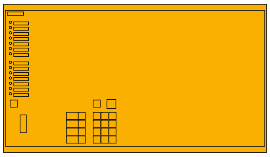
5) Version with 3-pole tripping.

6) Version with 1/3-pole tripping.

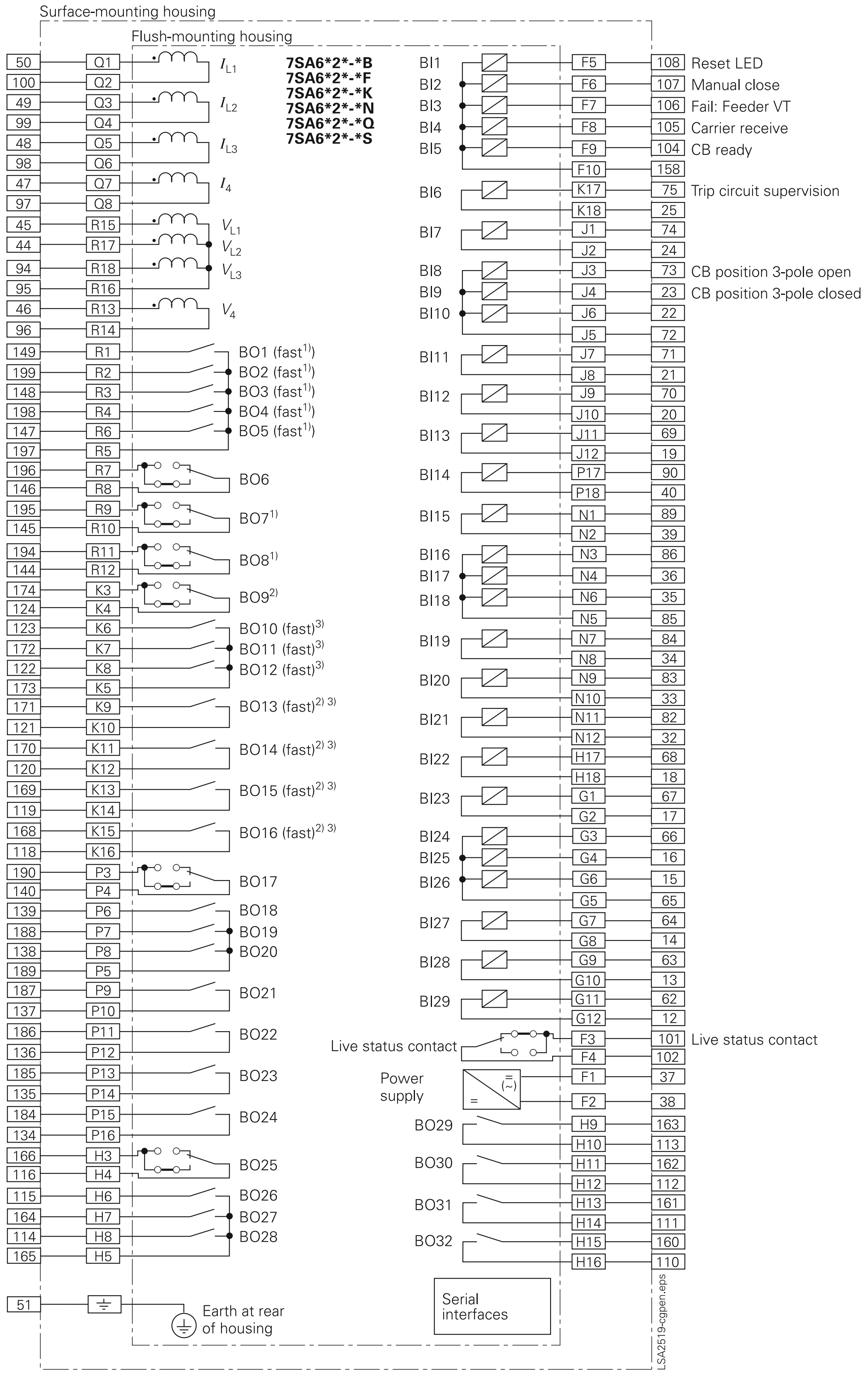
Note: For serial interfaces see Fig. 6/40.

Fig. 6/44
Connection diagram

Connection diagram



LSA2546-agpen.eps



1) Starting from unit version .../EE.

2) High-speed trip outputs in versions 7SA6*2*-*N, 7SA6*2*-*Q, 7SA6*2*-*S.

3) Time advantage with fast relay approx. 3 ms.

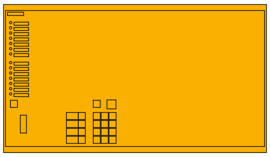
4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping. Time advantage of high-speed relays over fast relays: approx. 5 ms.

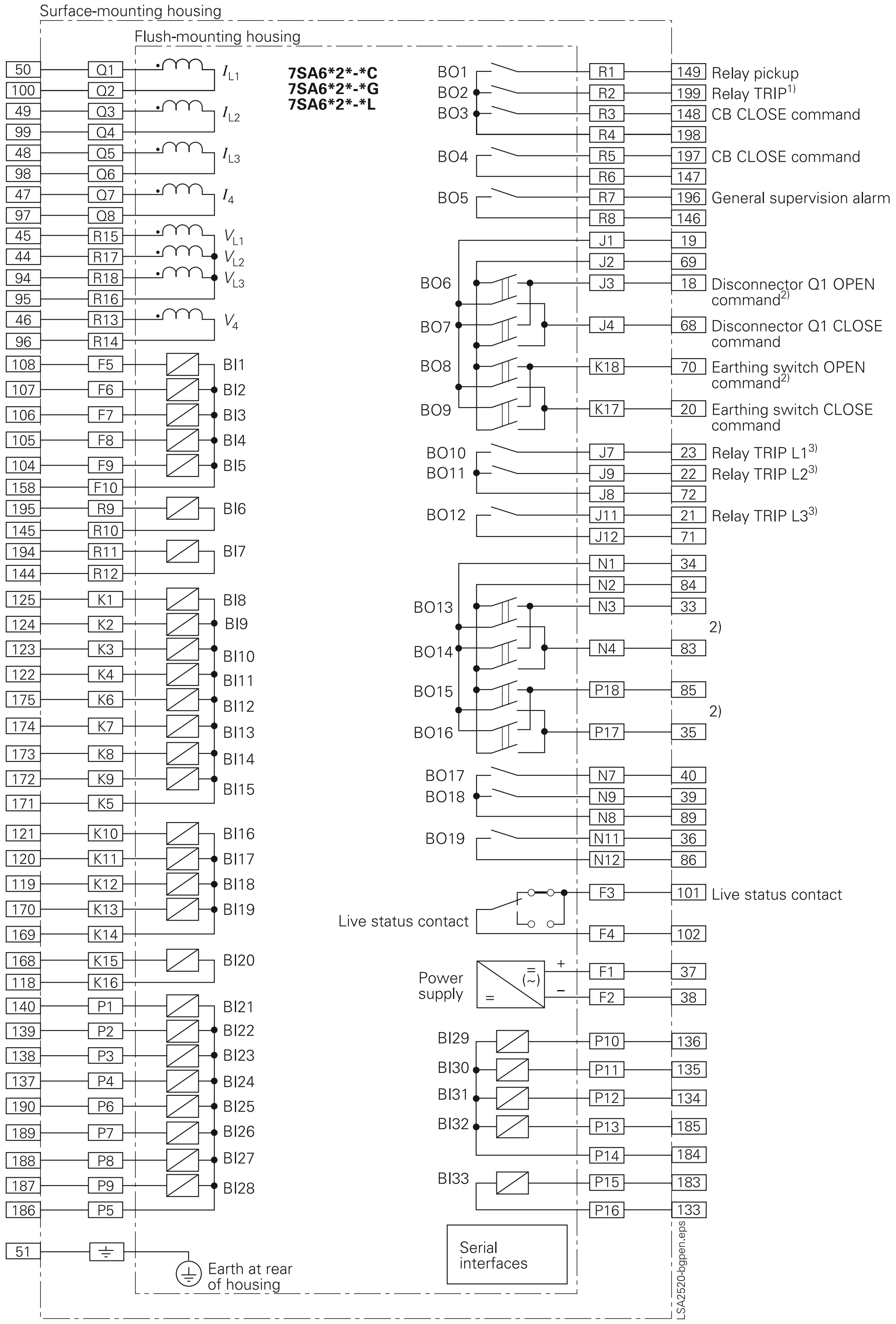
Note: For serial interfaces see Fig. 6/40.

Fig. 6/45 Connection diagram

Connection diagram



LSA2546-agpen.eps



1) Version with 3-pole tripping.

2) Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

3) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

Fig. 6/46 Connection diagram

SIPROTEC 4 7SA522
Distance Protection Relay for Transmission Lines

Fig. 6/47 SIPROTEC 4
7SA522 distance protection relay

Description

The SIPROTEC 4 7SA522 relay provides full-scheme distance protection and incorporates all functions usually required for the protection of a power line. The relay is designed to provide fast and selective fault clearance on transmission and subtransmission cables and overhead lines with or without series capacitor compensation. The power system star point can be solid or resistance grounded (earthed), resonant-earthed via Peterson coil or isolated. The 7SA522 is suitable for single-pole and three-pole tripping applications with and without tele (pilot) protection schemes.

The 7SA522 incorporates several protective functions usually required for transmission line protection.

– High-speed tripping time

– Suitable for cables and overhead lines with or without series capacitor compensation

– Self-setting power swing detection for power swing frequencies upt to 7 Hz

– Digital relay-to-relay communication for two and three terminal topologies

– Adaptive auto-reclosure (ADT)

Function overview

Protection functions

- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance ground (earth)-fault protection for single- and three-pole tripping (50N/51N/67N)
- Tele (pilot) protection (85)
- Fault locator (FL)
- Power swing detection/tripping (68/68T)
- Phase-overcurrent protection (50/51/67)
- STUB bus overcurrent protection (50 STUB)
- Switch-onto-fault protection (50HS)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79)
- Synchro-check (25)
- Breaker failure protection (50BF)

Control functions

- Commands f. control of CB and isolators

Monitoring functions

- Trip circuit supervision (74TC)
- Self-supervision of the relay
- Measured-value supervision
- Event logging/fault logging
- Oscillographic fault recording
- Switching statistics

Front design

- User-friendly local operation with numeric keys
- LEDs for local alarm
- PC front port for convenient relay setting
- Function keys

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  - IEC 61850 Ethernet
  - IEC 60870-5-103 protocol
  - PROFIBUS-FMS/-DP
  - DNP 3.0
- 2 serial protection data interfaces for tele (pilot) protection
- Rear-side service/modem interface
- Time synchronization via IRIG B or DCF77 or system interface

Hardware

- Binary inputs: 8/16/24
- Output relays: 16/24/32
- High-speed trip outputs: 5 (optional)

Application

The 7SA522 relay provides full-scheme distance protection and incorporates all functions usually required for the protection of a power line. The relay is designed to provide fast and selective fault clearance on transmission and subtransmission cables and overhead lines with or without series capacitor compensation. This contributes towards improved stability and availability of your electrical power transmission system. The power system star point can be solid or impedance grounded (earthed), resonant-earthed via Peterson coil or isolated. The 7SA522 is suitable for single and three-pole tripping applications with and without tele (pilot) protection schemes.

The effect of apparent impedances in unfaulted fault loops is eliminated by a sophisticated and improved method which uses pattern recognition with symmetrical components and load compensation. The correct phase selection is essential for selective tripping and reliable fault location.

During network power swings, an improved power swing blocking feature prevents the distance protection from unwanted tripping and optionally provides controlled tripping in the event of loss of synchronism (out of step). This function guarantees power transmission even under critical network operating conditions.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

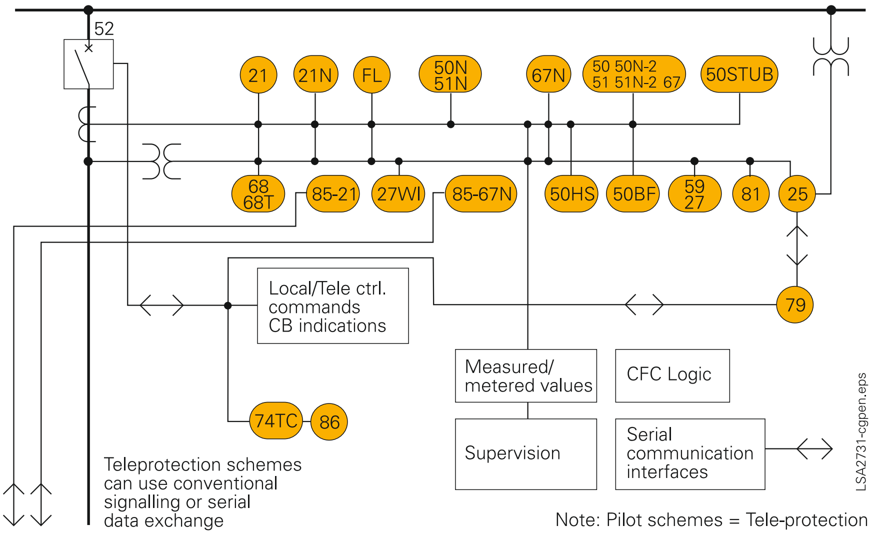
The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control and interlocking change, it is possible in the majority of the cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

Features

- High speed tripping time
- Suitable for cables and overhead lines with or without series capacitor compensation
- Self setting power swing detection fo frequencies up to 7 Hz
- Digital relay-to-relay communication for two and three terminal topologies
- Adaptive auto-reclosure (ADT)

ANSI	Protection function
21/21N	Distance protection
FL	Fault locator
50N/51N 67N	Directional earth(ground)-fault protection
50/51/67	Backup overcurrent protection
50 STUB	STUB-bus overcurrent stage
68/68T	Power swing detection/tripping
85/21	Teleprotection for distance protection
27WI	Weak-infeed protection
85/67N	Teleprotection for earth(ground)-fault protection
50HS	Switch-onto-fault protection
50BF	Breaker failure protection
59/27	Overvoltage/undervoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)



Teleprotection schemes can use conventional signalling or serial data exchange

Note: Pilot schemes = Tele-protection

Fig. 6/48

Single-line diagram

Construction

Connection techniques and housing with many advantages

1/2 and 1/1-rack sizes

These are the available housing widths of the SIPROTEC 4 7SA522 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

LSP2310-afpen.tif

Fig. 6/49

Housing widths 1/2 x 19″ and 1/1 x 19″

LSP2174-afp.tif

Fig. 6/50

Rear view with screw-type terminals and serial interfaces

LSP2166-afp.tif

Fig. 6/51

Rear view with terminal covers and wiring

Protection functions

Distance protection (ANSI 21, 21N)

The main function of the 7SA522 is a full-scheme distance protection. By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of faults. The shortest tripping time is less than one cycle. Single-pole and three-pole tripping is possible. The distance protection is suitable for cables and overhead lines with or without series capacitor compensation.

Mho and quadrilateral characteristics

The 7SA522 relay provides quadrilateral as well as mho zone characteristics. Both characteristics can be used separately for phase and ground (earth) faults. Resistance ground (earth) faults can, for instance, be covered with the quadrilateral characteristic and phase faults with the mho characteristic.

Load zone

In order to guarantee a reliable discrimination between load operation and short-circuit - especially on long high loaded lines - the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The 7SA522 distance protection incorporates a well-proven, highly sophisticated phase selection algorithm. The pickup of unfaulted loops is reliably eliminated to prevent the adverse influence of currents and voltages in the fault-free loops. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range.

Parallel line compensation

The influence of wrong distance measurement due to parallel lines can be compensated by feeding the neutral current of the parallel line to the relay. Parallel line compensation can be used for distance protection as well as for the fault locator.

7 distance zones

Six independant distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partly separate for single-phase or multi-phase faults. Ground (earth) faults are detected by monitoring the neutral current $3I_0$ and the zero-sequence voltage $3V_0$.

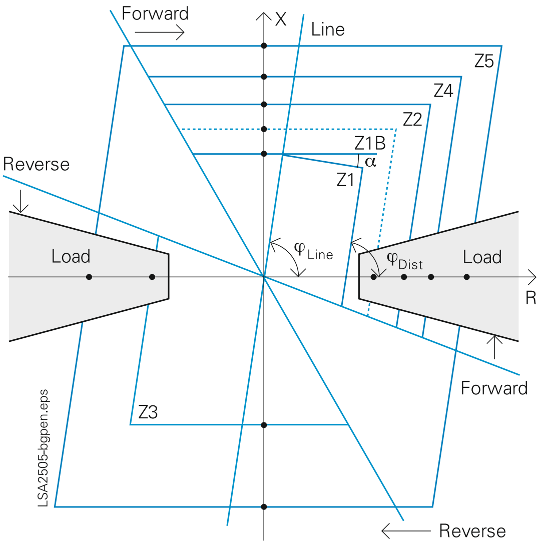


Fig. 6/52
Distance protection: quadrilateral characteristic

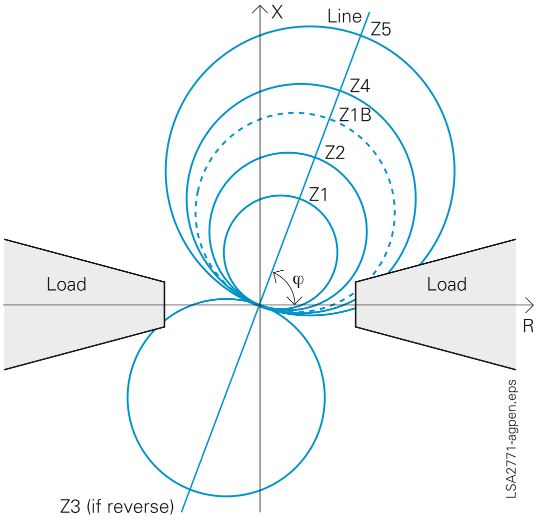


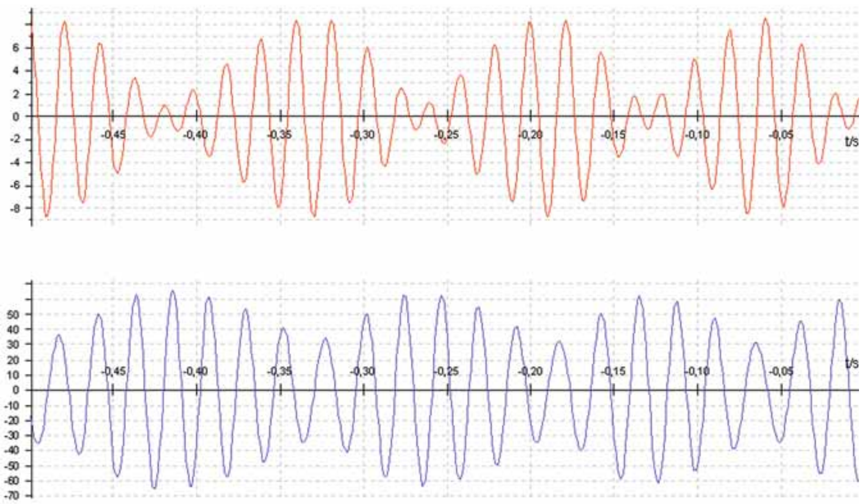
Fig. 6/53
Distance protection: mho characteristic

The quadrilateral tripping characteristic permits separate setting of the reactance X and the resistance R. The resistance section R can be set separately for faults with and without earth involvement. This characteristic has therefore an optimal performance in case of faults with fault resistance. The distance zones can be set forward, reverse or non-directional. Sound phase polarization and voltage memory provides a dynamically unlimited directional sensitivity.

Mho

The mho tripping characteristic provides sound phase respectively memory polarization for all distance zones. The diagram shows characteristic without the expansion due to polarizing. During a forward fault the polarizing expands the mho circle towards the source so that the origin is included. This mho circle expansion guarantees safe and selective operation for all types of faults, even for close-in faults.

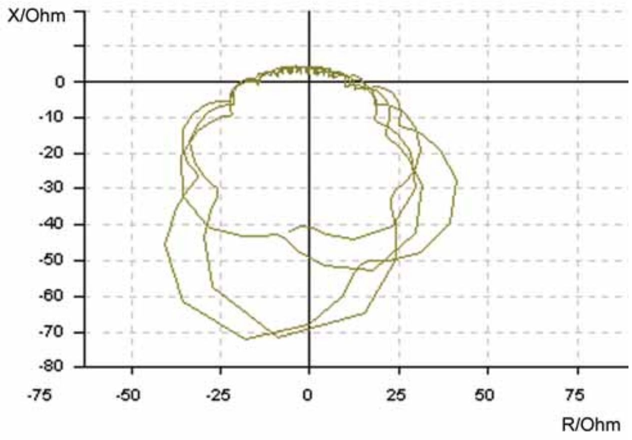
Protection functions



LSP2311-afp.tif

Fig. 6/54

Power swing current and voltage wave forms



LSP2312-afp.tif

Fig. 6/55

Power swing circle diagram

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.

The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and, in this case, the EMERGENCY definite-time overcurrent protection can be activated.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The result is displayed in ohms, miles, kilometers or in percent of the line length. Parallel line and load current compensation is also available.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SA522 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- PUTT, permissive underreaching zone transfer trip
- POTT, permissive overreaching zone transfer trip
- UNBLOCKING
- BLOCKING
- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function)

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are power-line carrier, microwave radio and fiber-optic links. A serial protection data interface for direct connection to a digital communication network or fiber-optic link is available as well.

7SA522 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if two single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines).

Phase-selective transmission is also possible with multi-end applications, if some user-specific linkages are implemented by way of the integrated CFC logic. During disturbances in the transmission receiver or on the transmission circuit, the teleprotection function can be blocked by a binary input signal without losing the zone selectivity. The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function. A transient blocking function (Current reversal guard) is provided in order to suppress interference signals during tripping of parallel lines.

Protection functions

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SA522 relay is equipped with phase-selective "external trip inputs" that can be assigned to the received inter-trip signal for this purpose.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided.
If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate tripping at the weak-infeed end. A phase-selective 1-pole or 3-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-earth voltage drops correspondingly. As an option, the weak infeed logic can be equipped according to a French specification.

Directional ground(earth)-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In grounded (earthed) networks, it may happen that the distance protection sensitivity is not sufficient to detect high-resistance ground (earth) faults. The 7SA522 protection relay therefore has protection functions for faults of this nature.

The ground (earth)-fault overcurrent protection can be used with 3 definite-time stages and one inverse-time stage (IDMT). A 4th definite-time stage can be applied instead of the one inverse-time stage.

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”). An additional logarithmic inverse-time characteristic is also available.

The direction decision can be determined by the neutral current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2. In addition or as an alternative to the directional determination with zero-sequence voltage, the star-point current of an grounded (earthed) power transformer may also be used for polarization. Dual polarization applications can therefore be fulfilled.

Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or for both directions (non-directional).

As an option, the 7SA522 relay can be provided with a sensitive neutral (residual) current transformer. This feature provides a measuring range for the neutral (residual) current from 5 mA to 100 A with a nominal relay current of 1 A and from 5 mA to 500 A with a nominal relay current of 5 A. Thus the ground(earth)-fault overcurrent protection can be applied with extreme sensitivity.

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for low zero-sequence fault currents which usually have a high content of 3rd and 5th harmonics. Inrush stabilization and instantaneous switch-onto-fault trip can be activated separately for each stage as well.

Different operating modes can be selected. The ground(earth)-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole autoreclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional ground(earth)-fault protection (ANSI 85-67N)

The directional ground(earth)-fault overcurrent protection can be combined with one of the following teleprotection schemes:

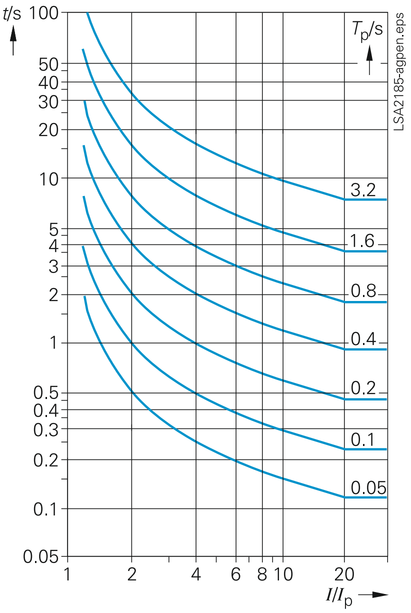
- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground(earth)-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N, 67)

The 7SA522 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the neutral (residual) current.



$$t = \frac{0.14}{\left(I/I_p\right)^{0.02} - 1} T_p$$

Fig. 6/56 Normal inverse

The application can be extended to a directional overcurrent protection (ANSI 67) by taking into account the decision of the available direction detection elements.

Two operating modes are selectable. The function can run in parallel to the distance protection or only during failure of the voltage in the VT secondary circuit (emergency operation).

The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”).

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated from a binary input signalling that the line isolator (disconnector) is open.
Settings are available for phase and ground(earth)-faults.

Protection functions

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast 3-pole tripping.

With lower fault currents, instantaneous tripping after switch-onto-fault is also possible with the overreach distance zone Z1B or just with pickup in any zone.

The switch-onto-fault initiation can be detected via the binary input “manual close” or automatically via measurement.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or that are only lightly loaded. The 7SA522 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SA522 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Breaker failure protection (ANSI 50BF)

The 7SA522 relay incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes.

If the fault current is not interrupted after a time delay has expired, a retrip command or the busbar trip command will be generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Auto-reclosure (ANSI 79)

The 7SA522 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without earth, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without earth and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed: When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g., checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Protection functions

Fuse failure monitoring and other supervision functions

The 7SA522 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit, the distance protection would respond with an unwanted trip due to this loss of voltage. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection and switching to the backup-emergency protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Broken-conductor supervision
- Summation of currents and voltages
- Phase-sequence supervision

Directional power protection

The 7SA522 has a function for detecting the power direction by measuring the phase angle of the positive-sequence system's power. Fig. 6/57 shows an application example displaying negative active power. An indication is issued in the case when the measured angle φ (S1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φ A and φ B.
Via CFC the output signal of the directional monitoring can be linked to the "Direct Transfer Trip (DTT)" function and thus, as reverse power protection, initiate tripping of the CB.

Fig.6/58 shows another application displaying capacitive reactive power. In the case of overvoltage being detected due to long lines under no-load conditions it is possible to select the lines where capacitive reactive power is measured.

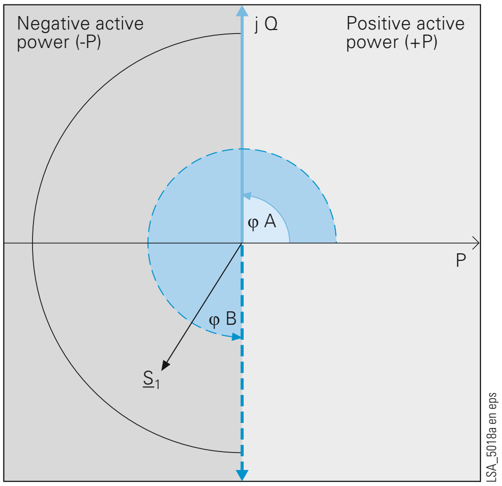


Fig. 6/57 Monitoring of active power direction

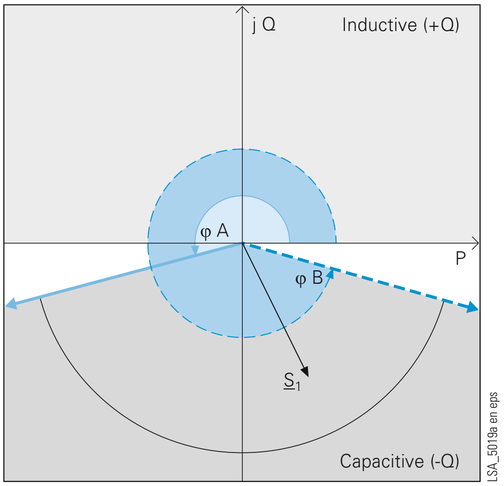


Fig. 6/58 Monitoring of reactive power

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

Under certain operating conditions, it is advisable to block CLOSE commands after a TRIP command of the relay has been issued. Only a manual "Reset" command unblocks the CLOSE command. The 7SA522 is equipped with such an interlocking logic.

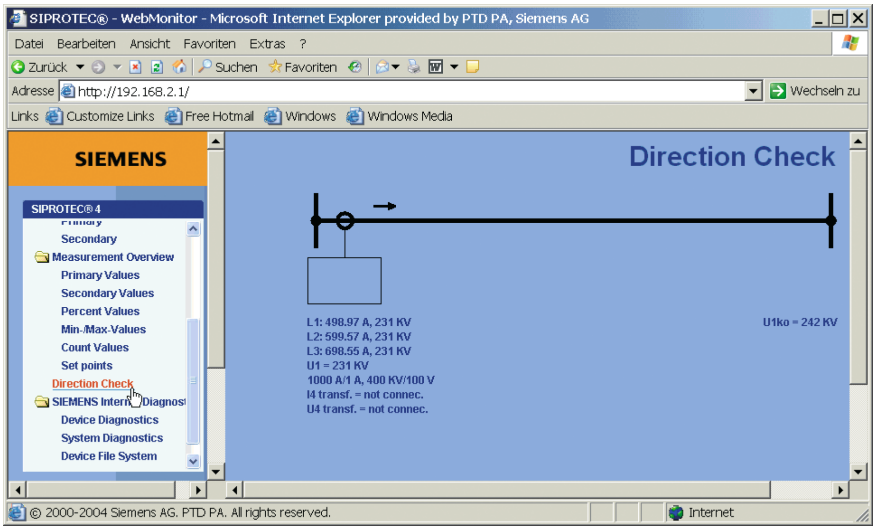
Protection functions

Commissioning and fault event analyzing

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged. For applications with serial protection data interface, all currents, voltages and phases are available via communication link at each local unit, displayed at the front of the unit with DIGSI 4 or with WEB Monitor.
A common time tagging facilitates the comparison of events and fault records.

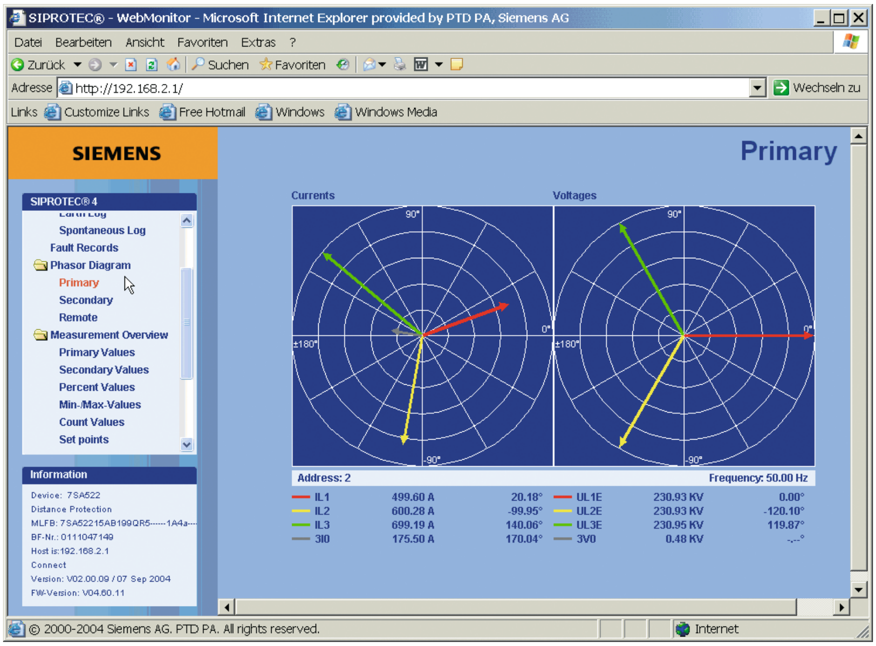
WEB Monitor – Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. Apart from numeric values, graphical displays in particular provide clear information and a high degree of operating reliability. Of course, it is also possible to call up detailed measured value displays and annunciation buffers. By emulation of the integrated unit operation on the PC it is also possible to adjust selected settings for commissioning purposes.



L1: 498.97 A, 231 KV
L2: 599.57 A, 231 KV
L3: 698.55 A, 231 KV
U1 = 231 KV
1000 A/1 A, 400 KV/100 V
I4 transf. = not connec.
U4 transf. = not connec.
U1ko = 242 KV

Fig. 6/59 Web Monitor: Display of the protection direction



Information
Device: 7SA522
Distance Protection
MLFB: 7SA52215AB199QR5------1A4a---
BF-Nr.: 0111047149
Host is:192.168.2.1
Connect
Version: V02.00.09 / 07 Sep 2004
FW-Version: V04.60.11

Address: 2
Frequency: 50.00 Hz

IL1	499.60 A	20.18°	UL1E	230.93 KV	0.00°
IL2	600.28 A	-99.95°	UL2E	230.93 KV	-120.10°
IL3	699.19 A	140.06°	UL3E	230.95 KV	119.87°
3I0	175.50 A	170.04°	3V0	0.48 KV	-.--°

Fig. 6/60 Web monitor: Supported commissioning by phasor diagram

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the device which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks which are already widely applied in the power supply sector.

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

By means of the RS 485/RS 232 interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants. With the optical version, centralized operation can be implemented by means of a star coupler.

Time synchronization

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problems.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should the unit fail, there is no effect on the communication with the rest of the system.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communcation protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet but is also possible with DIGSI. It is also possible to retrieve operating and fault records as well as fault recordings via a browser. This Web monitor will also provide a few items of unit-specific information in browser windows.

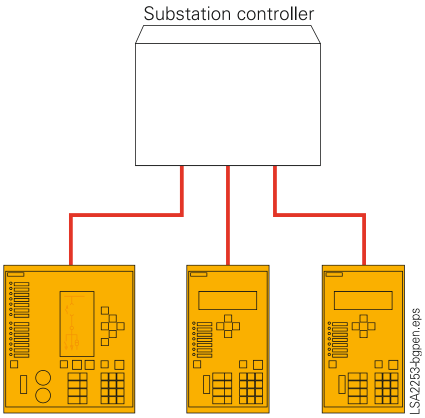


Fig. 6/61

IEC 60870-5-103 star type RS232 copper conductor connection or fiber-optic connection

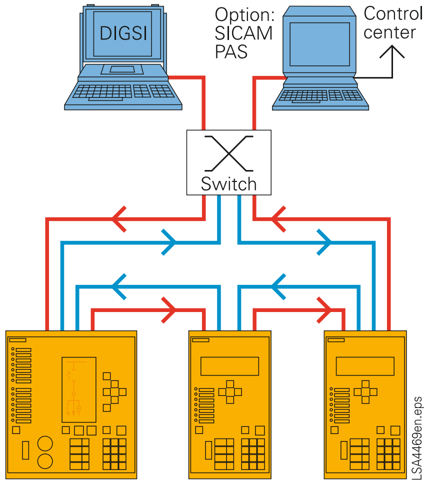


Fig. 6/62

Bus structure for station bus with Ethernet and IEC 61850

Communication

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays.
IEC 60870-5-103 is supported by a number of protection relay manufacturers and is used worldwide. Supplements for control functions are defined in the manufacturer-specific part of this standard.

PROFIBUS-DP

PROFIBUS-DP is an industrial communication standard and is supported by a number of PLC and protection relay manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link.

Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 6/67).

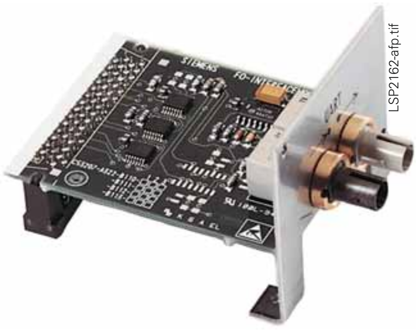


Fig. 6/63
820 nm fiber-optic communication module

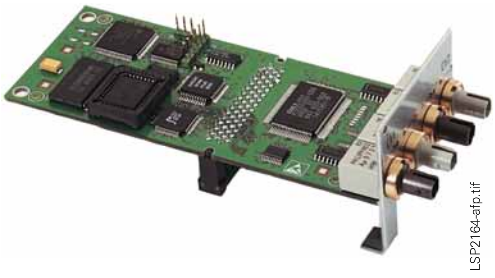


Fig. 6/64
PROFIBUS fiber-optic double ring communication module

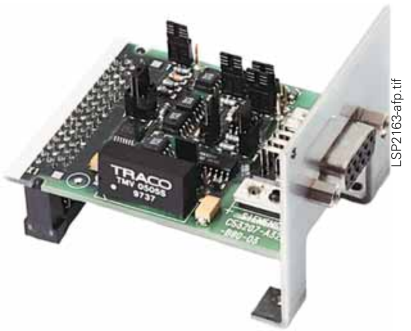


Fig. 6/65
RS232/RS485 electrical communication module

Fig. 6/66
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

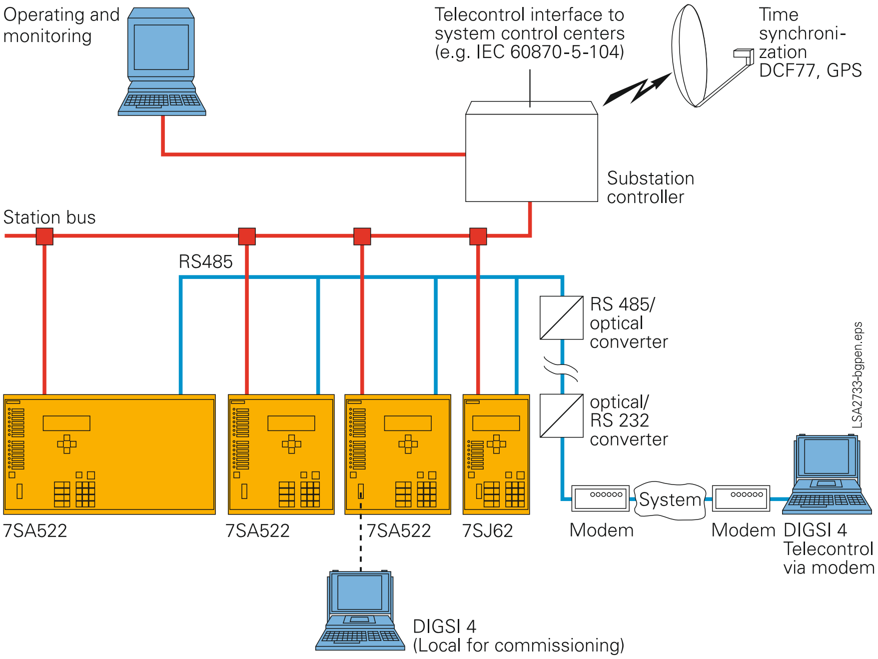


Fig. 6/67 Communication

Communication

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI and the Web monitor can also be used via the same station bus.

Serial protection data interface

The tele (pilot) protection schemes can be implemented using digital serial communication. The 7SA522 is capable of remote relay communication via direct links or multiplexed digital communication networks. The serial protection data interface has the following features:

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Signaling for directional ground(earth)-fault protection – directional comparison for high-resistance faults in solidly earthed systems.
- Echo-function
- Two and three-terminal line applications can be implemented without additional logic
- Interclose command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- Redundant communication path switchover is possible with the 7SA522 when 2 serial protection data interfaces are installed
- 28 remote signals for fast transfer of binary signals
- Flexible utilization of the communication channels by means of the programmable CFC logic
- Display of the operational measured values of the opposite terminal(s) with phase-angle information relative to a common reference vector
- Clock synchronization: the clock in only one of the relays must be synchronized from an external so called "Absolute Master" when using the serial protection data interface. This relay will then synchronize the clock of the other (or the two other relays in 3 terminal applications) via the protection data interface.
- 7SA522 and 7SA6 can be combined via the protection data interface.

The communication possibilities are identical to those for the line differential protection relays 7SD5 and 7SD610. The following options are available:

- FO5(1), OMA1(2) module: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for link to communication networks via communication converters or for direct FO cable connection
- FO6(1), OMA2(2) module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multi-mode FO cable
- FO17(1): for direct connection up to 24 km(3), 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18(1): for direct connection up to 60 km(3), 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19(1): for direct connection up to 100 km(3), 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30(1): for transmission with the IEEE C37.94 standard

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface. If the connection to the multiplexor supports IEEE C37.94 a direct fibre optic connection to the relay is possible using the FO30 module.

For operation via copper wire communication (pilot wires), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Communication data:

- Supported network interfaces G703.1 with 64 kbit/s; X21/RS422 with 64 or 128 or 512 kbit/s; IEEE C37.94
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC
- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.

Figure 6/68 shows four applications for the serial protection data interface on a two-terminal line.

---

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal fiber-optic module (OMA1) will be delivered together with an external repeater.

Communication

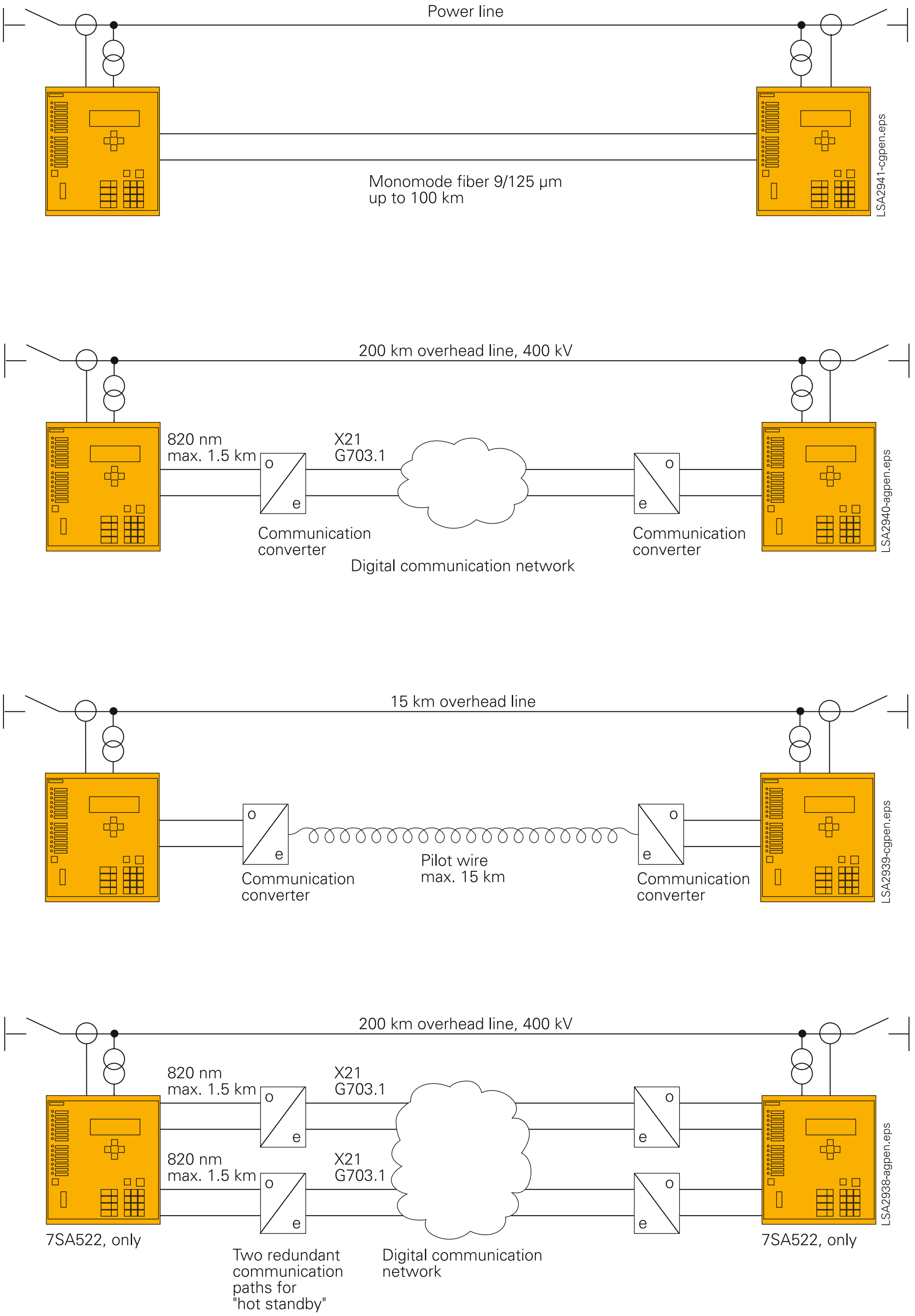
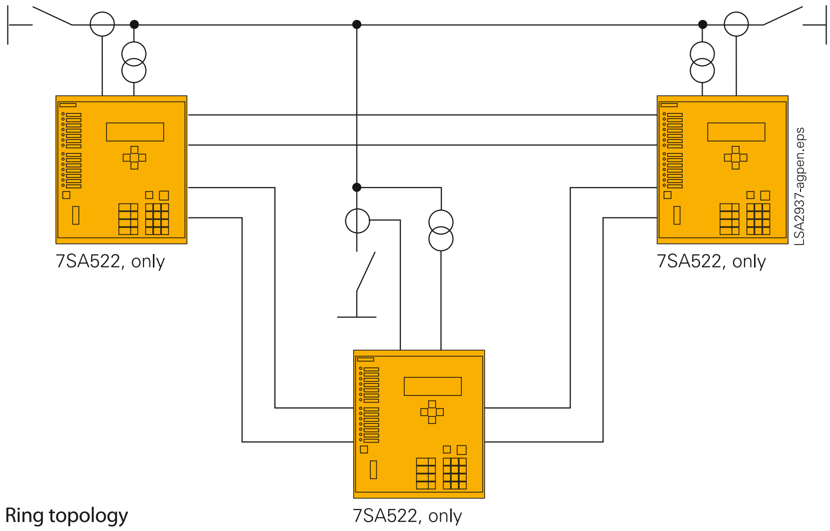


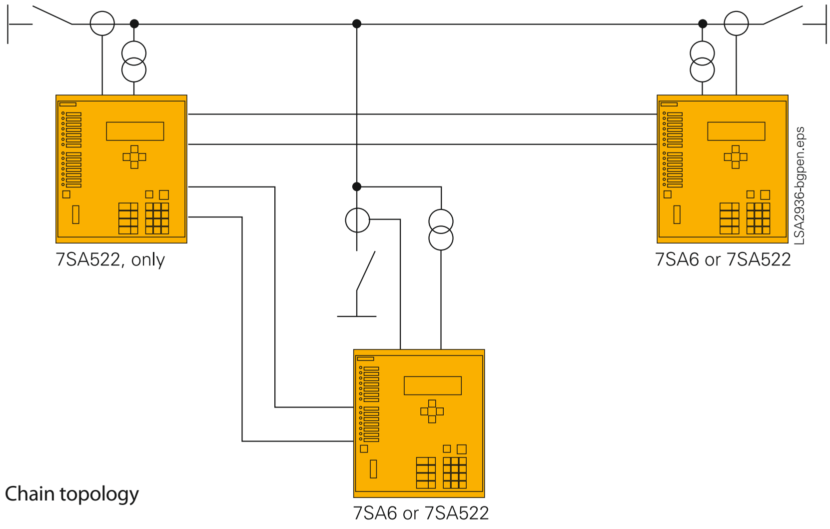
Fig. 6/68
Communication topologies for the serial protection data interface on a two-terminal line

Communication

Three-terminal lines can also be protected with a tele (pilot) protection scheme by using SIPROTEC 4 distance protection relays. The communication topology may then be a ring or a chain topology, see Fig. 6/69. In a ring topology a loss of one data connection is tolerated by the system. The topology is re-routed to become a chain topology within less than 100 ms. To reduce communication links and to save money for communications, a chain topology may be generally applied.



Ring topology



Chain topology

Fig. 6/69
Ring or chain communication topology

Typical connection

Connection for current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer (=$3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

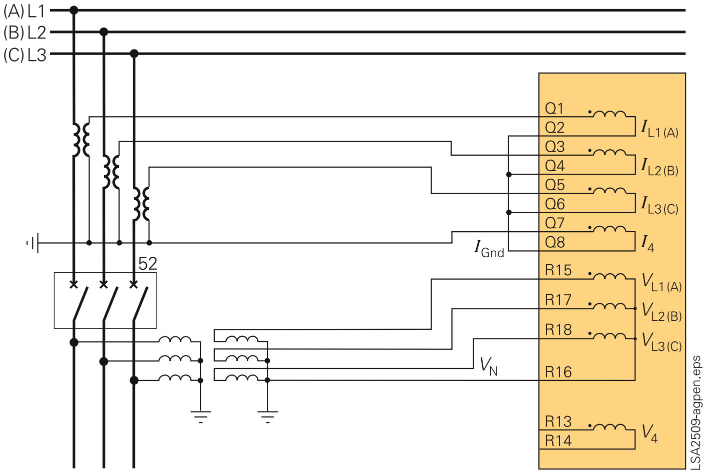


Fig. 6/70 Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core-balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 6/70, 6/74 or 6/75.

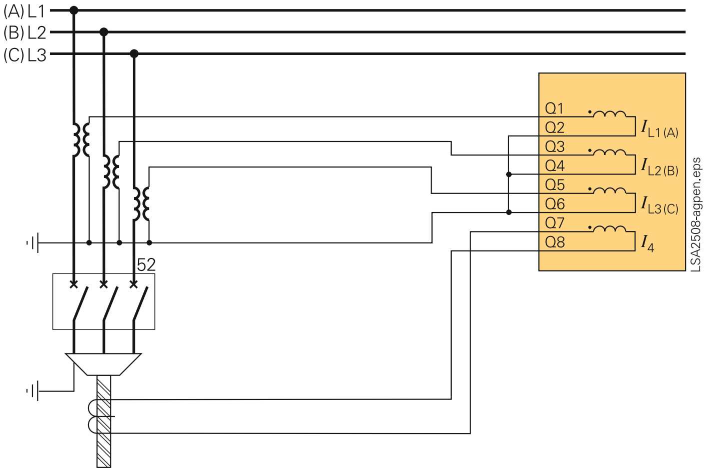


Fig. 6/71 Alternative connection of current transformers for sensitive ground(earth)-current measuring with core-balance current transformers

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for directional ground(earth)-fault protection. The voltage connection is effected in accordance with Fig. 6/70, 6/74 or 6/75.

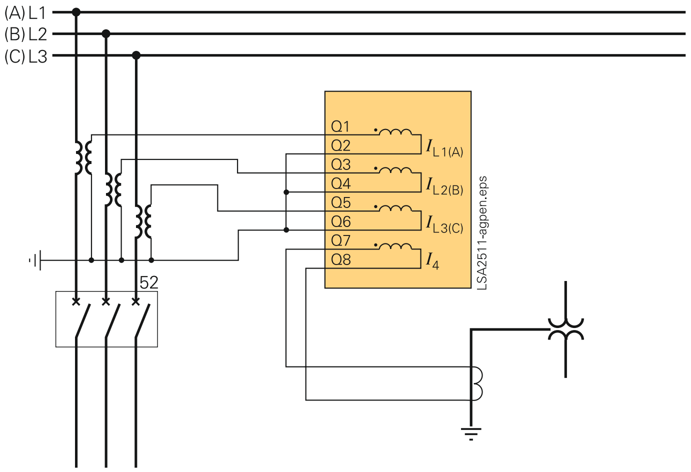


Fig. 6/72 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to the summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 6/70, 6/74 or 6/75.

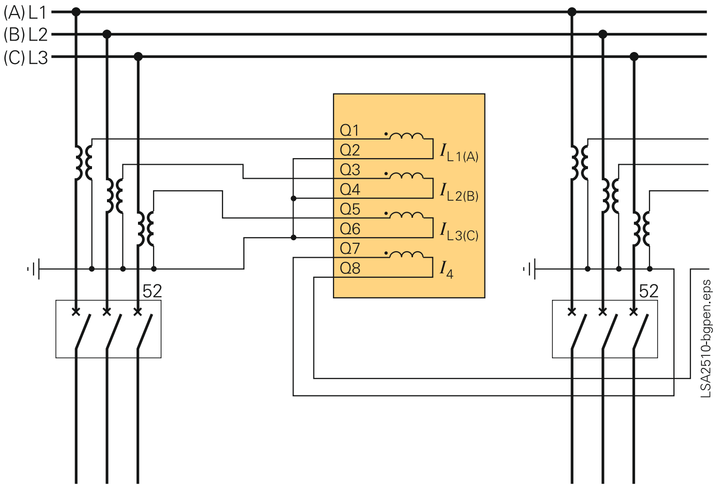


Fig. 6/73 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

Typical connection

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and ground(earth)-fault directional protection. The current connection is effected in accordance with Fig. 6/70, 6/71, 6/72 and 6/73.

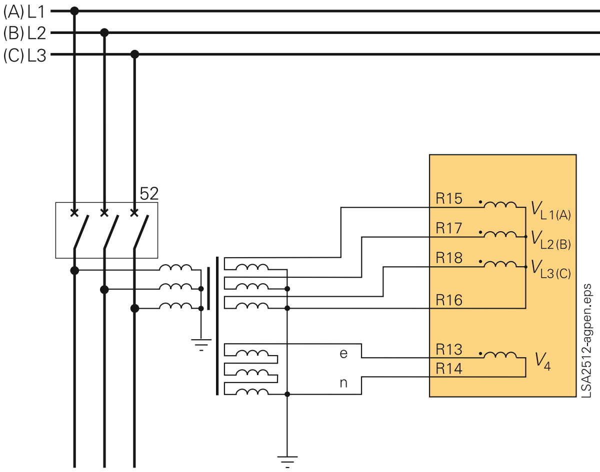


Fig. 6/74 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchrocheck.

Note: Any phase-to-phase or phase-to-ground(earth) voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 6/70, 6/71, 6/72 and 6/73.

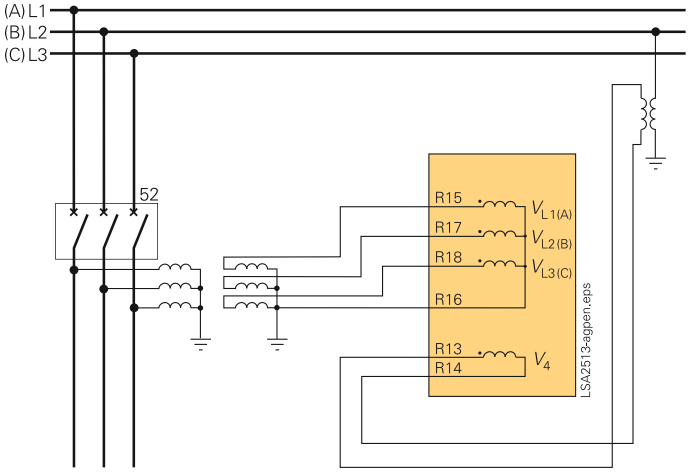


Fig. 6/75 Alternative connection of voltage transformers for measuring the busbar voltage

Technical data

General unit data

Analog input

Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage	80 to 125 V (selectable)
Power consumption	
In CT circuits with $I_{nom} = 1$ A	Approx. 0.05 VA
In CT circuits with $I_{nom} = 5$ A	Approx. 0.30 VA
In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code) at 1 A	Approx. 0.05 VA
In VT circuits	Approx. 0.10 VA
Thermal overload capacity	
In CT circuits	500 A for 1 s 150 A for 10 s 20 A continuous
In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code)	300 A for 1 s 100 A for 10 s 15 A continuous
In VT circuits	230 V continuous per phase
Dynamic overload capacity	
In CT circuits	1250 A (one half cycle)
In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code)	750 A (one half cycle)

Auxiliary voltage

Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V AC with 50/60 Hz
Permissible tolerance of the rated auxiliary voltage	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during auxiliary voltage failure	
$V_{aux} = 48$ V and $V_{aux} \geq 110$ V	≥ 50 ms

Binary inputs

Quantity	8 or 16 or 24 (refer to ordering code)
Functions are freely assignable	
Pickup/Reset voltage thresholds Ranges are settable by means of jumpers for each binary input	19 V DC/10 V DC or 88 V DC/44 V DC or 176 V DC/88 V DC, bipolar (3 nominal ranges 17/73/154 V DC)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time > 60 ms.

Output contacts

Quantity	8 or 16 or 24 (refer to ordering code)
Function can be assigned	
Switching capacity	
Make	1000 W/VA
Break, high-speed trip outputs	1000 W/VA
Break, contacts	30 VA
Break, contacts (for resistive load)	40 W
Break, contacts (for τ = L/R ≤ 50 ms)	25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous
Operating time, approx.	
NO contact	8 ms
NO/NC contact (selectable)	8 ms
Fast NO contact	5 ms
High-speed NO trip outputs	< 1 ms

LEDs

	Quantity
RUN (green)	1
ERROR (red)	1
Indication (red), function can be assigned	14

Unit design

Housing	7XP20
Dimension	1/2 x 19” or 1/1 x 19” Refer to ordering code, and see dimension drawings, part 15
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 20 with terminal cover put on
Weight	
Flush-mounting housing	
1/2 x 19”	6 kg
1/1 x 19”	10 kg
Surface-mounting housing	
1/2 x 19”	11 kg
1/1 x 19”	19 kg

Serial interfaces

Operating interface, front of unit for DIGSI 4

Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1

Time synchronization

DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Technical data

Service/modem interface (operating interface 2)

(refer to ordering code)	For DIGSI 4 / modem / service
Isolated RS232/RS485	9-pin subminiature connector
Dielectric test	500 V/ 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
Fiber-optic	Integrated ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance max.	1.5 km

System interface

(refer to ordering code)	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1000 m at 93.75 kbaud; 100 m at 12 Mbaud
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[4]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance	500 kbit/s 1.6 km 1500 kbit/s 530 m

Protection data relay interfaces

Quantity	Max. 2 (refer to ordering code)
FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors
FO30[1]: for direct fibre-optic connection to a multiplexor using IEEE C37.94 standard	For multi-mode fiber 62.5/125 µm, ST connectors
FO17[1]: for direct connection up to 24 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector

1) For flush-mouting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal fiber-optic module (OMA1) will be delivered together with an external repeater.

4) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order Code L0A (DP RS485) or 9 and Order Code L0G (DNP 3.0) and additionally a suitable external repeater.

Relay communication equipment

External communication converter 7XV5662-0AA00 with X21/RS422 or G703.1 interface

External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 with clock recovery) to the X21/RS422/G703.1 interface of the communication network	Electrical X21/RS422 or G703.1 interface settable by jumper Baud rate settable by jumper
FO interface with 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode fiber to protection relay
Electrical X21/RS422 interface	64/128/512 kbit (settable by jumper) max. 800 m, 15-pin connector to the communication network
Electrical G703.1 interface	64 kbit/s max. 800 m, screw-type terminal to the communication network

External communication converter 7XV5662-0AC00 for pilot wires

External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option w. clock recovery) to pilot wires.	Typical distance: 15 km
FO interface for 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode fiber to protection relay, 128 kbit
Electrical interface to pilot wires	5 kV-isolated

Electrical tests

Specifications

Standards	IEC 60255 (product standards) IEEE Std C37.90.0/.1/.2; UL 508 VDE 0435 Further standards see “Individual functions”

Insulation tests

Standards	IEC 60255–5 and 60870-2-1
High-voltage test (routine test)	
All circuits except for power supply, binary inputs, high-speed outputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage, binary inputs and high-speed outputs (routine test)	3.5 kV DC
only isolated communication interfaces and time synchronization interface (routine test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s

Technical data

Electrical tests (cont'd)

EMC tests for noise immunity; type tests

Standards	IEC 60255-6/-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 part 301 DIN VDE 0435-110
High-frequency test IEC 60255-22-1 class III and VDE 0435 Section 303, class III	2.5 kV (peak); 1 MHz; $\tau = 15\ \mu s$; 400 surges per s; test duration 2 s, $R_i = 200\ \Omega$
Electrostatic discharge IEC 60255-22-2 class IV and IEC 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz
IEC 61000-4-3, class III	10 V/m; 1.4 to 2 GHz: 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-31, IEC 61000-4-3, class III amplitude/pulse modulated	10 V/m; 80, 160, 450. 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common mode: 2 kV; 12 Ω; 9 µF Differential mode:1 kV; 2 Ω; 18 µF
Analog measurement inputs, binary inputs, relays output	Common mode: 2 kV; 42 Ω; 0.5 µF Differential mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field	30 A/m continuous; 300 A/m for 3 s;
IEC 61000-4-8, class IV;	50 Hz
IEC 60255-6	0.5 mT; 50 Hz
Oscillatory surge withstand capability, IEEE Std C37.90.1	2.5 kV (peak); 1 MHz $\tau = 50\ \mu s$; 400 surges per second, test duration 2 s, $R_i = 200\ \Omega$
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repition rate 300 ms, ; both polarities; test duration 1 min; $R_i = 50\ \Omega$
Radiated electromagnetic interference IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz, amplitude and pulse-modulated
Damped oscillations IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200\ \Omega$

EMC tests for noise emission; type test

Standard	EN 61000-6-3 (generic standard)
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B
Harmonic currents on the network lead at 230 V AC, IEC 61000-3-2	Class A limits are observed
Voltage fluctuations and flicker on the network incoming feeder at 230 V AC, IEC 61000-3-3	Limits are observed

Mechanical stress test

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255–21 and IEC 60068–2
Vibration IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Semi-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255–21–2, class 1 IEC 60068–3–3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255–21 and IEC 60068–2
Vibration IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Semi-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255–21–2, class 1 IEC 60068–2–29	Semi-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests

Standard	IEC 60255-6
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.

Technical data

Certifications

UL listing Models with threaded terminals	7SA522*-*A* 7SA522*-*C* 7SA522*-*D*
UL recognition Models with plug-in terminals	7SA522*-*J* 7SA522*-*L* 7SA522*-*M*

Functions

Distance protection *(ANSI 21, 21N)*

Distance protection zones	7, 1 of which as controlled zone, all zones can be set forward or/and reverse
Time stages for tripping delay Setting range 0 to 30 s or deactivated (steps 0.01 s)	7 for multi-phase faults 3 for single-phase faults
Characteristic Selectable separately for phase and ground (earth) faults	(refer to ordering code) quadrilateral and/or MHO
Time range	0.00 to 30 s (step 0.01 s) or deactivated
Line angle φ_L	10 ° to 89 ° (step 1 °)
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Quadrilateral reactance reach X	0.05 to 600 $\Omega_{(1A)}$ / 0.01 to 120 $\Omega_{(5A)}$ (step 0.001 Ω)
Quadrilateral resistance reach R for phase-to-phase faults and phase-to-ground(earth) faults	0.05 to 600 $\Omega_{(1A)}$ / 0.01 to 120 $\Omega_{(5A)}$ (step 0.001Ω)
MHO impedance reach ZR	0.05 to 200 $\Omega_{(1A)}$ / 0.01 to 40 $\Omega_{(5A)}$ (step 0.01 Ω)
Minimum phase current I	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Ground(earth)-fault pickup Neutral (residual) current 3 I_0 (Ground current)	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Zero-sequence voltage 3V_0	1 to 100 V (step 1V) or deactivated
Zero-sequence compensation selectable input formats	R_E/R_L and X_E/X_L k_0 and $\varphi(k_0)$
Separately selectable for zones	Z1 higher zones (Z1B, Z2 to Z5)
R_E/R_L and X_E/X_L	-0.33 to 7 (step 0.01)
k_0 $\varphi(k_0)$	0 to 4 (step 0.001) -135 to 135 ° (steps 0.01 °)
Parallel line mutual compensation R_M/R_L and X_M/X_L	(refer to ordering code) 0.00 to 8 (step 0.01)
Load encroachment Minimum load resistance	0.10 to 600 $\Omega_{(1A)}$ / 0.02 to 120 $\Omega_{(5A)}$ (step 0.001 Ω) or deactivated
Maximum load angle	20 to 60 ° (step 1 °)
Directional decision for all types of faults	With sound phase polarization and/or voltage memory
Directional sensitivity	Dynamically unlimited
Tolerances	For sinusoidal quantities $\left\lvert\frac{\Delta X}{X}\right\rvert \le 5\ \%$ for $30° \le \varphi_{SC} \le 90°$ $\left\lvert\frac{\Delta R}{R}\right\rvert \le 5\ \%$ for $0° \le \varphi_{SC} \le 60°$ $\left\lvert\frac{\Delta Z}{Z}\right\rvert \le 5\ \%$ for $-30° \le (\varphi_{SC} - \varphi_{line}) \le +30°$
Timer tolerance	± 1 % of set value or 10 ms
Operating times	
Minimum trip time	Approx. 17 ms at 50 Hz
with fast relays	Approx. 15 ms at 60 Hz
Minimum trip time	Approx. 12 ms at 50 Hz
with high-speed relays	Approx. 10 ms at 60 Hz
Reset time	Approx. 30 ms

Fault locator

Output of the distance to fault	*X*, *R* (secondary) in Ω *X*, *R* (primary) in Ω Distance in kilometers or miles Distance in % of line length
Start of calculation	With trip, with pickup reset
Reactance per unit length	0.005 to 6.5 Ω / $km_{(1A)}$ / 0.001 to 1.3 Ω / $km_{(5A)}$ or 0.005 to 10 Ω / mile (1A) / 0.001 to 2 Ω / mile (5A) (step 0.001 Ω / unit)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for $30° \le \varphi_{SC} \le 90°$ and $V_{SC}/V_N > 0.10$

BCD-coded output of fault location

Indicated value	Fault location in % of the line length
Output signals	Max. 10: d[1 %], d[2 %], d[4 %], d[8 %], d[10 %], d[20 %], d[401 %], d[80 %], d[100 %], d[release]
Indication range	0 % to 195 %

Power swing detection *(ANSI 68, 68T)*

Power swing detection principle	Measurement of the rate of impedance vector change and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping (out-of-step tripping)
Power swing blocking programs	All zones blocked Z1/Z1B blocked Z2 to Z6 blocked Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults

Technical data

Tele (pilot) protection for distance protection (ANSI 85-21)

Operating modes	POTT PUTT, DUTT Directional comparison: Blocking Directional comparison: Unblocking Directional comparison hybrid (POTT and echo with weak-infeed protection)
Transient blocking logic (current reversal guard)	For overreaching schemes
Send and receive signals	Suitable for 2- and 3- terminal lines, phase-segregated signals for selective single-phase tripping selectable

Direct transfer trip (DTT)

Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0.00 to 30 s (step 0.01 s) or deactivated
Timer tolerance	± 1 % of setting value or 10 ms

Directional ground(earth)-fault overcurrent protection (ANSI 50N, 51N, 67N)

Characteristics	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults selectable for every stage
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics	
Stages 1 and 2 (*I*>>> and *I*>>)	3rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 (*I*> and inverse 4th stage)	2nd and higher harmonics are completely suppressed by digital filtering

Definite-time stage

Pickup definite-time stage 1, $3I_0$	0.05 to 25 A$_{(1A)}$ / 0.25 to 125 A$_{(5A)}$ (step 0.01 A)
Pickup definite-time stage 2, $3I_0$	0.05 to 25 A$_{(1A)}$ / 0.25 to 125 A$_{(5A)}$ (step 0.01 A)
Pickup definite-time stage 3, $3I_0$	0.05 to 25 A$_{(1A)}$ / 0.25 to 125 A$_{(5A)}$ (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 25 A$_{(1A)}$ / 0.015 to 125 A$_{(5A)}$ (step 0.01 A) With high sensitive neutral (residual) current CT (refer to ordering code)
Pickup definite-time stage 4, $3I_0$	0.05 to 4 A$_{(1A)}$ / 0.25 to 20 A$_{(5A)}$ (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 4 A$_{(1A)}$ / 0.015 to 20 A$_{(5A)}$ (step 0.01 A) With high sensitive neutral (residual) current CT (refer to ordering code)
Time delay for definite-time stages	0.00 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current starting	≤ 3 % of setting value or 1 % of I_{nom}
Delay times	± 1 % of setting value or 10 ms
Pickup times	
Definite-time stages 1 and 2	Approx. 30 ms
Definite-time stages 3 and 4	Approx. 40 ms

Inverse-time stage

Current starting inverse-time stage $3I_0$	0.05 to 4 A$_{(1A)}$ / 0.25 to 20 A$_{(5A)}$ (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 4 A$_{(1A)}$ / 0.015 to 20 A$_{(5A)}$ (step 0.001 A) With high sensitive neutral (residual) current CT (refer to ordering code)
Characteristics according to IEC 60255-3	Normal inverse, very inverse, extremely inverse, long time inverse,
Time multiplier for IEC *T* characteristics	T_p = 0.05 to 3 s (step 0.01s) or deactivated
Pickup threshold	Approx. 1.1 x I / I_p
Reset threshold	Approx. 1.05 x I / I_p
Tolerances	
Operating time for $2 \leq I / I_p \leq 20$	≤ 5 % of setpoint ± 15 ms
Characteristics according to ANSI/IEEE	Inverse, short inverse, long inverse, moderately inverse, very inverse, extremely inverse, definite inverse
Time dial	0.50 to 15 s (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 x M
Reset threshold	Approx. 1.05 x M
Tolerances	
Operating time for 2 ≤ M ≤ 20	≤ 5 % of setpoint ± 15 ms
Characteristic according to logarithmic inverse characteristic	$t = T_{3I_{0P}\,\text{max}} - T_{3I_{0P}} \ln \frac{3I_0}{3I_{0\text{p}}}$
Pickup threshold	1.1 to 4.0 x I / I_p (step 0.1)
Characteristic according to compensated zero-sequence power	$S_r = 3I_0 \cdot 3V_0 \cdot \cos(\varphi - \varphi_{\text{comp.}})$
Polarizing quantities for directional decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_E (grounded (earthed) power transformer) or $3I_2$ and $3V_2$ (negative sequence) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Ground (earth) current I_E of grounded (earthed) power transformer	0.05 to 1 A$_{(1A)}$ / 0.25 to 5 A$_{(5A)}$ (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A$_{(1A)}$ / 0.25 to 5 A$_{(5A)}$ (step 0.01 A)
2nd harmonic ratio for inrush restraint	10 to 45 % of fundamental (step 1 %)
Maximum current, overriding inrush restraint	0.5 to 25 A$_{(1A)}$ / 2.5 to 125 A$_{(5A)}$ (step 0.01 A)

Tele (pilot) protection for directional ground(earth)-fault overcurrent protection (ANSI 85-67N)

Operating modes	Directional comparison: Pickup Directional comparison: Blocking Directional comparison: Unblocking
Transient blocking logic	For schemes with parallel lines
Send and receive signals	Suitable for 2- and 3- terminal lines

Technical data

***Weak-infeed protection with undervoltage** (ANSI 27WI)*	
Operating modes with carrier (signal) reception	Echo Echo and trip with undervoltage
Undervoltage phase – ground (earth)	2 to 70 V (step 1 V)
Time delay	0.00 to 30 s (step 0.01 s)
Echo impulse	0.00 to 30 s (step 0.01 s)
Tolerances	
Voltage threshold	≤ 5 % of setting value or 0.5 V
Timer	± 1 % of setting value or 10 ms
***Backup overcurrent protection** (ANSI 50N, 51N, 67)*	
Operating modes	Active only with loss of VT secondary circuit or always active
Characteristic	2 definite-time stages / 1 inverse-time stage, 1 definite-time Stub-protection stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Definite-time stage	
Pickup definite-time stage 1, phase current	0.1 to 25 $A_{(1A)}$ / 0.5 to 125 $A_{(5A)}$ (step 0.01 A)
Pickup definite-time stage 1, neutral (residual) current	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01A)
Pickup definite-time stage 2, phase current	0.1 to 25 $A_{(1A)}$ / 0.5 to 125 $A_{(5A)}$ (step 0.01A)
Pickup definite-time stage 2, neutral (residual) current	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01 A)
Time delay for definite-time stages	0.0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current starting	≤ 3 % of setting value or 1 % of I_{nom}
Delay times	± 1 % of setting value or 10 ms
Operating time	Approx. 25 ms
Inverse-time stage	
Phase current starting for inverse-time stage	0.1 to 4 $A_{(1A)}$ / 0.5 to 20 $A_{(5A)}$ (step 0.01 A)
Neutral (residual) current starting for inverse-time stage	0.05 to 4 $A_{(1A)}$ / 0.25 to 20 $A_{(5A)}$ (step 0.01 A)
Characteristic according to IEC 60255-3	Normal inverse, very inverse, extremely inverse, long time inverse
Time multiplier	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Pickup threshold	Approx. 1.1 x I / I_p
Reset threshold	Approx. 1.05 x I / I_p
Tolerances	
Operating time for $2 \leq I / I_p \leq 20$	≤ 5 % of setpoint ± 15 ms
Characteristics according to ANSI/IEEE	Inverse, short inverse, long inverse, moderately inverse, very inverse, extremely inverse, definite inverse
Time dial	D_{IP} 0.50 to 15 s (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 x M ($M = I/I_p$)
Reset threshold	Approx. 1.05 x M
Tolerances	
Operating time for $2 \leq M \leq 20$	≤ 5 % of setpoint ± 15 ms

***STUB bus overcurrent protection** (ANSI 50(N)STUB)*	
Operating modes	Active only with open isolator position (signaled via binary input)
Characteristic	1 definite-time stage
Instantaneous trip after switch-onto-fault	Selectable
Pickup phase current	0.1 to 25 $A_{(1A)}$ / 0.5 to 125 $A_{(5A)}$ (step 0.01 A)
Pickup neutral (residual) current	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01 A)
Time delay, separate for phase and ground (earth) stage	0.00 to 30 s (step 0.01 s) or deactivated
Reset ratio	Approx. 0.95
Tolerances	
Current starting	≤ 3 % of setting value or 1 % of I_{nom}
Delay times	± 1 % of setting value or 10 ms
***Instantaneous high-speed switch-onto-fault overcurrent protection** (ANSI 50HS)*	
Operating mode	Active only after CB closing; instantaneous trip after pickup
Pickup current	1 to 25 $A_{(1A)}$ / 5 to 125 $A_{(5A)}$ (step 0.01 A)
Reset ratio	Approx. 0.95
Tolerances	
Current starting	≤ 3 % of setting value or 1 % of I_{nom}
Operating time	
With fast relays	Approx. 13 ms
With high-speed trip outputs	Approx. 8 ms
***Voltage protection** (ANSI 59, 27)*	
Operating modes	Local tripping and/or carrier trip impulse for remote end, only indication
Overvoltage protection	
Pickup values V_{PH-Gnd}>>, V_{PH-Gnd}> (phase-earth overvoltage)	1 to 170 V (step 0.1 V)
Pickup values V_{PH-PH}>>, V_{PH-PH}> (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_0$>>, $3V_0$> ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values V_1>>, V_1> (positive-sequence overvoltage)	2 to 220 V (step 0.1 V)
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values V_2>>, V_2> (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)

Technical data

Undervoltage protection

Pickup values $V_{\text{PH-E}}<<$, $V_{\text{PH-E}}<$ (phase-earth undervoltage)	1 to 100 V (step 0.1 V)
Pickup values $V_{\text{PH-PH}}<<$, $V_{\text{PH-PH}}<$ (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_1<<$, $V_1<$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio (settable)	1.01 to 1.20 (step 0.01)
Time delays	
Time delay for 3 V_0 stages	0 to 100 s (step 0.01 s)or deactivated
Time delay for all other over- and undervoltage stages	0 to 30 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Command/pickup time for 3V_0 stages	Approx. 30 ms or 65 ms (settable)
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms

Frequency protection (ANSI 81)

Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-earth)
Pickup times	Approx. 80 ms
Dropout times	Approx. 80 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	15 mHz for $V_{\text{PH-PH}}$: 50 to 230 V
Delay times	1 % of the setting value or 10 ms

Breaker failure protection (ANSI 50BF)

Number of stages	2
Pickup of current element	0.05 to 20 $A_{(1A)}$ / 0.25 to 100 $A_{(5A)}$ (step 0.01 A)
Time delays $T1_{\text{1phase}}$, $T1_{\text{3phase}}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Reset time	12 ms, typical; 25 ms max.
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms

Auto-reclosure (ANSI 79)

Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1- or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{\text{1-PH}}$, $T_{\text{3-PH}}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage	30 to 90 V (step 1 V)
Dead line	2 to 70 V (step 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V

Synchro-check (ANSI 25)

Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	
with auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1 °)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 2 V

Trip circuit supervision (ANSI 74TC)

Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Technical data

Additional functions

Operational measured values

Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; $I_{\text{Gnd sensitve}}$; I_1; I_2; I_Y; $3_{I0\text{PAR}}$
Tolerances	Typical 0.3 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{\text{Phase-Ground}}$; 3 x $V_{\text{Phase-Phase}}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}
Tolerances	Typical 0.25 % of indicated measured value or 0.01 V_{nom}
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert\cos\varphi\rvert = 0.7$ to 1 and V/V_{nom}, $I/I_{\text{nom}} = 50$ to 120 %	Typical ≤ 1 %
Q: for $\lvert\sin\varphi\rvert = 0.7$ to 1 and V/V_{nom} , $I/I_{\text{nom}} = 50$ to 120 %	Typical ≤ 1 %
S: for V/V_{nom}, $I/I_{\text{nom}} = 50$ to 120 %	Typical ≤ 1 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	p.f. (cos φ)
Tolerance for $\lvert\cos\varphi\rvert = 0.7$ to 1	Typical ≤ 3 %
Load impedances with directional indication	3 x $R_{\text{Phase-Ground}}$, $X_{\text{Phase-Ground}}$ 3 x $R_{\text{Phase-Phase}}$, $X_{\text{Phase-Phase}}$

Long-term mean values

Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q-; S

Minimum/maximum memory

Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values	
Min./max. of measured values	3 x I_{Phase}; I_1; 3 x $V_{\text{Phase-Ground}}$; 3 x $V_{\text{Phase-to-phase}}$; $3V_0$; V_1; P+; P–; Q+; Q–; S; f; power factor (+); power factor (–)
Min./max. of mean values	3 x I_{Phase}; I_1; P; Q; S

Energy meters

Four-quadrant meters	$W_{\text{P+}}$; $W_{\text{P–}}$; $W_{\text{Q+}}$; $W_{\text{Q–}}$
Tolerance	
for $\lvert\cos\varphi\rvert > 0.7$ and $V > 50$ % V_{nom} and $I > 50$ % I_{nom}	5 %

Oscillographic fault recording

Analog channels	3 x I_{Phase}, $3I_0$, $3I_{0\text{ PAR}}$ 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	> 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	100

Control

Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys
Remote control	Control protection, DIGSI, pilot wires

Further additional functions

Measurement supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor Power direction
Annunciations	
Event logging	Buffer size 200
Fault logging	Storage of signals of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle 3-phase TRIP/CLOSE cycle per phase
Setting range	
Dead time for c.b. TRIP/CLOSE cycle	0.00 to 30 s (step 0.01 s)
Commissioning support	Operational measured values, CB. test, status display of binary indication inputs, setting of output relays, generation of indications for testing serial interfaces
Phase rotation adjustment	Clockwise or anti-clockwise

CE conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23/EEC).

This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directive and with the standard EN 60255-6 for the low-voltage directive.

This device is designed and produced for industrial use.

The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

Selection and ordering data

Description	Order No.
7SA522 distance protection relay for transmission lines	*7SA522□-□□□□□-□□□□ □□□*

see following pages

Current transformer

I_{PH} = 1 A¹⁾, I_{Gnd} = 1 A (min. = 0.05 A)	*1*
I_{PH} = 1 A¹⁾, I_{Gnd} = high sensitive (min. = 0.003 A)	*2*
I_{PH} = 5 A¹⁾, I_{Gnd} = 5 A (min. = 0.25 A)	*5*
I_{PH} = 5 A¹⁾, I_{Gnd} = high sensitive (min. = 0.003 A)	*6*

(Order code position 7 = 2 or 6 not available with position 14 = K, M, N, Q)

Rated auxiliary voltage (power supply, binary inputs)

24 to 48 V DC, binary input threshold 17 V DC³⁾	*2*
60 to 125 V DC²⁾, binary input threshold 17 V DC³⁾	*4*
110 to 250 V DC²⁾, 115 V AC, binary input threshold 73 V DC³⁾	*5*
220 to 250 V DC²⁾, 115 V AC, binary input threshold 154 V DC³⁾	*6*

Binary indication inputs	Signal/command outputs, incl. live status contact	Fast relays	High-speed trip outputs	Housing width referred to 19"	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
8	4	12	–	1/2	■			*A*
8	4	12	–	1/2			■	*E*
8	4	12	–	1/2		■		*J*
16	12	12	–	1/1	■			*C*
16	12	12	–	1/1			■	*G*
16	12	12	–	1/1		■		*L*
16	4	15	5	1/1	■			*N*
16	4	15	5	1/1			■	*Q*
16	4	15	5	1/1		■		*S*
24	20	12	–	1/1	■			*D*
24	20	12	–	1/1			■	*H*
24	20	12	–	1/1		■		*M*
24	12	15	5	1/1	■			*P*
24	12	15	5	1/1			■	*R*
24	24	3	5	1/1		■		*T*
22	32	12	–	1/1	■			*U*
24	4	18	10	1/1	■			*W*

Region-specific default settings/language settings (language selectable)

Region DE, language: German	*A*
Region World, language: English (GB)	*B*
Region US, language: English (US)	*C*
Region FR, language: French	*D*
Region World, language: Spanish	*E*
Region World, language: Italian	*F*
Region World, language: Russian	*G*
Region World, language: Polish	*H*

Regulation on region-specific presettings and function versions:

Region DE:	preset to f = 50 Hz and line length in km, only IEC, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r
Region US:	preset to f = 60 Hz and line length in miles, ANSI inverse characteristic only, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r, no U_0 inverse characteristic
Region World:	preset to f = 50 Hz and line length in km, directional ground-(earth) fault protection: no direction decision with zero-sequence S_r, no U_0 inverse characteristic
Region FR:	preset to f = 50 Hz and line length in km, directional ground-(earth) fault protection: no U_0 inverse characteristic, no logarithmic inverse characteristic, weak infeed logic selectable between French specification and World specification.

---

1) Rated current can be selected by means of jumpers.

2) Transition between the three auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected by means of jumpers.

Selection and ordering data

Description	Order No.	Order Code
7SA522 distance protection relay for transmission lines	*7SA522□-□□□□□-□□□□*	□□□

see following pages

Port B		
Empty	0	
System interface, IEC 60870-5-103 protocol, electrical RS232	1	
System interface, IEC 60870-5-103 protocol, electrical RS485	2	
System interface, IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
System interface, PROFIBUS-FMS Slave, electrical RS485 1)	4	
System interface, PROFIBUS-FMS Slave, optical, double ring, ST connector 1)2)	6	
System interface, PROFIBUS-DP Slave, RS485	9	L 0 A
System interface, PROFIBUS-DP Slave, 820 nm optical, double ring, ST connector 2)	9	L 0 B
System interface, DNP 3.0, RS485	9	L 0 G
System interface, DNP 3.0, 820 nm optical, ST connector 2)	9	L 0 H
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate, RJ45 plug connector	9	L 0 R
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, LC connector 5)	9	L 0 S

Port C and/or Port D		
Empty	0	
Port C: DIGSI/modem, electrical RS232; Port D: empty	1	
Port C: DIGSI/modem, electrical RS485; Port D: empty	2	
Port C: DIGSI/modem, optical 820 nm, ST connector; Port D: empty	3	
With Port D	9	M □□

Port C	
Empty	0
DIGSI/modem, electrical RS232	1
DIGSI/modem, electrical RS485	2
DIGSI/modem, optical 820 nm, ST connector	3

Port D	
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 1.5 km For direct connection via multi-mode FO cable or communication networks 3)	A
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable	B
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 24 km for direct connection via mono-mode FO cable 4)	G
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable 4)6)	H
Protection data interface: optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable 4)7)	J
FO30 optical 820 nm, 2-ST-connector, length of optical fibre up to 1.5 km for multimode fibre, for communication networks with IEEE C37.94 interface or direct optical fibre connection (not available for surface mounted housing)	S

---

1) For SICAM energy automation system.

2) Optical double ring interfaces are not available with surface-mounting housings. Please, order the version with RS485 interface and a separate electrical/ optical converter.

3) Suitable communication converters 7XV5662 (optical to G703.1/X21/ RS422 or optical to pilot wire or optical to ISDN) see “Accessories”.

4) For surface-mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

5) For surface-mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.

6) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

7) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Selection and ordering data

Description	Order No.	Order Code
7SA522 distance protection relay for transmission lines	*7SA522*□-□□□□□-□□□□	□□□
Functions 1 and Port E		see next page
Trip mode 3-pole; Port E: empty	*0*	
Trip mode 3-pole; BCD-coded output for fault location, Port E: empty	*1*	
Trip mode 1 and 3-pole; Port E: empty	*4*	
Trip mode 1 and 3-pole; BCD-coded output for fault location, Port E: empty	*5*	
With Port E	*9*	*N* □□
Functions 1		
Trip mode 3-pole		*0*
Trip mode 3-pole; BCD-coded output for fault location		*1*
Trip mode 1 and 3-pole		*4*
Trip mode 1 and 3-pole; BCD-coded output for fault location		*5*
Port E		
Protection data interface:		
FO5: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for communication networks[1] or direct connection via multi-mode FO cable		*A*
FO6: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km for direct connection via multi-mode FO cable		*B*
FO17: Optical 1300 nm, LC-Duplex connector FO cable length up to 24 km for direct connection via mono-mode FO cable[2]		*G*
FO18: Optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable[2][3]		*H*
FO19: Optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable[2][4]		*J*
FO30: Optical 820 nm, 2-ST-connector, length of optical fibre up to 1.5 km for multimode fibre, for communication networks with IEEE C37.94 interface or direct optical fibre connection (not available for surface mounted housing)		*S*

---

1) Suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire) see "Accessories".

2) For surface -mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

3) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

4) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Selection and ordering data

Description	Order No.
7SA522 distance protection relay for transmission lines	*7SA522*☐-☐☐☐☐☐-☐☐☐☐ ☐☐☐

Functions 2

Distance protection characteristic (ANSI 21, 21N)	Power swing detection (ANSI 68, 68T)	Parallel line compensation	
Quadrilateral			*C*
Quadrilateral and/or MHO			*E*
Quadrilateral	■		*F*
Quadrilateral and/or MHO	■		*H*
Quadrilateral		■ 1)	*K*
Quadrilateral and/or MHO		■ 1)	*M*
Quadrilateral	■	■ 1)	*N*
Quadrilateral and/or MHO	■	■ 1)	*Q*

Functions 3

Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	Breaker failure protection (ANSI 50BF)	Over-/undervoltage protection (ANSI 27, 59) Over-/underfrequency protection (ANSI 81)	
				A
			■	*B*
		■		*C*
		■	■	*D*
	■			*E*
	■		■	*F*
	■	■		*G*
	■	■	■	*H*
■				*J*
■			■	*K*
■		■		*L*
■		■	■	*M*
■	■			*N*
■	■		■	*P*
■	■	■		*Q*
■	■	■	■	*R*

Functions 4

Direction ground(earth)-fault protection, grounded (earthed) networks (ANSI 50N, 51N, 67N)	Measured values, extended Min, max, mean	
		0
	■	*1*
■		*4*
■	■	*5*

---

1) Only with position 7 of Order No. = *1* or *5*.

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional, device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC61850 system configurator	7XS5403-0AA00
IEC 61850 System configurator	
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
SIGRA 4	
(generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
Connecting cable (copper)	
Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Voltage transformer miniature circuit-breaker	
Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
Manual for 7SA522	
English, V4.61 and higher	C53000-G1176-C155-5
Opto-electric communication converters	
Optical to X21/RS422 or G703.1	7XV5662-0AA00
Optical to pilot wires	7XV5662-0AC00
Additional interface modules	
Protection data interface FO 5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	C53207-A351-D651-1
Protection data interface FO 6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
Protection data interface FO 17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	C53207-A322-B115-3
Protection data interface FO 18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A322-B116-3
Protection data interface FO 19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A322-B117-3
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	7XV5461-0BG00
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00

Accessories

Fig. 6/76 Mounting rail for 19" rack

Fig. 6/77
2-pin connector

Fig. 6/78
3-pin connector

Fig. 6/79
Short-circuit link for current contacts

Fig. 6/80
Short-circuit link for voltage contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	6/77
	3-pin	*C73334-A1-C36-1*	1	Siemens	6/78
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	*0-539635-1*	1	AMP 1)	
	and matching female	*0-539668-2*		AMP 1)	
	For CI2	*0-734372-1*	1	AMP 1)	
	and matching female	*1-734387-1*		AMP 1)	
19"-mounting rail		*C73165-A63-D200-1*	1	Siemens	6/76
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	6/79
	For other terminals	*C73334-A1-C34-1*	1	Siemens	6/80
Safety cover for terminals	Large	*C73334-A1-C31-1*	1	Siemens	6/51
	Small	*C73334-A1-C32-1*	1	Siemens	6/51

---

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram, IEC

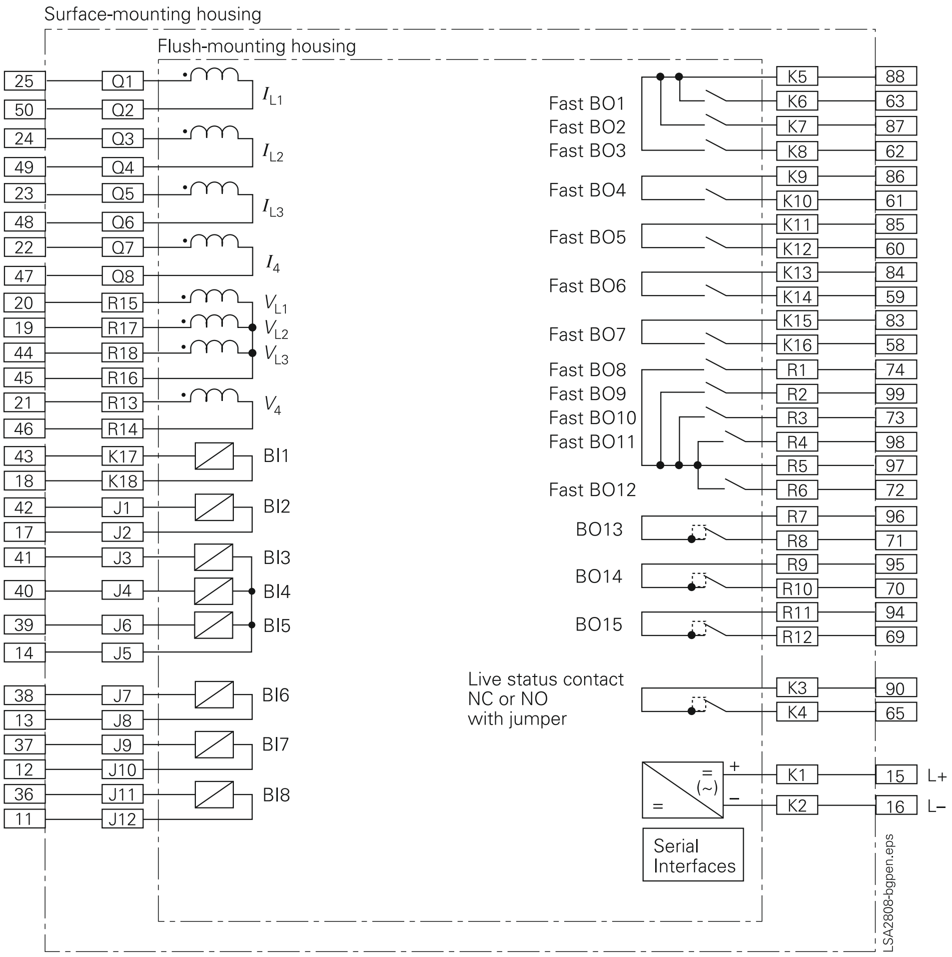


Fig. 6/81

Housing 1/2 x 19", basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ with 8 binary inputs and 16 binary outputs, hardware version .../FF

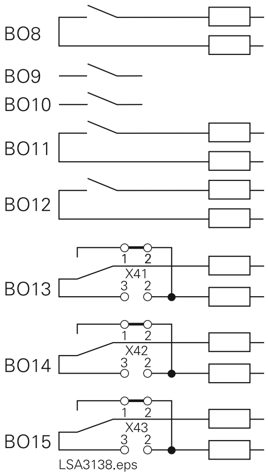


Fig. 6/81a

Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

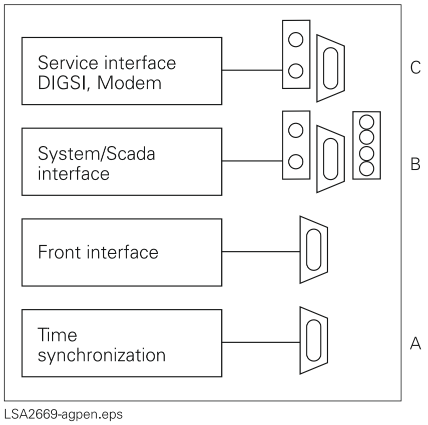


Fig. 6/82

Serial interfaces

Connection diagram, IEC

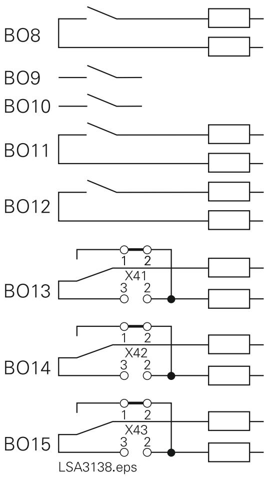


Fig. 6/83a

Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

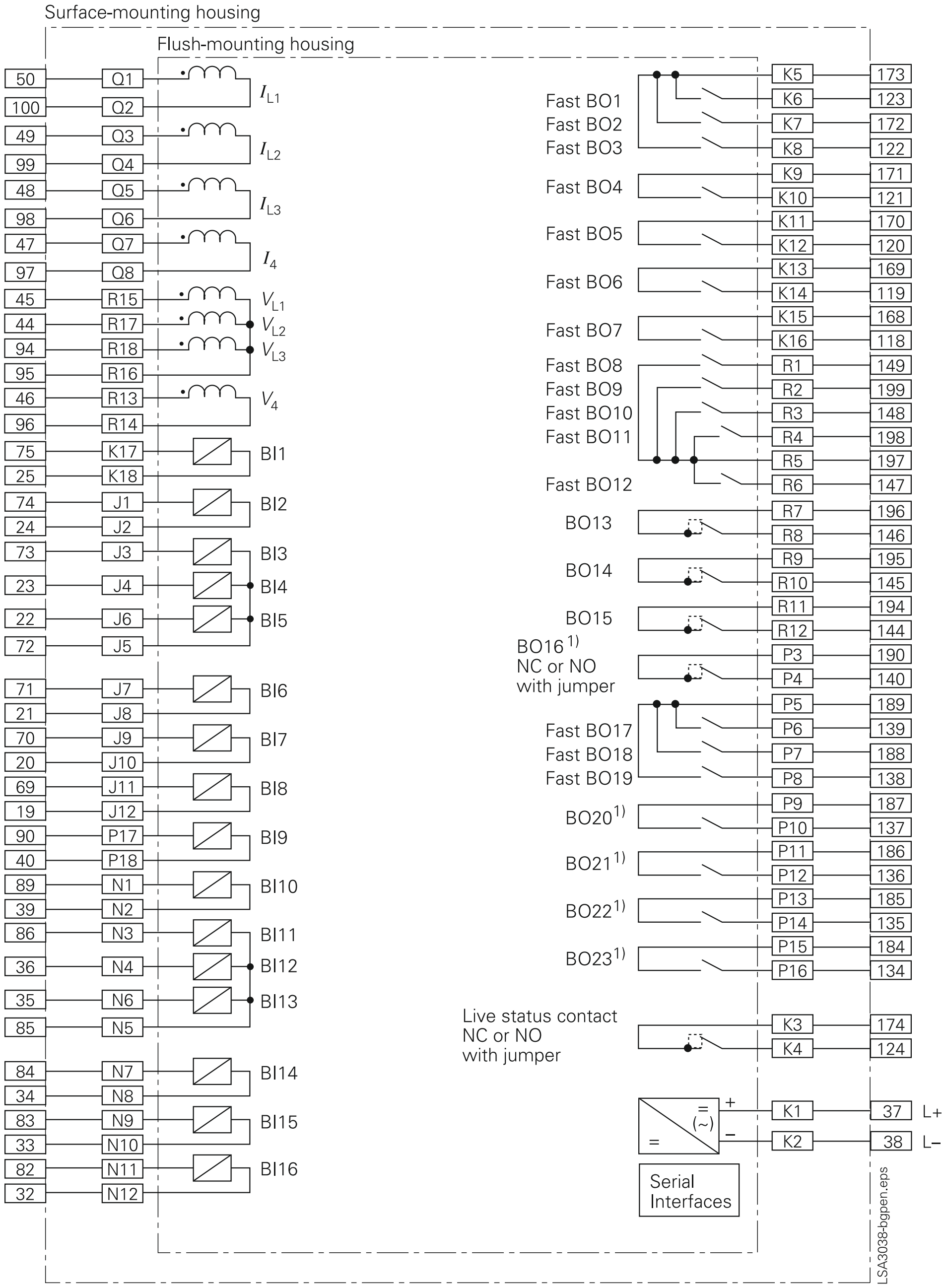


Fig. 6/83

Housing 1/1 x 19", medium version 7SA522x-xC, 7SA522x-xG, 7SA522x-xL, 7SA522x-xN, 7SA522x-xQ and 7SA522x-xS with 16 binary inputs and 24 binary outputs, hardware version .../FF

1) High-speed trip outputs in versions 7SA522x-xN, 7SA522x-xQ, 7SA522x-xS.

Note: For serial interfaces see Figure 6/82.

Connection diagram, IEC

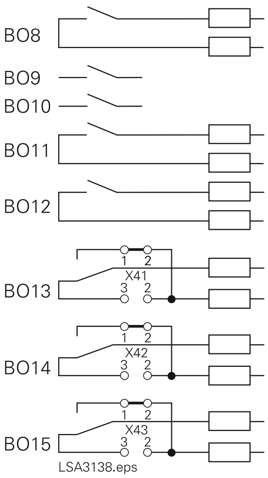


Fig. 6/84a

Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

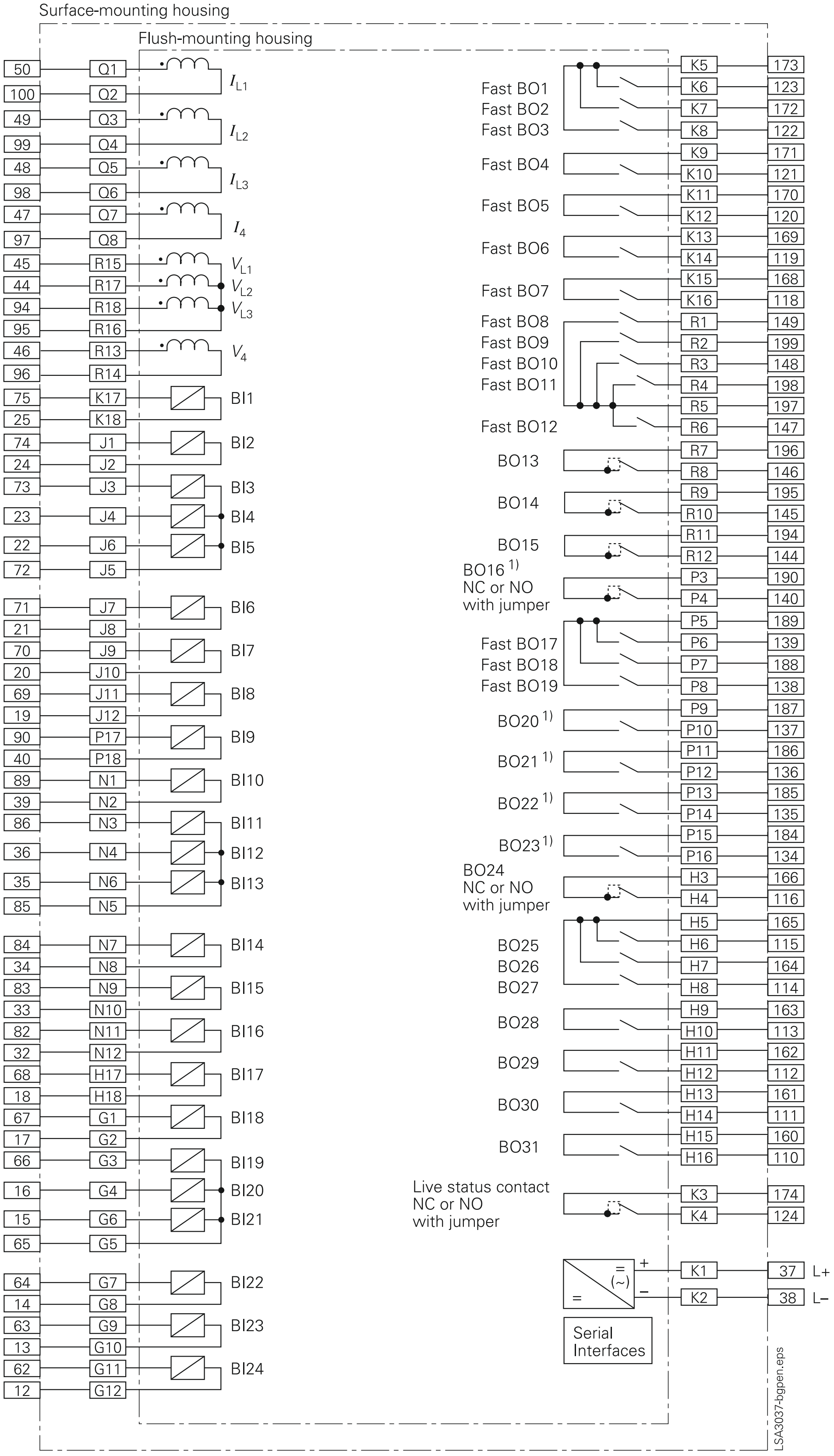


Fig. 6/84

Housing 1/1 x 19", maximum version 7SA522x-xD, 7SA522x-xH, 7SA522x-xM, 7SA522x-xP, 7SA522x-xR and 7SA522x-xT with 24 binary inputs and 32 binary outputs, hardware version .../FF

[1] High-speed trip outputs in versions 7SA522x-xP, 7SA522x-xR, 7SA522x-xT.

Note: For serial interfaces see Figure 6/82.

Connection diagram, ANSI

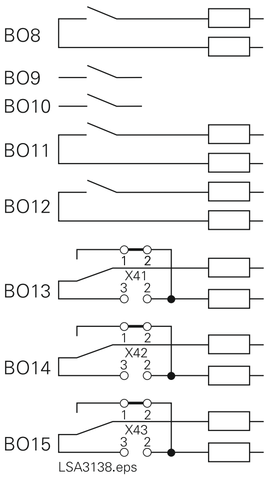


Fig. 6/85a

Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82.
Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

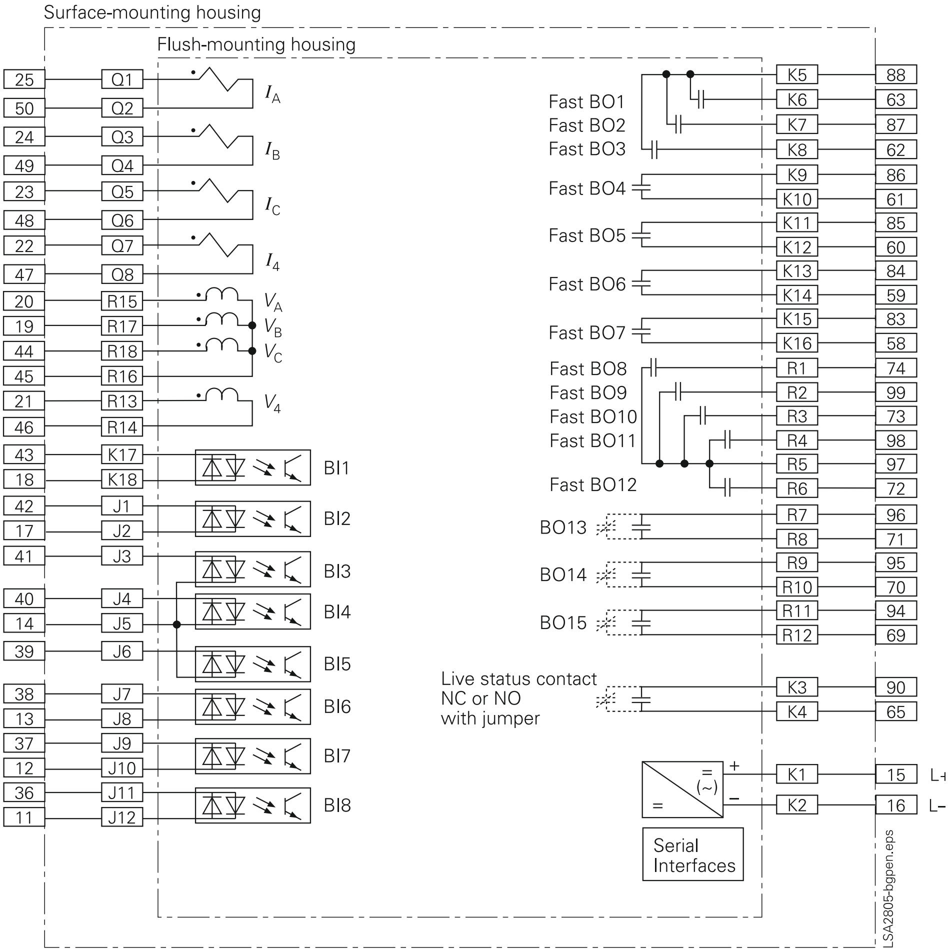


Fig. 6/85

Housing 1/2 x 19", basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ with 8 binary inputs and 16 binary outputs, hardware version .../FF

Note: For serial interfaces see Figure 6/82.

Connection diagram, ANSI

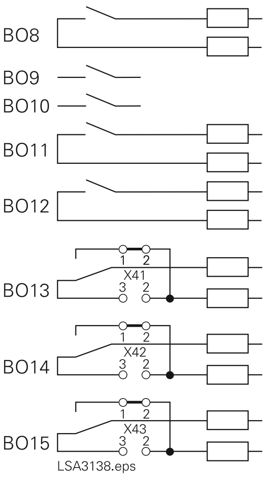


Fig. 6/86a

Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82.
Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

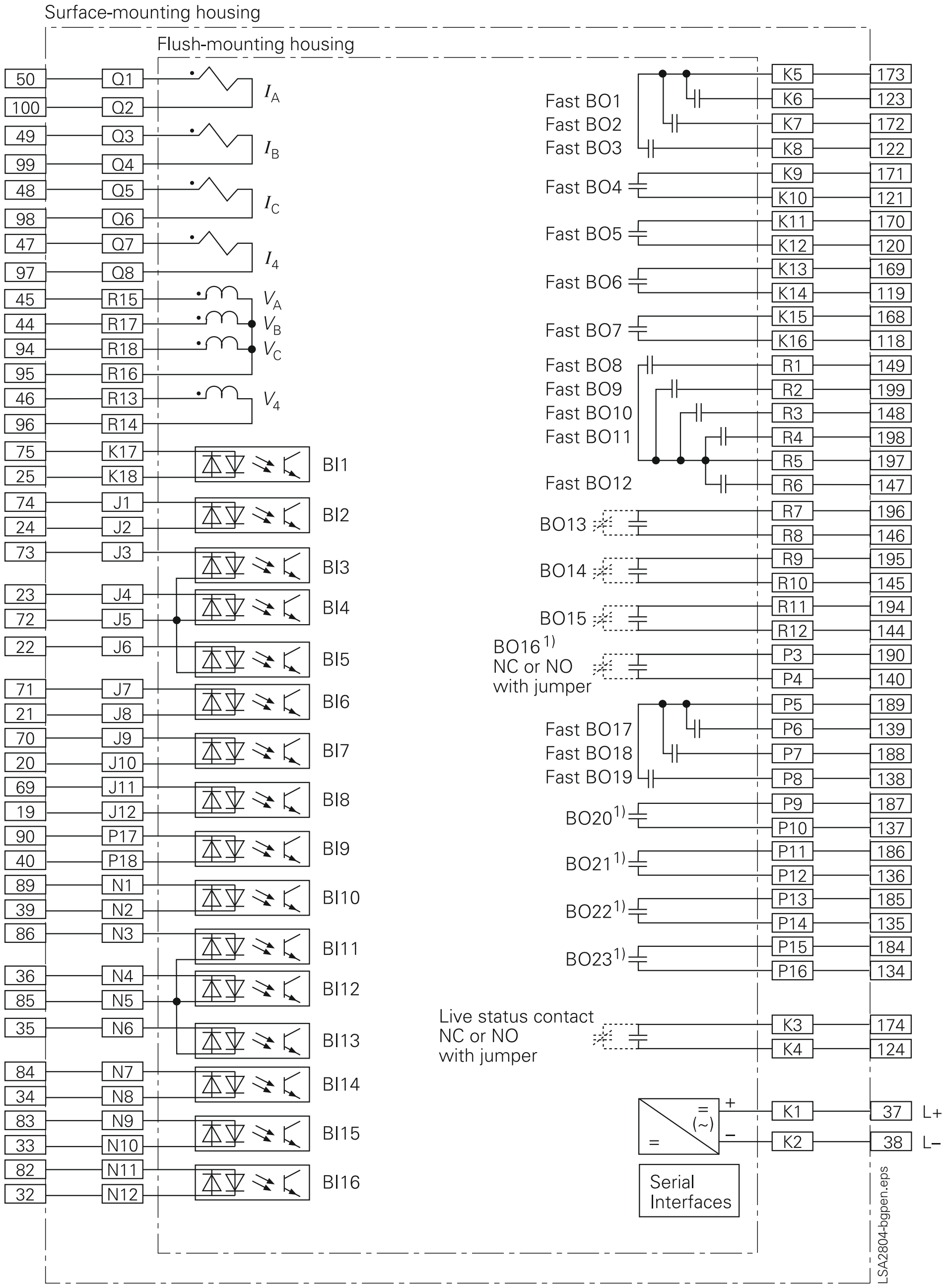


Fig. 6/86

Housing 1/1 x 19", medium version 7SA522x-xC, 7SA522x-xG, 7SA522x-xL, 7SA522x-xN, 7SA522x-xQ and 7SA522x-xS with 16 binary inputs and 24 binary outputs, hardware version .../FF

1) High-speed trip outputs in versions 7SA522x-xN, 7SA522x-xQ, 7SA522x-xS.

Note: For serial interfaces see Figure 6/82.

Connection diagram, ANSI

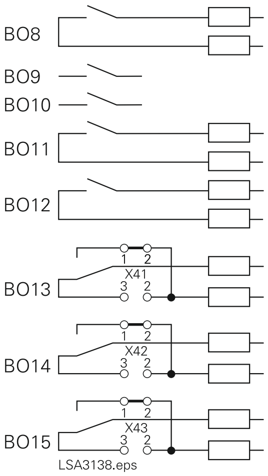


Fig. 6/87a

Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

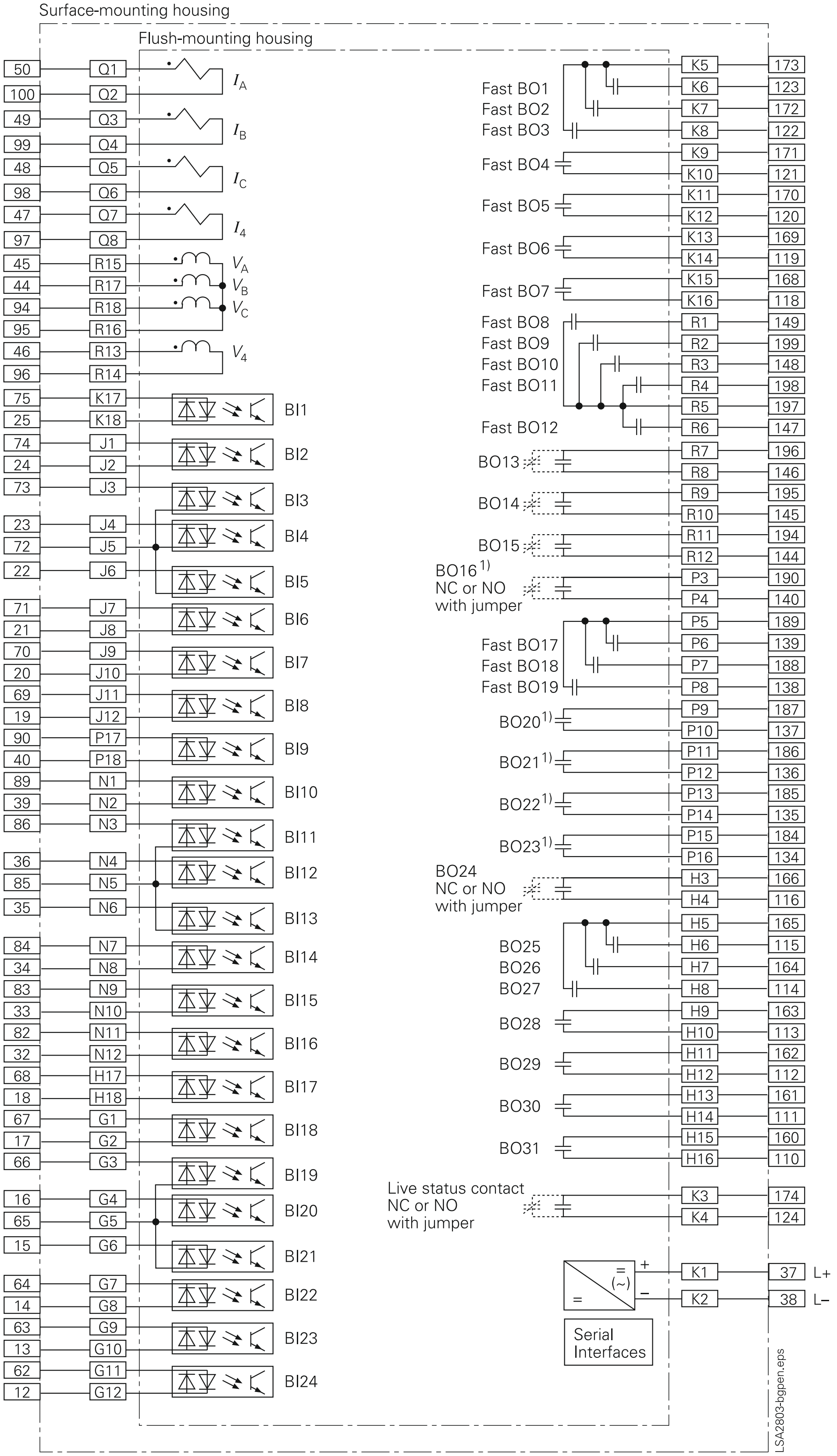


Fig. 6/87

Housing 1/1 x 19", maximum version 7SA522x-xD, 7SA522x-xH and 7SA522x-xM with 24 binary inputs and 32 binary outputs, hardware version ../FF

---

1) High-speed trip outputs in versions 7SA522x-xP, 7SA522x-xR, 7SA522x-xT.

Note: For serial interfaces see Figure 6/82.

Line Differential Protection

SIPROTEC 7SD60
Numerical Pilot-Wire Current Differential Protection Relay

Fig. 7/1
SIPROTEC 7SD600
numerical current differential protection relay

Description

The 7SD600 relay is a numerical current differential protection relay, simple to set, operating in conjunction with the remote station via a two pilot-wire link. It is connected to the primary current transformers via an external summation current transformer. The primary field of application of the relay is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. Features like inrush restraint, lockout, modern PCM-intertrip facilities, full self-monitoring facilities, local and remote interrogation are integrated in the unit.

Function overview

Differential protection relay for overhead lines and cables

- Current differential protection with external summation current transformer 4AM49 (87L)
- Suitable for use for distances of approx. 12 km max. via two pilot wires (1200 Ω loop resistance)
- Differential protection can be combined with an overcurrent release
- Pilot-wire monitoring function
- Bidirectional remote tripping
- Circuit-breaker intertripping at the remote station
- Seal-in of the TRIP command until manual reset (Lockout function)
- Minimal current transformer requirements due to integrated saturation detector
- Restraint against inrush/undelayed trip for high differential fault currents
- Emergency overcurrent protection

Operational measured values

- Local and remote current
- Differential current
- Restraint current

Monitoring functions

- Hardware
- Firmware
- Spill current supervision

Hardware

- Local operation by means of integrated keyboard
- LCD display for settings and analysis
- Housing
  - Flush-mounting housing 1/6 19" 7XP20
  - Surface-mounting housing 1/6 19" 7XP20

Communication

- Via personal computer and DIGSI 3
- Via RS232↔RS485 converter
- With modem
- With substation control system via IEC 60870-5-103 protocol
- 2 kV isolated RS485 interface, bus connection possible

Application

The 7SD60 relay is a numerical current differential protection relay, simple to set, and is operated in conjunction with the remote station via a two pilot-wire link.

It is connected to the primary current transformers via an external summation current transformer. The unit operates internally on the summated current taken from the secondary side of the summation current transformer. The link to the remote station is realized by means of a pair of symmetrical pilot wires allowing distances of up to approximately 12 km. Adaptation to the pilot-wire resistance is effected by means of software within the unit. Therefore, matching is not necessary.

The primary field of application of the unit is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. The unit can be fitted with inrush restraint in such cases. A differential protection instantaneous tripping stage is also provided in this case. Vector group adaptation is not effected inside the unit and must, if necessary, be effected by means of a matching current transformer.

The 7SD60 can be fitted with a pilot-wire monitoring function. In addition to monitoring the pilot-wire link to the remote station, this also includes bidirectional circuit-breaker intertripping and a remote tripping command.

If the differential protection becomes inactive due to a pilot-wire failure, the relay has an emergency overcurrent function as an option. It includes one definite-time overcurrent stage and can be delayed.

This unit substitutes the 7SD24 steady-state differential protection. However, direct interoperation with the 7SD24 is not possible. On replacement of a 7SD24, its external summation current transformer can be used as the input transformer for the 7SD60.

ANSI	
(87L, 87T)	Δ*I* for lines/cables, transformers
(85)	Intertrip, remote trip
(86)	Lockout function
(50)	Single-stage, definite-time emergency overcurrent protection

Construction

The compact 7SD60 protection relay contains all the components for:

- Measured-value acquisition and evaluation
- Operation and LCD indications
- Alarm and command contacts
- Input and evaluation of binary signals
- Data transmission via the RS485 bus interface to DIGSI or a substation control system
- Auxiliary voltage supply

The primary current transformers are connected to the 4AM49 summation current transformer. At the rated current value of either 1 A or 5 A, the latter outputs a current of 20 mA which is measured by the 7SD60 unit. The summation current transformer is supplied together with the protection unit, if so ordered.

The unit can be supplied in two different housings. The one for flush mounting in a panel or cubicle has connection terminals at the rear.

The version for panel surface mounting is supplied with terminals accessible from the front. Alternatively, the unit can be supplied with two-tier terminals arranged above and below the unit.

Fig. 7/2
Rear view flush-mountig housing

Protection functions

Mode of operation of the differential protection relay

An external summation current transformer 4AM49, which can be supplied as an accessory either in a 1 A or a 5 A version, allows any secondary currents of the primary current transformers (see Fig. 7/3) to be connected. The standard ratios of the three primary windings of the summation current transformer are IL1:IL2:IL3 = 5:3:4 (IL1:IL3:IL0 = 2:1:3) (see Fig. 7/6). In consequence, the sensitivity of the tripping characteristic for single-phase faults is appreciably higher compared to that for two-phase and three-phase faults. Since the current on such faults is often weak, an amplification factor of 1.7 to 2.8 referred to the symmetrical response value is achieved.

Other sensitivity values can, however, be obtained by altering the connections at the summation CT.

With a symmetrical three-phase current of 1 x I_N, the secondary current of the summation current transformer is 20 mA.

The 7SD60 measures and digitalizes the current I_{M1} of the local relay by means of a sensitive current input (see Fig. 7/6). A voltage drop occurs across a fixed-value resistor R_b installed in the unit. With a through-flowing load or a through- flowing short-circuit current, the voltage drop at both ends of the line is approximately equal but of opposite polarity, so that no current flows through the pilot wire. On occurrence of an internal fault, different values are obtained for the voltage drop across R_b at both ends. In consequence, a current I_a flows through the pilot wire, which is measured by means of the current transformer. In conjunction with the pilot- wire resistance (available as a parameter in the unit) and the internal resistor R_a, it is possible to calculate the differential current from the measured current flowing through the pilot wire. As soon as an adjustable value is reached, the protection relay trips the line at both ends.

Matching of the sensitivity of the unit for different values of pilot-wire resistance is effected by the firmware of the unit during parameter setting, so that time-consuming matching of the pilot-wire resistance is unnecessary.

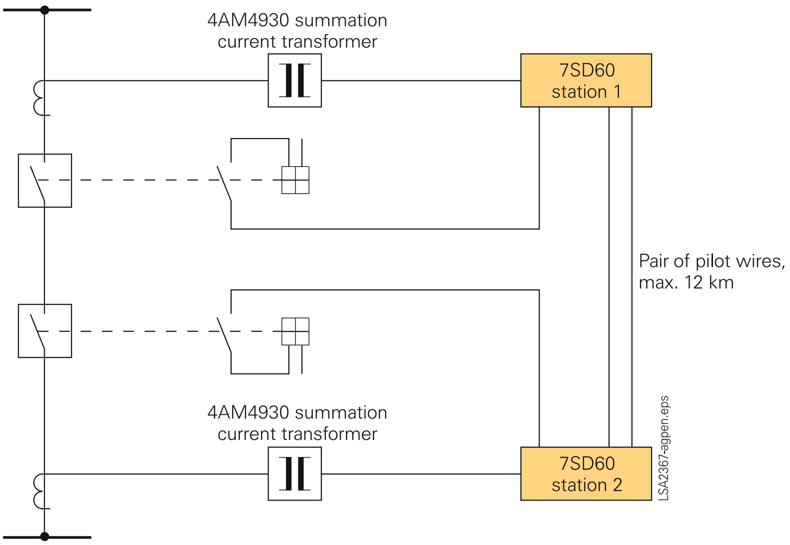
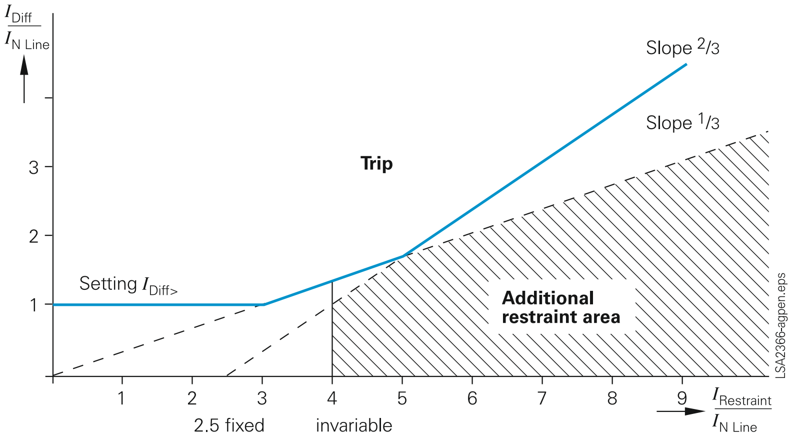


Fig. 7/3
7SD60 line differential protection for operation with two pilot wires



I_{Diff} = $|I_1 + I_2|$
$I_{Restraint}$ = $|I_1| + |I_2|$
I_1 = current at local relay end of line, current flowing into the line is positive
I_2 = current at remote relay, current flowing into the line is positive
$I_{N\ Line}$ = rated current of the line

Fig. 7/4
Trip characteristic of differential protection

Trip characteristic of the differential protection relay

The main function of the unit is current comparison protection. The trip characteristic is fixed and takes into account both the linear and the non-linear errors of the current transformers. It is only necessary to set the tripping value $I_{Diff>}$, although the standard setting is suitable for most applications. It should be parameterized according to the rated current of the line; sensitive setting is possible even when the current transformer rated currents and the line rated currents differ by as much as a factor of 2. Differences in the current transformation ratios at the ends of the line must, however, be compensated for by means of external matching current transformers.

In some cases, this can be realized by the summation current transformer.

Protection functions

Overcurrent release / differential current monitoring

The differential protection function can be combined with an additional overcurrent release. To this end, the criteria “overcurrent” and “differential current” are linked logically so that a TRIP command is given out by the differential function only when a differential current and an overcurrent coexist.

By this means it is often possible to avoid malfunctioning due to pilot-wire short-circuit or wire-break of a connection between a current transformer and the summation current transformer. For this purpose, the 7SD60 is fitted with an additional differential current monitoring function, which can effectively block the differential protection after a delay of some seconds on reaching of an adjustable value of differential current in conjunction with simultaneous operational current I_{M1} within the load range.

Saturation detector

Improved stability on single-ended saturation of the primary current transformers is ensured by means of an integrated saturation detector. It provides additional stability during external faults. 5 ms are enough time to measure an external fault due to a high restraint and small differential current. Indication is done within the additional restraint area (see Fig. 7/4). If – due to CT saturation – the differential current flows into the trip area, the differential trip is blocked for a certain time. Transient saturation of current transformers caused by decaying DC components in the short-circuit current can thus be recognized.

As a result, the requirements on the current transformers are reduced so that they are only required to conduct the steady-state through-flowing short-circuit current without saturation.

Pilot-wire link / pilot-wire monitoring

The link to the remote station comprises a symmetrical pair of wires (e.g. telephone lines). The maximum permissible distance between two stations is approximately 12 km. 7XR9513 (20 kV) or 7XR9515 (5 kV) isolation transformers can be employed for potential isolation against interference induced by longitudinal voltages where the pilot wires run parallel to power cables over long distances.

Since the pilot wires form an integral part of the differential protection, these are normally monitored continuously. This function is available as an option. To achieve this, 2 kHz pulses with a defined pulse width ratio are transmitted to the remote relay via the pilot wires. Detection of a fault in the pilot-wire link results in blocking of the differential protection.

Emergency overcurrent protection

If the differential protection becomes inactive due to a pilot-wire failure or an internal or external blocking of the differential function, the relay offers a single-stage, definite-time overcurrent function. It works with the local flowing operational current I_{M1}. The pickup value and the delay time are settable via parameters in the device.

Circuit-breaker intertripping / remote tripping

Normally, tripping is effected at both stations as a result of current comparison. Tripping at one end only can occur when an overcurrent release is used or with short-circuit currents only slightly above the tripping value. Circuit-breaker intertripping can be parameterized in the unit with integral pilot-wire monitor, so that definite tripping at both ends of the line is assured.

In addition, it is possible by means of a binary input to output a remote tripping command for both directions. The command transmission time is approximately 80 ms.

Lockout of the TRIP command with manual reset

The TRIP command can be locked-out after tripping. In particular, in the case of transformers within the protection zone, reclosure of the line is normally effected only after the cause of the fault has been ascertained by the user. Manual reset is possible either via the operator panel (with password) or via a binary input. As a result, premature reclosure of the circuit-breaker is prevented. The logic state of the TRIP command remains stored even during failure of the auxiliary supply voltage, so that it is still present on restoration of the auxiliary supply voltage.

Inrush restraint / instantaneous tripping stage

Where transformers or reactors are located within the protection zone, inrush restraint can be supplied as an option. This inrush restraint evaluates the second harmonic of the differential current, which is typical for inrush phenomena. If the second harmonic value of the differential current referred to the fundamental frequency exceeds a preset value, tripping by the differential protection is blocked. In the case of high-current internal faults, whose amplitude exceeds the inrush current peak, tripping can be carried out instantaneously.

Vector group adaptation is not effected inside the unit and must, where necessary, be brought about by means of an external matching transformer scheme.

Features

Serial data transmission

As standard, the unit is fitted with an RS485 interface. This is suitable for connection to a bus and allows up to 32 devices to be connected via a two-wire serial interface (use of a third core for earth is recommended). A PC is connected via this interface using an RS232↔RS485 converter, thus allowing the DIGSI operator program to be used, by means of which PC-aided planning, parameter setting and evaluation can be performed. By this readout, it is also possible to output the fault recordings stored by the unit on occurrence of faults.

Using an RS485↔820 nm optical converter as an accessory (7XV5650, 7XV5651), it is possible to provide an interference-free and isolated link to a central control system or a remote control system employing DIGSI, thus allowing economically viable configurations to be used, e.g. for remote diagnostics.

The serial interface can also be set to the IEC 60870-5-103 protocol (VDEW - Association of German Utilities - interface), thus allowing the unit to be integrated in a substation control system. However, only 2 messages (ready for operation and the trip signal) and the fault recording are available.
For this reason, it is recommended to use the 7SD610 unit combined with an external communication converter for pilot wires in those cases in which integration in the substation control system is a prime consideration.

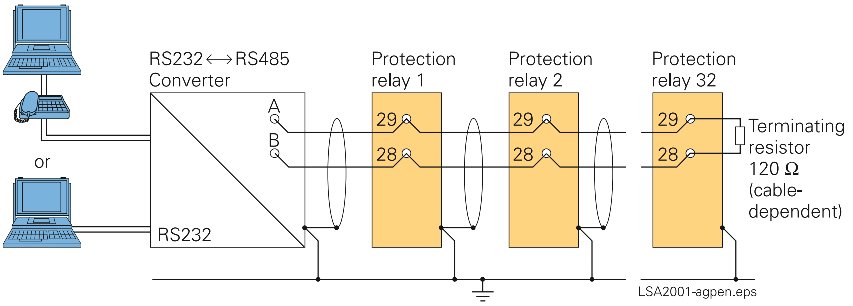
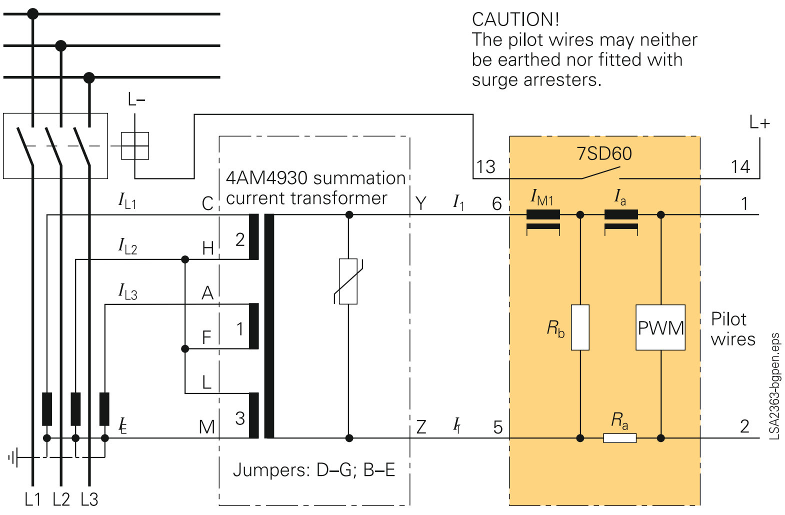


Fig. 7/4
Bus communication via RS485 interface
For convenient wiring of RS485 bus, use bus cable system 7XV5103 (see part 13 of this catalog).

Connection diagrams



CAUTION!
The pilot wires may neither be earthed nor fitted with surge arresters.

PWM Pilot-wire monitoring

Fig. 7/6
Standard connection L1-L3-E, suitable for all types of networks

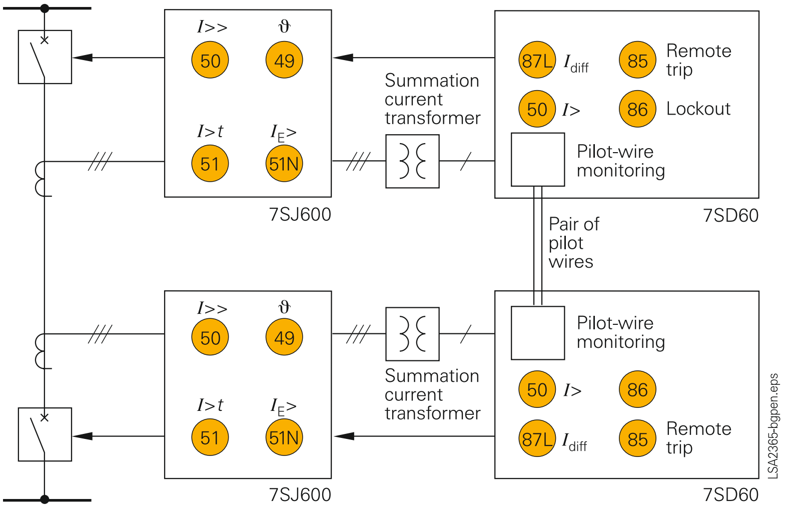


Fig. 7/7
Protection configuration with main (7SD60) and backup overcurrent (7SJ60) protection

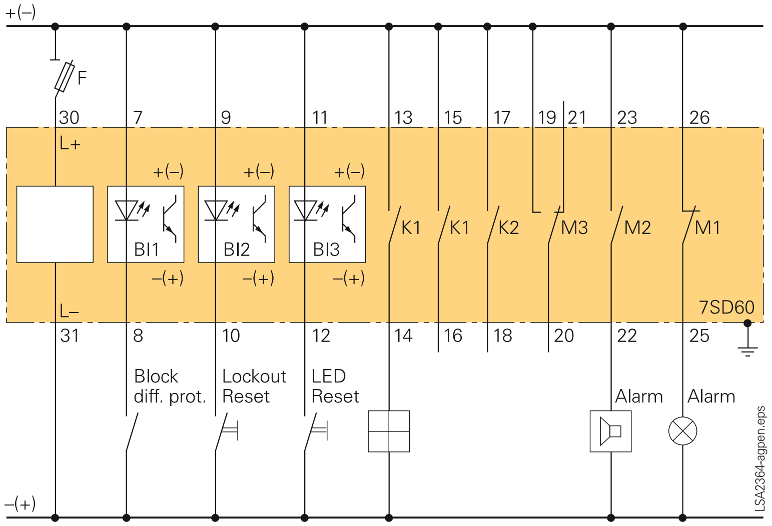


Fig. 7/8
Typical circuit for auxiliary voltage supply

Technical data

General unit data

Input circuits

Rated current I_N	20 mA without summation current transformer 1 or 5 A with summation current transformer	
Rated frequency f_N	50/60 Hz parameterizable	
Thermal overload capability current path		
Continuous	2 x I_N	
For 10 s	30 x I_N	
For 1 s	100 x I_N	

Auxiliary voltage

Auxiliary voltage via integrated DC/DC converter		
Rated auxiliary DC voltage/ permissible variations	24/48 V DC	/19 to 58 V DC
	60/110/125 V DC	/48 to 150 V DC
	220/250 V DC	/176 to 300 V DC
Superimposed AC voltage V_{aux}	≤ 12 % at rated voltage	
Peak-to-peak	≤ 6 % at limits of admissible voltage	
Power consumption		
Quiescent	Approx. 2 W	
Energized	Approx. 4 W	
Bridging time during failure/	≥ 50 ms (at $V_{aux} \geq$ 100 V AC/DC)	
short-circuit of auxiliary voltage	≥ 20 ms (at $V_{aux} \geq$ 24 V DC)	
Rated auxiliary voltage AC V_{aux}/ permissible variations	115 V AC / 88 to 133 V AC	

Command contacts

Number of relays	2 (marshallable)
Contacts per relay	2 NO or 1 NO
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V
Permissible current	
Continuous	5 A
For 0.5 s	30 A

Signal contacts

Number of relays	3 (2 marshallable)
Contacts per relay	1 CO
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	5 A

Binary inputs

Number	3 (marshallable)
Operating voltage	24 to 250 V DC
Current consumption, energized	Approx. 2.5 mA independent of operating voltage
Pick-up threshold reconnectable	By solder bridges
Rated aux. voltages 24/48/60 V DC	
$V_{\text{pick-up}}$	≥ 17 V DC
$V_{\text{drop-off}}$	< 8 V DC
Rated aux. voltages 110/125/220/250 V DC	
$V_{\text{pick-up}}$	≥ 74 V DC
$V_{\text{drop-off}}$	< 45 V DC

Unit design

Housing	7XP20
Dimensions	For dimensions, see dimension drawings, part 15
Weight	
With housing for surface mounting	Approx. 4.5 kg
With housing for flush mounting/cubicle mounting	Approx. 4 kg
Degree of protection acc. to EN 60529	
Housing	IP 51
Terminals	IP 21

Serial interface (Isolated)

Standard	RS485
Test voltage	2.8 kV DC for 1 min
Connection	Via wire to housing terminals, 2 data transmission lines, 1 earthing cable for connection to an RS485↔RS232 converter, cables have to be shielded, screen has to be earthed Setting at supply: 9600 baud
Baud rate	Min. 1200 baud; max. 19200 baud

Technical data

Electrical tests

Specification

Standards	IEC 60255-5 ANSI/IEEE C37.90.0

Insulation tests

Voltage test (routine test)	
All circuits except DC voltage supply and RS485	2 kV (r.m.s.), 50 Hz
Only DC voltage supply and RS485	2.8 kV DC
Impulse voltage test (type test)	
All circuits, class III	5 kV (peak), 1.2/50 µs, 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
Test crosswise: Measurement circuits, pilot wire connections, power supply, binary inputs, class III, (no tests crosswise over open contacts, RS458 interface terminals)	

EMC tests for noise immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (international product standard) EN 50082-2 (generic standard) VDE 0435, Part 303 (German product standard)
High-frequency test IEC 60255-22-1, VDE 0435 Part 303; class III	2.5 kV (peak); 1 MHz; $\tau = 15$ µs; 400 surges; duration 2 s
Electrostatic discharge IEC 60255-22-2, EN 61000-4-2; class III	4/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 class III	10 V/m 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3; class III	10 V/m 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, duty cycle 50 %
Fast transients/bursts IEC 60255-22-3, IEC 61000-4-4, class IV	2 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; duration 1 min
Line-conducted RF amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8; class IV; EN 60255-6	30 A/m; 50 Hz, continuous 300 A/m for 3 s; 50 Hz; 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak), 1 MHz to 1.5 MHz decaying oscillation; 50 shots per s; duration 2 s; $R_i = 150\ \Omega$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV; 10/150 ns; 50 shots per s both polarities; duration 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity) 100 kHz, 1 MHz, 10 and 50 MHz, decaying oscillation; $R_i = 50\ \Omega$

EMC tests for interference emission; type tests

Standard	EN 50081- (generic standard)
Conducted interference voltage on lines, auxiliary voltage only, EN 55022, VDE 0878 Part 22, CISPR 22, limit value, limit class B	150 kHz to 30 MHz
Interference field strength EN 55011, VDE 0875 Part 11, IEC CISPR 11, limit value, limit class A	30 to 1000 MHz

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21; IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.035 mm amplitude; 60 to 150 Hz; 0.5 *g* acceleration; sweep rate 1 octave/min; 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine 5 *g* acceleration, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-2-6	Sinusoidal 1 to 8 Hz; ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz; ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz; 1 *g* acceleration (horizontal axis) 8 to 35 Hz; 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21; IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ±7.5 mm amplitude 8 Hz to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine Acceleration 15 *g*, duration 11 ms, 3 shocks
IEC 60068-2-27	Shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine Acceleration 10 *g*, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Technical data

Climatic stress test

Temperatures

Standards	EN 60255-6, IEC 60255-6 DIN VDE 0435 Part 303	
Recommended temperature	-5 to +55 °C (>55 °C/131 °F decreased display contrast)	
Limit temperature		
During service	-20 to +70 °C	- 4 to +158 °F
During storage	-25 to +55 °C	-13 to +131 °F
During transport	-25 to +70 °C	-13 to +158 °F
(Storage and transport with standard works packing!)		

Humidity

It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Mean value per year ≤ 75 % relative humidity, on 30 days a year up to 95 % relative humidity, condensation not permissible!

Functions

Line differential protection

Note	All current values refer to the symmetrical current using standard connection
Setting ranges	
Current threshold I_1 (release by local station current)	$I/I_{\text{N Line}}$: 0 to 1.5 (step 0.01)
Differential current	$I/I_{\text{N Line}}$: 0.5 to 2.5 (step 0.01)
Delay time t	0 to 60 s (step 0.01 s)
Restraint by 2nd harmonic (see Fig. 7/4)	
$2f_N / f_N$	10 to 80 %
Reset ratio	Approx. 0.7 – drop-off ratio ($I_{\text{Restraint}} = 0$)
Inherent delays	
TRIP time for two-end supply at 4 x set value	Approx. 20 to 28 ms without restraint by 2nd harmonic Approx. 32 to 42 ms with restraint by 2nd harmonic
Drop-off time	Approx. 35 ms
Tolerances at preset values under reference conditions	
Local station current threshold	± 3 % of setpoint, min. 0.02 x I_N
Differential current	± 5 % of setpoint, min. 0.02 x I_N
Influence parameters	
Auxiliary supply voltage $0.8 \leq V_{\text{aux}}/V_{\text{auxN}} \leq$ x 1.15	≤ 1 %
Temperature in range $0\,°C \leq \Theta_{\text{amb}} \leq 40\,°C$	≤ 1 %/10 K
Frequency in range $0.9 \leq f/f_N \leq 1.1$	≤ 4 %
Pilot wires	
Number	2 Symmetric telephone pairs are recommended with loop resistance 73 Ω/km and capacitance 60 nF/km
Core-to-core asymmetry at 800 Hz	Max. 10^{-3}
Maximum loop resistance	1200 Ω
Permissible induced longitudinal voltages	
On direct connection of the pilot wires	≤ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires
For connection via isolating transformer	≥ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires and max. 60 % of the test voltage of the isolating transformers
Pilot-wire monitoring and intertripping (optional)	
Monitoring signal	2000 Hz, pulse-code modulation
Alarm signal delay	1 to 60 s (step 1 s)
Inherent delay time of intertripping	Approx. 65 ms
Extension of the intertripping signal	0 to 5 s (step 0.01 s)

Emergency overcurrent protection

Setting ranges	
Overcurrent pickup value	
$I_{M1} / I_{\text{Nline}}$	0.1 to 15 (step 0.1)
Delay time	0.0 to 60 s (step 0.01 s)

Remote trip

Note	Tripping of the remote end circuit-breaker for units with pilot-wire monitoring only
Setting ranges	
Prolongation time for transmission to remote station	0 to 60 s (step 0.01 s)
Delay time for reception from the remote station	0 to 60 s (step 0.01 s)
Prolongation time for reception from the remote station	0 to 60 s (step 0.01 s)
Tolerances	
Delay time/release delay	1 % and 10 ms respectively
Inherent delay	
Transmission time without delay	Approx. 80 ms

Lockout function

Lockout seal-in of trip command	For differential protection and remote trip until reset
Lockout reset	By means of binary input and/or local operator panel/DIGSI

Additional functions

Operational measured values	
Operational currents	I_1, I_2, I_{Diff}, $I_{\text{restraint}}$
Measurement range	0 to 240 % I_N
Tolerance (I_1)	3 % of rated value or of measured value
Fault event recording	Storage of the events relating to the last 8 faults
Time-tagging	
Resolution for operational events	1 s
for fault events	1 ms
Fault recording (max. 8 faults)	
Storage time (from response or trip command)	Total of 5 s max., pre-trigger and post-fault time settable
Maximum length per recording T_{max}	0.30 to 5.00 s (step 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (step 0.01 s)
Post-fault time T_{post}	0.05 to 0.50 s (step 0.01 s)
Time resolution at 50 Hz	1 instantaneous value per 1.66 ms
Time resolution at 60 Hz	1 instantaneous value per 1.38 ms
Circuit-breaker test	Using test circuit

Technical data

4AM4930 summation current transformer

Power consumption in the circuit with standard connection L1-L3-E (Fig. 7/6) referred to the through-flowing rated current (7SD600 unit in operation).

I_N		in phase (approx. VA)		
		L1	L2	L3
1 A	Single-phase	2.2	1.3	1.7
	Symmetrical three-phase	0.6	0.2	0.35
5 A	Single-phase	3.5	1.5	2.2
	Symmetrical three-phase	0.7	0.2	0.5

	Connections	4AM4930-7DB	4AM4930-6DB
CT rated current		$I_N = 1$ A	$I_N = 5$ A
Number of turns			
Primary windings	A to B	5	1
	C to D	10	2
	E to F	15	3
	G to H	30	6
	I to K	30	6
	K to L	30	6
	L to M	60	12
Secondary windings	Y to Z	1736	1736
Thermal rating			
Continuous current in Amperes	A to B	4.5	20
	C to D	4.5	20
	E to F	4.5	20
	G to H	4.5	20
	I to K	1.2	6.5
	K to L	1.2	6.5
	L to M	1.2	6.5
	Y to Z	0.2	0.2
Secondary rated current with standard connection (see Fig. 7/6) and symmetrical 3-phase current	Y to Z	20 mA	20 mA

Requirements for the current transformers (CT)

$$K'ssc \geq \frac{I_{\text{scc max (ext. fault)}}}{I_{\text{pn}}}$$

and:

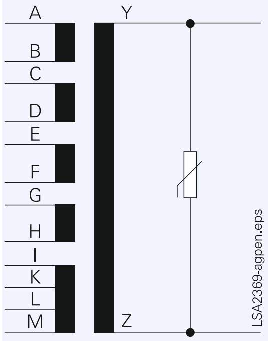
$$\frac{3}{4} \leq \frac{(K'_{\text{ssc}} . I_{\text{pn}})_{\text{end 1}}}{(K'_{\text{ssc}} . I_{\text{pn}})_{\text{end 2}}} \leq \frac{4}{3}$$

K'_{ssc1} = effective symmetrical short-circuit current factor end 1

K'_{ssc2} = effective symmetrical short-circuit current factor end 2

$I_{\text{scc max}}$ = maximum symmetrical short-circuit current

I_{pn} = CT rated primary current



CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.
7SD60 numerical pilot-wire current comparison protection relay	*7SD600☐-☐ ☐A☐ 0-☐ DA0*
Rated current; rated frequency	
20 mA, 50/60 Hz; without external summation current transformer	0
1 A, 50/60 Hz; with external summation CT 4AM4930-7DB00-0AN2	1
5 A, 50/60 Hz; with external summation CT 4AM4930-6DB00-0AN2	5
Rated auxiliary voltage	
24, 48 V DC	2
60, 110, 125 V DC	4
220, 250 V DC, 115 V AC, 50/60 Hz	5
Unit design	
For panel surface mounting with terminals at the side	B
with terminals on top and bottom	D
For panel flush mounting or cubicle mounting	E
Operating language	
English – alternatively either German or Spanish can be selected	0
Scope of functions	
Differential protection	0
Differential protection, inrush restraint	1
Differential protection, pilot-wire monitoring, remote trip	2
Differential protection, pilot-wire monitoring, remote trip, inrush restraint	3

Accessories

DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000 or XP Professional) device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000 and XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*

Accessories

Description	Order No.
*Converter R232 (V.24) - RS485**	
With connecting cable 1 m, PC adapter, with plug-in power supply unit 230 V AC	*7XV5700-0☐☐00*1)
With plug-in power supply unit 110 V AC	*7XV5700-1☐☐00*1)
Converter RS485-FO	
Rated auxiliary voltage 24 to 250 V DC and 250 V AC	
Single optical interface	*7XV5650-0BA00*
Double optical interface (cascadable)	*7XV5651-0BA00*
Summation current transformer	
1 A, 50/60 Hz, for 7SD600	*4AM4930-7DB00-0AN2*
5 A, 50/60 Hz, for 7SD600	*4AM4930-6DB00-0AN2*
Isolating transformer	
Up to 20 kV	*7XR9513*
Up to 5 kV	*7XR9515*
Manual for 7SD60	
English	*E50417-G1176-C069-A3*

---

1) Possible versions see part 13.

* RS485 bus system up to 115 kbaud
RS485 bus cable and adaptor
7XV5103-☐AA☐☐; see part 13.

Connection diagram

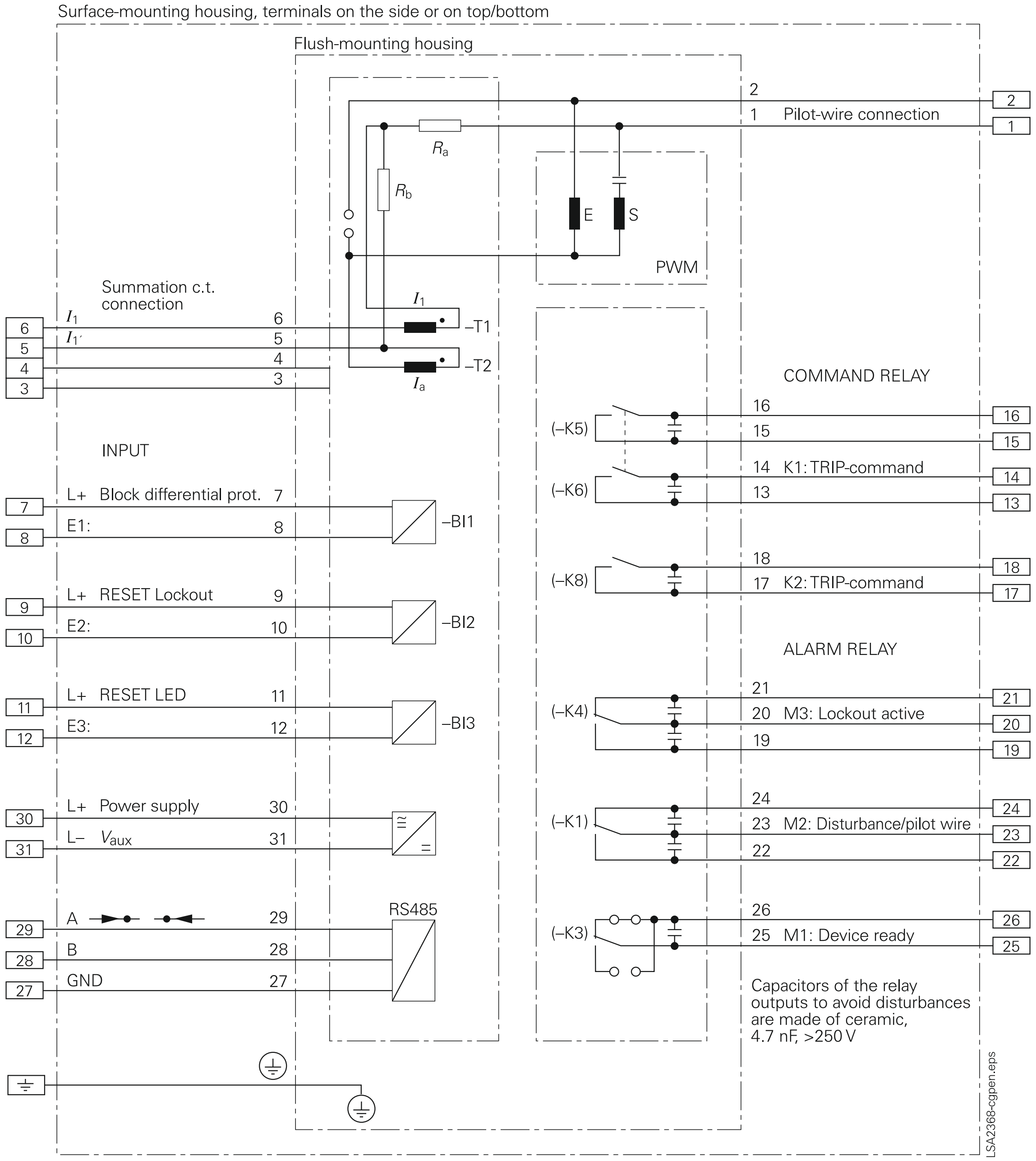


Fig. 7/9 Connection diagram of the 7SD60 current differential protection

SIPROTEC 4 7SD61
Differential Protection Relay for Two Line Ends

Fig. 7/10
SIPROTEC 4 7SD61
differential protection relay

Description

The 7SD610 relay is a differential protection relay suitable for all types of applications and incorporating all those functions required for differential protection of lines, cables and transformers. Transformers and compensation coils within the differential protection zone are protected by means of integrated functions, which were previously to be found only in transformer differential protection. It is also well-suited for complex applications such as series and parallel compensation of lines and cables.

It is designed to provide differential and directional back-up protection for all voltage levels and types of networks. The relay features high speed and phase-selective short-circuit measurement. The unit is thus suitable for single-phase and three-phase fault clearance.

Digital data communication for differential current measurement is effected via fiber-optic cables, networks or pilot wires connections, so that the line ends can be quite far apart. The serial protection data interface (R2R interface) of the relay can flexibly be adapted to the requirements of all existing communication media. If the communication method is changed, flexible retrofitting of communication modules to the existing configuration is possible.

Apart from the main protection function, i.e. the differential protection, the 7SD610 has a full range of configurable emergency and / or back-up protection functions such as phase and earth overcurrent protection with directional elements if voltage transformers are connected. Overload, under- and over-voltage/frequency and breaker-failure protection round off the functional scope of the 7SD610.

Function overview

Protection functions

- Differential protection for universal use with power lines and cables on all voltage levels with phase-segregated measurement (87L)
- Two line ends capability
- Suitable for transformers in protected zones (87T)
- Restricted earth-fault protection (87N) if a transformer is within the protection zone
- Well-suited for serial compensated lines
- Two independent differential stages: one stage for sensitive measuring for high-resistance faults and one stage for high-current faults and fast fault clearance
- Breaker-failure protection (50BF)
- Phase and earth overcurrent protection with directional element (50, 50N, 51, 51N, 67, 67N)
- Phase-selective intertripping (85)
- Overload protection (49)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure single/three-pole (79)

Control functions

- Command and inputs for ctrl. of CB and disconnectors (isolators)

Monitoring functions

- Self-supervision of the relay
- Trip circuit supervision (74TC)
- 8 oscillographic fault records
- CT-secondary current supervision
- Event logging / fault logging
- Switching statistics

Front design

- User-friendly local operation
- PC front port for convenient relay setting
- Function keys and 8 LEDs f. local alarm

Communication interfaces

- 1 serial protection data (R2R) interface
- Front interface for PC connection
- System interface
  - – IEC 61850 Ethernet
  - – IEC 60870-5-103 protocol
  - – PROFIBUS-DP, DNP 3.0 and MODBUS
- Service / modem interface (rear)
- Time synchronization via IRIG-B, DCF77 or system interface

Features

- Browser-based commissioning tool
- Direct connection to digital communication networks

Application

The 7SD610 relay is a differential protection relay suitable for all types of applications and incorporating all those functions required for differential protection of lines, cables and transformers.
Transformers and compensation coils within the differential protection zone are protected by means of integrated functions, which were previously to be found only in transformer differential protection. It is also well-suited for complex applications such as series and parallel compensation of lines and cables.

It is designed to provide protection for all voltage levels and types of networks; two line ends may lie within the protection zone. The relay features very high-speed and phase-selective short-circuit measurement. The unit is thus suitable for single and three-phase fault clearance. The necessary restraint current for secure operation is calculated from the current transformer data by the differential protection unit itself.

Digital data communication for differential current measurement is effected via fiber-optic cables, digital communication networks or pilot wires, so that the line ends can be quite far apart. Thanks to special product characteristics, the relay is particularly suitable for use in conjunction with digital communication networks.

The units measure the delay time in the communication network and adaptively match their measurements accordingly. The units can be operated through pilot wires or twisted telephone pairs at typical distances of 8 km by means of special converters.

The serial communication interfaces for data transmission between the ends are replaceable by virtue of plug-in modules and can easily be adapted to multi-mode and mono-mode fiber-optic cables and to leased lines within the communication networks. Secure, selective and sensitive protection of two-end lines can now be provided by means of these relays.

ANSI	
(87L)	ΔI for lines/cables
(87T)	ΔI for lines / cables with transformers
(87N)	Restricted earth-fault protection
(85)	Phase-selective intertrip, remote trip
(86)	Lockout function
(50) (50N) (51) (51N) (67) (67N)	Three-stage overcurrent protection with directional elements
(50HS)	Instantaneous high-current tripping (switch-onto-fault)
(79)	Single or three-pole auto-reclosure with new adaptive technology
(49)	Overload protection
(50BF)	Breaker failure protection
(59) (27)	Over/undervoltage protection
(81O/U)	Over/underfrequency protection
(74TC)	Trip circuit supervision

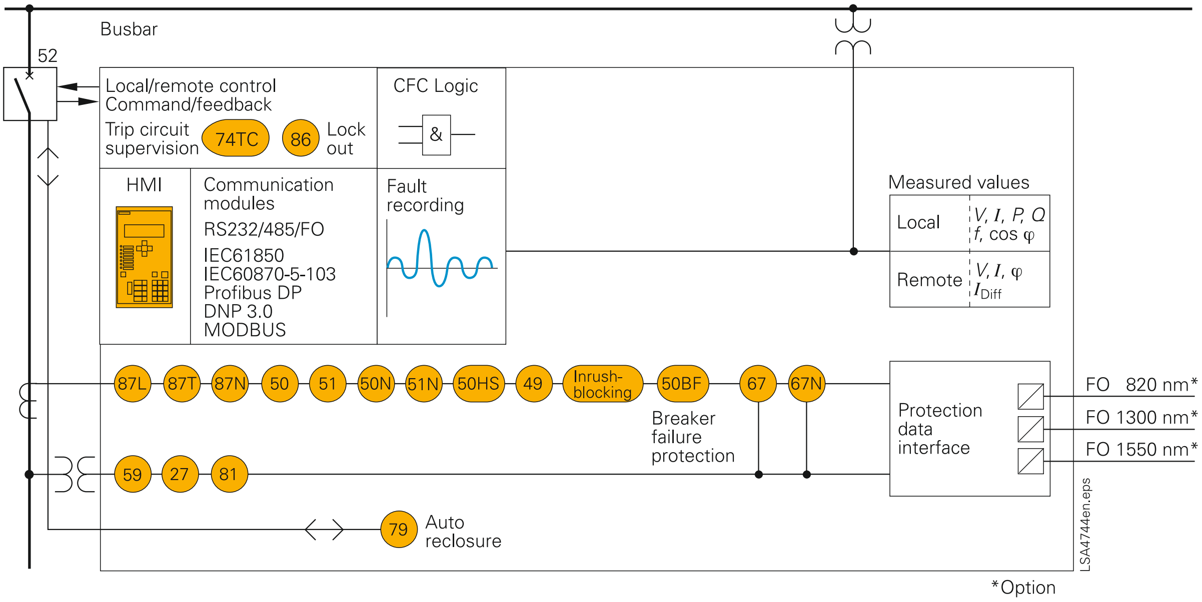


Fig. 7/11

Application

Typical applications employing fiber-optic cables or communication networks

Four applications are shown in Fig. 7/12. The 7SD610 differential protection relay is connected to the current transformers and to the voltage transformers at one end of the cable, although only the currents are required for the differential protection function. The voltage connection improves, among other things, the frequency measurement and allows the measured values and the fault records to be extended. Direct connection to the other units is effected via mono-mode fiber-optic cables and is thus immune to interference.

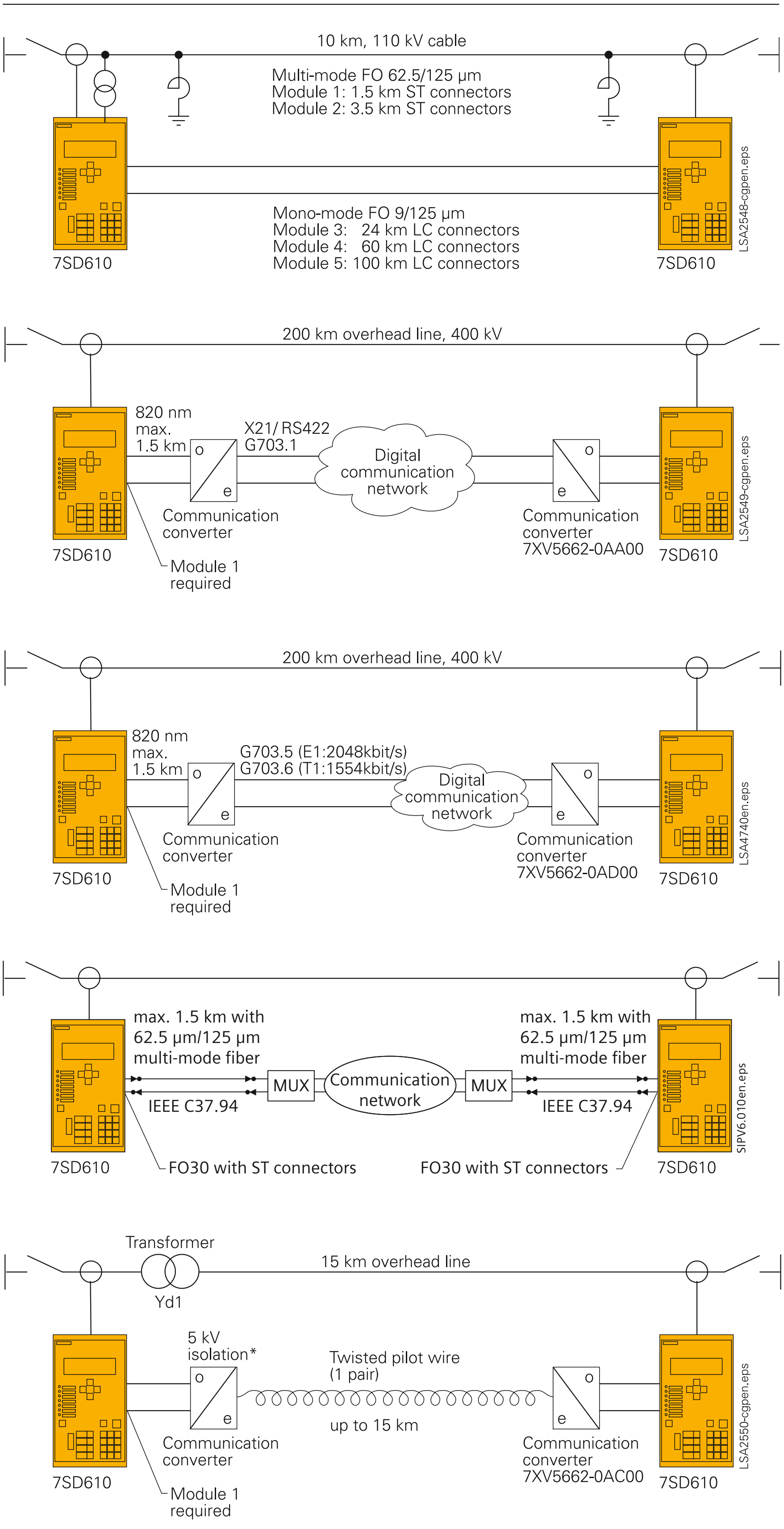
Five different modules are available. In the case of direct connection via fiber-optic cables, data communication is effected at 512 kbit/s and the command time of the protection unit is reduced to 15 ms. Parallel compensation (for the load currents) is provided within the protection zone of the cable. By means of the integrated inrush restraint, the differential protection relay can tolerate the surge on switching-on of the cable and the compensation reactors, and thus allows sensitive settings to be used under load conditions.

7SD610 offers many features to reliably and safely handle data exchange via communication networks.

Depending on the bandwidth available a communication converter for G703-64 kbit/s or X21-64/128/512 kbit/s can be selected. For higher communication speed a communication converter with G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s) is available. Furthermore the 7SD610 supports the IEEE C37.94 interface with 1/2/4 and 8 timeslots.

The connection to the communication converter is effected via a cost-effective 820 nm interface with multi-mode fiber. This communication converter converts the optical input to electrical signals in accordance to the specified telecommunication interface.

The fourth example shows the relays being connected via a twisted pilot pair. Data exchange and transmission is effected via pilot wires of a typical length of 15 km. Here a transformer is in the protected zone. In this application, 7SD610 is set like a transformer differential relay. Vector group matching and inrush restraint is provided by the relay.



* Note: 20 kV isolation with isolation transformer 7XR9516

Fig. 7/12
Typical applications

Construction

The 7SD610 is available in a housing width of 1/3, referred to a 19” module frame system. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings.

All cables can be connected with or without cable ring lugs. Plug-in terminals are available as an option, it is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located on the same sides of the housing. For dimensions, please refer to “Dimension drawings”.

Fig. 7/13

Protection functions

Differential protection (ANSI 87L, 87T, 87N)

The differential protection function has the following features:

- Measurements are performed separately for each phase; thus the trip sensitivity is independent of the fault type.
- An adaptive measurement method with high sensitivity for differential fault currents below the rated current offers the detection of highly resistive faults. This trip element uses special filters, which offer high security even with high level DC components in the short-circuit current. The trip time of this stage is about 35 ms, the pickup value is about 10 % of the rated current.
- A high-set differential trip stage which clears differential fault currents higher than the rated current within 15 ms offers fast tripping time and high-speed fault clearance time. A high-speed charging comparison method is employed for this function.
- When a long line or cable is switched on at one end, transient peaks of the charge current load the line. To avoid a higher setting of the sensitive differential trip stage, this setpoint may be increased for a settable time. This offers greater sensitivity under normal load conditions.
- A special feature of the unit is parameterization of the current transformer data. The unit automatically calculates the necessary restraint current by means of the previously entered current transformer error. The unit thus adaptively matches the working point on the tripping characteristic so that it is no longer necessary for the user to enter characteristic settings.
- Different current-transformer ratios may be employed at the ends of the line. A mismatch of 1:8 is permissible.
- Differential protection tripping can be guarded with overcurrent pickup. In this case, pickup of the protection relay is initiated only on simultaneous presence of differential current and overcurrent.
- Easy to set tripping characteristic. Because the relay works adaptively, only the setpoint $I_{\text{Diff}}>$ (sensitive stage) and $I_{\text{Diff}}>>$ (high-set current differential stage) must be set according to the charge current of the line/cable.
- Differential and restraint current are monitored continuously during normal operation and are displayed as operational measured values.
- High stability during external faults even with different current transformers saturation level. For an external fault, only 5 ms of saturation-free time are necessary to guarantee the stability of the differential protection.
- Single-phase short-circuits within the protection zone can be cleared using a time delay, whereas multi-phase faults are cleared instantaneously. Because of this function, the unit is optimally suited for applications in inductively compensated networks, where differential current can occur as a result of charge transfer phenomena on occurrence of a single-phase earth fault within the protection zone, thus resulting in undesired tripping by the differential protection relay. Undesired tripping of the differential protection can be suppressed by making use of the provision for introduction of a time delay on occurrence of single-phase faults.
- With transformers or compensation coils in the protection zone, the sensitive response threshold $I_{\text{Diff}}>$ can be blocked by an inrush detection function. Like in transformer differential protection, it works with the second harmonic of the measured current compared with the fundamental component. Blocking is cancelled when an adjustable threshold value of the short-circuit current is reached, so that very high current faults are switched off instantaneously.
- In the case of transformers within the protection zone, vector group adaptation and matching of different current transformer ratios is carried out within the unit. The interference zero current, which flows through the earthed winding, is eliminated from the differential current measurement. The 7SD610 thus behaves like a transformer differential relay whose ends, however, can be quite far apart.
- A more sensitive protection for transformers within the protection zone is given by measurement of the star-point current on an earthed winding. Therefore the I_E current measurement input has to be used.

Protection functions

If the sum of the phase currents of a winding is compared with the measured starpoint current, a sensitive earth-current differential protection (REF) can be implemented. This function is substantially more sensitive than the differential protection during faults to earth in a winding, detecting fault currents as small as 10 % of the transformer rated current.

Characteristics of differential protection communciation through the remote relay interfaces

The 7SD610 is ideally adapted for application in communication networks.

The data required for measurement of differential currents and numerous other variables are exchanged between the protection units in the form of synchronous serial telegrams employing the full duplex mode. The telegrams are secured using 32-bit checksums so that transmission errors in a communication network are detected immediately. Moreover, each telegram carries a time stamp accurate to a microsecond, thus allowing measurement and monitoring of the continuous transmission delay times.

- Data communication is immune to electromagnetic interference, since fiber-optic cables are employed in the critical region, e.g. in the relay house or relay room.
- Monitoring of each individual incoming telegram and of overall communication between the units, no need of supplementary equipment. The check sum (correctness of the telegram contents), the address of the neighboring unit and the transmission delay time of the telegram are monitored.
- Unambiguous identification of each unit is ensured by assignment of a settable communication address within a differential protection topology. Only those units mutually known to each other can cooperate. Incorrect interconnection of the communication links results in blocking of the protection system.
- Detection of telegrams, which are reflected back to the transmitting unit within the communication network.
- Detection of path switching in a communication network. Automatic restraint of the protection function until measurement of the parameters of the new communication link has been completed.
- Continuous measurement of the transmission delay time to the remote line end. Taking into account the delay time in differential current measurement and compensation thereof, including monitoring of a settable maximum permissible delay time of 30 ms.
- Generation of alarm signals on disturbed communication links. Statistical values for the percentage availability of the communication links per minute and per hour are available as operational measured values.
- With a GPS high-precision 1-s pulse from a GPS receiver the relays can be syncronized with an absolute, exact time at each line end. In this way, the delay in the receive and transmit path can be measured exactly. With this optional feature the relay can used in communication networks where this delay times are quite different.

Phase-selective intertrip and remote trip/indications

Normally the differential current is calculated for each line end nearly at the same time. This leads to fast and uniform tripping times. Under weak infeed conditions, especially when the differential function is combined with an overcurrent pickup, a phase-selective intertrip offers a tripping of both line ends.

- 7SD610 has 4 intertrip signals which are transmitted in high-speed mode (20 ms) to the other terminals. These intertrip signals can also be initiated and transmitted by an external relay via binary inputs. In cases where these signals are not employed for breaker intertripping, other alternative information can be rapidly transmitted to the remote end of the line.
- In addition, four high-speed remote commands are available, which can be introduced either via a binary input or by means of an internal event and then rapidly communicated to the other end.
- Provided that the circuit-breaker auxiliary contacts are wired to binary inputs at the line ends, the switching status of the circuit-breakers is indicated and evaluated at the remote ends of the line. Otherwise the switching status is derived from the measured current.

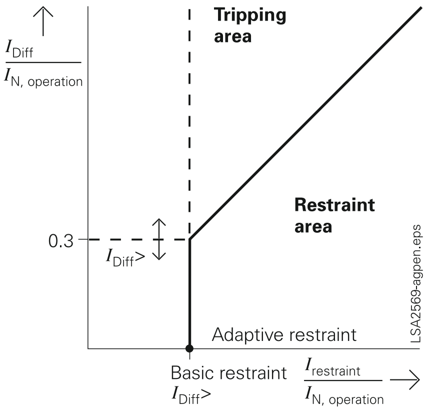


Fig. 7/14
Tripping characteristic

Possible modes of operation of the differential protection section

Special modes of operation such as the "Commissioning mode" and "Test operation" are advantageous for commissioning and servicing the units.

- In general, an alarm indication is generated on interruption of the communication links and an attempt is made to re-establish the communication link. The units operate in the emergency mode, provided that these have been parameterized.
- The complete configuration can also be used in a testing mode. The local end is in an operating mode, which, for example, allows the pickup values to be tested. The current values received from the remote end of the line are set to zero, so as to achieve defined test conditions. The remote-end unit ignores the differential currents, which occur as a result of testing, and blocks differential protection and breaker intertripping. It may optionally operate in the backup protection mode.
- Differential protection is activated in the commissioning mode. However, test currents injected at one end of the line and which generate a differential current do not lead to output of a TRIP command by the differential protection or to breaker intertripping. All those indications that would actually occur in conjunction with a genuine short-circuit are generated and displayed. TRIP commands can be issued by the backup protection.

Protection functions

Thermal overload protection (ANSI 49)

A built-in overload protection with a current and thermal alarm stage is provided for thermal protection of cables and transformers.

The trip time characteristics are exponential functions according to IEC 60255-8. The preload is considered in the trip times for overloads.

An adjustable alarm stage can initiate an alarm before tripping is initiated.

Overcurrent protection (ANSI 50, 50N, 51, 51N, 67, 67N)

The 7SD610 provides a three-stage overcurrent protection. Two definite-time stages and one inverse-time stage (IDMT) are available, separately for phase currents and for the earth current. Two operating modes (backup, emergency) are selectable. Two stages e.g. can run in backup mode, whereas the third stage is configured for emergency operation, e.g. during interruption of the protection communication and/or failure of the voltage in the VT secondary circuit. The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature cicuit-breaker (VT m.c.b. trip).

The following ANSI/IEC inverse-time characteristics are available:

- Inverse
- Short inverse
- Long inverse
- Moderately inverse
- Very inverse
- Extremely inverse
- Definite inverse

If VTs are connected, separate stages with directional measurement are available, two definite-time and two inverse-time stages (each for phase and earth). Using the forward pickup indication as a signal to the remote end, a 100 % protection coverage of the line can be operated in parallel to the differential protection.

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. On large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast three-pole tripping.

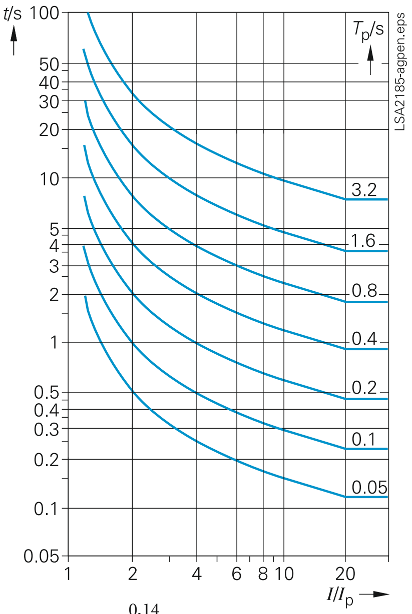
Circuit-breaker closure onto a faulty line is also possible provided that the circuit-breaker auxiliary contacts of the remote end are connected and monitored. If an overcurrent arises on closing of the circuit-breaker at one end of a line (while the other end is energized) the measured current can only be due to a short-circuit. In this case, the energizing line end is tripped instantaneously.

In the case of circuit-breaker closure, the auto-reclosure is blocked at both ends of the line to prevent a further unsuccessful closure onto a short-circuit.
If circuit-breaker intertripping to the remote end is activated, intertripping is also blocked.

Auto-reclosure (ANSI 79)

The 7SD610 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without earth, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without earth and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Adaptive auto-reclosure. Only one line end is closed after the dead time. If the fault persists this line end is switched off. Otherwise the other line ends are closed via a command over the communication links. This avoids stress when heavy fault currents are fed from all line ends again.
- Interaction with an external synchro-check



$$t = \frac{0{,}14}{\left(I/I_p\right)^{0{,}02} - 1} T_p$$

Fig. 7/15 Inverse

- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed:
  When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Protection functions

Breaker failure protection (ANSI 50BF)

The 7SD610 relay incorporates a two-stage breaker failure protection to detect the failure of tripping command execution, for example, due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command is generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or are only lightly loaded. The 7SD610 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SD610 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Protection functions

Monitoring and supervision functions

The 7SD610 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

Current transformer / Monitoring functions

A broken wire between the CTs and relay inputs under load may lead to maloperation of a differential relay if the load current exceeds the differential setpoint. The 7SD610 provides fast broken wire supervision which immediatelly blocks all line ends if a broken wire condition is measured by a local relay. This avoids maloperation due to broken wire condition. Only the phase where the broken wire is detected is blocked. The other phases remain under differential operation.

Fuse failure monitoring

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit the distance protection would respond with an unwanted trip due to this loss of voltage. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Summation of currents and voltages

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only be issued after the lockout state is reset.

Local measured values

The measured values are calculated from the measured current and voltage signals along with the power factor (cos φ), the frequency, the active and reactive power. Measured values are displayed as primary or secondary values or in percent of the specific line rated current and voltage. The relay uses a 20 bit high-resolution AD converter and the analog inputs are factory-calibrated, so a high accuracy is reached. The following values are available for measured-value processing:

- Currents 3 x I_{Phase}, 3 I_0, I_{E}, $I_{\text{E sensitive}}$
- Voltages 3 x $V_{\text{Phase-Ground, 3 x}}$ $V_{\text{Phase-Phase}}$, 3 V_0, V_{en},
- Symmetrical components I_1, I_2, V_1, V_2
- Real power P (Watt), reactive power Q (Var), apparent power S (VA)
- Power factor PF (= cos φ)
- Frequency f
- Differential and restraint current per phase
- Availability of the data connection to the remote line ends per minute and per hour
- Regarding delay time measuring with the GPS-version the absolute time for transmit and receive path is displayed separately.

Limit value monitoring: Limit values are monitored by means of the CFC. Commands can be derived from these limit value indications.

Protection functions

Measured values at remote line ends

Every two seconds the currents and voltages are freezed at the same time at all line ends and transmitted via the communication link. At a local line end, currents and voltages are thus available with their amount and phases (angle) locally and remotely. This allows checking the whole configuration under load conditions. In addition, the differential and restraint currents are also displayed. Important communication measurements, such as delay time or faulty telegrams per minute/hour are also available as measurements. These measured values can be processed with the help of the CFC logic editor.

Commissioning

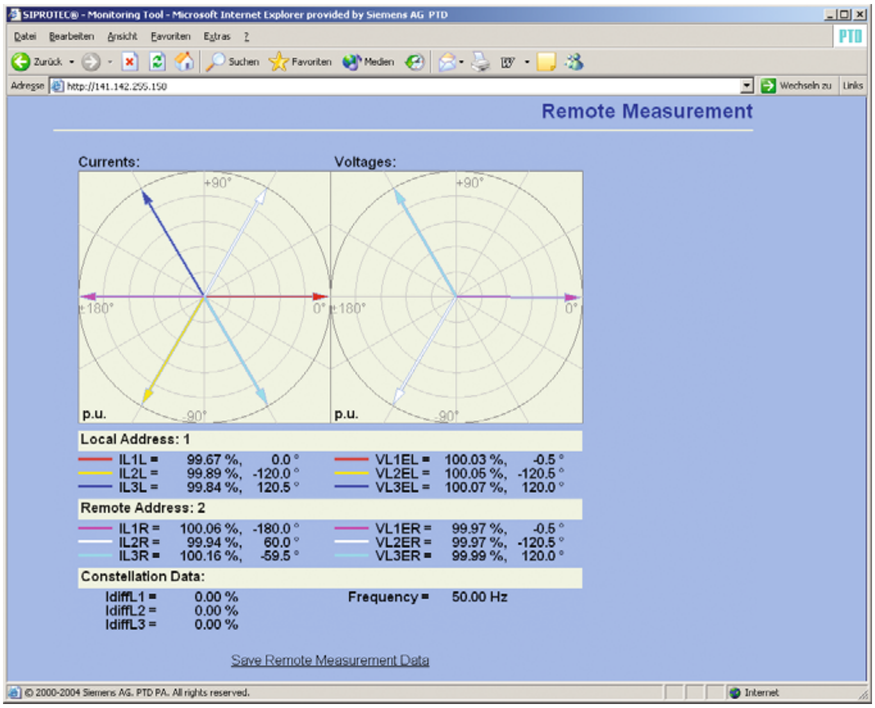
Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged.

Furthermore, all currents and optional voltages and phases are available via communication link at the local relay and are displayed in the relay, with DIGSI 4 or with the Web Monitor.

The operational and fault events and fault records from all line ends share a common time tagging which allows to compare events registered in the different line ends on a common time base.

WEB Monitor – Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. This program shows the protection topology and comprehensive measurements from local and remote line ends. Local and remote measurements are shown as phasors and the breaker positions of each line end are depicted. It is possible to check the correct connection of the current transformers or the correct vector group of a transformer.



Remote Measurement

Currents:

Voltages:

Local Address: 1

IL1L = 99.67 %, 0.0 °
IL2L = 99.89 %, -120.0 °
IL3L = 99.84 %, 120.5 °
VL1EL = 100.03 %, -0.5 °
VL2EL = 100.05 %, -120.5 °
VL3EL = 100.07 %, 120.0 °

Remote Address: 2

IL1R = 100.06 %, -180.0 °
IL2R = 99.94 %, 60.0 °
IL3R = 100.16 %, -59.5 °
VL1ER = 99.97 %, -0.5 °
VL2ER = 99.97 %, -120.5 °
VL3ER = 99.99 %, 120.0 °

Constellation Data:

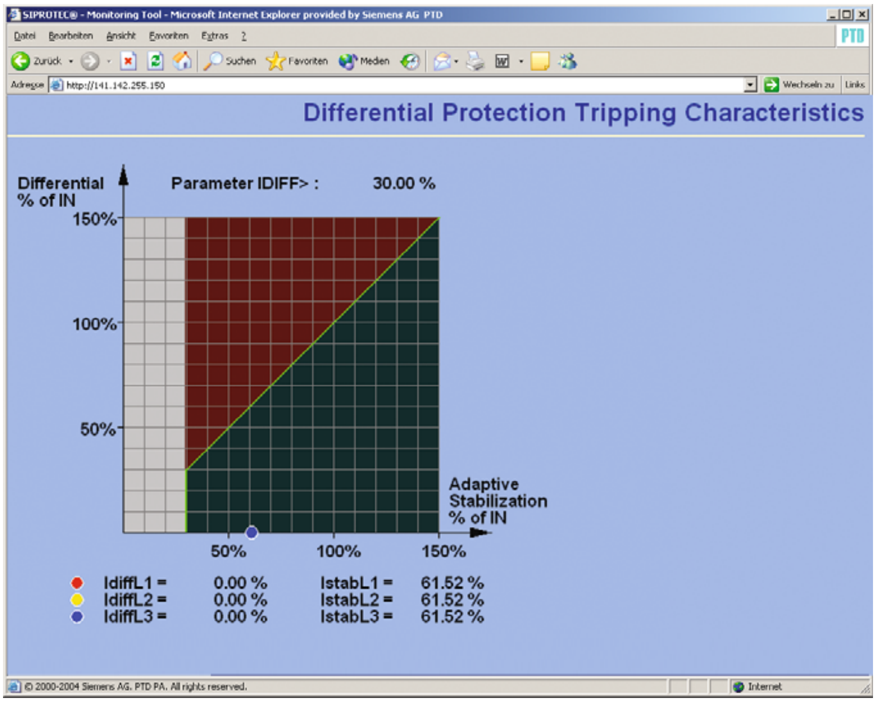
IdiffL1 = 0.00 %
IdiffL2 = 0.00 %
IdiffL3 = 0.00 %
Frequency = 50.00 Hz

Save Remote Measurement Data

© 2000-2004 Siemens AG. PTD PA. All rights reserved.

LSP2845.tif

Fig. 7/16
Browser-aided commissioning: Phasor diagram



Differential Protection Tripping Characteristics

Parameter IDIFF> : 30.00 %

● IdiffL1 = 0.00 % IstabL1 = 61.52 %
● IdiffL2 = 0.00 % IstabL2 = 61.52 %
● IdiffL3 = 0.00 % IstabL3 = 61.52 %

© 2000-2004 Siemens AG. PTD PA. All rights reserved.

LSP2846.tif

Fig. 7/17
Browser-aided commissioning:
Differential protection tripping characteristic

Stability can be checked by using the operating characteristic as well as the calculated differential and restraint values in the browser windows.

Event log and trip log messages are also available. Remote control can be used, if the local front panel cannot be accessed.

Functions

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Functions

With respect to communication, particular emphasis has been placed on high flexibility, data security and use of customary standards in the field of energy automation. The concept of the communication modules allows interchangeability on the one hand, and, on the other hand, is open for future standards.

Local PC interface

The PC interface provided on the front panel on the unit allows the parameters, status and fault event data to be rapidly accessed by means of the DIGSI 4 operating program. Use of this program is particularly advantageous during testing and commissioning.

Rear-mounted interfaces

The service and system communication interfaces are located at the rear of the unit. In addition, the 7SD610 is provided with a protection interface. The interface complement is variable and retrofitting is possible without any difficulty. These interfaces ensure that the requirements for different communication interfaces (electrical and optical) and protocols can be met.

The interfaces are designed for the following applications:

Service / modem interface

By means of the RS485 interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants.

In the case of the 7SD610, a PC with a standard browser can be connected to the service interface (refer to “Commissioning program”).

System interface

This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7SD610, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to “Commissioning program”). The relays include a small Web server and sends its HTML pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 61850 Ethernet, IEC 60870-5-103, PROFIBUS-DP, DNP 3.0, MODBUS, DIGSI, etc.) are required, such demands can be met.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

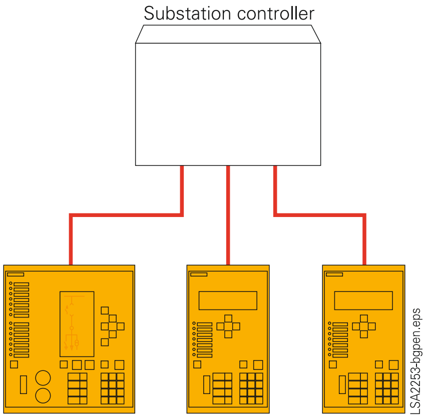


Fig. 7/18
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

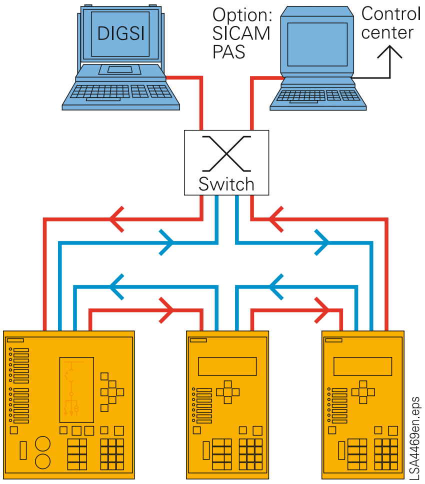


Fig. 7/19
Bus structure for station bus with Ethernet and IEC 61850

Communication

IEC 61850 Ethernet

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay ans system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area.
IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

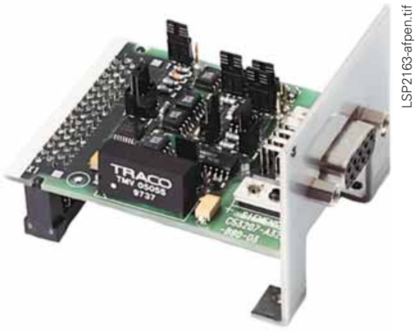


Fig. 7/20
RS232/RS485 electrical communication module

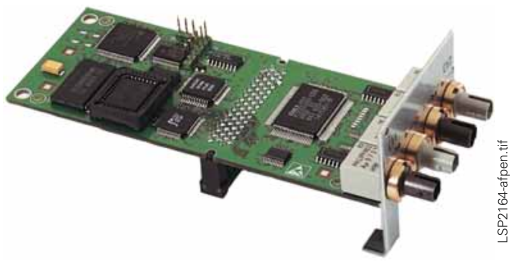


Fig. 7/21
PROFIBUS communication module, optical double-ring

Fig. 7/22
820 nm fiber-optic communication module

Fig. 7/23
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

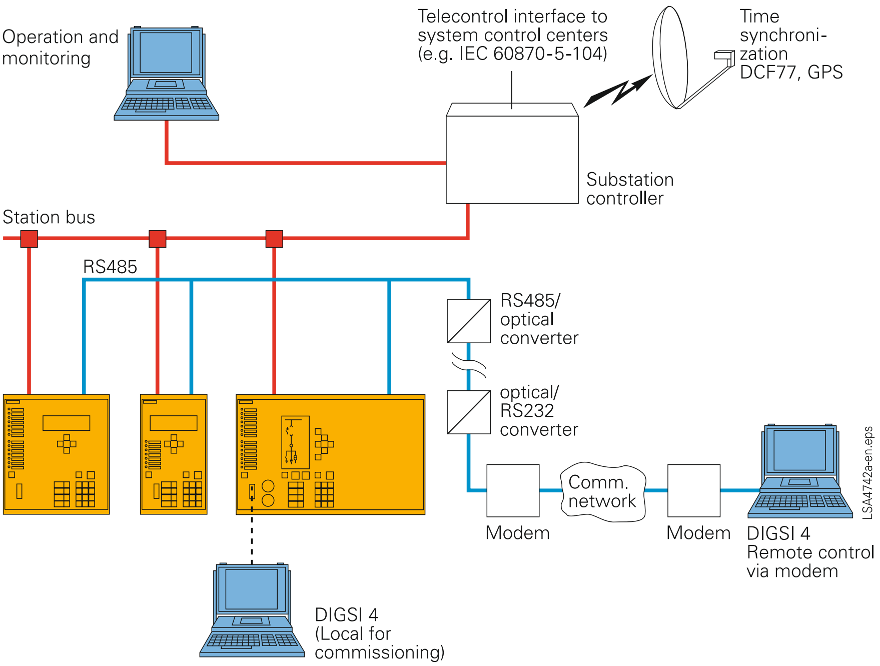


Fig. 7/24
System solution: Communications

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 7/18).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 7/19).

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

Serial protection data interface (R2R interface)

The 7SD610 provides one protection data interface to cover two line end applications.

In addition to the differential protection function, other protection functions can use this interface to increase selectivity and sensitivity as well as covering advanced applications.

- Fast phase-selective teleprotection signaling using the directional stages of the overcurrent protection with POTT or PUTT schemes
- Two terminal line applications can be implemented without additional logic
- Interclose command transfer with the auto-reclosure “Adaptive dead time” (ADT) mode
- 4 remote signals for fast transfer of binary signals
- Flexible utilization of the communication channels by means of the programmable CFC logic

The protection data interfaces have different options to cover new and existing communication infrastructures.

- FO5[1], OMA1[2] module:
  820 nm fiber-optic interface with clock recovery/ST connectors for direct connection with multi-mode FO cable up to 1.5 km for the connection to a communication converter.
- FO6[1], OMA2[2] module:
  820 nm fiber-optic interface/ST connectors for direct connection up to 3.5 km with multi-mode FO cable.

New fiber-optic interfaces, series FO1x

- FO17[1]: For direct connection up to 24 km[3], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1]: For direct connection up to 60 km[3], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1]: For direct connection up to 100 km[3], 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30: 820 nm fiber-optic interface/ST connectors for direct connection up to 1.5 km and for connections to a IEEE C37.94 multiplexer interface.

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21/G703-64 kbit/s or G703-E1/-T1 interface. Furthermore the IEEE C37.94 interface is supported by the FO30 module.

For operation via copper wire communication (pilot wires or twisted telephone pair), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. The connection via FO cable to the relay is interference-free. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (up to 8 km) and all three-wire protection systems using existing copper communication links.

Different communication converters are listed under "Accessories".

<u>Communication data:</u>

- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.
- Supported network interfaces X21/RS422 with 64 or 128 or 512 kbit/s; or G703-64 kbit/s and G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s) or IEEE C37.94.
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC

---

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Communication

Communication possibilities between relays

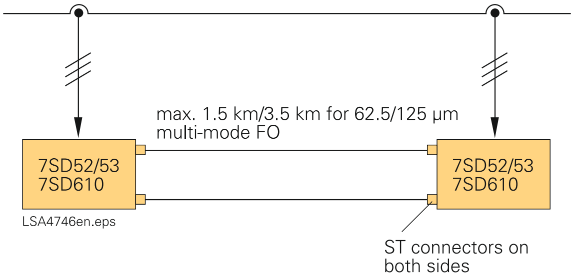


Fig. 7/25
Direct optical link up to 1.5 km/3.5 km, 820 nm

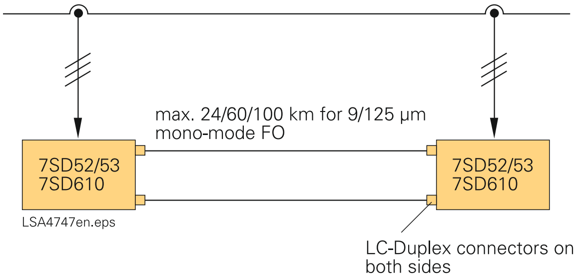


Fig. 7/26
Direct optical link up to 25/60 km with 1300 nm
or up to 100 km with 1550 nm

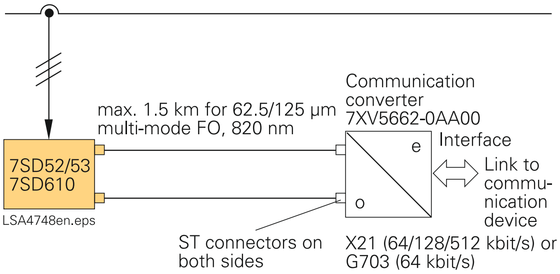


Fig. 7/27
Connection to a communication network CC-XG

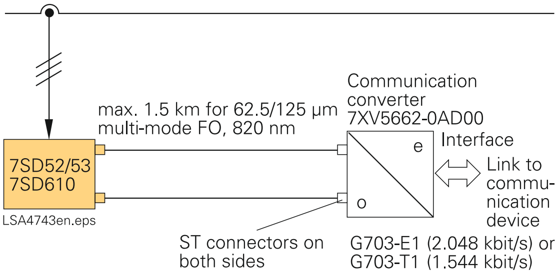


Fig. 7/28
Connection to a communication network CC-2M

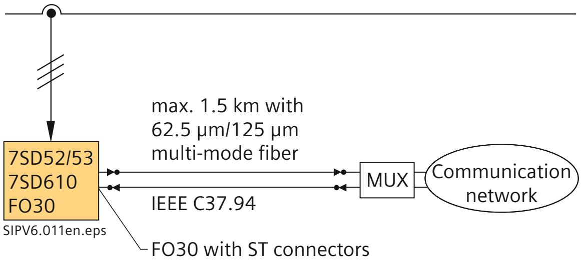


Fig. 7/29
Connection to a communication network via IEEE C37.94

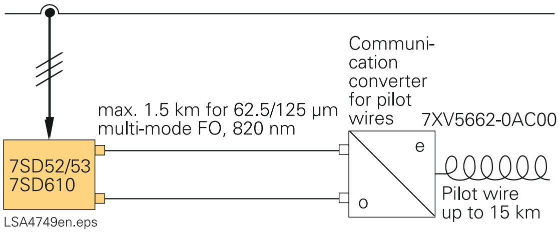


Fig. 7/30
Connection to a pilot wire

Typical connection

Connection to current and voltage transformers

A typical connection is to the phase CT. The residual current at the I_E input is formed by summation of the phase currents. This ensures optimum supervision functions for the current.

Optionally, voltages are measured by means of voltage transformers and are fed to the unit as a phase-to-earth voltage. The zero voltage is derived from the summation voltage by calculation performed in the unit.

As a matter of fact, the 7SD610 unit does not require any voltage transformers for operation of the differential protection.

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for restricted earth-fault protection (REF) or directional ground (earth)-fault protection.

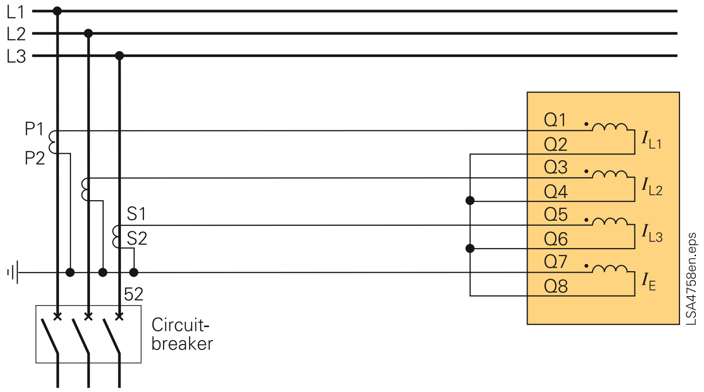


Fig. 7/31
Typical connection to current transformers

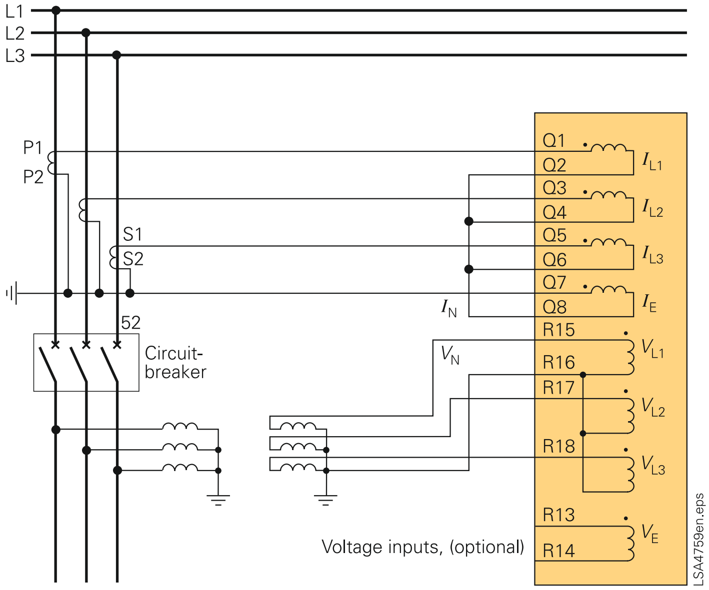


Fig. 7/32
Typical connection to current transformers with optional voltage inputs

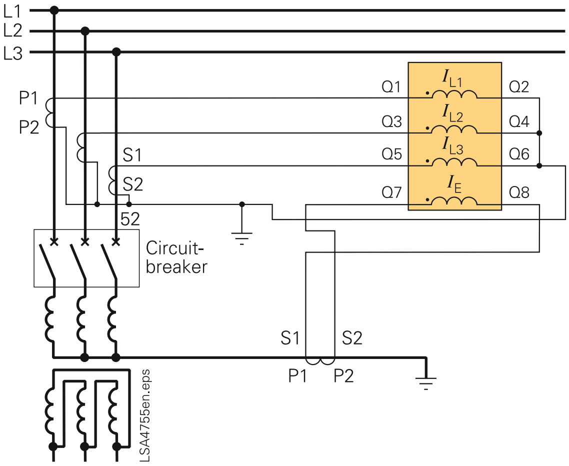


Fig. 7/33
Connection for transformer with restricted earth-fault protection (REF)

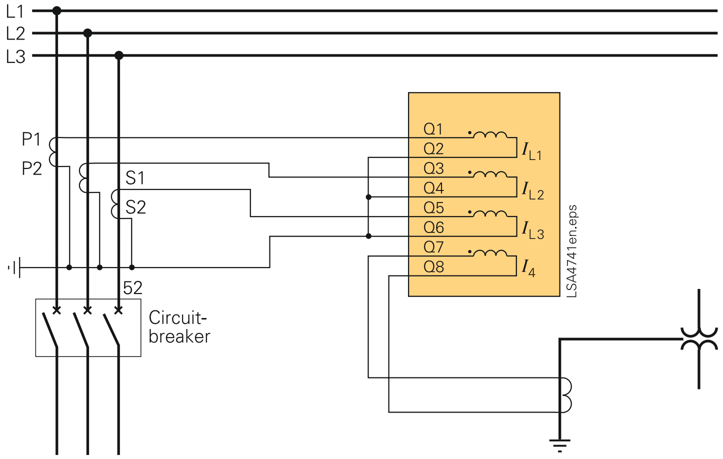


Fig. 7/34
Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Technical data

General unit data

Analog inputs

Rated frequency	50 or 60 Hz (selectable)
Rated current I_N	1 or 5 A (selectable)
Rated voltage V_N	80 to 125 V (selectable)
Power consumption	
in CT circuits with $I_N = 1$ A	Approx. 0.05 VA
with $I_N = 5$ A	Approx. 0.3 VA
in VT circuits	Approx. 0.1 VA
Thermal overload capacity	I_N
in CT circuits (for $I_N = 5$ A)	100 A for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak value)	250 I_N (half sine)
In VT circuits for highly sensitive earth-fault protection	300 A for 1 s 100 A for 10 s 15 A continuous
in VT circuits	230 V per phase continuous

Auxiliary voltage

Rated voltages Ranges are settable by means of jumpers	24 to 48 V DC 60 to 125 V DC$^{1)}$ 110 to 250 V DC$^{1)}$ and 115 V AC (50/60 Hz)$^{1)}$
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Under normal operating conditions	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during failure of the auxiliary voltage $V_{aux} \geq 110$ V	≥ 50 ms

Binary inputs

Number	7 (marshallable)
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	17 or 73 V (selectable)
Functions are freely assignable	
Minimum pickup threshold	
Ranges are settable by means of jumpers for each binary input	17 or 73 V DC, bipolar
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

Output relay

Command / indication relay	
Number	5 (marshallable) 1 alarm contact (not marshallable)
Switching capacity	
Make	1000 W/VA
Break	30 VA
Break (with resistive load)	40 W
Break (with L/R ≤ 50 ms)	25 W
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous

1) Ranges are settable by means of jumpers.

LEDs

Number	
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	7

Unit design

Housing 7XP20	For dimensions refer to dimension drawings, part 15
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
front	IP 51
rear	IP 50
for the terminals	IP 20 with terminal cover put on
Weight	
Flush-mounting housing 1/3 x 19"	4 kg
Surface-mounting housing 1/3 x 19"	6 kg

Serial interfaces

Operating interface 1 for DIGSI 4 or browser *(front of unit)*

Connection	Non-isolated, RS232, front panel, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud, setting as supplied: 38400 baud; parity 8E1

Time synchronization *(rear of unit DCF77/IRIG-B signal format IRIG-B000)*

Connection	9-pin subminiature connector (SUB-D) (terminals with surface-mounting housing)
Voltage levels	5, 12 or 24 V (optional)
Dielectric test	500 V/50 Hz

Service interface (op. interface 2) for DIGSI 4/modem/service/browser *(rear of unit)*

Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

System interface *(rear of unit)*

Refer to ordering code	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-DP DNP 3.0, MODBUS
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
For fiber-optic cable	ST connector
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance (spanned)	Max. 1.5 km

Technical data

System interface, continued

PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kbd; 100 m at 12 Mbd
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[2]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance	500 kbit/s 1.6 km; 1500 kbit/s 530 m

Protection data interface (R2R interface)

FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a comm. converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 8 dB
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 16 dB
New fiber-optic interfaces, series FO1	
FO30: Fiber-optic interface to support the IEEE C37.94 interface and for direct fiber – optic connection up to 1.5 km	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 8 dB
FO17[1]: for direct connection up to 24 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 13 dB
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 29 dB
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 29 dB

Relay communication equipment

External communication converter 7XV5662-0AA00 for communication networks X21/G703-64 kbit/s

External communication converter to interface between the relays, optical 820 nm interface and the X21/RS422/G703-64 kbit/s interface of a communication device	
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers	
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable to device side
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector
G703-64 kbit/s electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal

External communication converter 7XV5662-0AD00 for communication networks with G703-E1 or G703-T1

External communication converter to interface between the relays, optical 820 nm interfac and G703-E1 or G703-T1 interface of a communication network	
Inputs: 2 fiber-optic inputs 820 nm, 1 RS232 input	Max. 1.5 km with 62.5/125µm multi-mode 1 FO cable to device side
Output:	
G703.5	E1: 2,048 kbit/s
G703.6	T1: 1,554 kbit/s
Electrical interface on communication network	max. 800 m, screw-type terminal

External communication converter 7XV5662-0AC00 for pilot wires

External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Typical distance	15 km
Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable
Pilot wire	Screw-type terminal 5 kV isolated
Permissible time delay (duration of data transmission)	
Delay of telegrams due to transmission for one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path Permissible max. value can be selected

Electrical tests

Specification

Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 For further standards see “Individual functions”

Insulation tests

Standards	IEC 60255-5
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50 / 60 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 / 60 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for noise immunity; type tests

Standards	IEC 60255-6, IEC 60255-22 (product standards) (type tests) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz

---

1) For flush-mounting housing.

2) For surface mounting housing.

3) For surface mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Technical data

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 μs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω; 9 μF Differential (transversal) mode: 1 kV; 2 Ω; 18 μF
Measurement inputs, binary inputs, binary output relays	Common (longitudinal) mode: 2 kV; 42 Ω; 0.5 μF Differential (transversal) mode: 1 kV; 42 Ω; 0.5 μF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second, duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 impulses per second; both polarities; duration 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillation IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200\ \Omega$

EMC tests for interference emission; type tests

Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis), 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis), 8 to 35 Hz: 1 *g* acceleration (horizontal axis), 8 to 35 Hz: 0.5 *g* acceleration (vertical axis), frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration, Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress test

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	–25 °C to +85 °C / –13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	–20 °C to +70 °C / –4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °C)	–5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	–25 °C to +55 °C / –13 °F to +131 °F
– Limiting temperature during transport	–25 °C to +70 °C / –13 °F to +158 °F

Humidity

Permissible humidity stress; It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; moisture condensation during operation is not permitted

Technical data

Functions

Differential protection (ANSI 87L, 87T)

Sensitive differential current trip stage $I_{Diff}>$

Setting range	
$I_{Diff}> I_N$ secondary 1 A	0.1 to 20 A (steps 0.01 A)
secondary 5 A	0.5 to 100 A
Tripping time $I_{Diff}>$ 2 x $I_{Diff}>$ (setting value)	Typical 35 ms with FO cable

High current differential trip stage $I_{Diff}>>$

Setting range	
$I_{Diff}>>$ secondary 1 A	0.8 to 100 A (steps 0.01 A)
secondary 5 A	4.0 to 50 A
Tripping time $I_{Diff}>$ 2 x $I_{Diff}>>$ (setting value)	Typical 16 ms with FO cable

Vector group adaption with transformers in the differential zone

Adaption of connection sympol	0 to 11 (x 30°)(step 1)
Neutral point connection	Grounded (earthed) or not grounded (earthed)(for each winding)

Inrush restaint

Restraint ratio 2^{nd} harmonic I_{2fn}/I_{fN}	10 % to 45 % (step 1 %)
Max. current for restraint	1.1 A to 25 $A^{1)}$ (step 0.1 A)
Crossblock function	Can be switched on and off
Max. operative time for crossblock $T_{oper\ crossblk}$	0 to 60 s (step 0.01 s) or deactivated (operating up to release)

Backup / emergency overcurrent protection (ANSI 50N, 51N, 67, 67N)

Operating modes	Backup (always active) or emergency (e.g. loss of data connection)
Characteristic	2 definite-time stages / 1 inverse-time stage

Definite-time stage (ANSI 50, 50N)

Phase current pickup $I_{ph}>>$	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A) or deactivated
Earth current pickup $3I_0>>$	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) or deactivated
Phase current pickup $I_{ph}>$	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A)
Earth current pickup $3I_0>$	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A)
Phase current pickup $I_{ph}>$ with directional element	0.1 to 25 A(1 A) / 0.5 to 125 A(5 A)
Earth current pickup $3I_0>$ with directional element	0.05 to 25 A(1 A) / 0.25 to 125 A(5 A) (step 0.01 A)
Time delay	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % setting value or 1 % of I_N
Delay times	± 1 % setting value or 10 ms
Operating time	Approx. 25 ms

Inverse-time stage (ANSI 51, 51N)

Phase current pickup I_p	0.1 to 4 A (1A) / 0.5 to 20 A (5A) (step 0.01 A)
Earth current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Phase current pickup $I_p>$ with directional element	0.1 to 4 A(1 A) / 0.5 to 20 A(5 A) (step 0.01 A)
Earth current pickup $3I_{0P}>$ with directional element	0.05 to 25(1 A) / 0.25 to 20 A(5 A) (step 0.01 A)

Tripping characteristics

Tripping time characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time inverse
Tripping time characteristics acc. to ANSI/IEEE (not for DE region, see selection and ordering data 10th position)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Time multiplier for IEC characteristics T	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Time multiplier for ANSI characteristics D	D_{IP} = 0.5 to 15 (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 I/I_p (ANSI: I/I_p = M)
Reset threshold	Approx. 1.05 x I/I_p (ANSI: I/I_p = M)
Tolerances	
Operating time for 2 ≤ I/I_p ≤ 20	≤ 5 % of setpoint ± 15 ms

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Operating mode	Active only with connected auxiliary contacts
Characteristic	2 independent stages
Pickup current $I>>>$	0.1 to 15 A (1A) / 0.5 to 75 A (5A) (step 0.01 A) or deactivated
Pickup current $I>>>>$	1 to 25 A (1A) / 5 to 125 A (5A) (step 0.01 A) or deactivated
Reset ratio	Approx. 0.95
Tolerances	
Current starting	≤ 3 % of setting value or 1 % I_N

Auto-reclosure (ANSI 79)

Number of auto-reclosures	Up to 8
Operating modes with line voltage check	Only 1-pole; only 3-pole, 1 or 3-pole, adaptive AR Discrimination between successful and non-successful reclose attempts
Dead times $T_{1\text{-}ph}$, $T_{3\text{-}ph}$, T_{Seq}	0.01 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
CLOSE command duration	0.01 to 30 s (steps 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V

Technical data

Breaker failure protection (ANSI 50BF)

Number of stages	2
Pickup of current element	0.05 to 20 A (1A) / 0.25 to 100 A (5A) (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	CB synchronism monitoring
Reset time	10 ms, typical
Tolerances	
Current limit value	≤ 3 % of setting value or 1 % I_N
Time stages	1 % of setting value or 10 ms

Voltage protection (ANSI 59, 27)

Operating modes	Local tripping or only indication
Overvoltage protection	
Pickup values $V_{PH-Gnd}>>$, $V_{PH-Gnd}>$ (phase-ground (earth) overvoltage)	1 to 170 V (step 0.1 V) or deactivated
Pickup values $V_{PH-PH}>>$, $V_{PH-PH}>$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Pickup values $3V_0>>$, $3V_0>$ ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V) or deactivated
Pickup values $V_1>>$, $V_1>$ (positive-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values $V_2>>$, $V_2>$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{PH-Gnd}<<$, $V_{PH-Gnd}<$ (phase-ground (earth) undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Pickup values $V_{PH-PH}<<$, $V_{PH-PH}<$ (phase-phase undervoltage)	1 to 175 V (step 0.1 V) or deactivated
Pickup values $V_1<<$, $V_1<$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all over- and undervoltage stages	0 to 100 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 40 ms
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms

Frequency protection (ANSI 81)

Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground (earth))
Pickup times	Approx. 85 ms
Dropout times	Approx. 30 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	12 m Hz for V = 29 to 230 V
Delay times	1 % of the setting value or 10 ms

Restricted earth-fault protection (ANSI 87N)

Multiple availability	2 times (option)
Settings	
Differential current $I_{REF}>/I_{Nobj}$	0.05 to 2.00 (steps 0.01)
Limit angle φ REF	110 ° (fixed)
Time delay T_{REF}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
The set times are pure delay times	

Operating times

Pickup time (in ms) at frequency	50 Hz	60 Hz
At 1.5 · setting value $I_{REF}>$, approx.	35	30
At 2.5 · setting value $I_{REF}>$, approx.	33	29
Dropout time (in ms), approx.	26	23
Dropout ratio, approx.	0.7	

Overcurrent-time protection for phase and residual currents

Multiple availability	3 times (option)
Characteristics	
Definite-time stages (DT)	$I_{Ph}>>$, $3I_0>>$, $I_{Ph}>$, $3I_0>$
Inverse-time stages (IT)	I_P, $3I_{0P}$
Acc. to IEC	Inverse, very inverse, extremely inverse, long-time inverse
Acc. to ANSI	Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)	Acc. to ANSI with disk emulation

Current stages

High-current stages	$I_{Ph}>>$	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IPh}>>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0>>$	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{3I0}>>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stages	$I_{Ph}>$	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	T_{IPh}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0>$	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{3I0}>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)

Technical data

Inverse-time stages	I_P	0.10 to 4.00 A [1]	(steps 0.01 A)
Acc. to IEC	T_{IP}	0.05 to 3.20 s or deactivated (no trip)	(steps 0.01 s)
	$3I_{0P}$	0.05 to 4.00 A [1]	(steps 0.01 A)
	T_{3I0P}	0.05 to 3.20 s or deactivated (no trip)	(steps 0.01 s)
Inverse-time stages	I_P	0.10 to 4.00 A [1]	(steps 0.01 A)
Acc. to ANSI	D_{IP}	0.50 to 15.00 s or deactivated (no trip)	(steps 0.01 s)
	$3I_{0P}$	0.05 to 4.00 A [1]	(steps 0.01 A)
	D_{3I0P}	0.50 to 15.00 s or deactivated (no trip)	(steps 0.01 s)

Thermal overload protection (ANSI 49)

Setting range	
Factor k to IEC 60255.8	0.1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{Alarm}/\Theta_{Trip}$	50 to 100 % referred to tripping temperature (steps 1 %)
Current-based alarm stage I_{alarm}	0.1 to 4 $A_{(1A)}$ / 0.5 to 5 $A_{(5A)}$ (steps 0.01 A)
Calculating mode for overtemperature	Θ_{max}, Θ_{mean}, Θ with I_{max}
Pickup time characteristic	$t = \tau \ln \dfrac{I^2 - I_{pre}^2}{I^2 - (k\, I_N)^2}$
Reset ratio	
Θ/Θ_{Alarm}	Approx. 0.99
Θ/Θ_{Trip}	Approx. 0.99
$I\,/\,I_{Alarm}$	Approx. 0.99
Tolerances	Class 10 % acc. to IEC 60255-8

Additional functions

Operational measured values

Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; I_E; I_1; I_2
Tolerances	
10 to 50 % I_N	Typical ≤ 1 % of 50 % I_N
50 to 200 % I_N	Typical ≤ 1 % of measured value
Voltages	3 x $V_{Phase\text{-}Earth}$; 3 x $V_{Phase\text{-}Phase}$; $3V_0$, V_1, V_2, V_{en}
Tolerances	
10 to 50 % V_N	Typical ≤ 1 % of 50 % V_N
50 to 200 % V_N	Typical ≤ 1 % of measured value
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert\cos\varphi\rvert = 0.7$ to 1 and V/V_N, $I/I_N = 50$ to 120 %	Typical ≤ 3 %
Q: for $\lvert\sin\varphi\rvert = 0.7$ to 1 and V/V_N, $I/I_N = 50$ to 120 %	Typical ≤ 3 %
S: for V/V_N , $I/I_N = 50$ to 120 %	Typical ≤ 2 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	p.f. (cos φ)
Tolerance for $\lvert\cos\varphi\rvert = 0.7$ to 1	Typical ≤ 3 %
Remote measurements	3 x $I_{Phase\text{-}Earth}$; 3 I_0, 3 x $V_{Phase\text{-}Earth}$; $3V_0$
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}

Fault record storage

Measured analog channels	3 x I_{Phase}, $3I_0$, $3I_{Diff}$ 3 x V_{Phase}, $3V_0$, $3I_{Restraint}$
Max. number of available recordings	8, backed up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 10 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user

Further additional functions

Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor
Indications	
Operational indications	Buffer size 200
System disturbance indication	Storage of signals of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operations Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE cycle per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, CB test, status display of binary indication inputs, setting of output relays, generation of indications for testing serial interfaces, commissioning support via Web-browser, test mode, commissioning mode

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Short code
7SD61 numerical line differential protection *87L SIPROTEC 4 for two-line ends,* allows transformers in the protection zone	*7SD610* ☐ - ☐☐☐☐☐ - ☐☐☐☐ - ☐☐☐	

see next page

Current transformers

I_{ph} = 1 A 1), I_e = 1 A 1)	*1*
I_{ph} = 5 A 1), I_e = 5 A 1)	*5*

Auxiliary voltage

(Power supply, BI operating voltage)

24 to 48 V DC, trigger level binary input 19 V 3)	*2*
60 to 125 V DC 2), trigger level binary input 19 V 3)	*4*
110 to 250 V DC 2), 115 to 230 V AC, trigger level binary input 88 V 3)	*5*
110 to 250 V DC 2), 115 to 230 V AC, trigger level binary input 176 V 3)	*6*

Housing, number of binary inputs/outputs

Flush-mounting housing with screw-type terminals 1/3 19", 7 BI, 5 BO, 1 live-status contact	*B*
Surface-mounting housing with screw-type terminals 1/3 19", 7 BI, 5 BO, 1 live-status contact	*F*
Flush-mounting housing with plug-in term., 1/3 19", 7 BI, 5 BO , 1 live-status contact	*K*

Region-specific default settings/ function versions and language settings

Region DE, German language (language changeable)	*A*
Region world, English language (language changeable)	*B*
Region US, US-English language (language changeable)	*C*
Region world, French language (language changeable)	*D*
Region world, Spanish language (language changeable)	*E*
Region world, Italian language (language changeable)	*F*

System interfaces, functions and hardware

Without system interface	*0*
IEC 60870-5-103 protocol, electric RS232	*1*
IEC 60870-5-103 protocol, electric RS485	*2*
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*
Further protocols see supplement L	*9*

L 0 ☐

PROFIBUS DP slave, RS485	*A*
PROFIBUS DP slave, optical 820 nm, double ring, ST connector 4)	*B*
MODBUS, RS485	*D*
MODBUS, optical 820 nm, ST connector 4)	*E*
DNP 3.0, RS485	*G*
DNP 3.0, optical 820 nm, ST connector 4)	*H*
IEC 61850, 100 Mbit Ethernet electrical, double, RS45 connector (EN 100)	*R*
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC connector 5)	*S*

BI = Binary input
BO = Binary output

---

1) Rated current 1/5 A can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) Setting of the BI thresholds can be made for each binary input via jumpers in 3 steps.

4) Not possible for surface mounting housing (Order No. pos. 9 = *F*). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and an external FO-converter

5) Not possible for surface mounting housing (Order No. pos. 9 = *F*) please order the relay with electrical interface and use a separate fiber-optic switch

Selection and ordering data

Description	Order No.	Short code
7SD61 numerical line differential protection 87L SIPROTEC 4 (continued)	*7SD610☐-☐☐☐☐☐-☐☐☐☐-☐☐☐*	

DIGSI/Modem interface (on rear of device) and protection interface 1	*9*	*M☐☐*
DIGSI/Modem interface (on rear of device) DIGSI 4, electrical RS232		*1*
DIGSI 4, electrical RS485		*2*

Protection data interface 1	
FO5: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication converter or direct FO connection [1]	*A*
FO6: Optical 820 nm, 2 ST-plugs, line length up to 3.5 km via multimode FO cable for direct FO connection	*B*
FO17: Optical 1300 nm, LC-Duplex-plugs, line length up to 24 km [2] via monomode FO cable for direct FO connection [2]	*G*
FO18: Optical 1300 nm, LC-Duplex-plugs, line length up to 60 km via monomode FO cable for direct FO connection [2][3]	*H*
FO19: Optical 1550 nm, LC-Duplex-plugs, line length up to 100 km via monomode FO cable for direct FO connection [2][4]	*J*
FO30: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication networks with IEEE C37.94 interface or direct FO connection [5]	*S*

Functions 1	
Trip mode 3-pole only without auto reclosure	*0*
Trip mode 3-pole only with auto reclosure	*1*
Trip mode 1- and 3-pole without auto reclosure	*2*
Trip mode 1- and 3-pole with auto reclosure	*3*

Back-up functions	
with emergency or back-up overcurrent protection	*B*
without with emergency or back-up overcurrent and breaker failure protection	*C*
with directional – emergency or back-up overcurrent protection	*R*
with directional – emergency or back-up overcurrent and breaker failure protection	*S*

Additional functions 1

4 Remote commands/ 24 Remote indications	Transformer expansions	Voltage-/frequence protection	Restricted earth fault (low impedance)	
				A
		■		*B*
	■			*E*
	■	■		*F*
■				*J*
■		■		*K*
■	■			*N*
■	■	■		*P*
■	■		■	*S*
■	■	■	■	*T*

without external GPS synchronisation of differential protection	*0*
with external GPS synchronisation of differential protection	*1*

---

1) Communication converter 7XV5662, see Accessories.

2) Device for surface mounting housing (Order No. pos. 9 = *F*) will be delivered with external repeater 7XV5461-0Bx00.

3) For distances less than 25 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.

4) For distances less than 50 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.

5) Only available in flush-mounting housing (Order No. pos. 9 = *B*, *K*).

Accessories

Description	Order No.
Opto-electric communication converter CC-XG (connection to communication network)	
Converter to interface to X21 or RS422 or G703-64 kbit/s synchronous communication interfaces Connection via FO cable for 62.5 / 125 µm or 50 / 120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via X21/RS422 or G703-64 kbit/s interface	*7XV5662-0AA00*
Opto-electric communication converter CC-2M to G703-E1/-T1 communication networks with 2,048 / 1,554 kbit/s	
Converter to interface between optical 820 nm interface and G703-E1/-T1 interface of a communication network Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via G703-E1/-T1 interface	*7XV5662-0AD00*
Opto-electric communication converter (connection to pilot wire)	
Converter to interface to a pilot wire or twisted telephone pair (typical 15 km length) Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector; max. distance 1.5 km, screw-type terminals to pilot wire	*7XV5662-0AC00*
Additional interface modules	
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km	*C53207-A351-D651-1*
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	*C53207-A351-D652-1*
Further modules	
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*C53207-A351-D655-1*
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*C53207-A351-D656-1*
Protection data interface mod. opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	*C53207-A351-D657-1*
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km support of IEEE C37.94	*C53207-A351-D658-1*
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*7XV5461-0BG00*
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*7XV5461-0BH00*
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	*7XV5461-0BJ00*
Time synchronizing unit with GPS output	
GPS 1 sec pulse and time telegram IRIG B/DCF 77	*7XV5664-0AA00*
Isolation transformer (20 kV) for pilot wire communication	*7XR9516*
Voltage transformer miniature circuit-breaker	
Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	*3RV1611-1AG14*

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000/XP Professional) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000/XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Manual for 7SD61 V4.6 English	*C53000-G1176-C145-4*


LSP2089-afpen.tif

Fig. 7/35 Mounting rail for 19" rack


LSP2090-afpen.eps

Fig. 7/36
2-pin connector


LSP2091-afpen.eps

Fig. 7/37
3-pin connector


LSP2093-afpen.eps

Fig. 7/38
Short-circuit link for current terminals


LSP2092-afpen.eps

Fig. 7/39
Short-circuit link for voltage terminals/ indications terminals

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	7/36
	3-pin	*C73334-A1-C36-1*	1	Siemens	7/37
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	*0-539635-1*	1	AMP 1)	
	and matching female	*0-539668-2*		AMP 1)	
	For CI2	*0-734372-1*	1	AMP 1)	
	and matching female	*1-734387-1*		AMP 1)	
19" mounting rail		*C73165-A63-D200-1*	1	Siemens	7/35
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	7/38
	For other terminals	*C73334-A1-C34-1*	1	Siemens	7/39
Safety cover for terminals	Large	*C73334-A1-C31-1*	1	Siemens	
	Small	*C73334-A1-C32-1*	1	Siemens	

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

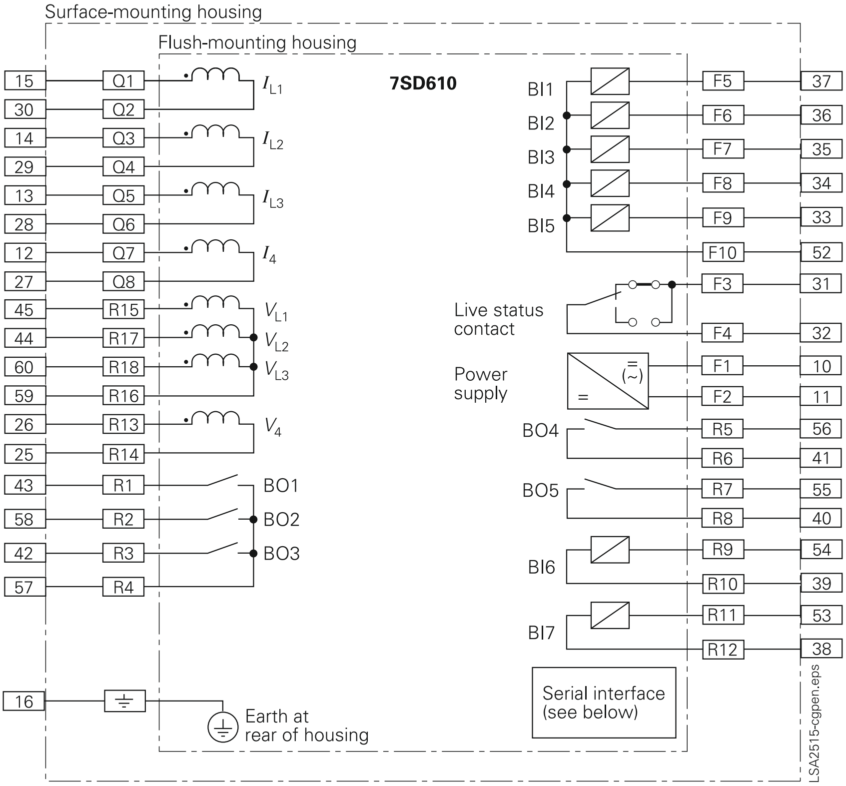


Fig. 7/40
Connection diagram

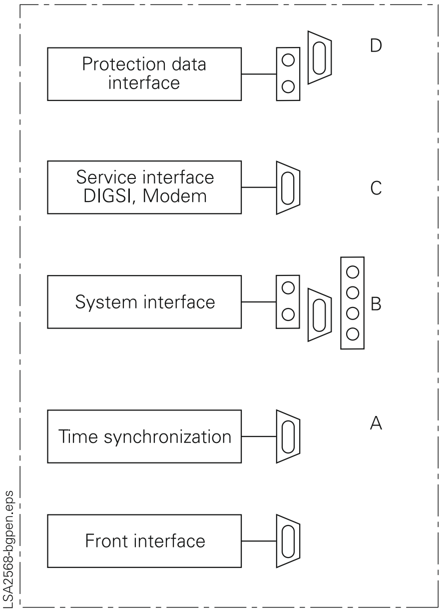


Fig. 7/41
Serial interfaces

SIPROTEC 4 7SD52/53
Multi-End Differential and Distance Protection in One Relay

Fig. 7/42
SIPROTEC 4
7SD52/53 differential protection relay

Description

The 7SD52/53 relay provides full scheme differential protection and incorporates all functions usually required for the protection of power lines. It is designed for all power and distribution levels and protects lines with two up to six line ends. The relay is designed to provide high-speed and phase-selective fault clearance. The relay uses fiber-optic cables or digital communication networks to exchange telegrams and includes special features for the use in multiplexed communication networks. Also pilot wires connections can be used with an external converter. This contributes toward improved reliability and availability of the electrical power system.

The relay is suitable for single and three-phase tripping applications for two up to six line ends. Also, transformers and compensation coils within the differential protection zone are protected as are serial and parallel-compensated lines and cables. The relays may be employed with any type of system earthing.
The relay also provides a full-scheme and non-switched distance protection as an optional main 2 protection. Several teleprotection schemes ensure maximum selectivity and high-speed tripping time.

The units measure the delay time in the communication networks and adaptively match their measurements accordingly.

A special GPS-option allows the use of the relays in communication networks, where the delay time in the transmit and receive path may be quite different.

The 7SD52/53 has the following features:

- 2 full-scheme main protections in one unit (differential and distance protection)
- High-speed tripping 10 - 15 ms
- The serial protection data interfaces (R2R interfaces) of the relays can flexibly be adapted to the requirements of all communication media available.
- If the communication method is changed, flexible retrofitting of communication modules to the existing configuration is possible.
- Tolerates loss of one data connection in a ring topology (routing in 120 ms). The differential protection scheme is fully available in a chain topology.
- Browser-based commissioning tool.
- Fault locator for one and two terminal measurement for high accuracy on long lines with high load and high fault resistance.
- Capacitive charge current compensation increases the sensitivity of the differential protection on cables and long lines.

Function overview

Protection functions

- Differential protection with phase-segregated measurement (87L, 87T)
- Restricted earth-fault protection (87N) if a transformer is within the protection zone
- Sensitive meas. stage f. high-resist. faults
- Non-switched distance protection with 7 measuring systems (21/21N)
- High resistance ground (earth)-fault protection for single and three-pole tripping (50N/51N/67N)
- Phase-selective intertripping (85)
- Earth-fault detection in isolated and resonant-earthed networks
- Tele (pilot) protection (85/21, 85/67N)
- Weak-infeed protection (27WI)
- Fault locator (FL)
- Power swing detection/tripping (68/68T)
- 3-stage overcurrent protection (50, 50N, 51, 51N)
- STUB bus protection (50 STUB)
- Switch-onto-fault protection (50HS)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79), Synchro-check (25)
- Breaker failure protection (50BF)
- Overload protection (49)
- Lockout function (86)

Control functions

- Commands f. ctrl of CB and isolators

Monitoring functions

- Self-supervision of relay and protection data (R2R) communication
- Trip circuit supervision (74TC)
- Measured-value supervision
- Oscillographic fault recording
- Event logging/fault logging
- Switching statistics

Front design

- User-friendly local operation
- PC front port for relay setting
- Function keys and 14 LEDs f. local alarm

Communication interfaces

- 2 serial protection data (R2R) interfaces for ring and chain topology
- Front interface for connecting a PC
- System interface for connection to a control system via various protocols
  - IEC 61850 Ethernet
  - IEC 60870-5-103
  - PROFIBUS-FMS/-DP and DNP 3.0
- Rear-side service/modem interface
- Time synchronization via IRIG-B or DCF77 or system interface

Application

ANSI		ANSI	
87L	Δ *I* for lines / cables	50HS	Instantaneous high-current tripping (switch-onto-fault)
87T	Δ *I* for lines / cables with transformers	59 27	Overvoltage/undervoltage protection
87N	Low impedance restricted earth-fault protection for transformers	81O/U	Over/underfrequency protection
85	Phase-selective intertrip, remote trip	25	Synchro-check
86	Lockout function	79	Single or three-pole auto-reclosure with new adaptive technology
21 21N	Distance protection	49	Overload protection
FL	Fault locator	50BF	Breaker failure protection
68 68T	Power swing detection/tripping	74TC	Trip circuit supervision
85/21	Teleprotection for distance protection	50-STUB	STUB bus protection
27WI	Weak-infeed protection		
50N 51N 67N	Directional earth(ground)-fault protection		
85/67N	Teleprotection for earth (ground)-fault protection		
50 50N 51 51N	Three-stage overcurrent protection		

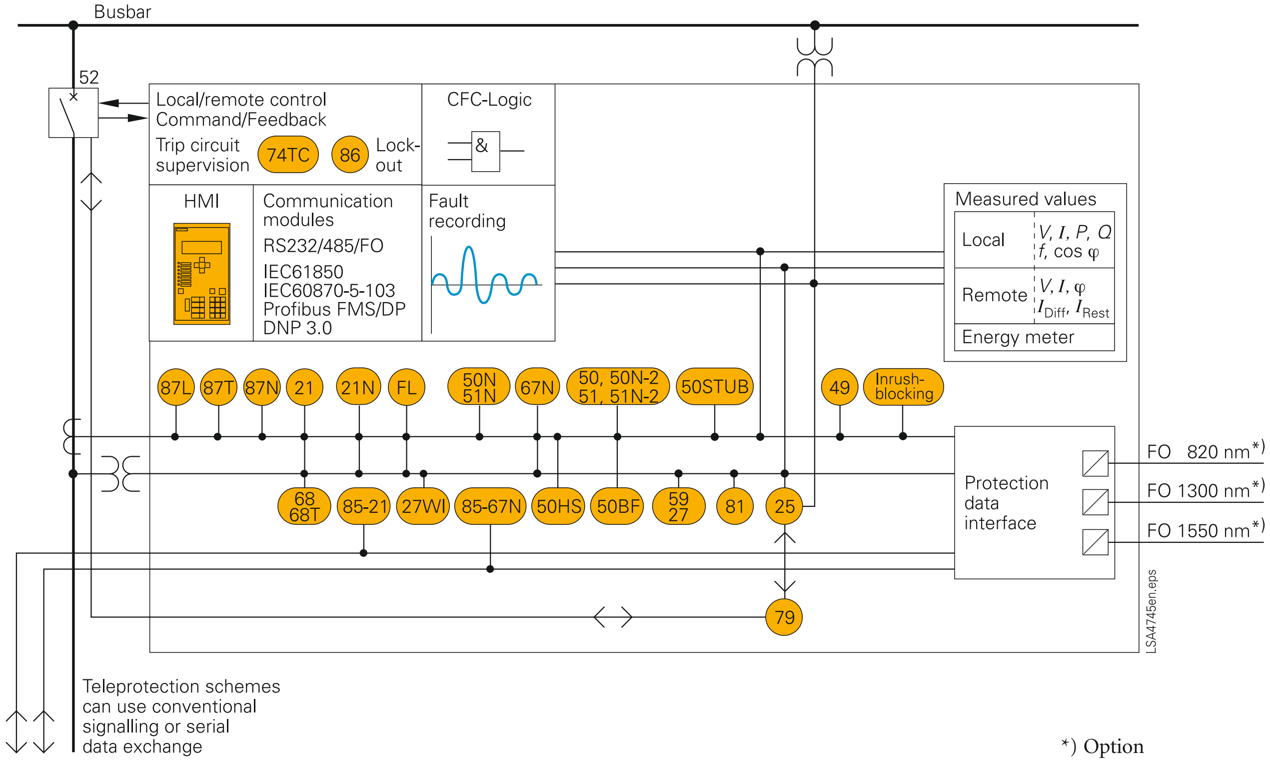


Fig. 7/43

Application

Typical applications

SIPROTEC 7SD52/53 is a full-scheme differential protection relay for two up to six line ends, incorporating all the additional functions for protection of overhead lines and cables at all voltage levels. Also transformers and compensation coils within the protection zone are protected. The 7SD52/53 is suitable for single-pole and three-pole tripping. The power system star point can be solid or impedance-grounded (earthed), resonant-earthed via Peterson coil or isolated. On the TAP-line, the 7SD52/53 differential relay is connected to current (CT) and optionally voltage (VT) transformers. For the differential functions, only CTs are necessary. By connecting the relay to VTs, the integrated "main 2" distance protection can be applied (full-scheme, nonswitched). Therefore, no separate distance protection relay is required.

The link to the other relays is made by multi-mode or mono-mode FO cables. There are 5 options available, which correspondingly cover:

- 820 nm, up to 1.5 km, multi-mode
- 820 nm, up to 3.5 km, multi-mode
- 1300 nm, up to 24 km, mono-mode
- 820 nm support of the IEEE C37.94 interface
- 1300 nm, up to 60 km, mono-mode
- 1550 nm, up to 100 km, mono-mode

Direct fiber-optic connection offers high-speed data exchange with 512 kbit/s and improves the speed for remote signaling.

At the main line two differential relays are connected to CTs. The communication is made via a multiplexed communication network.

The 7SD52/53 offers many features to reliably and safely handle data exchange via communication networks.

Depending on the bandwidth available in the communication system, 64, 128 or 512 kbits/s can be selected for the X21 (RS422) interface; the G703 interface with 64 kbit/s, and G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s). Furthermore the 7SD610 supports the IEEE C37.94 interface with 1/2/4 and 8 timeslots.

The connection to the communication device is effected via cost-effective 820 nm interface with multi-mode FO cables. A communication converter converts the optical to electrical signals. This offers an interference-free and isolated connection between the relay and the communication device.

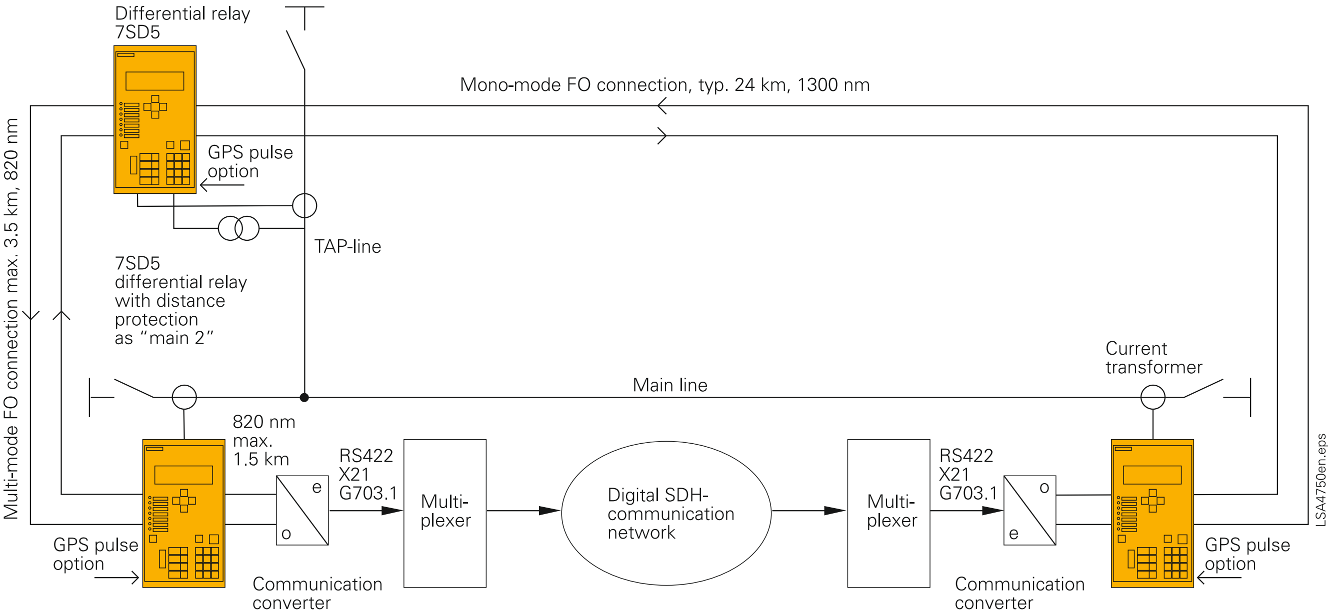


Fig. 7/44 Application for three line ends (Ring topology)

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy- to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control or interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

Construction

Connection techniques and housing with many advantages

1/3, 1/2, 2/3, and 1/1-rack sizes:
These are the available housing widths of the 7SD52/53 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option. It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Fig. 7/45
Flush-mounting housing with screw-type terminals

Fig. 7/46
Rear view of flush-mounting housing with covered connection terminals and wirings

Fig. 7/47
Surface-mounting housing with screw-type terminals

Fig. 7/48
Communication interfaces in a sloped case in a surface-mounting housing

Protection functions

Differential protection (ANSI 87L, 87T, 87N)

The differential protection function has the following features:

- It is possible to select the operating mode as "main" or as "main 1", if the back-up distance protection is activated as "main 2".
- Measurements are performed separately for each phase; thus the trip sensitivity is independent of the fault type.
- An adaptive, sensitive measurement method with high sensitivity for differential fault currents below the rated current offers the detection of highly resistive faults. This trip element uses special filters, which offers high security even with high level DC-components in the short-circuit current. The trip time of this stage is about 30 ms.
- A high-set differential trip stage which clears differential fault currents higher than the rated current within 10 – 15 ms offers fast tripping time and high-speed fault clearence time.
- When a long line or cable is switched on, transient charge currents load the line. To avoid a higher setting of the sensitive differential trip stage, this setpoint may be increased for a settable time. This offers greater sensitivity under normal load conditions.
- With the setting of the CT-errors the relay automatically calculates the restraint/stabilization current and adapts its permissible sensitivity according to the CT's data in the differential configuration, optimizing sensitivity.
- Different CT ratios at the line ends are handled inside the relay. The mismatch of 1 to 6 is allowed.
- The differential protection trip can be guarded with an overcurrent pickup. Thus differential current and overcurrent lead to a final trip decision.
- Easy to set tripping characteristic. Because the relay works adaptively, only the setpoint $I_{\text{Diff}}>$ (sensitive stage) and $I_{\text{Diff}}>>$ (high-set current differential stage) must be set according to the charge current of the line/cable.
- With an optional capacitive charge current compensation, the sensitivity can be increased to 40 % of the normal setting of $I_{\text{DIFF}}>$. This function is recommended for long cables and long lines.
- Differential and restraint currents are monitored continuously during normal operation and are displayed as operational measurements.
- High stability during external faults even with different current transformers saturation level. For an external fault, only 5 ms saturation-free time are necessary to guarantee the stability of the differential configuration.
- With transformers or compensation coils in the protection zone, the sensitive trip stage can be blocked by an inrush detection function. It works with the second harmonic of the measured current which is compared with the fundamental component.
- With transformers in the protection zone, vector group adaptation and matching of different CT ratios are carried out in the relay. Additionally, the zero-sequence current flowing through an earthed neutral is eliminated from the differential measurement. The 7SD52/53 therefore works like a transformer differential relay, whereas the line ends may be far away.
- A more sensitive protection for transformers within the protection zone is given by measurement of the star-point current on an earthed winding. Therefore the I_E current measuring input has to be used.

  If the sum of the phase currents of winding is compared with the measured star-point current, a sensitive earth-current differential protection (REF) can be implemented.

  This function is substantially more sensitive than the differential protection during faults to earth in a winding, detecting fault currents as small as 10 % of the transformer rated current.

Enhanced communication features for communication networks

The data required for the differential calculations are cyclically exchanged in full-duplex mode in form of synchronous, serial telegrams between the protection units. The telegrams are secured with CRC check sums, so that transmission errors in a communication network are immediately detected.

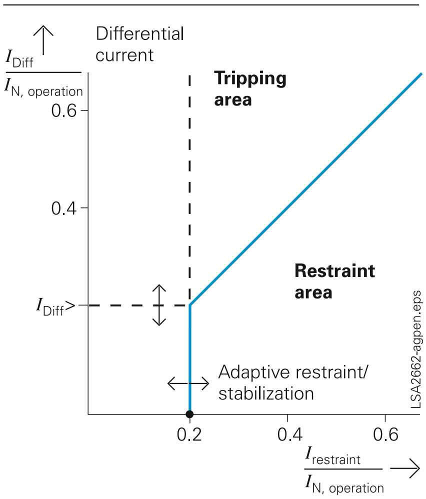


Fig. 7/49 Tripping characteristic

- Data communication is immune to electromagnetic interference because fiber-optic cables are employed in the critical region
- Supervision of each individual incoming telegram and of the entire communication path between the units without additional equipment.
- Unambiguous identification of each unit is ensured by assignment of a settable communication address within a differential protection topology. Only those units mutually known to each other can cooperate. Incorrect interconnection of the communication links results in blocking of the protection system.
- Detection of reflected telegrams in the communication system.
- Detection of delay time changes in communication networks.
- Measurement of the delay time to the remote line ends with dynamic compensation of the delay in the differential measurement. Supervision of the maximum permissible delay time is included.
- Generation of alarms on heavily disturbed communication links. Faulty telegram counters are available as operational measurement.
- With a GPS high-precision 1-s pulse from a GPS receiver the relays can be synchronized with an absolute, exact time at each line end. In this way, the delay in the receive and transmit path can be measured exactly. With this optional feature the relay can be used in communication networks where this delay times are quite different.

Protection functions

Phase-selective intertrip and remote trip/indications

Normally the differential fault current is calculated for each line end nearly at the same time. This leads to fast and uniform tripping times. Under weak infeed conditions, especially when the differential function is combined with an overcurrent pickup a phase-selective intertrip offers a tripping of all line ends.

- 7SD52/53 has 4 intertrip signals which are transmitted in high-speed (< 20 ms) to the other line ends. These intertrip signals can also be initiated by an external relay via binary inputs and therefore be used to indicate, for example, a directional decision of the backup distance relay.
- In addition, 4 high-speed remote trip signals are available, which may be initiated by an external or internal event.
- 24 remote signals can be freely assigned to inputs and outputs at each line end and are circulating between the different devices.

Communication topologies / modes of operation

The differential relays may work in a ring or daisy chain line topology. Use of a test mode offer advantages under commissioning and service conditions.

- The system tolerates the loss of one data connection in a ring topology. The ring topology is rerouted within 20 ms forming then a chain topology, while the differential protection function is immediately reactivated.
- When the communication connections need to be reduced or when these are not available, the whole system is able to function without interruption as chain topology. At the line ends, only cost-effective 7SD52/53 relays with one protection data interface are necessary for this application.
- The two-end line is a special case, because when the main connection is interrupted, the communication switches over from a main path to a secondary path. This hot standby transmission function ensures a high availability of the system and protects differential protection against communication route failure on important lines.

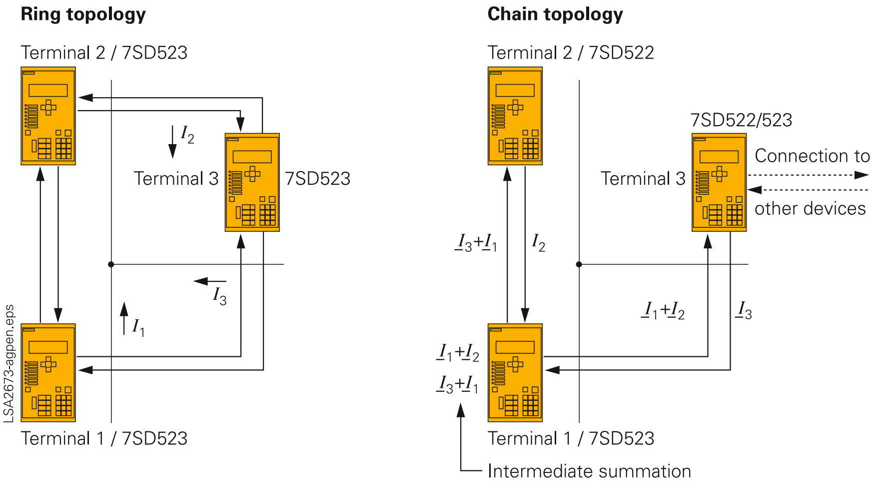


Fig. 7/50 Differential protection in ring or chain topology

- In a ring topology, one line end can be logged out from the differential protection topology for service or maintenance reasons by a signal via binary input. Checks for the breaker position and load current are made before this logout is initiated. In a chain topology, the relays at the end of the line can be logged out from the differential protection topology.
- The whole configuration can be set up into a test mode. All functions and indications are available except the breakers are not tripped. The local relay can be tested and no trip or intertrip reaction is effected by the other relays.

Protection functions

Distance protection (ANSI 21, 21N)

7SD52/53 provides a non-switched distance protection featuring all well-proven algogrithms of 7SA522 and 7SA6. It is possible to select the operating mode "main" or "main 2", if the back-up differential is activated as "main 1". By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of faults. The shortest tripping time is less than one cycle. All methods of neutral-point connection (resonant earthing, isolated, solid or low-resistance earthing) are reliably dealt with. Single and three-pole tripping is possible. Overhead lines can be equipped with or without series capacitor compensation.

Quadrilateral and mho characteristics

The 7SD52/53 relay provides quadrilateral as well as mho zone characteristics. Both characteristics can be used separately for phase and ground (earth) faults. Resistance ground (earth) faults can, for instance, be covered with the quadrilateral characteristic and phase faults with the mho characteristic.

Alternatively, the quadrilateral characteristic is available with 4 different pickup methods:

- Overcurrent pickup *I*>>
- Voltage-dependent overcurrent pickup *V*/*I*
- Voltage-dependent and phase angle-dependent overcurrent pickup *V*/*I*/φ
- Impedance pickup *Z*<

Load zone

In order to guarantee a reliable discrimination between load operation and short-circuit – especially on long high loaded lines – the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The distance protection incorporates a well-proven highly sophisticated phase selection algorithm. The pickup of unfaulted loops is reliably eliminated to prevent the adverse influence of currents and voltages in the fault-free loops. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range.

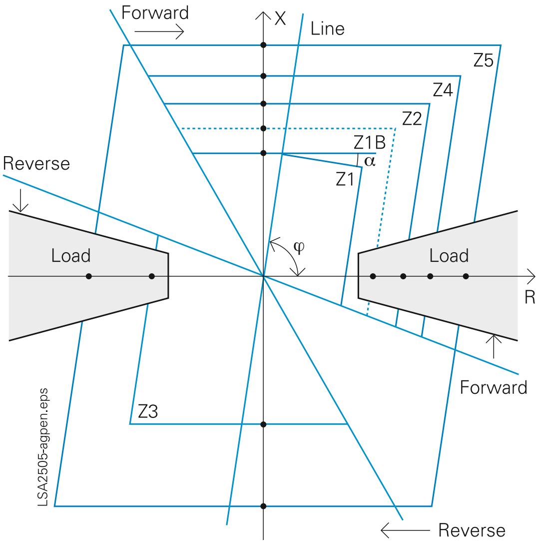


Fig. 7/51
Distance protection: quadrilateral characteristic

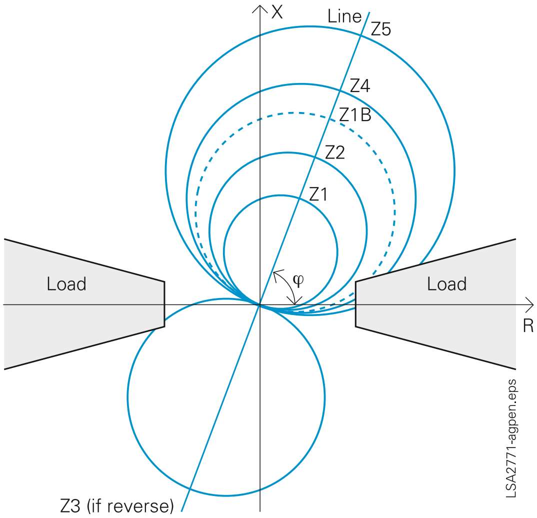


Fig. 7/52
Distance protection: mho characteristic

Parallel line compensation

The influence of wrong distance measurement due to parallel lines can be compensated by feeding the neutral current of the parallel line to the relay. Parallel line compensation can be used for distance protection as well as for fault locating.

7 distance zones

6 independent distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partly separate for single-phase or multiphase faults. Ground (earth) faults are detected by monitoring the neutral current 3I_0 and the zero-sequence voltage 3V_0.

The quadrilateral tripping characteristic permits separate setting of the reactance *X* and the resistance *R*. The resistance section *R* can be set separately for faults with and without earth involvement. This characteristic has therefore an optimal performance in case of faults with fault resistance. The distance zones can be set forward, reverse or non-directional. Sound phase polarization and voltage memory provides a dynamically unlimited directional sensitivity.

Mho

The mho tripping characteristic provides sound phase respectively memory polarization for all distance zones. The diagram shows characteristic without the expansion due to polarizing. During a forward fault the polarizing expands the mho circle towards the source so that the origin is included. This mho circle expansion guarantees safe and selective operation for all types of faults, even for close-in faults.

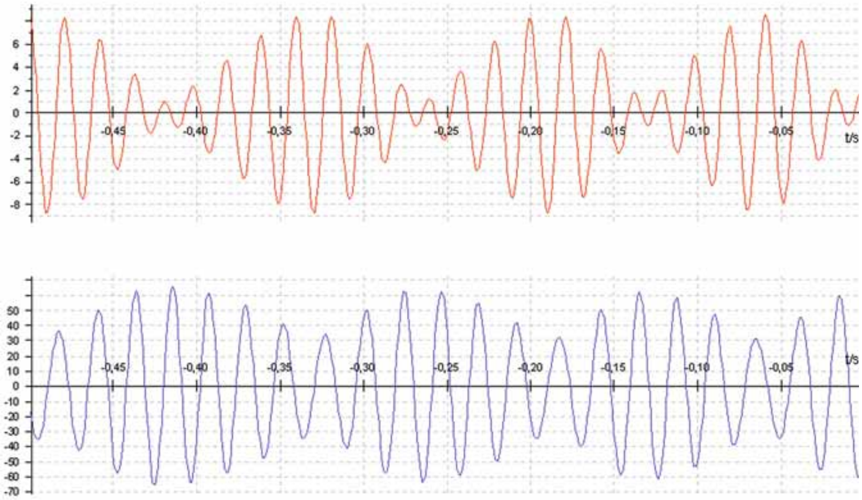


Fig. 7/53
Power swing current and voltage wave forms

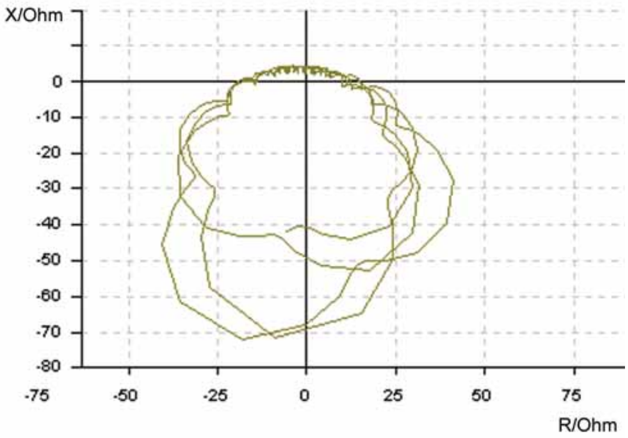


Fig. 7/54
Power swing circle diagram

Protection functions

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.

The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and, in this case, the EMERGENCY definite-time overcurrent protection can be activated.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SD52/53 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- PUTT, permissive underreaching zone transfer trip
- POTT, permissive overreaching zone transfer trip
- UNBLOCKING
- BLOCKING
- Directional comparison pickup
- Pilot-wire comparison
- Reverse interlocking
- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function)

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are power-line carrier, microwave radio and fiber-optic links. The serial protection data interface can be used for direct connection to a digital communication network, fiber-optic or pilot-wire link as well.

7SD52/53 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if two single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines).

Phase-selective transmission is also possible with multi-end applications, if some user-specific linkages are implemented by way of the integrated CFC logic. During disturbances in the transmission receiver or on the transmission circuit, the teleprotection function can be blocked by a binary input signal without losing the zone selectivity. The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function.
A transient blocking function (Current reversal guard) is provided in order to suppress interference signals during tripping of parallel lines.

Protection functions

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SD52/53 relay is equipped with phase-selective “external trip inputs” that can be assigned to the received inter-trip signal for this purpose.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided.
If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate tripping at the weak-infeed end. A phase-selective 1-pole or 3-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-earth voltage drops correspondingly. As an option, the weak-infeed logic can be equipped according to a French specification.

Directional ground(earth)-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In grounded (earthed) networks, it may happen that the distance protection sensitivity is not sufficient to detect high-resistance ground (earth) faults. The 7SD52/53 protection relay has therefore protection functions for faults of this nature.

The ground (earth)-fault overcurrent protection can be used with 3 definite-time stages and one inverse-time stage (IDMT). A 4th definite-time stage can be applied instead of the 1st inverse-time stage.

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”). An additional logarithmic inverse-time characteristic is also available.

The direction decision can be determined by the neutral current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2. In addition or as an alternative to the directional determination with zero-sequence voltage, the star-point current of a grounded (earthed) power transformer may also be used for polarization. Dual polarization applications can therefore be fulfilled. Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or for both directions (non-directional). As an option the 7SD52/53 relay can be provided with a sensitive neutral (residual) current transformer. This feature provides a measuring range for the neutral (residual) current from 5 mA to 100 A with a nominal relay current of 1 A and from 5 mA to 500 A with a nominal relay current of 5 A. Thus the ground (earth)-fault overcurrent protection can be applied with extreme sensitivity.

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for low zero-sequence fault currents which usually have a high content of 3rd and 5th harmonics. Inrush stabilization and instantaneous switch-onto-fault trip can be activated separately for each stage as well.

Different operating modes can be selected. The ground(earth)-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional ground(earth)-fault protection (ANSI 85-67N)

The directional ground(earth)-fault overcurrent protection can be combined with one of the following teleprotection schemes:

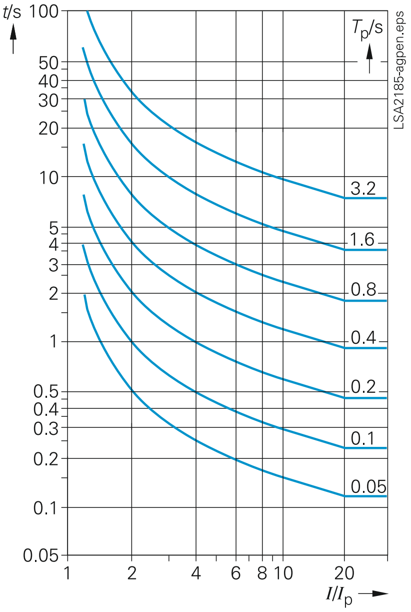
- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground(earth)-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N)

The 7SD52/53 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the neutral (residual) current. Two operating modes are selectable. The function can run in parallel to the differential protection and the distance protection or only during interruption of the protection communication and/or failure of the voltage in the VT secondary circuit (emergency operation). The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).



$$t = \frac{0.14}{\left(I/I_p\right)^{0.02} - 1} \cdot T_p$$

Fig. 7/55 Normal inverse

The following inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided:

- Inverse
- Short inverse
- Long inverse
- Moderately inverse
- Very inverse
- Extremely inverse
- Definite inverse

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated from a binary input signaling the line isolator (disconnector) is open. Settings are available for phase and ground (earth)-faults.

Protection functions

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast 3-pole tripping.

With lower fault currents, instantaneous tripping after switch-onto-fault is also possible

- if the breaker positions at the line ends are monitored and connected to the relays. This breaker position monitor offers a high-speed trip during switch-onto-fault conditions.
- with the overreach distance zone Z1B or just with pickup in any zone.

The switch-onto-fault initiation can be detected via the binary input "manual close" or automatically via measurement.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The result is displayed in ohms, miles, kilometers or in percent of the line length. Parallel line and load current compensation is also available.

As an option for a line with two ends, a fault locator function with measurement at both ends of the line is available. Thanks to this feature, accuracy of measurement on long lines under high load conditions and high fault resistances is considerably increased.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or are only lightly loaded. The 7SD52/53 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SD52/53 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Breaker failure protection (ANSI 50BF)

The 7SD52/53 relay incorporates a two-stage breaker failure protection to detect the failure of tripping command execution, for example due to a defective ciruit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command is generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Auto-reclosure (ANSI 79)

The 7SD52/53 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without earth, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without earth and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Adaptive auto-reclosure. Only one line end is closed after the dead time. If the fault persists this line end is switched off. Otherwise the other line ends are closed via a command over the communication links. This avoids stress when heavy fault currents are fed from all line ends again.
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).

Protection functions

- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed: When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g., checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Thermal overload protection (ANSI 49)

A built-in overload protection with a current and thermal alarm stage is provided for the thermal protection of cables and transformers. The trip time characteristics are exponential functions according to IEC 60255-8. The preload is thus considered in the trip times for overloads. An adjustable alarm stage can initiate an alarm before tripping is initiated.

Monitoring and supervision functions

The 7SD52/53 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

Current transformer / Monitoring functions

A broken wire between the CTs and relay inputs under load may lead to maloperation of a differential relay if the load current exceeds the differential setpoint. The 7SD52/53 provides fast broken wire supervision which immediatelly blocks all line ends if a broken wire condition is measured by a local relay. This avoids maloperation due to broken wire condition. Only the phase where the broken wire is detected is blocked. The other phases remain under differential operation.

Fuse failure monitoring

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit the distance protection would respond with an unwanted trip due to this loss of voltage. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Summation of currents and voltages

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only be issued after the lockout state is reset.

Local measured values

The measured values are calculated from the measured current and voltage signals along with the power factor (cos φ), the frequency, the active and reactive power. Measured values are displayed as primary or secondary values or in percent of the specific line rated current and voltage. The relay uses a 20 bit high-resolution AD converter and the analog inputs are factory-calibrated, so a high accuracy is reached. The following values are available for measured-value processing:

- Currents 3 x I_{Phase}, 3 I_0, I_E, $I_{E \text{ sensitive}}$
- Voltages 3 x $V_{\text{Phase-Ground}}$, 3 x $V_{\text{Phase-Phase}}$, 3 V_0,V_{en}, V_{SYNC}, V_{COMP}
- Symmetrical components I_1, I_2, V_1, V_2
- Real power P (Watt), reactive power Q (Var), apparent power S (VA)
- Power factor PF (= cos φ)
- Frequency f
- Differential and restraint current per phase
- Load impedances with directional indication
  3 x $R_{\text{Phase-Ground}}$, $X_{\text{Phase-Ground}}$
  3 x $R_{\text{Phase-Phase}}$, $X_{\text{Phase-Phase}}$
- Long term mean values
  3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q-; S
- Minimum/maximum memory
  3 x I_{Phase}; I_1; 3 x $V_{\text{Phase-Ground}}$
  3 x $V_{\text{Phase-Phase}}$, 3V_0; V_1; P+; P-; Q+; Q-; S; f; power factor (+); power factor (-);
  from mean values
  3 x I_{Phase}; I_1; P; Q; S
- Energy meters
  W_{p+}; W_{p-}; W_{Q+}; W_{Q-}
- Availability of the data connection to the remote line ends per minute and per hour
- Regarding delay time measuring with the GPS-version the absolute time for transmit and receive path is displayed separately.

Limit value monitoring: Limit values are monitored by means of the CFC. Commands can be derived from these limit value indications.

Protection functions

Measured values at remote line ends

Every two seconds the currents and voltages are freezed at the same time at all line ends and transmitted via the communication link. At a local line end, currents and voltages are thus available with their amount and phases (angle) locally and remotely. This allows checking the whole configuration under load conditions. In addition, the differential and restraint currents are also displayed. Important communication measurements, such as delay time or faulty telegrams per minute/hour are also available as measurements. These measured values can be processed with the help of the CFC logic editor.

Commissioning

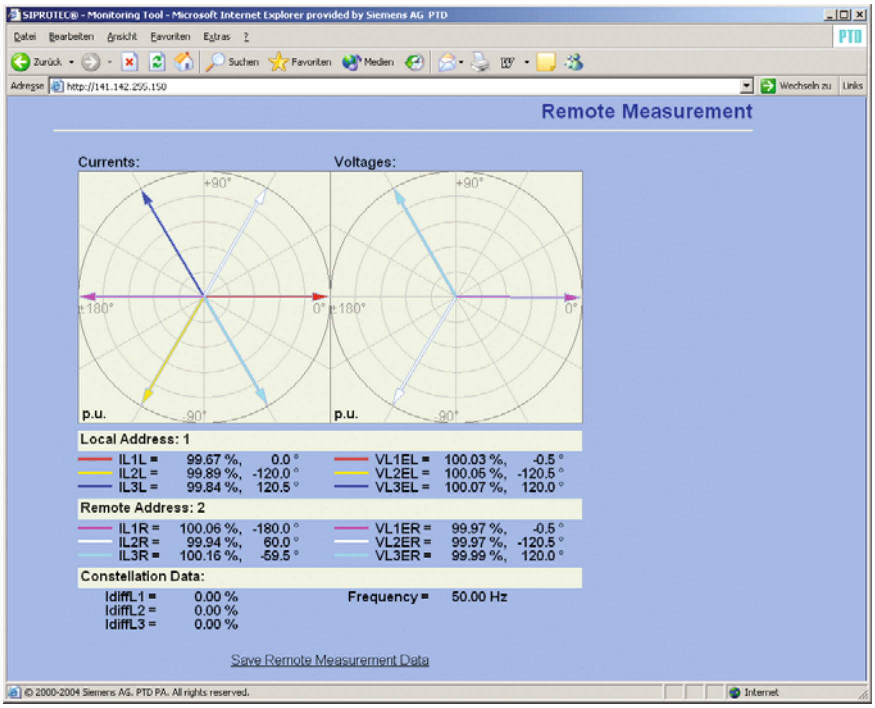
Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged.

Furthermore, all currents and optional voltages and phases are available via communication link at the local relay and are displayed in the relay, with DIGSI 4 or with the Web Monitor.

The operational and fault events and fault records from all line ends share a common time tagging which allows to compare events registered in the different line ends on a common time base.

WEB Monitor – Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. This program shows the protection topology and comprehensive measurements from local and remote line ends. Local and remote measurements are shown as phasors and the breaker positions of each line end are depicted. It is possible to check the correct connection of the current transformers or the correct vector group of a transformer.



Remote Measurement

Local Address: 1

IL1L = 99.67 %, 0.0 °
IL2L = 99.89 %, -120.0 °
IL3L = 99.84 %, 120.5 °
VL1EL = 100.03 %, -0.5 °
VL2EL = 100.05 %, -120.5 °
VL3EL = 100.07 %, 120.0 °

Remote Address: 2

IL1R = 100.06 %, -180.0 °
IL2R = 99.94 %, 60.0 °
IL3R = 100.16 %, -59.5 °
VL1ER = 99.97 %, -0.5 °
VL2ER = 99.97 %, -120.5 °
VL3ER = 99.99 %, 120.0 °

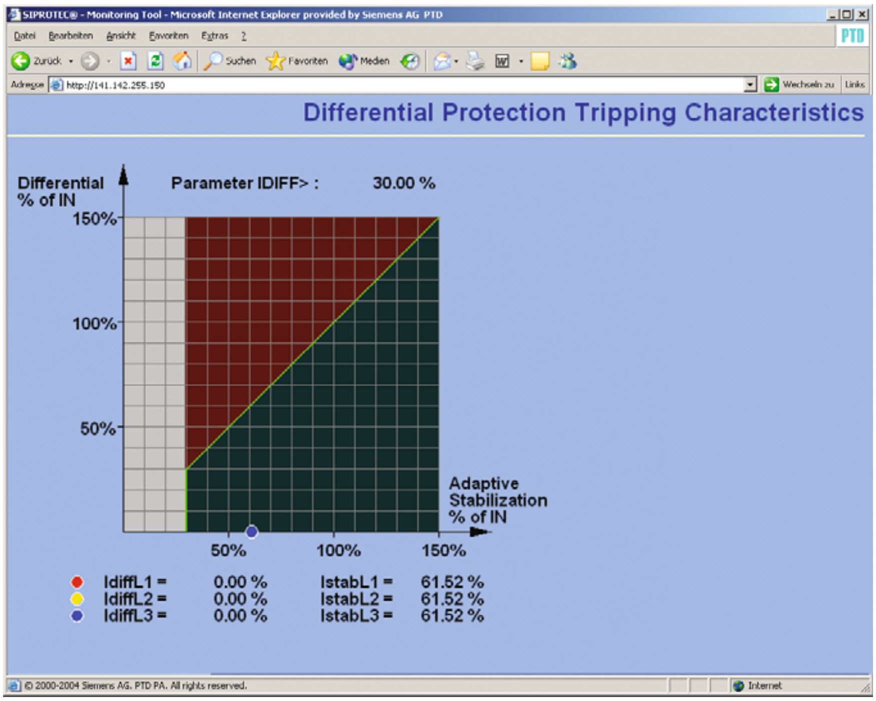
Constellation Data:

IdiffL1 = 0.00 %
IdiffL2 = 0.00 %
IdiffL3 = 0.00 %
Frequency = 50.00 Hz

Save Remote Measurement Data

© 2000-2004 Siemens AG. PTD PA. All rights reserved.

Fig. 7/56
Browser-aided commissioning: Phasor diagram



Differential Protection Tripping Characteristics

Parameter IDIFF> : 30.00 %

IdiffL1 = 0.00 %
IdiffL2 = 0.00 %
IdiffL3 = 0.00 %
IstabL1 = 61.52 %
IstabL2 = 61.52 %
IstabL3 = 61.52 %

© 2000-2004 Siemens AG. PTD PA. All rights reserved.

Fig. 7/57
Browser-aided commissioning:
Differential protection tripping characteristic

Stability can be checked by using the operating characteristic as well as the calculated differential and restraint values in the browser windows.
If the distance protection is active, then the valid zone characteristic (quadrilateral/mho) is displayed.

Event log and trip log messages are also available. Remote control can be used, if the local front panel cannot be accessed.

Protection functions

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation/user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

Rear-mounted interfaces

Two communication modules located on the rear of the unit incorporate optional equipment complements and readily permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces.

The interfaces make provision for the following applications:

- Service /modem interface
  By means of the RS232/RS485 or optical interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4 or standard browser. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants.
  With the optical version, centralized operation can be implemented by means of a star coupler.
- System interface
  This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7SD52/53, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to “Commissioning program”). The relays include a small Web server that sends its HTML pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 61850 Ethernet, IEC 60870-5-103, PROFIBUS-FMS/-DP, DNP 3.0, DIGSI, etc.) are required, such demands can be met.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

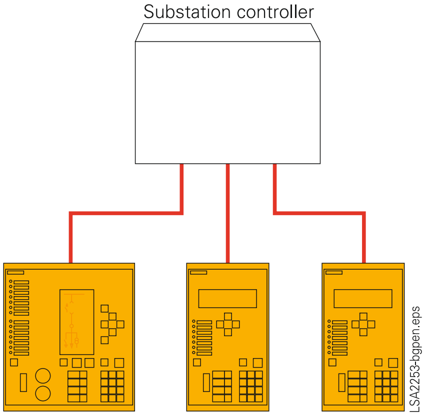


Fig. 7/58
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

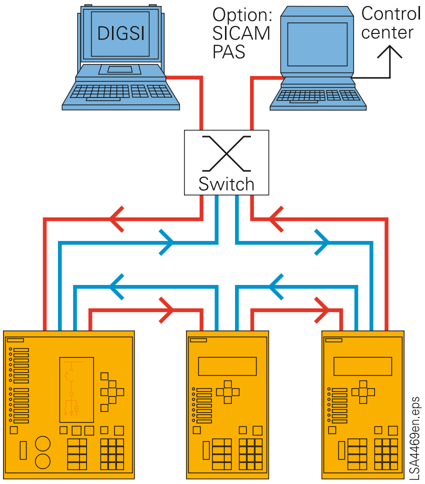


Fig. 7/59
Bus structure for station bus with Ethernet and IEC 61850

Communication

IEC 61850 Ethernet

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

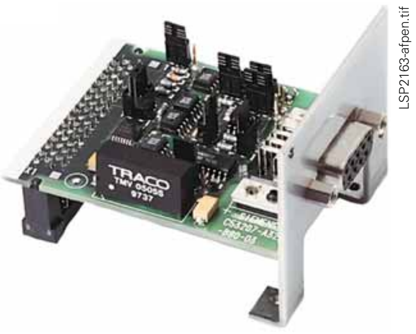


Fig. 7/60
RS232/RS485 electrical communication module

Fig. 7/61
PROFIBUS communication module, optical double-ring

Fig. 7/62
820 nm fiber-optic communication module

Fig. 7/63
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

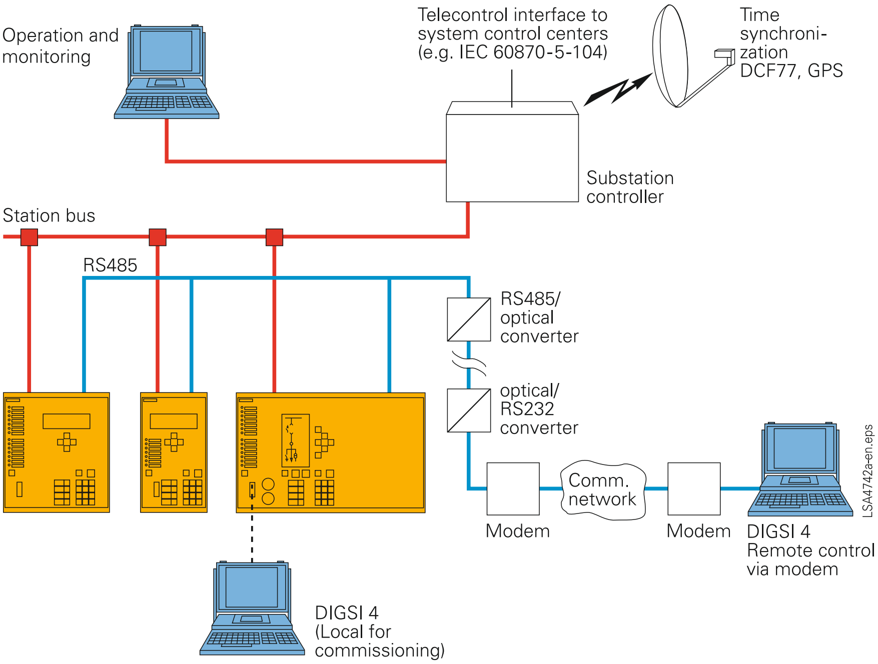


Fig. 7/64
System solution: Communications

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 7/58).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 7/59).

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

Serial protection data interface (R2R interface)

As an option, the 7SD52/53 provides one or two protection data interfaces to cover two up to six line end applications in ring or chain topology and hot standby communication between two line ends.

In addition to the differential protection function, other protection functions can use this interface to increase selectivity and sensitivity as well as covering advanced applications.

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Two and three-terminal line applications can be implemented without additional logic
- Signaling for directional ground(earth)-fault protection – directional comparison for high-resistance faults in solidly earthed systems
- Echo function
- Interclose command transfer with the auto-reclosure “Adaptive dead time” (ADT) mode
- 28 remote signals for fast transfer of binary signals

Flexible utilization of the communication channels by means of the programmable CFC logic

The protection data interfaces have different options to cover new and existing communication infrastructures.

- FO5[1], OMA1[2] module:
  820 nm fiber-optic interface with clock recovery/ST connectors for direct connection with multi-mode FO cable up to 1.5 km for the connection to a communication converter.
- FO6[1], OMA2[2] module:
  820 nm fiber-optic interface/ST connectors for direct connection up to 3.5 km with multi-mode FO cable.

New fiber-optic interfaces, series FO1x

- FO17[1]: For direct connection up to 24 km[3], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1]: For direct connection up to 60 km[3], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1]: For direct connection up to 100 km[3], 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30: 820 nm fiber-optic interface/ ST connectors for direct connection up to 1.5 km and for connections to a IEEE C37.94 multiplexer interface.

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703/-E1/-T1 interface. Furthermore the IEEE C37.94 interface is supported by the FO30 module.

For operation via copper wire communication (pilot wires or twisted telephone pair), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. The connection via FO cable to the relay is interference-free. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 8 km) and all three-wire protection systems using existing copper communication links.

Different communication converters are listed under "Accessories".

Communication data:

- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.
- Supported network interfaces X21/RS422 with 64 or 128 or 512 kbit/s; or G703-64 kbit/s and G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s).
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms) or IEEE C37.94.
- Protocol HDLC

---

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Communication

Communication possibilities between relays

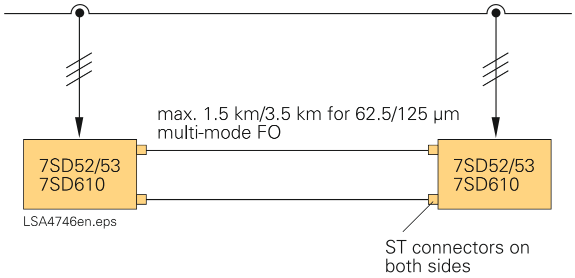


Fig. 7/65
Direct optical link up to 1.5 km/3.5 km, 820 nm

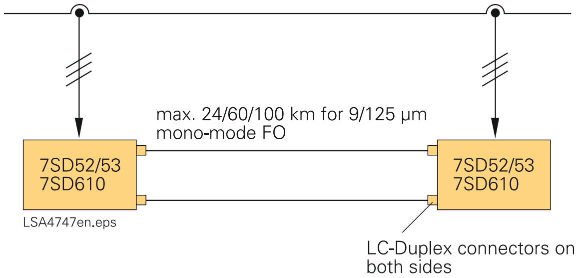


Fig. 7/66
Direct optical link up to 25/60 km with 1300 nm
or up to 100 km with 1550 nm

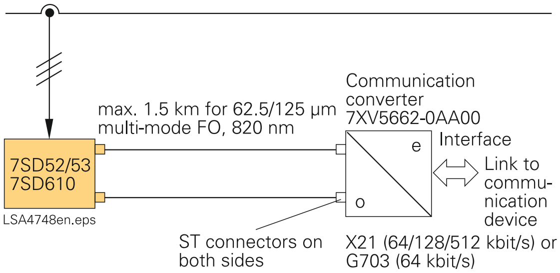


Fig. 7/67
Connection to a communication network CC-XG

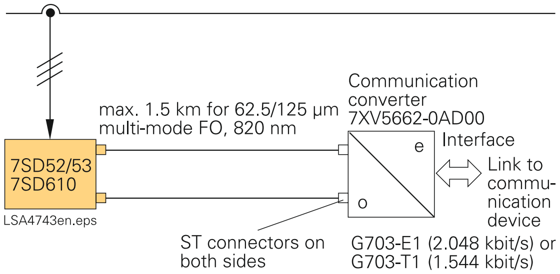


Fig. 7/68
Connection to a communication network CC-2M

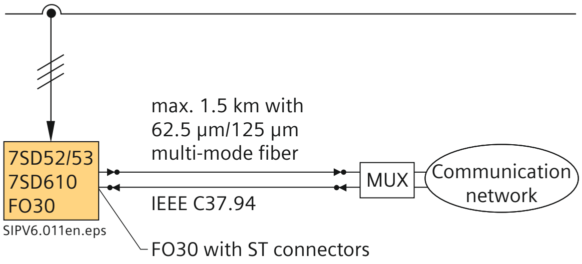


Fig. 7/69
Connection to a communication network via IEEE C37.94

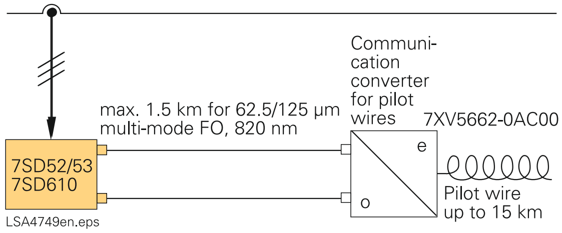


Fig. 7/70
Connection to a pilot wire

Typical connection

Typical connection for current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer (=$3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

Note:
Voltage inputs are always available in the relay. But there is no need to connect it to voltage transformers for the differential protection function.

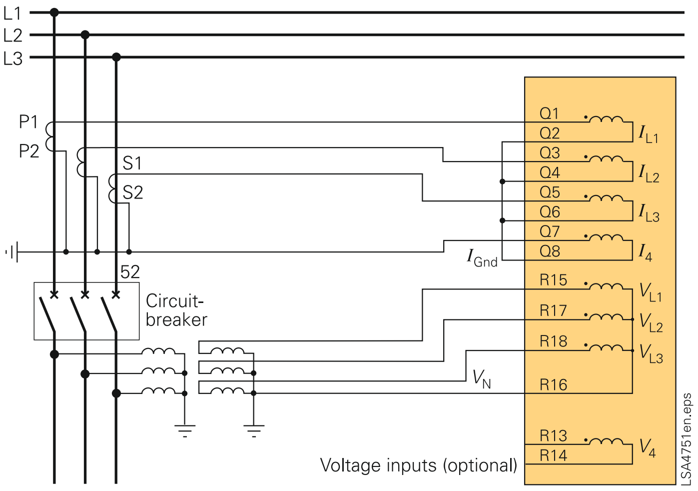


Fig. 7/71
Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core-balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 7/71, 7/76 or 7/77.

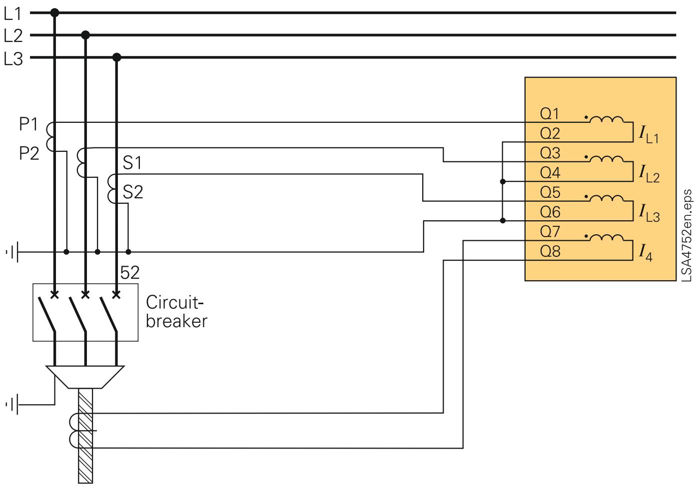


Fig. 7/72
Alternative connection of current transformers for sensitive ground(earth)-current measuring with core-balance current transformers

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for directional ground(earth)-fault protection. The voltage connection is effected in accordance with Fig. 7/71, 7/76 or 7/77.

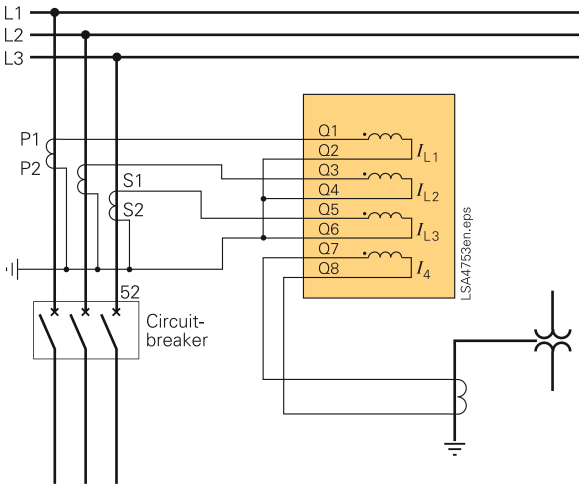


Fig. 7/73 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to the summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 7/71, 7/76 or 7/77.

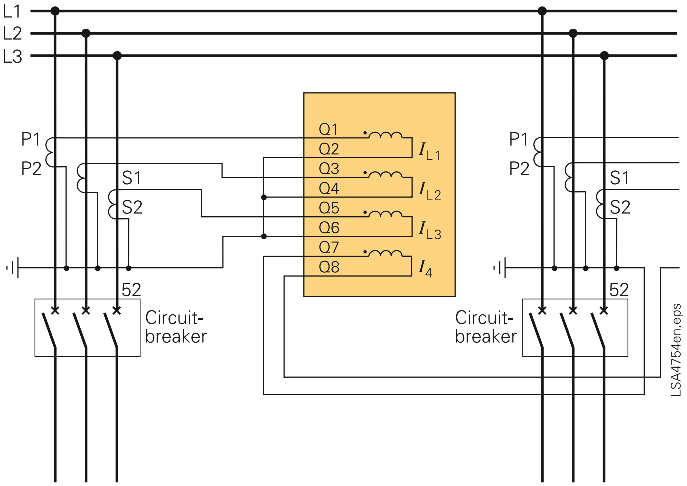


Fig. 7/74 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

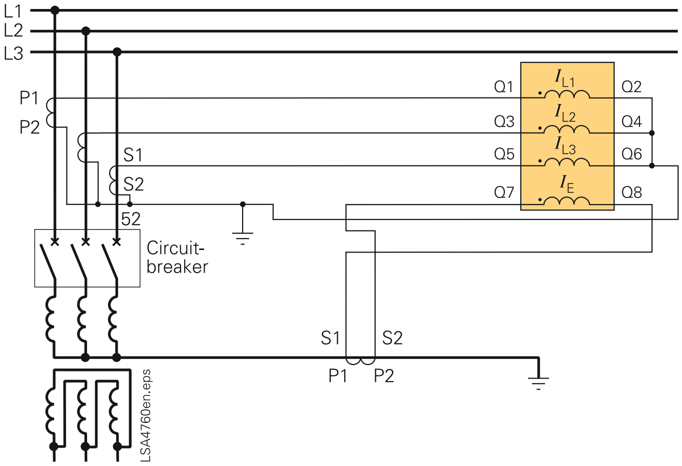


Fig. 7/75 Connection of current transformer with restricted earth-fault protection (REF)

Typical connection

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and ground(earth)-fault directional protection. The current connection is effected in accordance with Fig. 7/71, 7/72, 7/73 and 7/74.

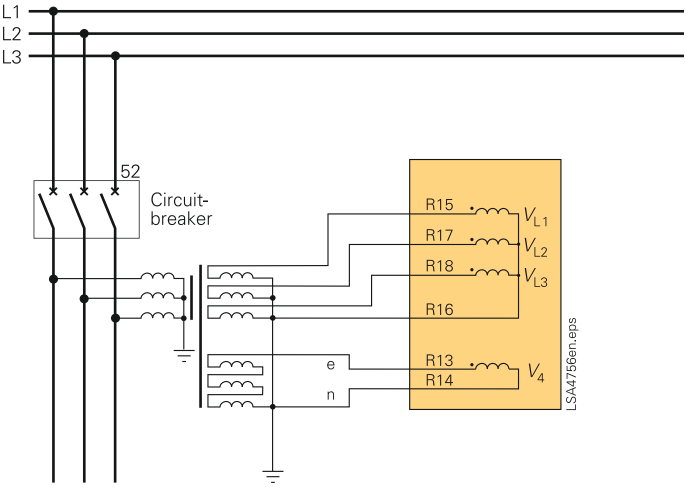


Fig. 7/76 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchro-check.

Note: Any phase-to-phase or phase-to-ground(earth) voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 7/71, 7/72, 7/73 and 7/74.

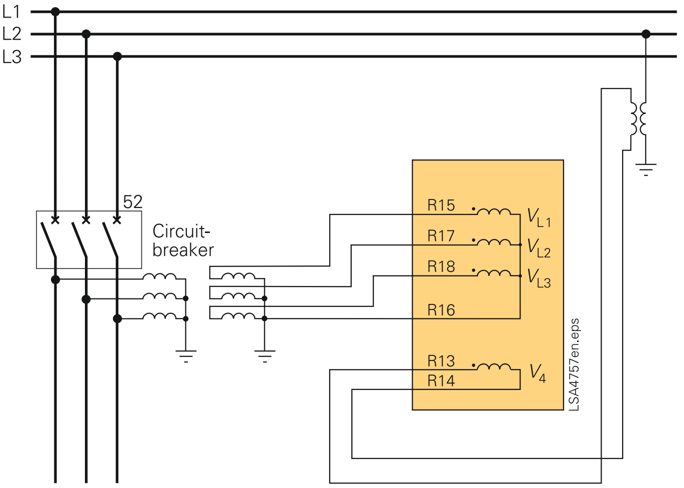


Fig. 7/77 Alternative connection of voltage transformers for measuring the busbar voltage

Technical data

General unit data

Analog inputs

Rated frequency	50 or 60 Hz (selectable)
Rated current I_N	1 or 5 A (selectable, controlled by firmware)
Rated voltage	80 to 125 V (selectable)
Power consumption	
In CT circuits with $I_N = 1$ A	Approx. 0.05 VA
In CT circuits with $I_N = 5$ A	Approx. 0.30 VA
In VT circuits	Approx. 0.10 VA
Thermal overload capacity	
In CT circuits	500 A for 1 s 150 A for 10 s 4 x I_N continuous
In VT circuits	230 V, continuous per phase
Dynamic overload capacity	
In CT circuits	1250 A (half cycle)
In the CT circuit for high sensitive earth-fault protection (refer to ordering code)	

Auxiliary voltage

Rated voltage	24 to 48 V DC 60 to 125 V DC 1) 110 to 250 V DC 1) and 115 V AC with 50/60 Hz1)
Permissible tolerance	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during auxiliary voltage failure V_{aux} 110 V AC/DC	≥ 50 ms

Binary inputs

Quantity Function can be assigned	8 or 16 or 24
Minimum permissible voltage Range is selectable with jumpers for each binary input	19 or 88 or 176 V DC, bipolar (3 operating ranges)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

Output relays

Quantity Function can be assigned	16 or 24 or 32
Switching capacity	
Make	1000 W /VA
Break	30 VA
Break (for resistive load)	40 W
Break (for $\tau = L/R \leq 50$ ms)	25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous

---

1) Ranges are settable by means of jumpers.

LEDs

	Quantity
RUN (green)	1
ERROR (red)	1
Indication (red), function can be assigned	14

Unit design

Housing 7XP20 1/2 x 19″ or 1/1 x 19″	See dimension drawings, part 15
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Rear	IP 50
Front	IP 51
For the terminals	IP 2x with cover cap
Weight	
Flush-mounting housing	
1/2 x 19″	6 kg
1/1 x 19″	10 kg
Surface-mounting housing	
1/2 x 19″	11 kg
1/1 x 19″	19 kg

Serial interfaces *(front of unit)*

Operating interface 1 for DIGSI 4 or browser

Connection	Front panel, non-isolated, RS232, 9-pin subminiature connector
Baud rate	4800 to 115200 baud

Time synchronization *(rear of unit)*

IRIG-B/DCF77/SCADA or 1 sec pulse from GPS (format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D)
Voltage levels	5 or 12 or 24 V
Dielectric test	500 V/50 Hz

Service interface (operating interface 2) for DIGSI 4 / modem / service

Isolated RS232/RS485	9-pin subminiature connector
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485, depends on the baud rate	Max. 1000 m
Fiber-optic	Integrated ST connector
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	Max. 1.5 km

System interface

(refer to ordering code)	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

Technical data

System interface, continued

PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kB; 100 m at 12 MB
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[2]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	500 kB/s 1.6 km, 1500 kB/s 530 m

Protection data interface (R2R interface)

FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 8 dB
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 16 dB
New fiber-optic interfaces, series FO1x	
FO17[1]: for direct connection up to 24 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 13 dB
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB

Relay communication equipment

External communication converter 7XV5662-0AA00 for communication networks ***X21/G703-64 kbit/s***

External communication converter to interface between the relays, optical 820 nm interface and the X21(RS422) G703-64 kbit/s interface of a communication device	
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers	
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable to device side
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector
G703-64 kbit/s electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal

External communication converter 7XV5662-0AD00 for communication networks with G703-E1 or G703-T1

External communication converter to interface between the relays, optical 820 nm interface and G703-E1 or G703-T1 interface of a communication network.	
Inputs: 2 fiber-optic inputs 820 nm, 1RS232 input	Max. 1.5 km with 62.5/125µm multi-mode 1 FO cable to device side
Output:	
G703.5	E1: 2,048 kbit/s
G703.6	T1: 1,554 kbit/s
Electrical interface on communication network	max. 800 m, screw-type terminal

External communication converter 7XV5662-0AC00 for pilot wires

External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Typical distance	15 km
Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable
Pilot wire	Screw-type terminal 5 kV isolated
Permissible time delay (duration of data transmission)	
Delay of telegrams due to transmission for one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path Permissible max. value can be selected

Electrical tests

Specifications

Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 For further standards see "Individual functions"

Insulation tests

Standards	IEC 60255-5
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50/60 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50/60 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for noise immunity; *type tests*

Standards	IEC 60255-6, IEC 60255-22 (product standards) (type tests) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz

---

[1] For flush-mounting housing.

[2] For surface-mounting housing.

[3] For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Technical data

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min
High-energy surge voltages (SURGE) IEC 61000-4-5, installation class III	
Auxiliary supply	Common mode: 2 kV, 12 Ω, 9 µF Differential mode: 1 kV; 2 Ω, 18 µF
Measurements inputs, binary inputs, binary outputs	Common mode: 2 kV, 42 Ω, 0.5 µF Differential mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz; 0.5 mT; 50 MHz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz Damped wave; 50 surges per second; Duration 2 s; $R_i = 150\ \Omega$ to $200\ \Omega$
Fast transient surge withstand capability, ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference, IEEE C37.90.2	35 V/m; 25 to 1000 MHz amplitude and pulse-modulated
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz 1, 10 and 50 MHz, $R_i = 200\ \Omega$

EMC tests for interference emission; type tests

Standard	EN 50081-* (generic standard)
Conducted interference voltage on lines, only auxiliary supply, IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 othogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis), 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis), 8 to 35 Hz: 1 *g* acceleration (horizontal axis), 8 to 35 Hz: 0.5 *g* acceleration (vertical axis), frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60255-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks each in both directions of the 3 axes

Climatic stress tests

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F

Humidity

Permissible humidity stress It is recommended to arrange the units in such a way, that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Yearly average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; condensation is not permitted

Functions

Differential protection (ANSI 87L, 87T)

Sensitive normal trip stage $I_{\text{Diff}}>$

Setting range of $I_{\text{Diff}}>$ secondary 1 A secondary 5 A	 0.1 to 20 A (step 0.1) 0.5 to 100 A
Tripping time (three line ends) $I_{\text{Diff}} > 2.5 \times I_{\text{Diff}} >$ (setting)	50 Hz Min. 27 ms Typ. 29 ms 60 Hz Min. 24 ms Typ. 26 ms

Delay time of $I_{\text{Diff}}>$ trip stage

Delay time	0 to 60 s (step 0.01 s)

Capacitive current load compensation

Restraint ratio $I_{\text{C STAB}} / I_{\text{CN}}$	2 to 4 (steps 0.1)

High-set fast trip stage $I_{\text{Diff}}>>$

Setting range $I_{\text{Diff}}>>$ secondary 1 A secondary 5 A	 0.8 to 100 A (step 0.1) 4 to 500 A (step 0.5)
Tripping time (three line ends) $I_{\text{Diff}} \geq 2.5 \times I_{\text{Diff}}>>$ (setting)	Min. 9 ms1) Typ. 12 ms1)

1) Ordering option with high-speed contacts required.

Technical data

Vector group adaptation with transformers in the differential zone	
Adaptation of connection symbol	0 to 11 (x 30 °) (step 1)
Neutral point connection	Grounded (earthed) or not grounded (earthed) (for each winding)
Inrush restraint	
Restraint ratio 2nd harmonic I_{2fN}/I_{fN}	 10 % to 45 % (step 1 %)
Max. current for restraint	1.1 A to 25 A 1) (step 0.1 A)
Crossblock function	Can be switched on and off
Max. operative time for crossblock $T_{\text{oper crossblk}}$	0 to 60 s (step 0.01 s) or deactivated (operating up to release)
***Distance protection** (ANSI 21, 21N)*	
Distance protection zones	6, 1 of which as controlled zone, all zones can be set forward or/and reverse
Time stages for tripping delay Setting range	6 for multi-phase faults 3 for single-phase faults 0 to 30 s or deactivated (steps 0.01 s)
Characteristic Selectable separately for phase and ground (earth) faults	(refer to ordering code) quadrilateral and/or Mho (only impedance pickup)
Types of pickup	Overcurrent pickup ($I>$); Voltage-dependent overcurrent pickup ($V< / I>$); Voltage-dependent and phase angle-dependent overcurrent pickup ($V< / I> / \varphi>$); Impedance pickup ($Z<$)
Types of tripping	Three-pole for all types of faults; Single-pole for single-phase faults / otherwise three-pole; Single-pole for single-phase faults and two-pole phase-to-phase faults / otherwise three-pole
Time range	0 to 30 s (step 0.01 s) or deactivated
Line angle φ_L	30 ° to 89 ° (step 1 °)
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Quadrilateral reactance reach X	0.05 to 600 Ω(1A) / 0.01 to 120 Ω(5A) (step 0.001 Ω)
Quadrilateral resistance reach R for phase-to-phase faults and phase-to-ground(earth) faults	 0.05 to 600 Ω(1A) / 0.01 to 120 Ω(5A) (step 0.001Ω)
Mho impedance reach ZR	0.05 to 200 Ω(1A) / 0.01 to 40 Ω(5A) (step 0.01 Ω)
Minimum phase current I	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Overcurrent pickup $I>>$ (for $I>>$, $V</I>$, $V</I>/\varphi>$)	0.25 to 10 A (1A) / 1.25 to 50 A (5A) (step 0.01 A)
Minimum current pickup $I>$ (for $V</I>$, $V</I>/\varphi>$ and $Z<$)	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Minimum current pickup $I_\varphi>$ (for $V</I>$, $V</I>/\varphi>$)	0.1 to 8 A (1A) / 0.5 to 40 A (5A) (step 0.01 A)
Undervoltage pickup (for $V</I>$ and $V</I>/\varphi>$) $V_{\text{ph-e}}<$ $V_{\text{ph-ph}}<$	 20 to 70 V (step 1 V) 40 to 130 V (step 1 V)
Load angle pickup (for $V</I>/\varphi>$) Load angle φ Load angle φ	 30 ° to 80 ° 90 ° to 120 °

Ground(earth)-fault pickup Neutral (residual) current $3I_0$ (Ground current)	 0.05 to 4 A (1A)/ 0.25 to 20 A (5A) (step 0.01 A)
Zero-sequence voltage $3V_0>$ for earthed networks for resonant-earthed networks	 1 to 100 V (step 1 V) or deactivated 10 to 200 V (step 1 V)
Zero-sequence compensation Selectable input formats	 R_E/R_L and X_E/X_L k_0 and $\varphi(k_0)$
Separately selectable for zones	Z1 higher zones (Z1B, Z2 to Z5)
R_E/R_L and X_E/X_L	-0.33 to 7 (step 0.01)
k_0 $\varphi(k_0)$	0 to 4 (step 0.001) -135 to 135 ° (step 0.01 °)
Parallel line mutual compensation R_M/R_L and X_M/X_L	(refer to ordering code) 0.00 to 8 (step 0.01)
Phase reference on double earth-faults in resonant-earthed/ non-earthed network	Phase preference or no preference (selectable)
Load encroachment Minimum load resistance	 0.10 to 600 Ω(1A) / 0.02 to 120 Ω(5A) (step 0.001 Ω) or deactivated
Maximum load angle	20 to 60 ° (step 1 °)
Directional decision for all types of faults	With sound phase polarization and/or voltage memory
Directional sensitivity	Dynamically unlimited
Tolerances Impedances (in conformity with DIN 57435, Part 303)	For sinusodial quantities $\left\lvert\frac{\Delta X}{X}\right\rvert \leq 5\ \%$ for $30° \leq \varphi_{SC} \leq 90°$ $\left\lvert\frac{\Delta R}{R}\right\rvert \leq 5\ \%$ for $0° \leq \varphi_{SC} \leq 60°$ $\left\lvert\frac{\Delta Z}{Z}\right\rvert \leq 5\ \%$ for $-30° \leq (\varphi_{SC} - \varphi_{line}) \leq +30°$
Response values (in conformity with DIN 57435, Part 303) V and I Angle (φ)	 ≤ 5 % of setting value ≤ 3 °
Timer tolerance	± 1 % of set value or 10 ms
Operating times Minimum trip time with fast relays Minimum trip time with high-speed relays Reset time	 Approx. 17 ms at 50 Hz Approx. 15 ms at 60 Hz Approx. 12 ms at 50 Hz Approx. 10 ms at 60 Hz Approx. 30 ms

1) Secondary data for I_N = 1 A; with I_N = 5 A the values must be multiplied.

Technical data

***Power swing detection** (ANSI 68, 68T)*

Power swing detection principle	Measurement of the rate of impedance vector change and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping (out-of-step tripping)
Power swing blocking programs	All zones blocked Z1/Z1B blocked Z2 to Z5 blocked Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults

***Tele (pilot) protection for distance protection** (ANSI 85-21)*

Modes of operation	PUTT (Z1B acceleration); DUTT PUTT (acceleration with pickup); POTT; Directional comparison; Reverse interlocking Pilot-wire comparison; Unblocking; Blocking
Additional functions	Echo function (refer to weak-infeed function) Transient blocking for schemes with measuring range extension
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines

Direct transfer trip (DTT)

Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0 to 30 s (step 0.01 s) or deactivated
Timer tolerance	± 1 % of setting value or 10 ms

Backup overcurrent protection (ANSI 50N, 51N)

Operating modes	Active only with loss of data connection and voltage or always active
Characteristics	3 definite-time stages / 1 inverse-time stage

***Definite-time stage** (ANSI 50, 50N)*

Pickup definite time stage 1, phase current	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 1, neutral (residual) current	0.5 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 2, phase current	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 2, neutral (residual) current	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 3, phase current	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 3, neutral (residual) current	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Time delay for definite-time stages	0 to 30 s, (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % of set value or 1 % of I_N
Delay times	± 1 % of set value or 10 ms
Operating time	Approx. 25 ms

***Inverse-time stage** (ANSI 51, 51N)*

Phase current pickup	0.1 to 4 A $_{(1A)}$ /0.5 to 20 A $_{(5A)}$ (step 0.01 A) or deactivated
Neutral (residual) current pickup	0.05 to 4 A $_{(1A)}$ /0.25 to 20 A $_{(5A)}$ (step 0.01 A) or deactivated
Characteristics	
Characteristics according to IEC 60255-3	Normal inverse Very inverse Extremely inverse Long time inverse
Time multiplier	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Pickup threshold	Approx. 1.1 x I / I_p
Reset threshold	Approx. 1.05 x I / I_p
Tolerances	
Operating time for 2 ≤I/I_p ≤ 20	≤ 5 % of setpoint ± 15 ms
Characteristics according to ANSI/IEEE	Inverse Short inverse Long inverse Moderately inverse Very inverse Extremely inverse Definite inverse
Time dial	0.5 to 15 (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 x M
Reset threshold	Approx. 1.05 x M
Tolerances	
Operating time for 2 ≤ M ≤ 20	≤ 5 % of setpoint ± 15 ms

***Instantaneous high-speed switch-onto-fault overcurrent protection** (ANSI 50HS)*

Operating mode	Active only after c.b. closing; instantaneous trip after pickup
Characteristic	2 definite-time stages
Pickup current I >>>	0.1 to 15 A $_{(1A)}$ /0.5 to 75 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup current I >>>>	1 to 25 A $_{(1A)}$/5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Reset ratio	Approx. 0.95
Tolerances	< 3 % of set value or 1 % of I_N

***Directional ground (earth)-fault overcurrent protection for high-resistance faults in systems with earthed star point** (ANSI 50N, 51N, 67N)*

Characteristic	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages or 3 definite-time stages / 1 $V_{0invers.}$ stage
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics	
Stages 1 and 2 (I>>> and I>>)	3rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 (I> and inverse 4th stage)	2nd and higher harmonics are completely suppressed by digital filtering

Technical data

Definite-time stage (ANSI 50N)

Pickup value $3I_0$>>>	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>>	0.2 to 25 A (1A) / 1 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Pickup value $3I_0$, 4th stage	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Time delay for definite-time stages	0 to 30 s (step 0.01 s) or deactivated
Tolerances Current pickup Delay times	 ≤ 3 % of setting value or 1 % I_N 1 % of setting value or 10 ms
Command / pickup times $3I_0$>>> and $3I_0$>>	Approx. 30 ms
Command / pickup times $3I_0$> and $3I_0$, 4th stage	Approx. 40 ms

Inverse-time stage (ANSI 51N)

Ground (earth)-current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7) 0.003 to 4 A (1A) / 0.015 to 20 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Tripping characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long inverse
ANSI/IEEE tripping characteristic (not for region DE, refer to ordering data, position 10)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Inverse logarithmic tripping characteristics (not for regions DE and US, refer to ordering data, position 10)	$t = T_{3I0\,\text{Pmax}} - T_{3I0\,\text{P}} \cdot \ln \frac{3I0}{3I0_{\text{p}}}$
Pickup threshold	1.1 to 4.0 x I/I_p (step 0.1 s)
Time multiplier for IEC T characteristics	T_p = 0.05 to 3 s (step 0.01 s)
Time multiplier for ANSI D characteristics	D_{I0P} = 0.5 to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 x I/I_p (ANSI: $I/I_p = M$)
Inverse logarithmic pickup threshold	1.1 to 4.0 x I/I_{0P} (step 0.1)
Reset threshold	Approx. 1.05 x I/I_{0P} (ANSI: $I/I_p = M$)
Tolerance Operating time for 2 ≤ I/I_p ≤ 20	 ≤ 5 % of setpoint ± 15 ms

Zero-sequence voltage protection $V_{0\text{inverse}}$

Tripping characteristic	$t = \dfrac{2\text{ s}}{\dfrac{V_0}{4} - V_{0\text{inv min}}}$

Direction decision (ANSI 67N)

Measured signals for direction decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_Y (star point current of an earthed power transformer) or $3I_2$ and $3V_2$ (negative-sequence system) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Min. current I_Y (of grounded (earthed) transformers)	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)

Inrush current blocking, capable of being activated for each stage

Component of the 2nd harmonic	10 to 45 % of the fundamental (step 1 %)
Max. current, which cancels inrush current blocking	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)

Tele (pilot) protection for directional ground(earth)-fault overcurrent protection (ANSI 85-67N)

Operating modes	Directional comparison: Pickup Directional comparison: Blocking Directional comparison: Unblocking
Additional functions	Echo (see function "weak infeed"); transient blocking for schemes with parallel lines
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines

Weak-infeed protection with undervoltage (ANSI 27WI)

Operating modes with carrier (signal) reception	Echo Echo and trip with undervoltage
Undervoltage phase – ground (earth)	2 to 70 V (step 1 V)
Time delay	0.00 to 30 s (step 0.01 s)
Echo impulse	0.00 to 30 s (step 0.01 s)
Tolerances Voltage threshold Timer	 ≤ 5 % of set value or 0.5 V ± 1 % of set value or 10 ms

Fault locator

Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or in % of line length
Start of calculation	With trip, with reset of pickup, with binary input
Reactance per unit length	0.005 to 6.5 Ω/km(1A) / 0.001 to 1.3 Ω/km(5A) (step 0.0001 Ω/km)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for 30 ° ≤ φ_{SC} ≤ 90 ° and V_{SC}/V_{nom} > 0.1

Technical data

Voltage protection (ANSI 59, 27)

Operating modes	Local tripping or only indication
Overvoltage protection	
Pickup values $V_{\text{PH-Gnd}}>>$, $V_{\text{PH-Gnd}}>$ (phase-ground (earth) overvoltage)	1 to 170 V (step 0.1 V) or deactivated
Pickup values $V_{\text{PH-PH}}>>$, $V_{\text{PH-PH}}>$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Pickup values $3V_0>>$, $3V_0>$ ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V) or deactivated
Pickup values $V_1>>$, $V_1>$ (positive-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values $V_2>>$, $V_2>$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{\text{PH-Gnd}}<<$, $V_{\text{PH-Gnd}}<$ (phase-ground (earth) undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Pickup values $V_{\text{PH-PH}}<<$, $V_{\text{PH-PH}}<$ (phase-phase undervoltage)	1 to 175 V (step 0.1 V) or deactivated
Pickup values $V_1<<$, $V_1<$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all over- and undervoltage stages	0 to 100 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms

Frequency protection (ANSI 81)

Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground (earth))
Pickup times	Approx. 80 ms
Dropout times	Approx. 80 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	12 m Hz for V = 29 to 230 V
Delay times	1 % of the setting value or 10 ms

Breaker failure protection (ANSI 50BF)

Number of stages	2
Pickup of current element	0.05 to 20 $A_{(1A)}$ / 0.25 to 100 $A_{(5A)}$ (step 0.01 A)
Time delays $T1_{\text{1phase}}$, $T1_{\text{3phase}}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Reset time	Approx. 15 ms, typical; 25 ms max.
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms

Auto-reclosure (ANSI 79)

Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1 or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{\text{1-ph}}$, $T_{\text{3-ph}}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage	30 to 90 V (step 1 V)
Dead line	2 to 70 V (step 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V

Synchro-check (ANSI 25)

Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	
with auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1 °)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 2 V

Technical data

Restricted earth-fault protection (ANSI 87N)

Multiple availability	2 times (option)	

Settings

Differential current $I_{REF}>/I_{Nobj}$	0.05 to 2.00	(steps 0.01)
Limit angle φ_{REF}	110 ° (fixed)	
Time delay T_{REF}	0.00 to 60.00 s or deactivated (no trip)	(steps 0.01 s)
The set times are pure delay times		

Operating times

Pickup time (in ms) at frequency	50 Hz	60 Hz
At 1.5 · setting value $I_{REF}>$, approx.	30	25
At 2.5 · setting value $I_{REF}>$, approx.	28	24
Dropout time (in ms), approx.	26	23
Dropout ratio, approx.	0.7	

Overcurrent-time protection for phase and residual currents

Multiple availability		3 times (option)	

Characteristics

Definite-time stages (DT)		$I_{Ph}>>$, $3I_0>>$, $I_{Ph}>$, $3I_0>$	
Inverse-time stages (IT)		I_P, $3I_{0P}$	
Acc. to IEC		Inverse, very inverse, extremely inverse, long-time inverse	
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse	
		Alternatively, user-specified trip and reset characteristics	
Reset characteristics (IT)		Acc. to ANSI with disk emulation	

Current stages

High-current stages	$I_{Ph}>>$	0.10 to 35.00 A [1)] or deactivated (stage ineffective)	(steps 0.01 A)
	$T_{IPh}>>$	0.00 to 60.00 s or deactivated (no trip)	(steps 0.01 s)
	$3I_0>>$	0.05 to 35.00 A [1)] or deactivated (stage ineffective)	(steps 0.01 A)
	$T_{3I0}>>$	0.00 to 60.00 s or deactivated (no trip)	(steps 0.01 s)
Definite-time stages	$I_{Ph}>$	0.10 to 35.00 A [1)] or deactivated (stage ineffective)	(steps 0.01 A)
	T_{IPh}	0.00 to 60.00 s or deactivated (no trip)	(steps 0.01 s)
	$3I_0>$	0.05 to 35.00 A [1)] or deactivated (stage ineffective)	(steps 0.01 A)
	$T_{3I0}>$	0.00 to 60.00 s or deactivated (no trip)	(steps 0.01 s)
Inverse-time stages	I_P	0.10 to 4.00 A [1)]	(steps 0.01 A)
Acc. to IEC	T_{IP}	0.05 to 3.20 s or deactivated (no trip)	(steps 0.01 s)
	$3I_{0P}$	0.05 to 4.00 A [1)]	(steps 0.01 A)
	T_{3I0P}	0.05 to 3.20 s or deactivated (no trip)	(steps 0.01 s)
Inverse-time stages	I_P	0.10 to 4.00 A [1)]	(steps 0.01 A)
Acc. to ANSI	D_{IP}	0.50 to 15.00 s or deactivated (no trip)	(steps 0.01 s)
	$3I_{0P}$	0.05 to 4.00 A [1)]	(steps 0.01 A)
	D_{3I0P}	0.50 to 15.00 s or deactivated (no trip)	(steps 0.01 s)

Thermal overload protection (ANSI 49)

Setting ranges	
Factor k acc. to IEC 60255-8	1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Temperature alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % in relation to the trip temperature
Current alarm stage I_{alarm}	
Secondary 1 A	0.1 to 4 A (step 0.1)
Secondary 5 A	0.5 to 20 A (step 0.1)
Trip time characteristic	$t=\tau\ln\frac{I^2-I_{pre}^2}{I^2-(k\cdot I_N)^2}$
Reset ratios	
Θ/Θ_{alarm}	Approx. 0.99
Θ/Θ_{trip}	Approx. 0.99
I/I_{alarm}	Approx. 0.99
Tolerances	Class 10 % acc. to IEC

Trip circuit supervision (ANSI 74TC)

Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Additional functions

Operational measured values

Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase}; $3I_0$; $I_{Gnd\ sensitve}$; I_1; I_2; I_Y; 3_{I0PAR} 3 x I_{Diff}, 3 x I_{Stab}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{Phase-Ground}$; 3 x $V_{Phase-Phase}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}, V_{COMP}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % V_{nom}
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert\cos\varphi\rvert = 0.7$ to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Q: for $\lvert\sin\varphi\rvert = 0.7$ to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
S: for V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	PF (cos φ)
Tolerance for $\lvert\cos\varphi\rvert = 0.7$ to 1	Typical ≤ 3 %
Load impedances with directional indication	3 x $R_{Phase-Ground}$, $X_{Phase-Ground}$ 3 x $R_{Phase-Phase}$, $X_{Phase-Phase}$
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}

Long-term mean values

Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q–; S

Technical data

Minimum/maximum memory

Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values	
Min./max. of measured values	3 x I_{Phase}; I_1; 3 x $V_{Phase-Ground}$; 3 x $V_{Phase-to-phase}$; $3V_0$; V_1; $P+$; $P-$; $Q+$; $Q-$; S; f; power factor (+); power factor (–)
Min./max. of mean values	3 x I_{Phase}; I_1; P; Q; S

Energy meters

Four-quadrant meters	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance for $\lvert\cos\varphi\rvert > 0.7$ and $V > 50$ % V_{nom} and $I > 50$ % I_{nom}	5 %

Oscillographic fault recording

Analog channels	3 x I_{Phase}, $3I_0$, $3I_{0PAR}$, $3I_{0\,Gnd\,sensitive}$, 3 x I_{Diff}, 3 x I_{Stab} 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}, V_x
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40

Control

Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys
Remote control	Control protection, DIGSI, pilot wires

Further additional functions

Measurement supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor
Annunciations	
Event logging	Buffer size 200
Fault logging	Storage of signals of the last 8 faults, buffer size 800
Switching statistics	Number of breaking operations per c.b. pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle 3-phase TRIP/CLOSE cycle per phase
Setting range	0.00 to 30 s (step 0.01 s)
Dead time for CB TRIP/CLOSE cycle	0.00 to 30 s (step 0.01 s)
Commissioning support	Operational measured values Circuit-breaker test Read binary test Initiate binary inputs Set binary outputs Set serial interface outputs Lockout of a device Test mode ot the differential protection topology

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection	*7SD5 ☐☐☐ - ☐☐☐☐☐ - ☐☐☐☐ - ☐☐☐*	

see next page

Device type 1)

Two-terminal differential relay with 4-line display	*2 2*
Two-terminal differential relay with grapical display	*3 2*
Multi-terminal differential relay with 4-line display	*2 3*
Multi-terminal differential relay with graphical display	*3 3*

Measurement input

I_{ph} = 1 A 2), I_e = 1 A 2)	*1*
I_{ph} = 1 A 2), I_e = sensitive (min. = 0.005 A)	*2*
I_{ph} = 5 A 2), I_e = 5 A 2)	*5*
I_{ph} = 5 A 2), I_e = sensitive (min. = 0.005 A)	*6*

Auxiliary voltage (Power supply, BI trigger level)

24 to 48 V DC, trigger level binary input 19 V 4)	*2*
60 to 125 V DC 3), trigger level binary input 19 V 4)	*4*
110 to 250 V DC 3), 115 V AC, trigger level binary input 88 V 4)	*5*
220 to 250 V DC 3), 115 V AC. trigger level binary input 176 V 4)	*6*

Binary / indication inputs	Signal / command outputs incl. one live contact	Fast relays 5)	High Speed 6) trip outputs	Housing width referred to 19"	Flush-mounting housing / screw-type terminals	Flush-mounting housing / plug-in terminals	Surface-mounting housing / screw-type terminals	
8	4	12	–	1/2	■			*A*
8	4	12	–	1/2			■	*E*
8	4	12	–	1/2		■		*J*
16	12	12	–	1/1	■			*C*
16	12	12	–	1/1			■	*G*
16	12	12	–	1/1		■		*L*
16	4	15	5	1/1	■			*N*
16	4	15	5	1/1			■	*Q*
16	4	15	5	1/1		■		*S*
24	20	12	–	1/1	■			*D*
24	20	12	–	1/1			■	*H*
24	20	12	–	1/1		■		*M*
24	12	15	5	1/1	■			*P*
24	12	15	5	1/1			■	*R*
24	12	15	5	1/1		■		*T*
24	4	18	10	1/1	■			*W*

Region-specific default/language settings and funtion versions

Region GE, German language (can be changed)	*A*
Region world, English language (can be changed)	*B*
Region US, US-English language (can be changed)	*C*
Region world, French language (can be changed)	*D*
Region world, Spanish language (can be changed)	*E*
Region world, Italian language (can be changed)	*F*

---

1) Redundant prot. data interface for Hot-Standby-service is possible with a two terminal differential relay (second prot. data interface is needed)

2) Rated current 1/5 A can be selected by the means of jumpers.

3) Transition between three auxiliary voltage ranges can be selected by means of jumpers.

4) The binary input thresholds are selectable in three stepy by means of jumpers.

5) Fast relays are indentified in the terminal diagram. The time advantage compared to signal/command outputs is approx. 3 ms, mainly for protection commands

6) High-speed trip outputs are identified in the in the terminal diagram. The time advantage compared to fast relays is approx. 5 ms

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection (continued)	*7SD52* ☐☐ - ☐☐☐☐☐ - ☐☐☐☐ - ☐☐☐	
System interfaces		
No system interface	*0*	see next page
IEC protocol, electrical RS232	*1*	
IEC protocol, electrical RS485	*2*	
IEC protocol, optical 820 nm, ST-plug	*3*	
PROFIBUS FMS Slave, electrical RS485	*4*	
PROFIBUS FMS Slave, optical 820 nm, twin-ring, ST-plug	*6*	
Further protocols see supplement L	*9*	*L 0* ☐
PROFIBUS DP slave, RS485		*A*
PROFIBUS DP slave, optical 820 nm, double ring, ST connector 1)		*B*
DNP 3.0, RS485		*G*
DNP 3.0, optical 820 nm, ST connector 1)		*H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RS45 connector (EN100)		*R*
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC-connector (EN100) 2)		*S*
DIGSI/Modem interface (on rear of device) and protection interface 1		
See additional indication M	*9*	*M*☐☐
DIGSI/Modem interface (on rear of device)		
Without DIGSI-interface on rear		*0*
DIGSI 4, electric RS232		*1*
DIGSI 4, electric RS485		*2*
DIGSI 4, optical 820 nm, ST plug		*3*
Protection data interface 1		
FO5: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication converter or direct FO connection 3)		*A*
FO6: Optical 820 nm, 2 ST-plugs, line length up to 3.5 km via multimode FO cable for direct FO connection		*B*
FO17: Optical 1300 nm, LC-Duplex-plugs, line length up to 24 km via monomode FO cable for direct FO connection 4)		*G*
FO18: Optical 1300 nm, LC-Duplex-plugs, line length up to 60 km via monomode FO cable for direct FO connection 4)5)		*H*
FO19: Optical 1550 nm, LC-Duplex-plugs, line length up to 100 km via monomode FO cable for direct FO connection 4)6)		*J*
FO30: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication networks with IEEE C37.94 interface or direct FO connection 7)		*S*

---

1) Not possible for surface mounting housing (Order No. pos. 9 = *E/G/H/Q/R*). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and an external FO-converter

2) Not possible for surface mounting housing (Order No. pos. 9 = *E/G/H/Q/R*) please order the relay with electrical interface and use a separate fiber-optic switch.

3) Communication converter 7XV5662, see Accessories.

4) Device for surface mounting housing (Order No. pos. 9 = *E/G/H/Q/R*) will be delivered with external repeater 7XV5461-0Bx00.

5) For distances less than 25 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element

6) For distances less than 50 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element

7) Only available in flush-mounting housing (Order No. pos. 9 ≠, *E/G/H/Q/R*).

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection (continued)	*7SD52* □□ - □□□□□ - □□□□ - □□□	

see next page

Functions 1 / Protection data interface 2

Trip mode	Auto-reclosure (ANSI 79)	Synchrocheck (ANSI 25)	
3-pole	without	without	*0*
3-pole	with	without	*1*
1-/3-pole	without	without	*2*
1-/3-pole	with	without	*3*
3-pole	without	with	*4*
3-pole	with	with	*5*
1-/3-pole	without	with	*6*
1-/3-pole	with	with	*7*

With protection data interface 2 see additional specification N
Relays (Ord.-No. 6 = *2*) are available with a second protection data interface (Hot Standby) *9* *N* □□

Functions 1

Trip mode	Auto-reclosure (ANSI 79)	Synchrocheck (ANSI 25)	
3-pole	without	without	*0*
3-pole	with	without	*1*
1-/3-pole	without	without	*2*
1-/3-pole	with	without	*3*
3-pole	without	with	*4*
3-pole	with	with	*5*
1-/3-pole	without	with	*6*
1-/3-pole	with	with	*7*

Protection interface 2

FO5: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication converter or direct FO connection [1]	*A*
FO6: Optical 820 nm, 2 ST-plugs, line length up to 3.5 km via multimode FO cable for direct FO connection	*B*
FO17: Optical 1300 nm, LC-Duplex-plugs, line length up to 24 km via monomode FO cable for direct FO connection [2]	*G*
FO18: Optical 1300 nm, LC-Duplex-plugs, line length up to 60 km via monomode FO cable for direct FO connection [2][3]	*H*
FO19: Optical 1550 nm, LC-Duplex-plugs, line length up to 100 km via monomode FO cable for direct FO connection [2][4]	*J*
FO 30: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication networks with IEEE C37.94 interface or direct FO connection [5]	*S*

1) Communication converter 7XV5662, see Accessories.

2) Device for surface mounting housing (Order No. pos. 9 = *E/G/H/Q/R*) will be delivered with external repeater 7XV5461-0Bx00.

3) For distances less than 25 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element

4) For distances less than 50 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element

5) Only available in flush-mounting housing (Order No. pos. 9 ≠, *E/G/H/Q/R*).

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection *(continued)*	*7SD5 ☐☐☐ - ☐☐☐☐☐ - ☐☐☐☐ - ☐☐☐*	

Functions

Time overcurrent protection/ Breaker failure protection (ANSI 50, 50N, 51, 51N, 50BF)	Earth fault protection (ANSI 67N)	Distance protection (Pickup $Z<$, polygon, MHO, parallel line comp.) Power Swing detection (ANSI 21, 21N, 68, 68T)	Distance protection (I_{pickup} $I>$,-VI/φ, -$Z<$), polygon, parallel line comp. 2), power swing det. (ANSI 21, 21N, 68, 68T)	Earth fault detection for isolated/compensated networks 1)	
with	without	without	without	without	*C*
with	without	without	with	without	*D*
with	without	with	without	without	*E*
with	with	without	without	without	*F*
with	with	without	with	without	*G*
with	with	with	without	without	*H*
with	without	without	without	with	*J*
with	without	without	with	with	*K*
with	with	without	without	with	*L*
with	with	without	with	with	*M*

Additional functions 1

4 Remote commands/24 Remote indications	Transformer expansions	Fault locator	Voltage protection, frequence protection (ANSI 27, 50)	Restricted earth fault low impedance (ANSI 87N) 2)	
with	without	1-side measuring	without	without	*J*
with	without	1-side measuring	with	without	*K*
with	without	2-side measuring	without	without	*L*
with	without	2-side measuring	with	without	*M*
with	with	1-side measuring	without	without	*N*
with	with	1-side measuring	with	without	*P*
with	with	2-side measuring	without	without	*Q*
with	with	2-side measuring	with	without	*R*
with	with	1-side measuring	without	with	*S*
with	with	1-side measuring	with	with	*T*
with	with	2-side measuring	without	with	*U*
with	with	2-side measuring	with	with	*V*

Additional functions 2

Measured values, extended, Min/Max values	External GPS synchronization	Capacitive current load compensation	
without	without	without	*0*
without	with	without	*1*
with	without	without	*2*
with	with	without	*3*
without	without	with	*4*
without	with	with	*5*
with	without	with	*6*
with	with	with	*7*

---

1) Only available with Order No. Pos. 7 = *2* or *6*

2) Only available with Order No. Pos. 7 = *1* or *5*

Accessories

Description	Order No.
Opto-electric communication converter CC-XG (connection to communication network)	
Converter to interface to X21 or RS422 or G703-64 kbit/s synchronous communication interfaces Connection via FO cable for 62.5 / 125 µm or 50 / 120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via X21/RS422 or G703-64 kbit/s interface	*7XV5662-0AA00*
Opto-electric communication converter CC-2M to G703-E1/-T1 communication networks with 2,048/1,554 kbit/s	
Converter to interface between optical 820 nm interface and G703-E1/-T1 interface of a communication network Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via G703-E1/-T1 interface	*7XV5662-0AD00*
Opto-electric communication converter (connection to pilot wire)	
Converter to interface to a pilot wire or twisted telephone pair (typical 15 km length) Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector; max. distance 1.5 km, screw-type terminals to pilot wire	*7XV5662-0AC00*
Additional interface modules	
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km	*C53207-A351-D651-1*
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	*C53207-A351-D652-1*
Further modules	
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*C53207-A351-D655-1*
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*C53207-A351-D656-1*
Protection data interface mod. opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	*C53207-A351-D657-1*
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*7XV5461-0BG00*
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*7XV5461-0BH00*
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	*7XV5461-0BJ00*
Time synchronizing unit with GPS output	
GPS 1 sec pulse and time telegram IRIG B/DCF 77	*7XV5664-0AA00*
Isolation transformer (20 kV) for pilot wire communication	*7XR9516*
Voltage transformer miniature circuit-breaker	
Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	*3RV1611-1AG14*

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000 or XP Professional) device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000 or XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Manual for 7SD522/523 V4.6 English	*C53000-G1176-C169*

Fig. 7/78 Mounting rail for 19" rack

Fig. 7/79
2-pin connector

Fig. 7/80
3-pin connector

Fig. 7/81
Short-circuit link for current contacts

Fig. 7/82
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	7/79
	3-pin	*C73334-A1-C36-1*	1	Siemens	7/80
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	*0-539635-1*	1	AMP 1)	
	and matching female	*0-539668-2*		AMP 1)	
	For CI2	*0-734372-1*	1	AMP 1)	
	and matching female	*1-734387-1*		AMP 1)	
19"-mounting rail		*C73165-A63-D200-1*	1	Siemens	7/78
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	7/81
	For other terminals	*C73334-A1-C34-1*	1	Siemens	7/82
Safety cover for terminals	large	*C73334-A1-C31-1*	1	Siemens	
	small	*C73334-A1-C32-1*	1	Siemens	

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

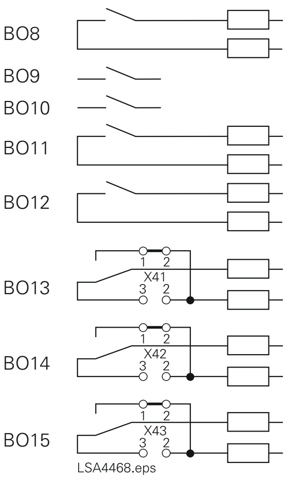


Fig. 7/85

Additional setting by jumpers:

Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.

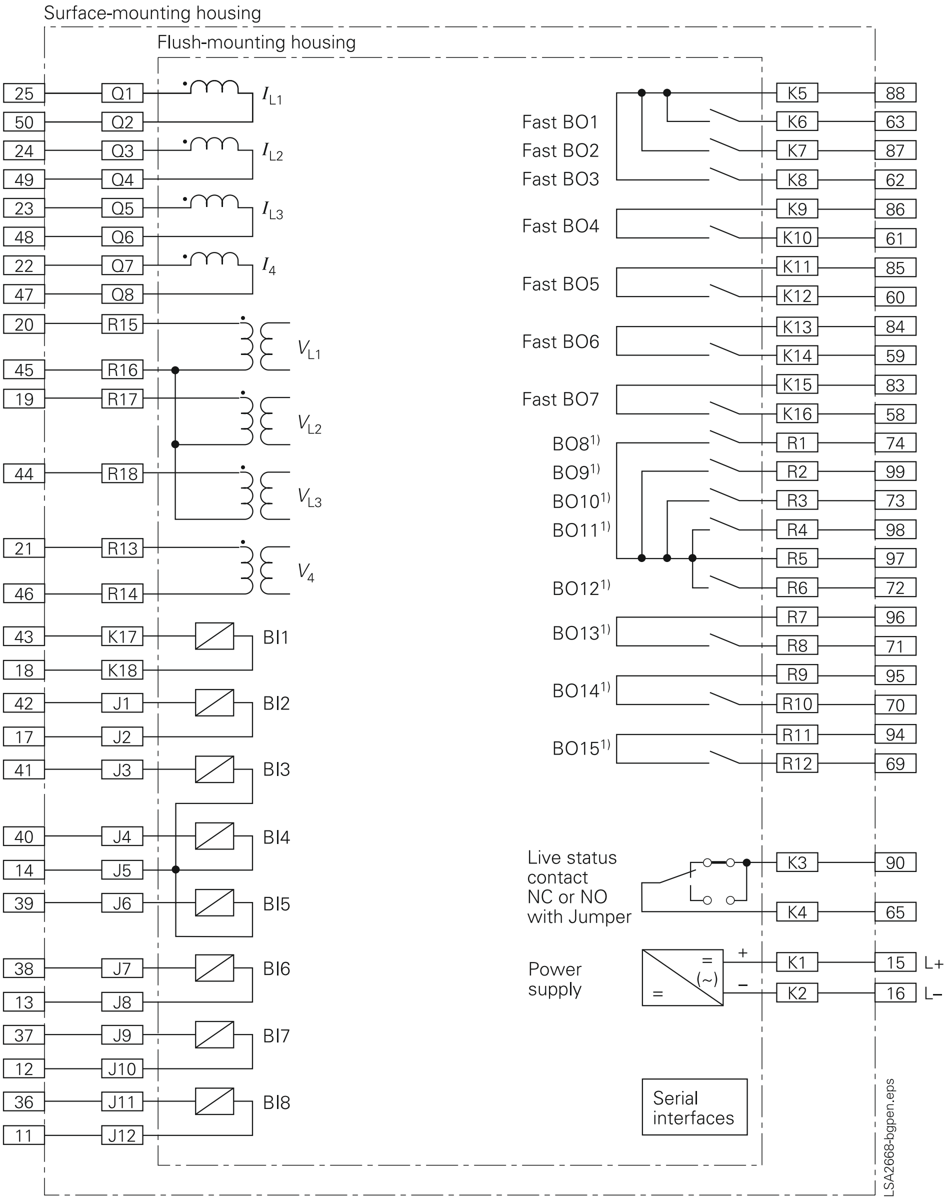


Fig. 7/83 Basic version in housing 1/2 x 19" with 8 binary inputs and 16 binary outputs

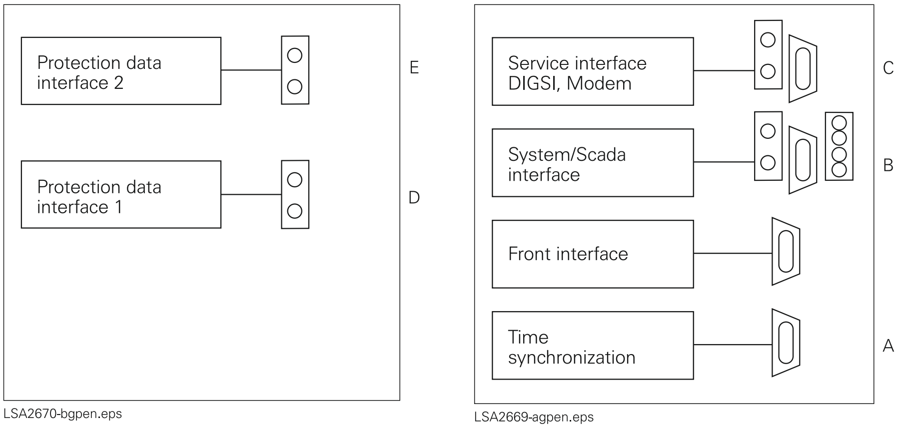


Fig. 7/84 Serial interfaces

---

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/85.

Connection diagram

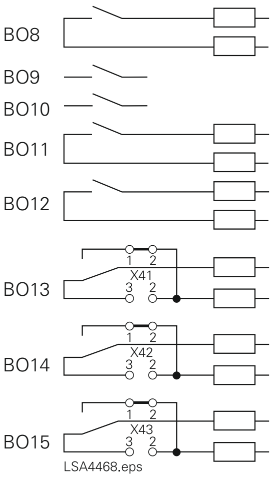


Fig. 7/87

Additional setting by jumpers:

Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.

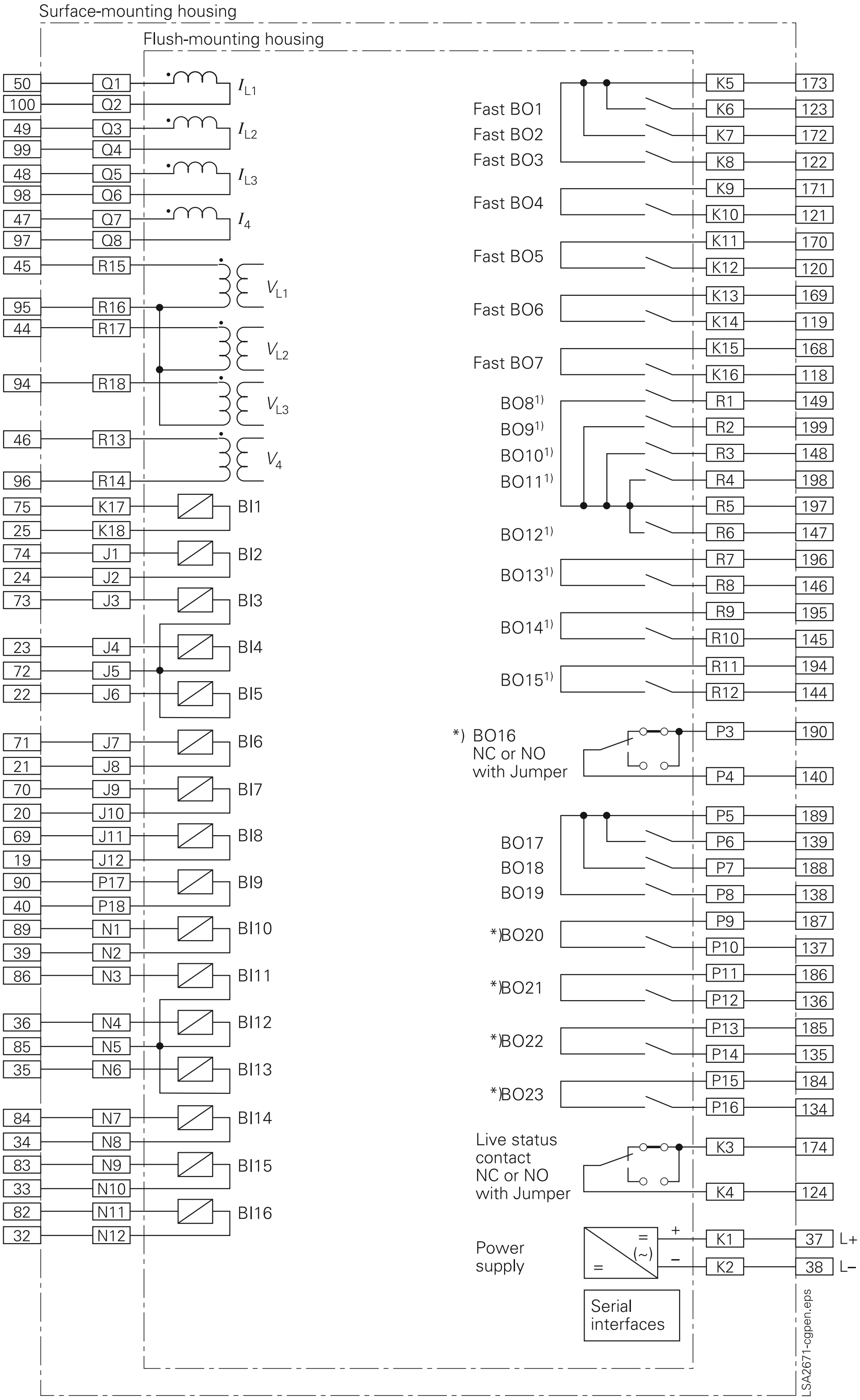


Fig. 7/86 Medium version in housing 1/1 x 19"

*) For unit version 7SD52xx-xN/S/Q high-speed contacts

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/87.

Connection diagram

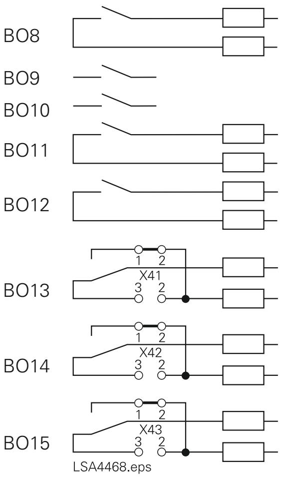


Fig. 7/89

Additional setting by jumpers:

Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.

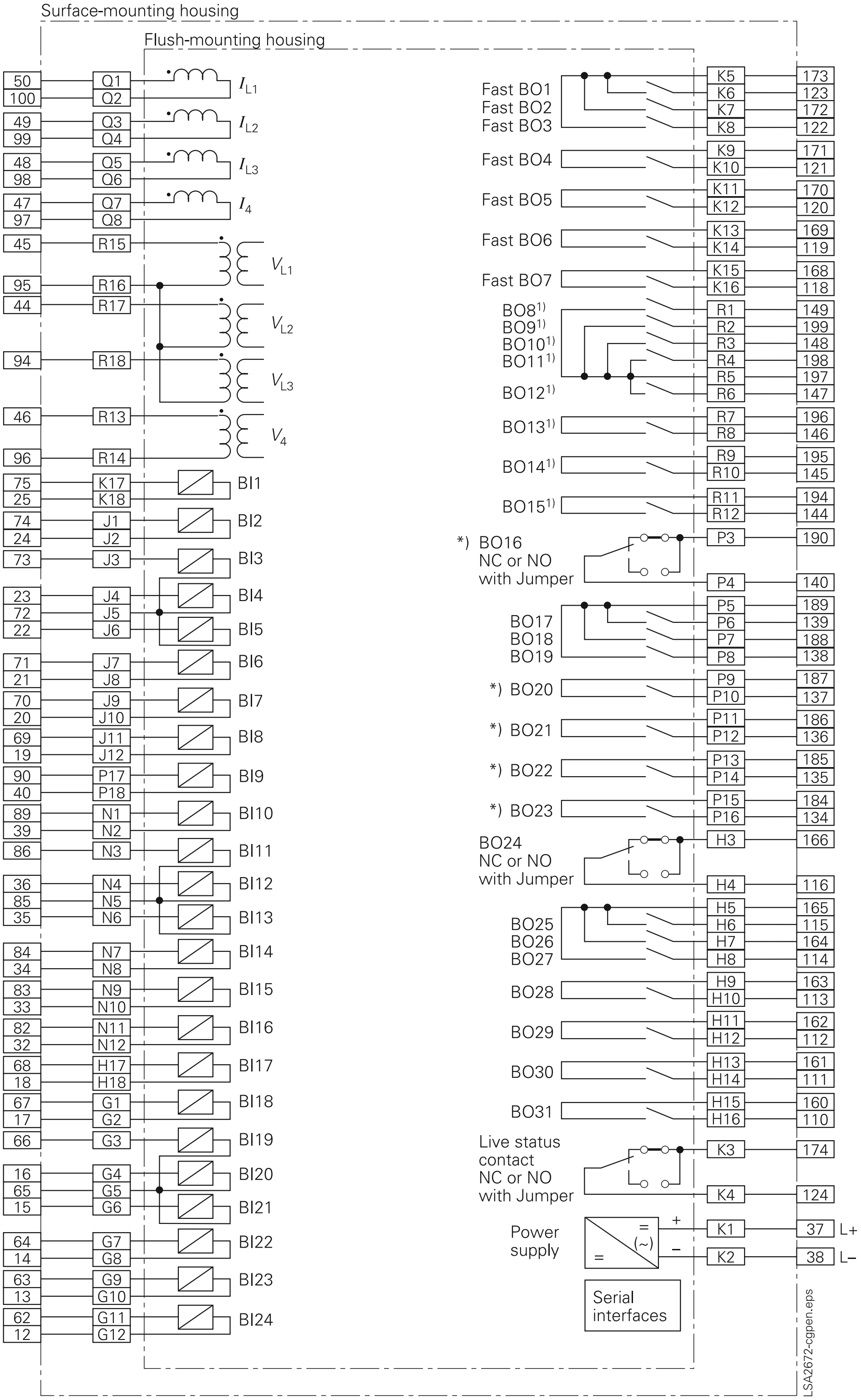


Fig. 7/88 Maximum version in housing 1/1 x 19"

---

*) For unit version 7SD52xx-xR/P/T high-speed contacts

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/89.

Transformer Differential Protection

SIPROTEC 4 7UT6 Differential Protection Relay for Transformers, Generators, Motors and Busbars

Fig. 8/1 SIPROTEC 4
7UT6 differential protection relay for transformers, generators, motors and busbars

Description

The SIPROTEC 7UT6 differential protection relays are used for fast and selective fault clearing of short-circuits in transformers of all voltage levels and also in rotating electric machines like motors and generators, for short lines and busbars.

The protection relay can be parameterized for use with three-phase and single-phase transformers.

The specific application can be chosen by parameterization. In this way an optimal adaptation of the relay to the protected object can be achieved.

In addition to the differential function, a backup overcurrent protection for 1 winding/star point is integrated in the relay. Optionally, a low or high-impedance restricted earth-fault protection, a negative-sequence protection and a breaker failure protection can be used. 7UT613 and 7UT633 feature 4 voltage inputs. With this option an overvoltage and undervoltage protection is available as well as frequency protection, reverse / forward power protection, fuse failure monitor and overexcitation protection. With external temperature monitoring boxes (thermo-boxes) temperatures can be measured and monitored in the relay. Therefore, complete thermal monitoring of a transformer is possible, e.g. hot-spot calculation of the oil temperature.

7UT613 and 7UT63x only feature full coverage of applications without external relays by the option of multiple protection functions e.g. overcurrent protection is available for each winding or measurement location of a transformer. Other functions are available twice: earth-fault differential protection, breaker failure protection and overload protection. Furthermore, up to 12 user-defined (flexible) protection functions may be activated by the customer with the choice of measured voltages, currents, power and frequency as input variables.

The relays provide easy-to-use local control and automation functions.
The integrated programmable logic (CFC) allows the users to implement their own functions, e.g. for the automation of switchgear (interlocking). User-defined messages can be generated as well.
The flexible communication interfaces are open for modem communication architectures with control system.

Function overview

- Differential protection for 2- up to 5-winding transformers (3-/1-phase)
- Differential protection for motors and generators
- Differential protection for short 2 up to 5 terminal lines
- Differential protection for busbars up to 12 feeders (phase-segregated or with summation CT)

Protection functions

- Differential protection with phase-segregated measurement
- Sensitive measuring for low-fault currents
- Fast tripping for high-fault currents
- Restraint against inrush of transformer
- Phase /earth overcurrent protection
- Overload protection with or without temperature measurement
- Negative-sequence protection
- Breaker failure protection
- Low/high-impedance restricted earth fault (REF)
- Voltage protection functions (7UT613/633)

Control functions

- Commands for control of circuit-breakers and isolators
- 7UT63x: Graphic display shows position of switching elements, local/remote switching by key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC

Monitoring functions

- Self-supervision of the relay
- Trip circuit supervision
- Oscillographic fault recording
- Permanent differential and restraint current measurement, extensive scope of operational values

Communication interfaces

- PC front port for setting with DIGSI 4
- System interface
  IEC 61850 Ethernet
  IEC 60870-5-103 protocol,
  PROFIBUS-FMS/-DP,
  MODBUS or DNP 3.0
- Service interface for DIGSI 4 (modem)/ temperature monitoring (thermo-box)
- Time synchronization via IRIG-B/DCF 77

Application

The numerical protection relays 7UT6 are primarily applied as differential protection on

- transformers
  7UT612: 2 windings
  7UT613/633: 2 up to 3 windings
  7UT635: 2 up to 5 windings,
- generators
- motors
- short line sections
- small busbars
- parallel and series reactors.

The user selects the type of object that is to be protected by setting during configuration of the relay. Subsequently, only those parameters that are relevant for this particular protected object need to be set. This concept, whereby only those parameters relevant to a particular protected object need to be set, substantially contributed to a simplification of the setting procedure. Only a few parameters must be set. Therefore the new 7UT6 relays also make use of and extend this concept. Apart from the protected plant objects defined in the 7UT6, a further differential protection function allows the protection of

- single busbars with up to 12 feeders.

The well-proven differential measuring algorithm of the 7UT51 relay is also used in the new relays, so that a similar response with regard to short-circuit detection, tripping time saturation detection and inrush restraint is achieved.

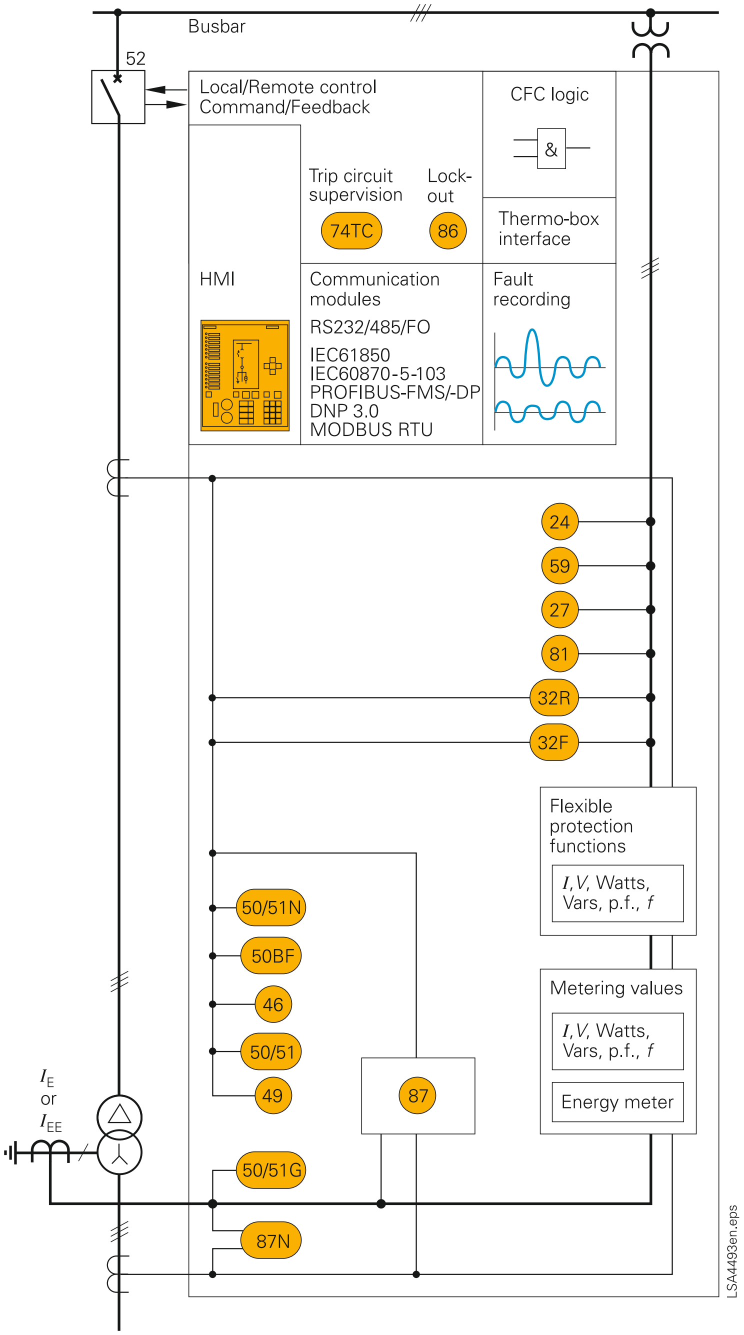


Fig. 8/2 Function diagram

Application

Protection functions	ANSI No.	7UT612	7UT613/33	7UT635	Three-phase transformer	Single-phase transformer	Auto-transformer	Generator/ Motor	Busbar, 3-phase	Busbar, 1-phase
Differential protection	87T/G/M/L	1	1	1	X	X	X	X	X	X
Earth-fault differential protection	87 N	1	2	2	X	X	X*)	X	–	–
Overcurrent-time protection, phases	50/51	1	3	3	X	X	X	X	X	–
Overcurrent-time protection $3I_0$	50/51N	1	3	3	X	–	X	X	X	–
Overcurrent-time protection, earth	50/51G	1	2	2	X	X	X	X	X	X
Overcurrent-time protection, single-phase		1	1	1	X	X	X	X	X	X
Negative-sequence protection	46	1	1	1	X	–	X	X	X	–
Overload protection IEC 60255-8	49	1	2	2	X	X	X	X	X	–
Overload protection IEC 60354	49	1	2	2	X	X	X	X	X	–
Overexcitation protection *) V/Hz	24	–	1	–	X	X	X	X	X	X
Overvoltage protection *) V>	59	–	1	–	X	X	X	X	–	–
Undervoltage protection *) V<	27	–	1	–	X	X	X	X	–	–
Frequency protection *) f>, f<	81	–	1	–	X	X	X	X	–	–
Reverse power protection *) -P	32R	–	1	–	X	X	X	X	–	–
Forward power protection*) P>, P<	32F	–	1	–	X	X	X	X	–	–
Fuse failure protection	60FL	–	1	–	X	X	X	X	–	–
Breaker failure protection	50 BF	1	2	2	X	X	X	X	X	–
External temperature monitoring (thermo-box)	38	X	X	X	X	X	X	X	X	X
Lockout	86	X	X	X	X	X	X	X	X	X
Measured-value supervision		X	X	X	X	X	X	X	X	X
Trip circuit supervision	74 TC	X	X	X	X	X	X	X	X	X
Direct coupling 1		X	X	X	X	X	X	X	X	X
Direct coupling 2		X	X	X	X	X	X	X	X	X
Operational measured values		X	X	X	X	X	X	X	X	X
Flexible protection functions	27, 32, 47, 50, 55, 59, 81	–	12	12	X	X	X	X	X	X

X Function applicable
– Function not applicable in this application
*) Only 7UT613/63x

Construction

The 7UT6 is available in three housing widths referred to a 19" module frame system. The height is 243 mm.

- – 1/3 (7UT612),
- – 1/2 (7UT613),
- – 1/1 (7UT633/635) of 19”

All cables can be connected with or without cable ring lugs. Plug-in terminals are available as an option, it is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located on the same sides of the housing. For dimensions please refer to the dimension drawings (part 15).

LSP2236F.tif

Fig. 8/3
Rear view with screw-type terminals

Protection functions

Differential protection for transformers (ANSI 87T)

When the 7UT6 is employed as fast and selective short-circuit protection for transformers the following properties apply:

- Tripping characteristic according to Fig. 8/4 with normal sensitive $I_{\mathrm{DIFF}}>$ and high-set trip stage $I_{\mathrm{DIFF}}>>$
- Vector group and ratio adaptation
- Depending on the treatment of the transformer neutral point, zero-sequence current conditioning can be set with or without consideration of the neutral current. With the 7UT6, the star-point current at the star-point CT can be measured and considered in the vector group treatment, which increases sensitivity by one third for single-phase faults.
- Fast clearance of heavy internal transformer faults with high-set differential element $I_{\mathrm{DIFF}}>>$.
- Restrain of inrush current with 2nd harmonic. Cross-block function that can be limited in time or switched off.
- Restrain against overfluxing with a choice of 3rd or 5th harmonic stabilization is only active up to a settable value for the fundamental component of the differential current.
- Additional restrain for an external fault with current transformer saturation (patented CT-saturation detector from 7UT51).
- Insensitivity to DC current and current transformer errors due to the freely programmable tripping characteristic and fundamental filtering.
- The differential protection function can be blocked externally by means of a binary input.

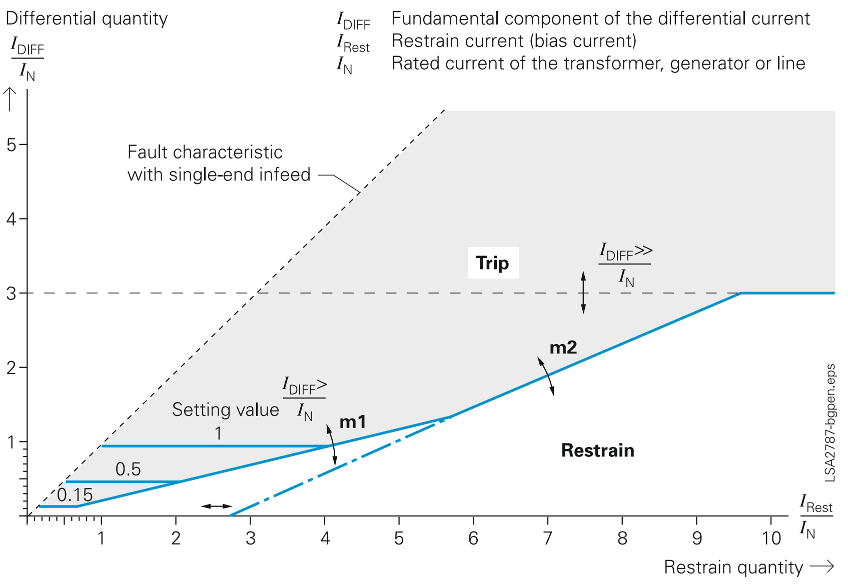


Fig. 8/4
Tripping characteristic with preset transformer parameters for three-phase faults

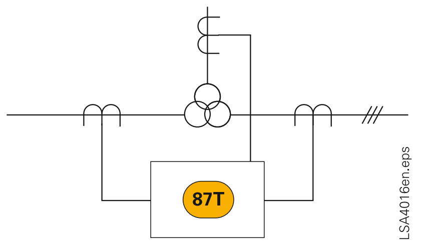


Fig. 8/5
3-winding transformers (1 or 3-phase)

Protection functions

Sensitive protection by measurement of star-point current (see Fig. 8/6) (ANSI 87N/87GD)

Apart from the current inputs for detection of the phase currents on the sides of the protected object, the 7UT6 also contains normal sensitivity I_E and high sensitivity I_{EE} current measuring inputs. Measurement of the star-point current of an earthed winding via the normal sensitivity measuring input, and consideration of this current by the differential protection, increases the sensitivity during internal single-phase faults by 33 %. If the sum of the phase currents of a winding is compared with the star-point current measured with the normal sensitivity input I_E, a sensitive earth current differential protection can be implemented (REF).

This function is substantially more sensitive than the differential protection during faults to earth in a winding, detecting fault currents as small as 10 % of the transformer rated current.

Furthermore, this relay contains a high-impedance differential protection input. The sum of the phase currents is compared with the star-point current. A voltage-dependent resistor (varistor) is applied in shunt (see Fig. 8/6). Via the sensitive current measuring input I_{EE}, the voltage across the varistor is measured; in the milli-amp range via the external resistor. The varistor and the resistor are mounted externally. An earth fault results in a voltage across the varistor that is larger than the voltage resulting from normal current transformer errors. A prerequisite is the application of accurate current transformers of the class 5P (TPY) which exhibit a small measuring error in the operational and overcurrent range. These current transformers may not be the same as used for the differential protection, as the varistor may cause rapid saturation of this current transformers.

Both high-impedance and low-impedance REF are each available twice (option) for transformers with two earthed windings. Thus separate REF relays are not required.

Differential protection for single-phase busbars (see Fig. 8/7) (ANSI 87L)

The short-circuit protection is characterized by the large number of current measuring inputs. The scope of busbar protection ranges from a few bays e.g. in conjunction with one and a half circuit-breaker applications, to large stations having up to more than 50 feeders. In particular in smaller stations, the busbar protection arrangements are too expensive. With the 7UT6 relays the current inputs may also be used to achieve a cost-effective busbar protection system for up to 12 feeders (Fig. 8/7). This busbar protection functions as a phase-selective protection with 1 or 5 A current transformers, whereby the protected phase is connected. All three phases can therefore be protected by applying three relays. Furthermore a single-phase protection can be implemented by connecting the three-phase currents via a summation transformer. The summation transformer connection has a rated current of 100 mA.

The selectivity of the protection can be improved by monitoring the current magnitude in all feeders, and only releasing the differential protection trip command when the overcurrent condition is also met. The security measures to prevent maloperation resulting from failures in the current transformer secondary circuits can be improved in this manner. This overcurrent release may also be used to implement a breaker failure protection. Should the release signal not reset within a settable time, this indicates that a breaker failure condition is present, as the short-circuit was not switched off by the bay circuit-breaker. After expiry of the time delay the circuit-breakers of the infeeds to the busbar may be tripped.

Differential protection for generators and motors (see Fig. 8/8) (ANSI 87G/M)

Equal conditions apply for generators, motors and series reactors. The protected zone is limited by the sets of current transfomers at each side of the protected object.

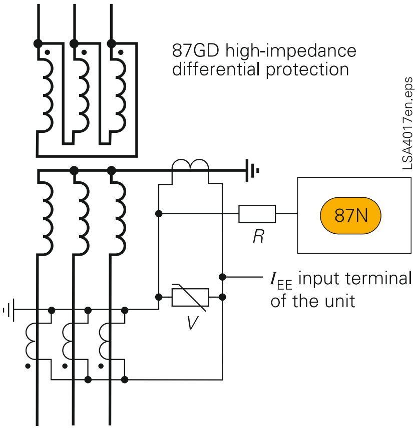


Fig. 8/6
High-impedance differential protection

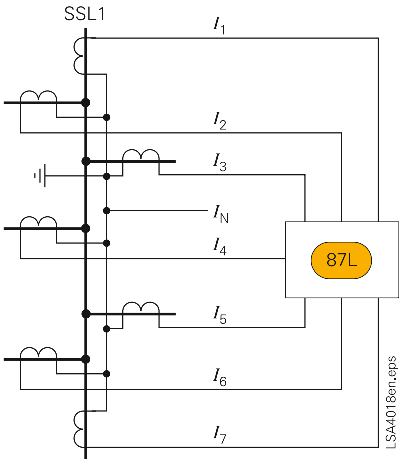


Fig. 8/7
Simple busbar protection with phase-selective configuration
7UT612: 7 feeders
7UT613/633: 9 feeders
7UT635: 12 feeders

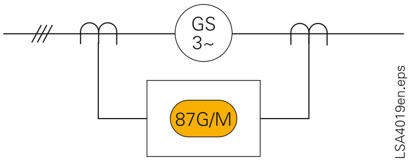


Fig. 8/8
Generator/motor differential protection

Protection functions

■ Backup protection functions

Overcurrent-time protection (ANSI 50, 50N, 51, 51N)

Backup protection on the transformer is achieved with a two-stage overcurrent protection for the phase currents and $3I_0$ for the calculated neutral current. This function may be configured for one of the sides or measurement locations of the protected object. The high-set stage is implemented as a definite-time stage, whereas the normal stage may have a definite-time or inverse-time characteristic. Optionally, IEC or ANSI characteristics may be selected for the inverse stage. The overcurrent protection $3I_0$ uses the calculated zero-sequence current of the configured side or measurement location.
Multiple availability: 3 times (option)

Overcurrent-time protection for earth (ANSI 50/51G)

The 7UT6 feature a separate 2-stage overcurrent-time protection for the earth. As an option, an inverse-time characteristic according to IEC or ANSI is available. In this way, it is possible to protect e.g. a resistor in the transformer star point against thermal overload, in the event of a single-phase short-circuit not being cleared within the time permitted by the thermal rating.
Multiple availability: 3 times (option)

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

Furthermore a negative-sequence protection may be defined for one of the sides or measurement locations. This provides sensitive overcurrent protection in the event of asymmetrical faults in the transformer. The set pickup threshold may be smaller than the rated current.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuing of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g., of an upstream (higher-level) protection relay.
Multiple availability: 2 times (option)

Overexcitation protection Volt/Hertz (ANSI 24) (7UT613/633 only)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to V/f) in generators or transformers, which leads to a thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via seven points derived from the manufacturer data.
In addition, a definite-time alarm stage and an instantaneous stage can be used.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

External trip coupling

For recording and processing of external trip information via binary inputs. They are provided for information from the Buchholz relay or specific commands and act like a protective function. Each input initiates a fault event and can be individually delayed by a timer.

Undervoltage protection (ANSI 27) (7UT613/633 only)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59) (7UT613/633 only)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-earth voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by earth faults. This function is implemented in two stages.

Frequency protection (ANSI 81) (7UT613/633 only)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency.
It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Protection functions

Reverse-power protection (ANSI 32R) (7UT613/633 only)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical power system faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (±) of the active power can be reversed via parameters.

Forward-power protection (ANSI 32F) (7UT613/633 only)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors exceeding of a limit value, while another stage monitors falling below another limit value. The power is calculated using the positive-sequence component of current and voltage. The function can be used to shut down idling motors.

Flexible protection functions (7UT613/63x only)

For customer-specific solutions up to 12 flexible protection functions are available and can be parameterized. Voltages, currents, power and frequency from all measurement locations can be chosen as inputs. Each protection function has a settable threshold, delay time, blocking input and can be configured as a 1-phase or 3-phase unit.

Monitoring functions

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, battery, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions. (7UT613/633 only)

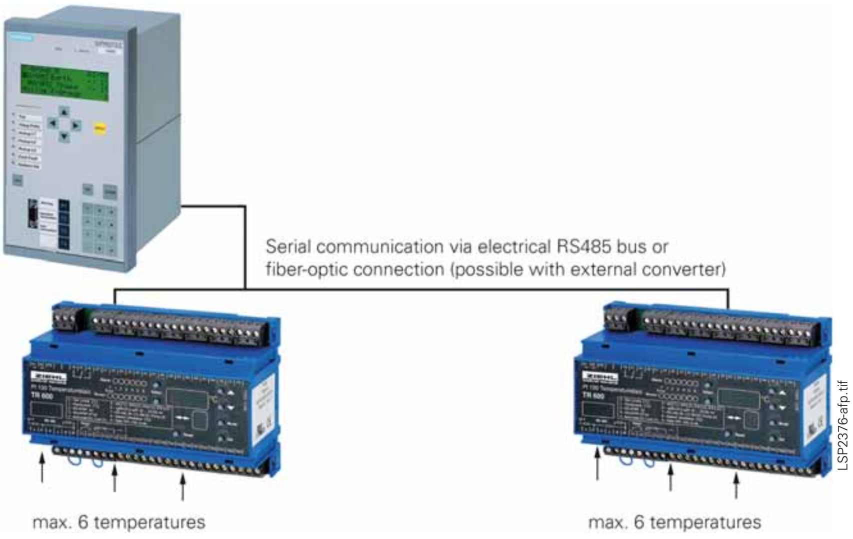


Fig. 8/9
Temperature measurement and monitoring with external thermo-boxes

Thermal monitoring of transformers

The importance of reducing the costs of transmitting and distributing energy by optimizing the system load has resulted in the increased importance of monitoring the thermal condition of transformers. This monitoring is one of the tasks of the monitoring systems, designed for medium and large transformers. Overload protection based on a simple thermal model, and using only the measured current for evaluation, has been integrated in differential protection systems for a number of years.

The ability of the 7UT6 to monitor the thermal condition can be improved by serial connection of a temperature monitoring box (also called thermo-box or RTD-box) (Fig. 8/9). The temperature of up to 12 measuring points (connection of 2 boxes) can be registered. The type of sensor (Pt100, Ni100, Ni120) can be selected individually for each measuring point. Two alarm stages are derived for each measuring point when the corresponding set threshold is exceeded.

Alternatively to the conventional overload protection, the relay can also provide a hot-spot calculation according to IEC 60345. The hot-spot calculation is carried out separately for each leg of the transformer and takes the different cooling modes of the transformer into consideration.

The oil temperature must be registered via the thermo-box for the implementation of this function. An alarm warning stage and final alarm stage is issued when the maximum hot-spot temperature of the three legs exceeds the threshold value.

For each transformer leg a relative rate of ageing, based on the ageing at 98 °C is indicated as a measured value. This value can be used to determine the thermal condition and the current thermal reserve of each transformer leg. Based on this rate of ageing, a remaining thermal reserve is indicated in % for the hottest spot before the alarm warning and final alarm stage is reached.

Protection functions

Measured values

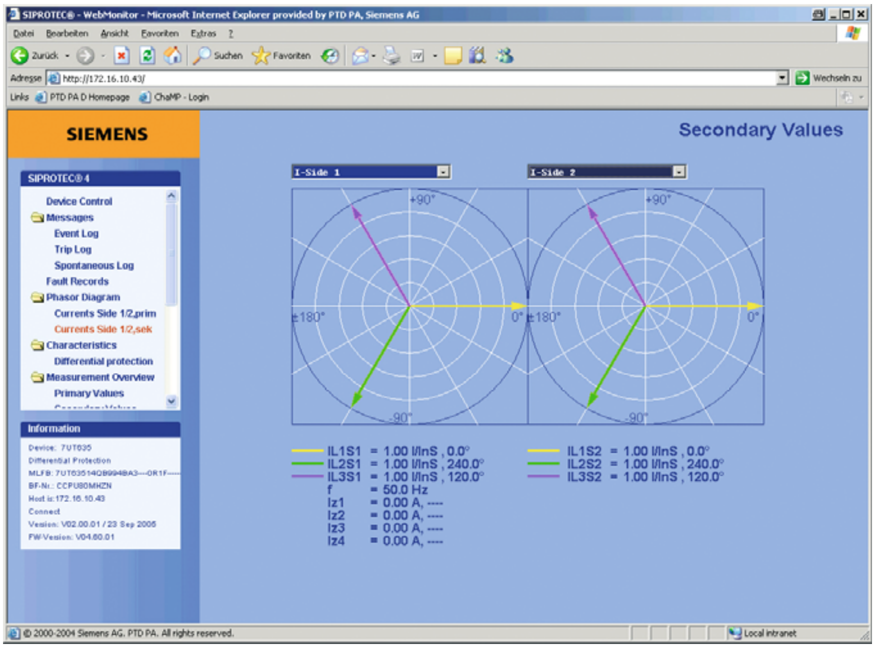
The operational measured values and statistic value registering in the 7UT6, apart from the registration of phase currents and voltages (7UT613/633 only) as primary and secondary values, comprises the following:

- Currents 3-phase I_{L1}, I_{L2}, I_{L3}, I_1, I_2, $3I_0$ for each side and measurement location
- Currents 1-phase I_1 to I_{12} for each feeder and further inputs I_{x1} to I_{x4}
- Voltages 3-phase V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}, V_1, V_2, V_0 and 1-phase V_{EN}, V_4
- Phase angles of all 3-phase/ 1-phase currents and voltages
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase selective)
- Power factor (cos φ),
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Min./max. and mean values of V_{PH-PH}, V_{PHE}, V_E, V_0, V_1, V_2, I_{PH}, I_1, I_2, $3I_0$, I_{DIFF}, $I_{RESTRAINT}$, S, P, Q, cos φ, f
- Operating hours counter
- Registration of the interrupted currents and counter for protection trip commands
- Mean operating temperature of overload function
- Measured temperatures of external thermo-boxes
- Differential and restraint currents of differential protection and REF

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values.

The 7UT6 relays may be integrated into monitoring systems by means of the diverse communication options available in the relays. An example for this is the connection to the SITRAM transformer monitoring system with PROFIBUS-DP interface.

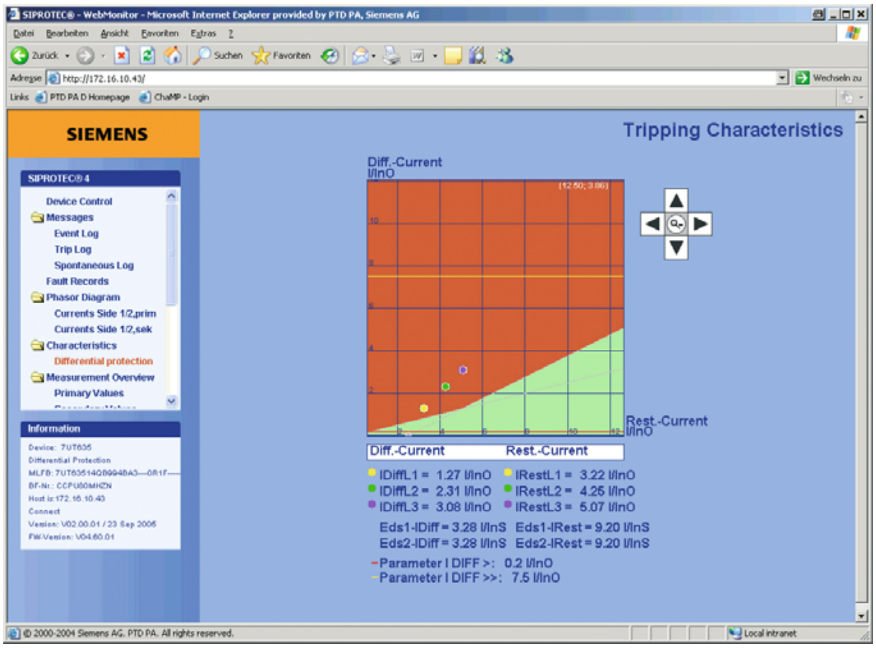


Device: 7UT635
Differential Protection
MLFB: 7UT63514QB994BA3---OR1F----
BF-Nr.: CCPU80MHZN
Host is:172.16.10.43
Connect
Version: V02.00.01 / 23 Sep 2005
FW-Version: V04.60.01

IL1S1 = 1.00 I/InS , 0.0°
IL2S1 = 1.00 I/InS , 240.0°
IL3S1 = 1.00 I/InS , 120.0°
f = 50.0 Hz
Iz1 = 0.00 A, ----
Iz2 = 0.00 A, ----
Iz3 = 0.00 A, ----
Iz4 = 0.00 A, ----

IL1S2 = 1.00 I/InS , 0.0°
IL2S2 = 1.00 I/InS , 240.0°
IL3S2 = 1.00 I/InS , 120.0°

Fig. 8/10
Commissioning via a standard Web browser: Phasor diagram



Device: 7UT635
Differential Protection
MLFB: 7UT63514QB994BA3---OR1F----
BF-Nr.: CCPU80MHZN
Host is:172.16.10.43
Connect
Version: V02.00.01 / 23 Sep 2005
FW-Version: V04.60.01

IDiffL1 = 1.27 I/InO IRestL1 = 3.22 I/InO
IDiffL2 = 2.31 I/InO IRestL2 = 4.25 I/InO
IDiffL3 = 3.08 I/InO IRestL3 = 5.07 I/InO

Eds1-IDiff = 3.28 I/InS Eds1-IRest = 9.20 I/InS
Eds2-IDiff = 3.28 I/InS Eds2-IRest = 9.20 I/InS

Parameter I DIFF >: 0.2 I/InO
Parameter I DIFF >>: 7.5 I/InO

Fig. 8/11
Commissioning via a standard Web browser: Operating characteristic

Commissioning and operating aids

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

All measured currents and voltages (7UT613/633 only) of the transformer can be indicated as primary or secondary values. The differential protection bases its pickup thresholds on the rated currents of the transformer. The referred differential and stabilising (restraint) currents are available as measured values per phase. If a thermo-box is connected, registered temperature values may also be displayed. To check the connection of the relay to the primary current and voltage transformers, a commissioning measurement is provided.

Protection functions

This measurement function works with only 5 to 10 % of the transformer rated current and indicates the current and the angle between the currents and voltages (if voltages applied). Termination errors between the primary current transfomers and input transformers of the relay are easily detected in this manner.

The operating state of the protection may therefore be checked online at any time. The fault records of the relay contain the phase and earth currents as well as the calculated differential and restraint currents. The fault records of the 7UT613/633 relays also contain voltages.

Browser-based commissioning aid

The 7UT6 provides a commissioning and test program which runs under a standard internet browser and is therefore independent of the configuration software provided by the manufacturer.

For example, the correct vector group of the transformer may be checked. These values may be displayed graphically as vector diagrams.

The stability check in the operating characteristic is available as well as event log and trip log messages. Remote control can be used if the local front panel cannot be accessed.

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit- breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

Rear-mounted interfaces

Two communication modules located on the rear of the unit incorporate optional equipment complements and readily permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces.

The interfaces make provision for the following applications:

- Service interface (Port C/Port D[1)])
  In the RS485 version, several protection units can be centrally operated with DIGSI 4. On connection of a modem, remote control is possible. Via this interface communication with thermo-boxes is executed.
- System interface (Port B)
  This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7UT6, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to “Commissioning program”). The relays include a small Web server and send their HTML-pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 61850 Ethernet, IEC 60870-5-103, PROFIBUS-FMS/-DP, MODBUS RTU, DNP 3.0, DIGSI, etc.) are required, such demands can be met.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors electromagnetic fault influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

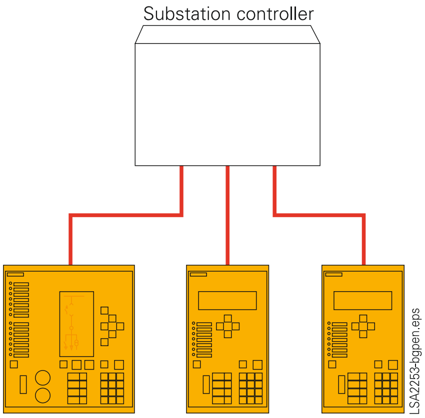


Fig. 8/12
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

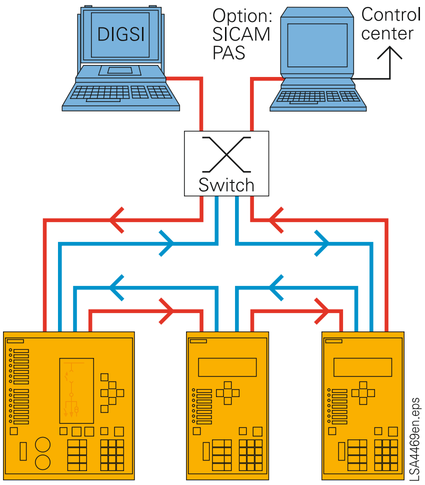


Fig. 8/13
Bus structure for station bus with Ethernet und IEC 61850, fiber-optic ring

---

1) Only for 7UT613/633/635

Communication

IEC 61850 Ethernet

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area.
IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0.
DNP 3.0 is supported by a number of protection device manufacturers.

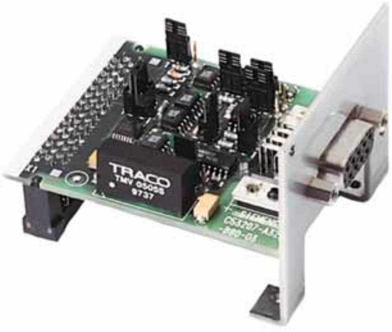


Fig. 8/14
RS232/RS485 electrical communication module

Fig. 8/15
820 nm fiber-optic communication module

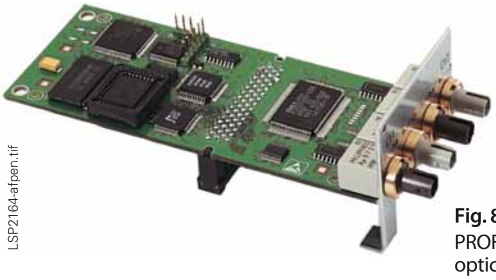


Fig. 8/16
PROFIBUS communication module, optical double-ring

Fig. 8/17
Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 8/12).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 8/13).

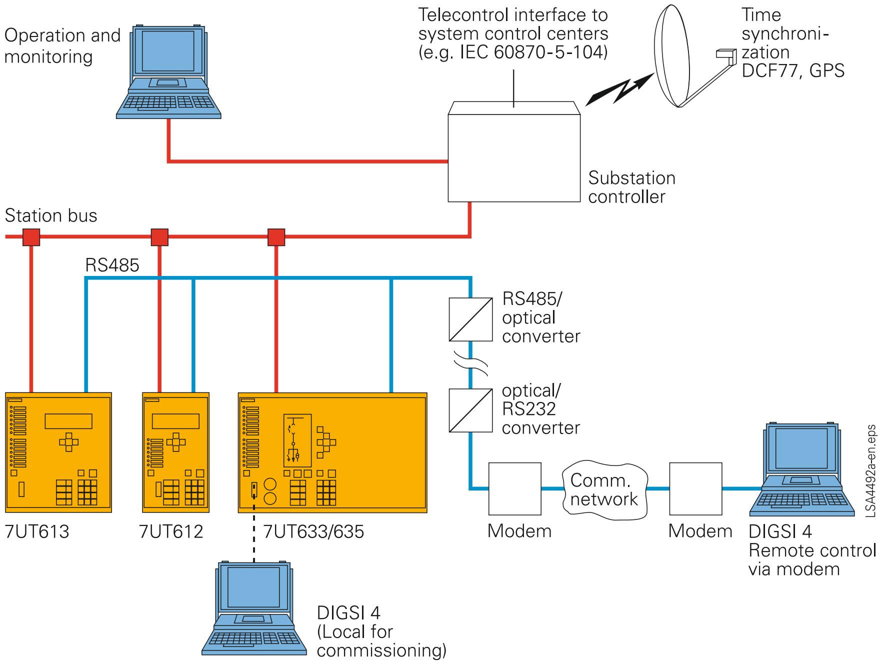


Fig. 8/18
System solution: Communications

Typical connections

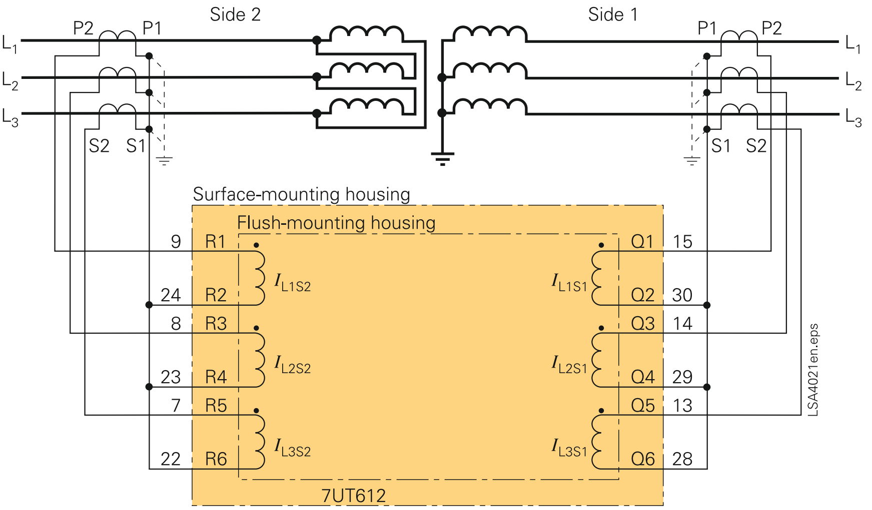


Fig. 8/19
Standard connection to a transformer without neutral current measurement

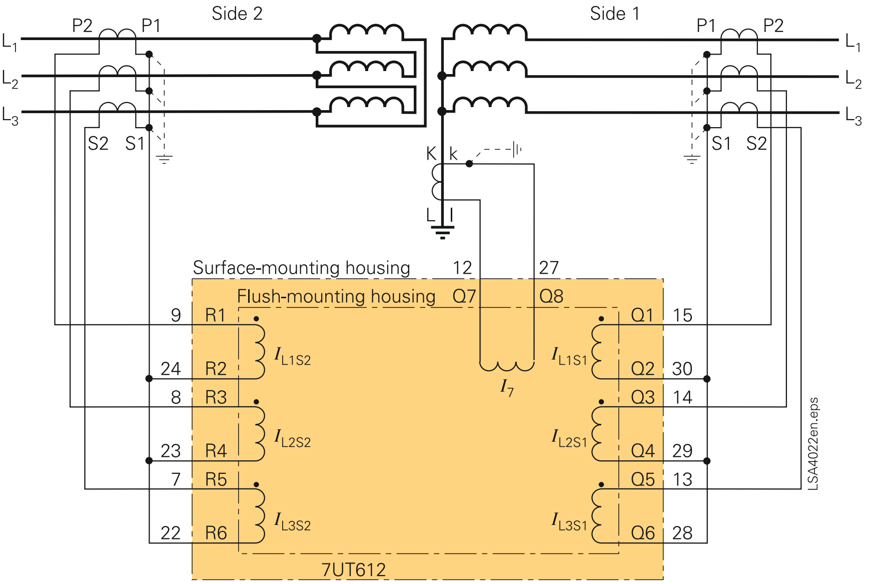


Fig. 8/20
Connection to a transformer with neutral current measurement

Typical connections

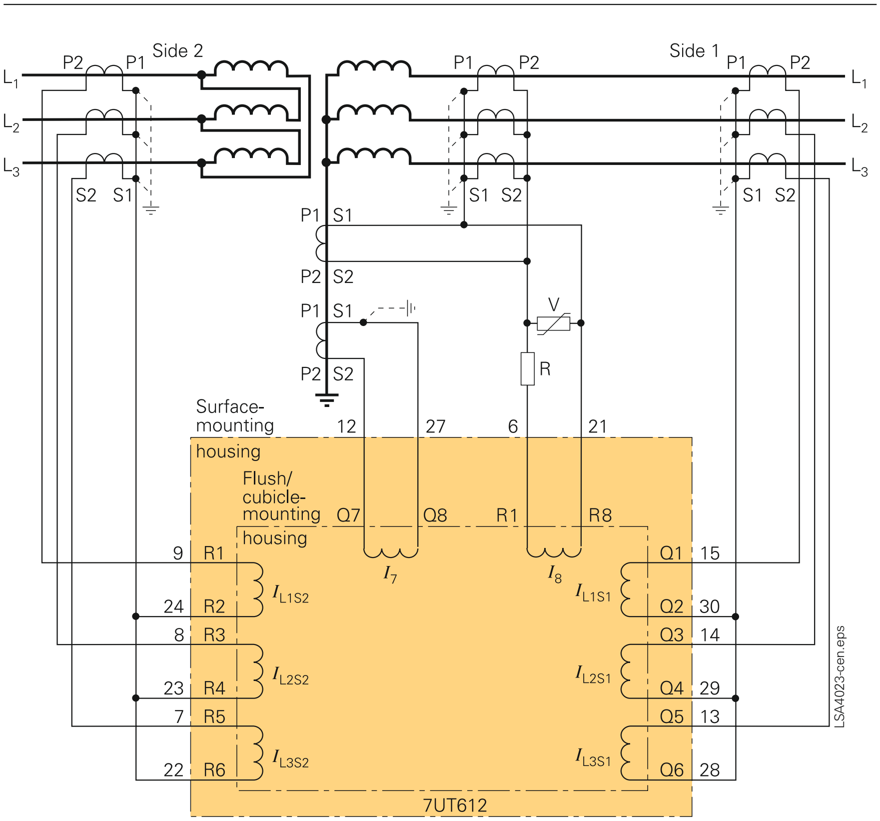


Fig. 8/21

Connection of transformer differential protection with high impedance REF (I_8) and neutral current measurement at I_7

Typical connections

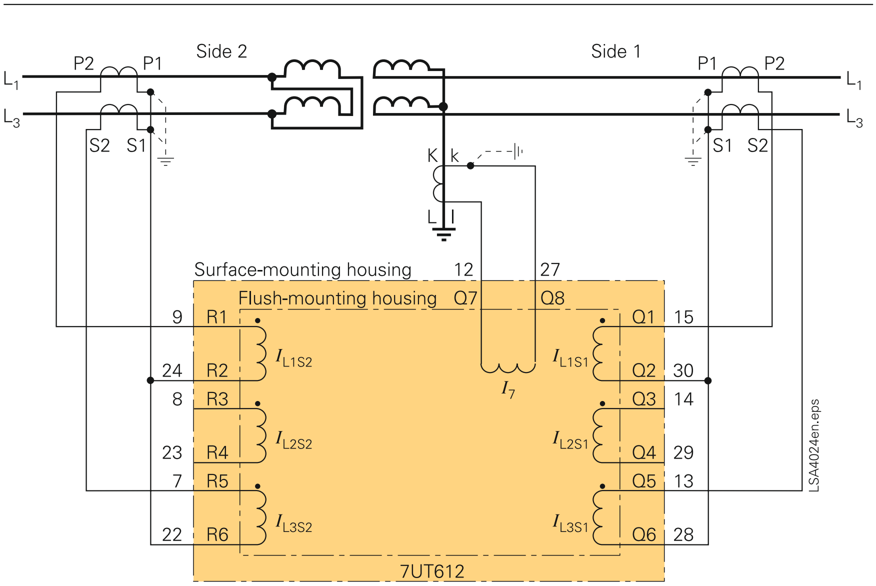


Fig. 8/22
Connection example to a single-phase power transformer with current transformer between starpoint and earthing point

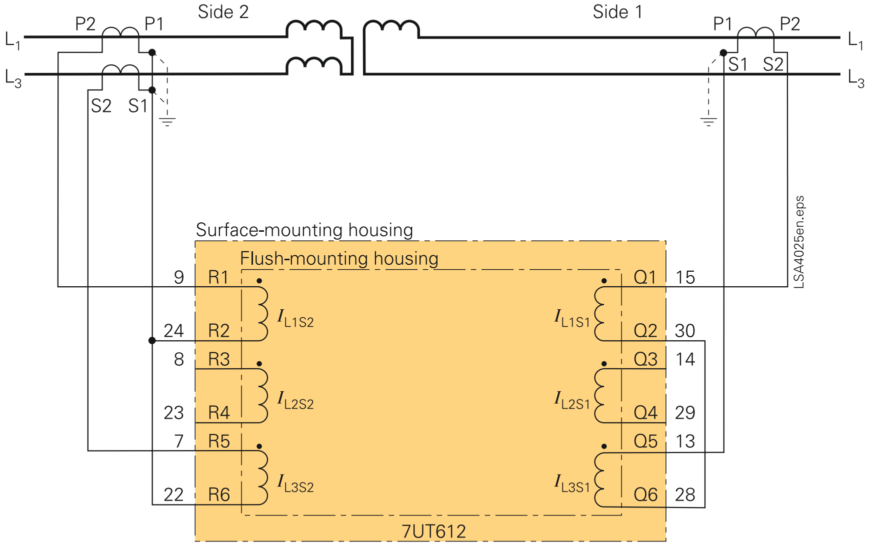


Fig. 8/23
Connection example to a single-phase power transformer with only one current transformer (right side)

Typical connections

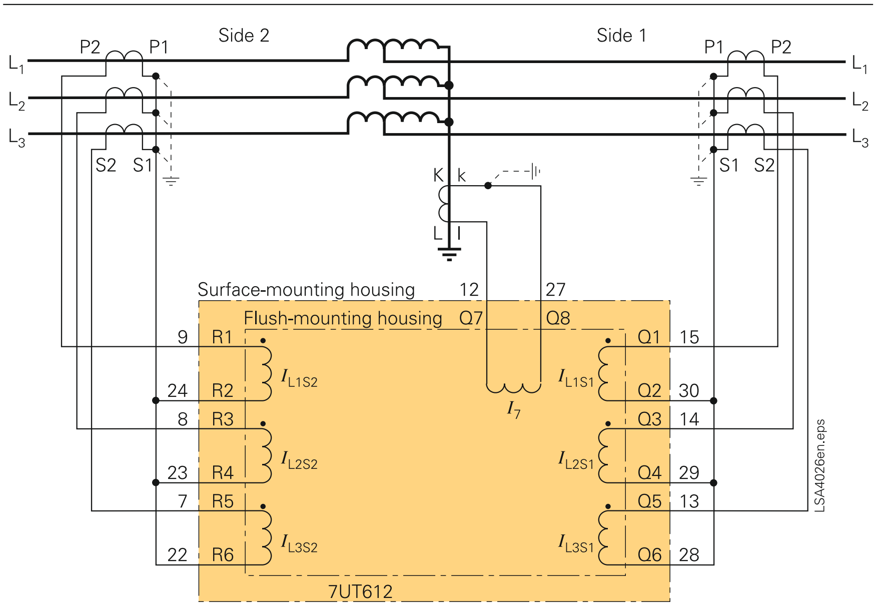


Fig. 8/24
Connection to a three-phase auto-transformer with current transformer between starpoint and earthing point

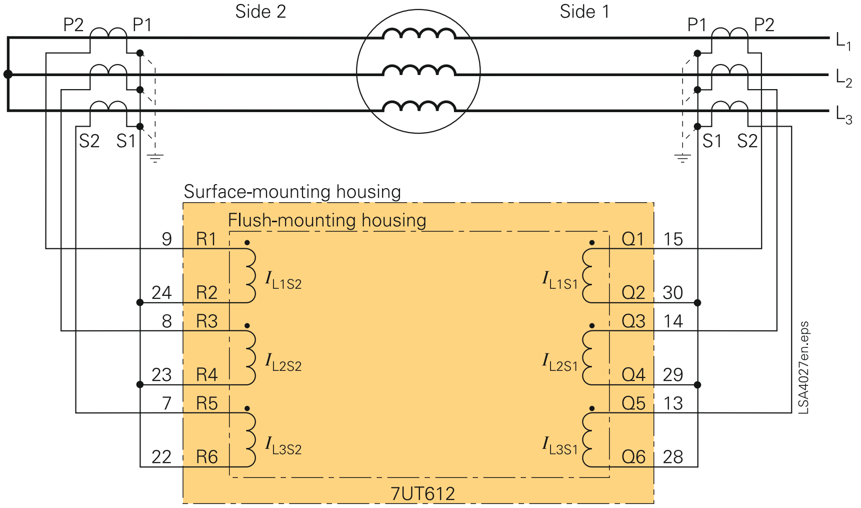


Fig. 8/25
Generator or motor protection

Typical connections

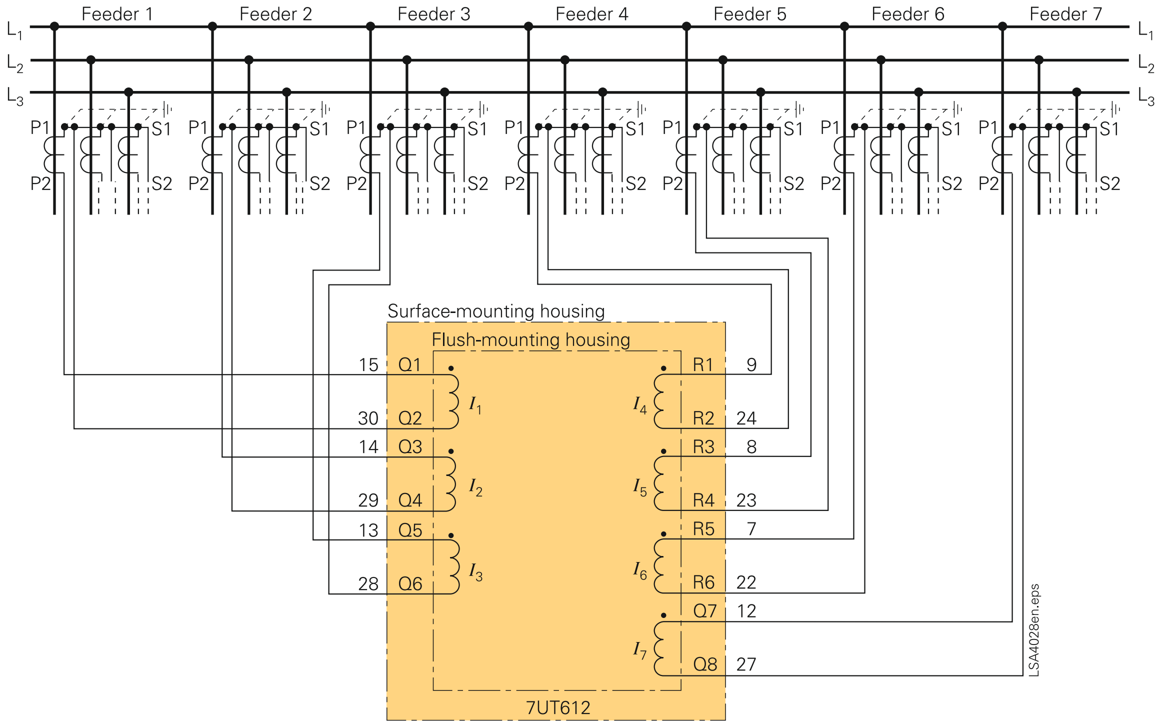


Fig. 8/26
Connection 7UT612 as single-phase busbar protection for 7 feeders, illustrated for phase L1

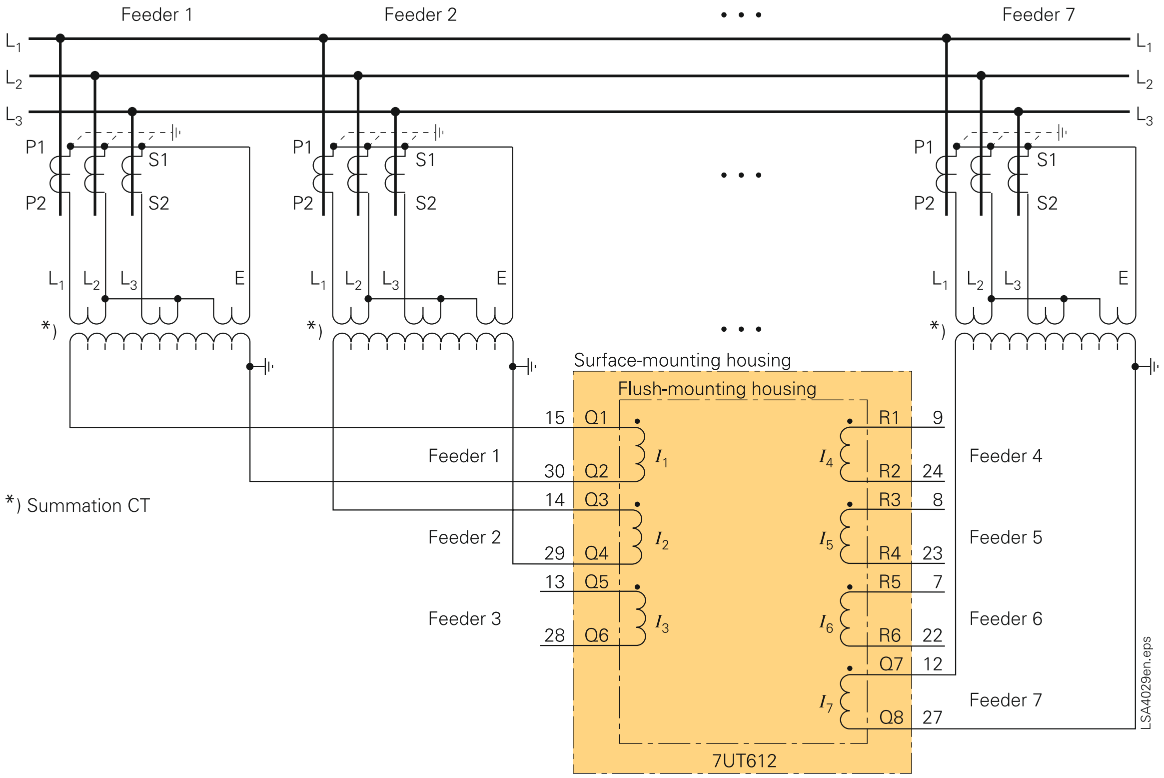


Fig. 8/27
Connection 7UT612 as busbar protection for feeders, connected via external summation current transformers (SCT) – partial illustration for feeders 1, 2 and 7

Typical connections

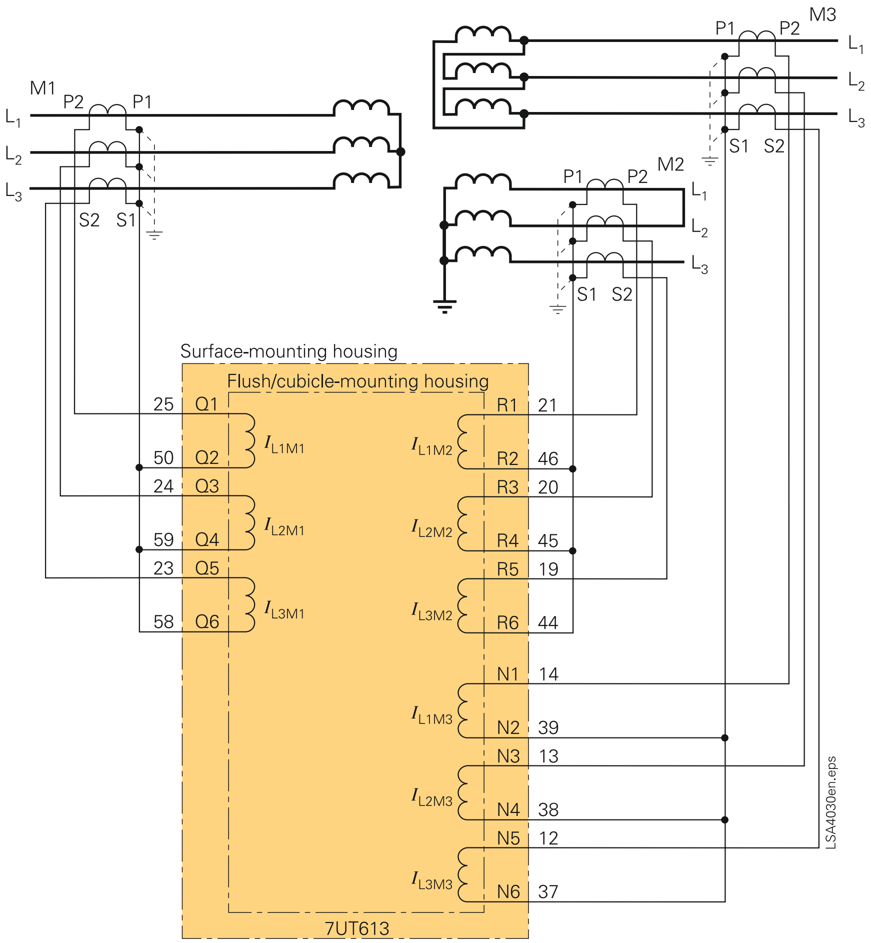


Fig. 8/28
Connection example 7UT613 for a three-winding power transformer

Typical connections

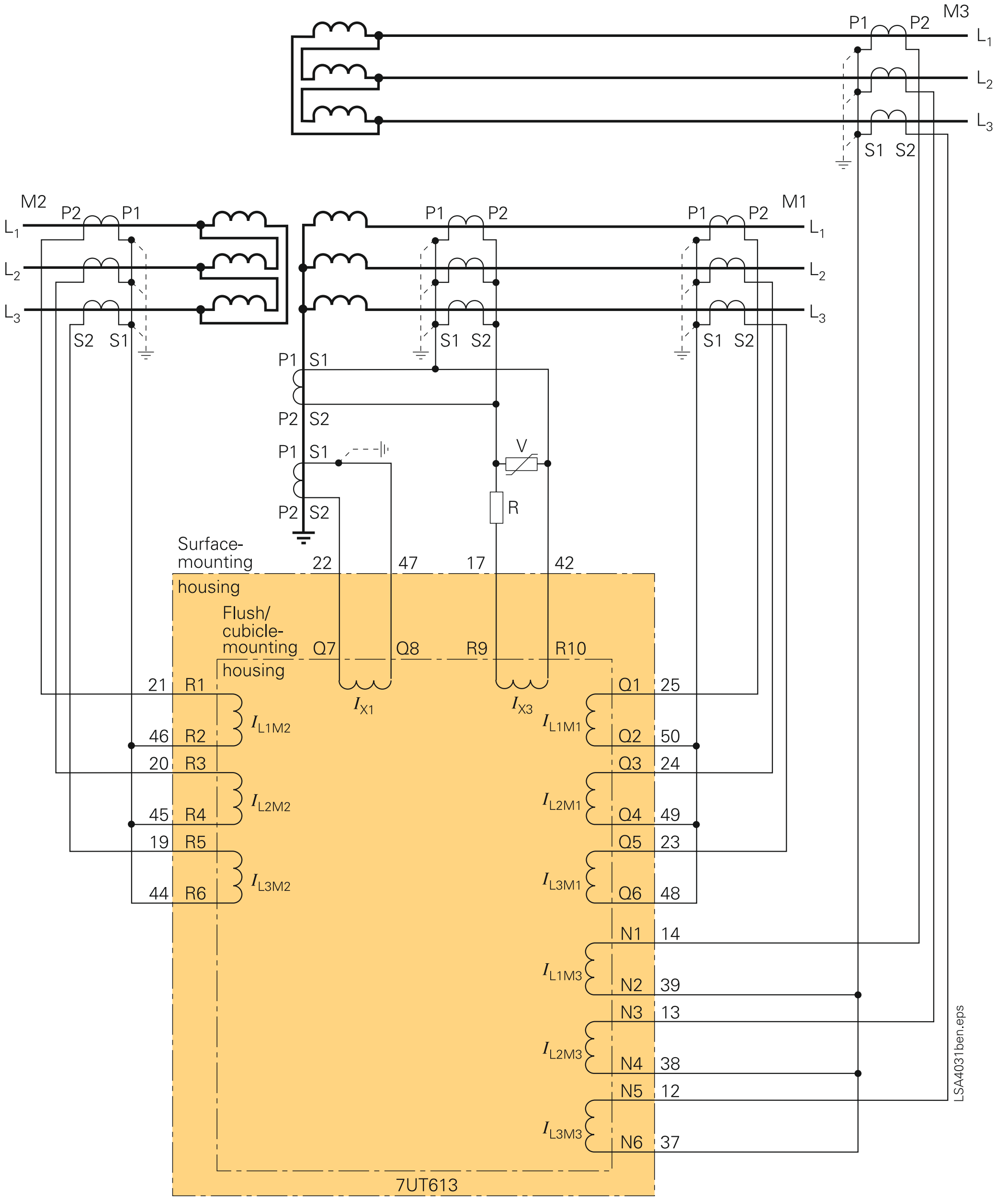


Fig. 8/29

Connection example 7UT613 for a three-winding power transformer with current transformers between starpoint and earthing point, additional connection for high-impedance protection; I_{X3} connected as high-sensitivity input

Typical connections

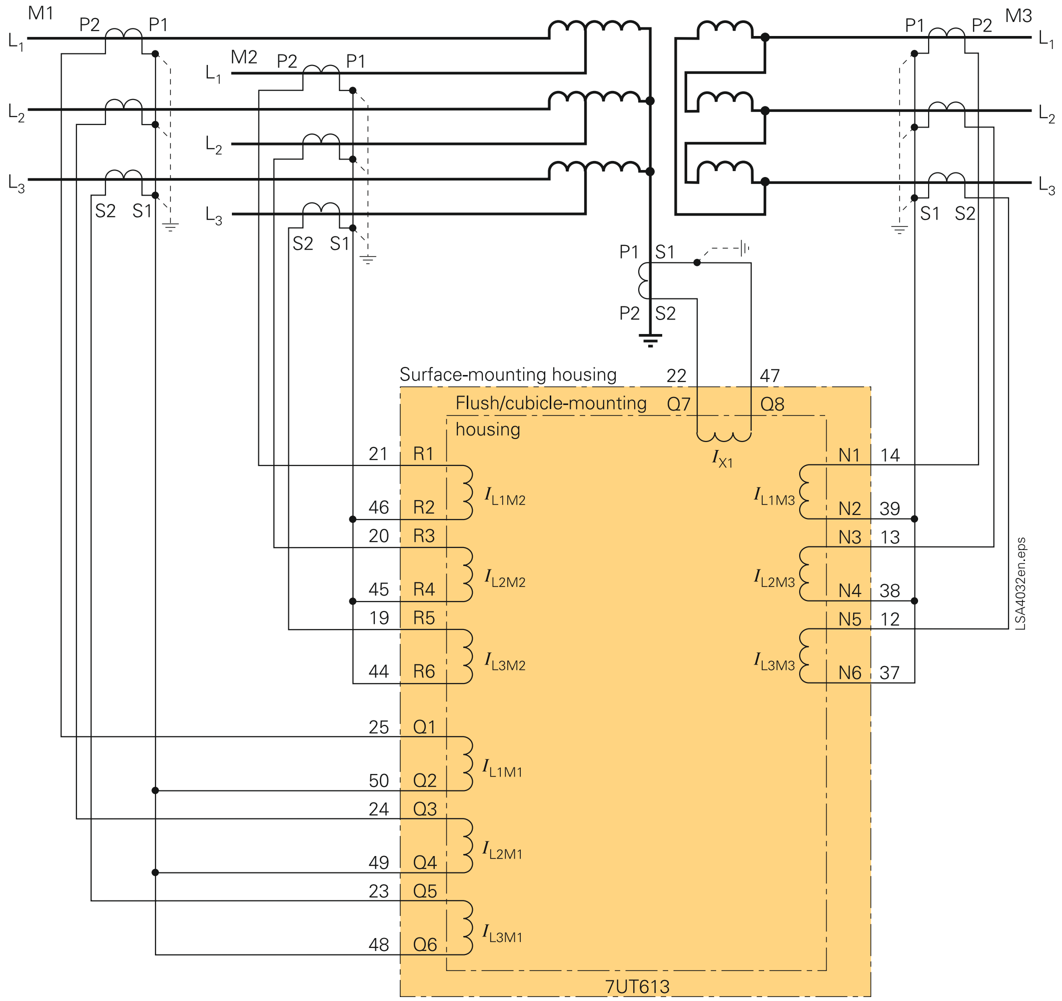


Fig. 8/30
Connection example 7UT613 for a three-phase auto-transformer with three-winding and current transformer between starpoint and earthing point

Typical connections

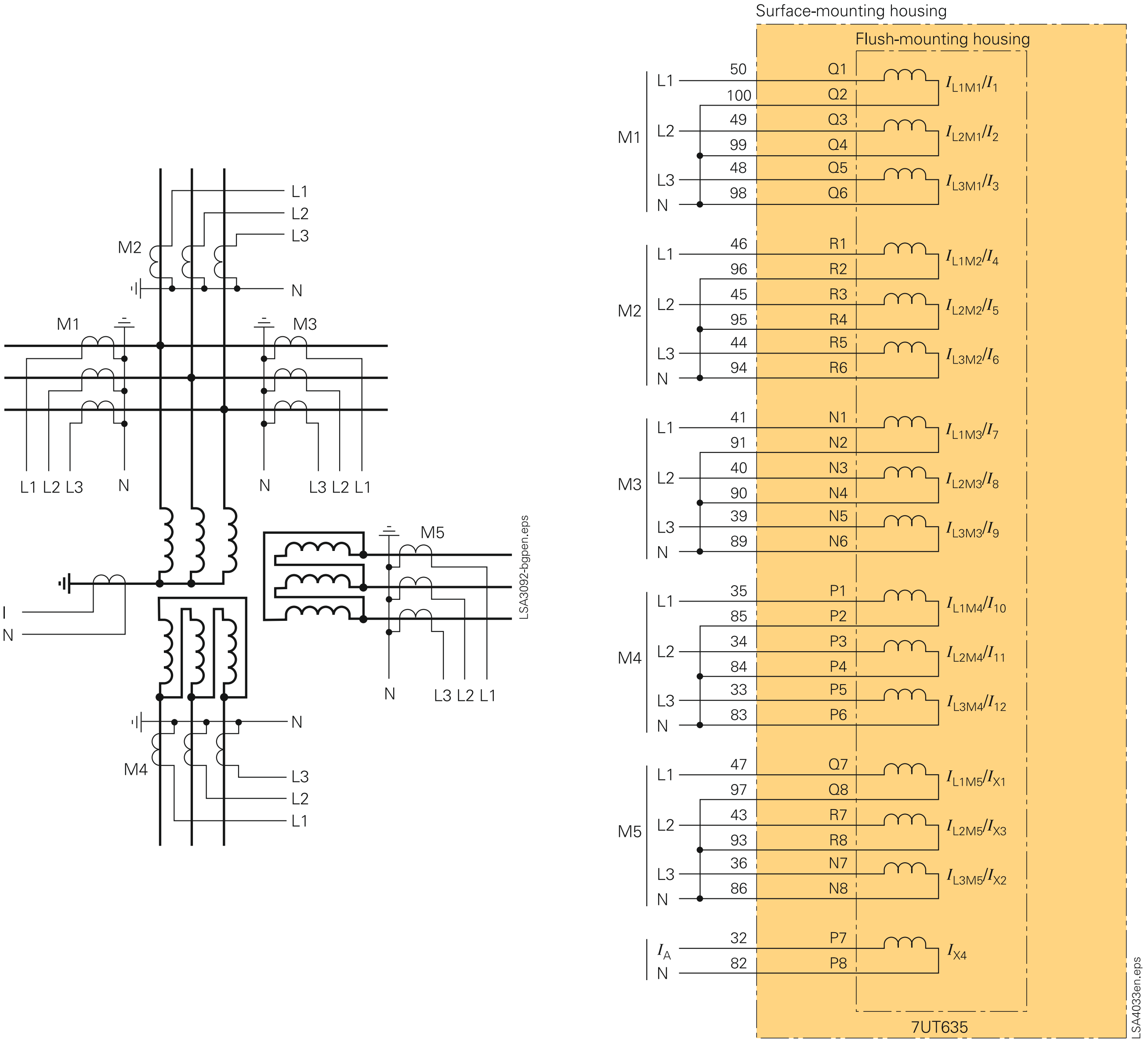


Fig. 8/31
Connection example 7UT635 for a three-winding power transformer with 5 measurement locations (3-phase) and neutral current measurement

Typical connections

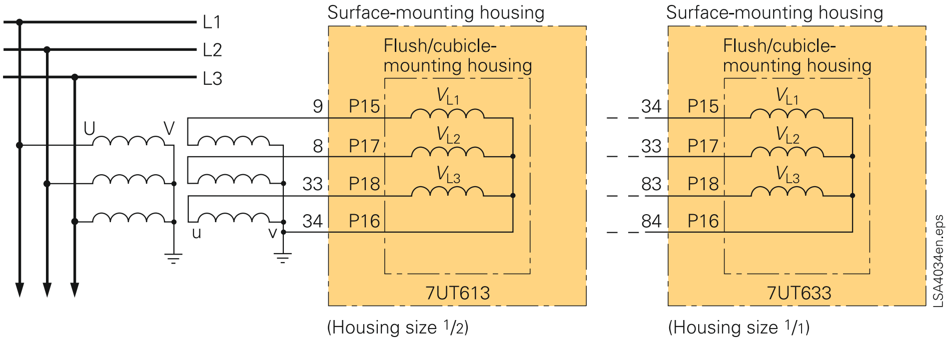


Fig. 8/32
Voltage transformer connection to 3 star-connected voltage transformers (7UT613 and 7UT633 only)

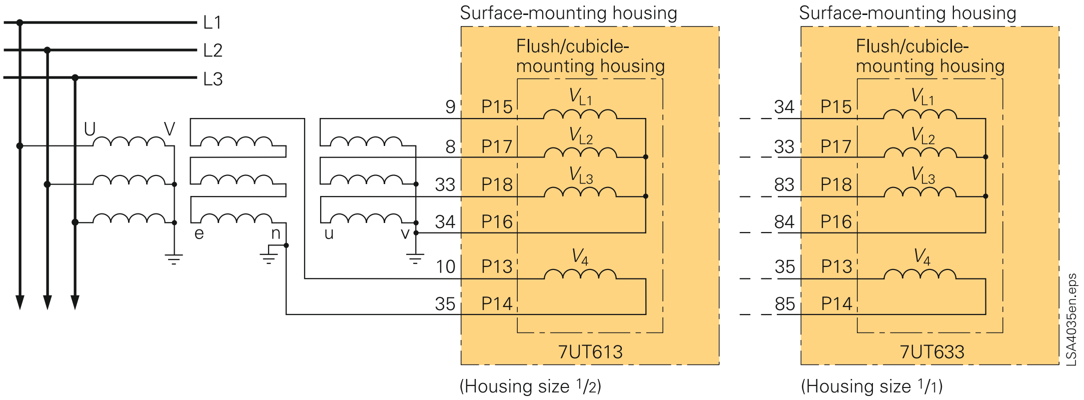


Fig. 8/33
Voltage transformer connection to 3 star-connected voltage transformers with additional delta winding (e-n-winding) (7UT613 and 7UT633 only)

Technical data

General unit data

Analog inputs

Rated frequency	50 or 60 Hz (selectable)
Rated current	0.1 or 1 or 5 A (selectable by jumper, 0.1 A)

Power consumption	7UT			
In CT circuits	612	613	633	635
with I_N = 1 A; in VA approx.	0.02	0.05	0.05	0.05
with I_N = 5 A; in VA approx.	0.2	0.3	0.3	0.3
with I_N = 0.1 A; in VA approx.	0.001	0.001	0.001	0.001
sensitive input; in VA approx.	0.05	0.05	0.05	0.05

Overload capacity In CT circuits	I_N
Thermal (r.m.s.)	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak value)	250 I_N (half cycle)
In CT circuits for highly sensitive input I_{EE}	
Thermal	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic	750 A (half cycle)
Rated voltage (7UT613/633 only)	80 to 125 V
Power consumption per phase at 100 V	≤ 0.1 VA
Overload capacity Thermal (r.m.s.)	230 V continuous

Auxiliary voltage

Rated voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V AC (50/60 Hz), 230 V AC
Permissible tolerance	-20 to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %

Power consumption (DC/AC)	7UT			
	612	613	633	635
Quiescent; in W approx.	5	6/12	6/12	6/12
Energized; in W approx. depending on design	7	12/19	20/28	20/28

Bridging time during failure of the auxiliary voltage V_{aux} ≥ 110 V	≥ 50 ms

Binary inputs

Functions are freely assignable

Quantity marshallable	7UT			
	612	613	633	635
	3	5	21	29

Rated voltage range	24 to 250 V, bipolar
Minimum pickup threshold Ranges are settable by means of jumpers for each binary input	19 or 88 V DC (bipolar)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

Output relay

Command / indication / alarm relay

Quantity each with 1 NO contact	7UT			
	612	613	633	635
(marshallable)	4	8	24	24
1 alarm contact, with 1 NO or NC contact (not marshallable)				

Switching capacity	
Make	1000 W / VA
Break	30 VA
Break (with resistive load)	40 W
Break (with L/R ≤ 50 ms)	25 W
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx.	
NO contact	8 ms
NO/NC contact (selectable)	8 ms
Fast NO contact	5 ms
High-speed*) NO trip outputs	< 1 ms

LEDs

Quantity	7UT			
	612	613	633	635
RUN (green)	1	1	1	1
ERROR (red)	1	1	1	1
LED (red), function can be assigned	7	14	14	14

Unit design

Housing 7XP20	For dimensions please refer to dimension drawings part 15
Degree of protection acc. to IEC 60529	
For the device	
in surface-mounting housing	IP 51
in flush-mounting housing	
front	IP 51
rear	IP 50
For personal safety	IP 2x with closed protection cover

Housing	7UT			
	612	613	633	635
Size, referred to 19” frame	1/3	1/2	1/1	1/1
Weight, in kg				
Flush-mounting housing	5.1	8.7	13.8	14.5
Surface-mounting housing	9.6	13.5	22.0	22.7

Serial interfaces

Operating interface 1 for DIGSI 4 or browser

Connection	Front side, non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Transmission rate in kbaud Setting as supplied: 38.4 kbaud, parity 8E1	7UT612: 4.8 to 38.4 kbaud 7UT613/633/635: 4.8 to 115 kbaud
Distance, max.	15 m

Time synchronization DCF77 / IRIG-B signal / IRIG-B000

Connection	Rear side, 9-pin subminiature connector (SUB-D) (terminals with surface-mounting housing)
Voltage levels	5, 12 or 24 V (optional)

Service interface (operating interface 2) for DIGSI 4 / modem / service

Isolated RS232/RS485/FO	9-pin subminiature connector (SUB-D)
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m / 49.2 ft
Distance for RS485	Max. 1000 m / 3300 ft
Distance for FO	1.5 km (1 mile)

---

*) With high-speed contacts all operating times are reduced by 4.5 ms.

Technical data

System interface

IEC 61850

Ethernet, electrical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit acc. to IEEE802.3
for surface-mounting case	At bottom part of the housing
Test voltage	500 V; 50 Hz
Transmission Speed	100 Mbits/s
Distance	20 m/66 ft
Ethernet, optical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", LC connector receiver/transmitter
for surface-mounting case	Not available
Optical wavelength	$\lambda = 1350$ nm
Transmission Speed	100 Mbits/s
Laser class 1 acc. to EN 60825-1/-2	glass fiber 50/125 µm or glass fiber 62/125µm
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125µm
Distance	Max. 800 m/0.5 mile

IEC 60870-5-103

Isolated RS232/RS485/FO	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 19200 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
For fiber-optic cable	
Connector type	ST connector
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	Max. 1.5 km

PROFIBUS RS485 (-FMS/-DP)

Connector type	9-pin subminiature connector (SUB-D)
Baud rate	Max. 1.5 Mbaud
Dielectric test	500 V / 50 Hz
Distance	Max. 1000 m (3300 ft) at $\leq$ 93.75 kbaud

PROFIBUS fiber optic (-FMS/-DP)

Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[1]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	500 kbaud 1.6 km (0.99 miles) 1500 kbaud 530 m (0.33 miles)

DNP 3.0 RS485 / MODBUS RS485

Connector type	9-pin subminiatur connector (SUB-D)
Baud rate	Max. 19200 baud
Dielectric test	500 V / 50 Hz
Distance	Max. 1000 m (3300 ft)

DNP 3.0 Optical/MODBUS FO

Connector type	ST connector
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	1.5 km (1 mile)

---

1) Conversion with external OLM
For fiber-optic interface please complete Order No. at 11th position with 4 (FMS RS485) or 9 (DP RS485) and Order code L0A and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Electrical tests

Specifications

Standards	IEC 60255 (Product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508

Insulation tests

Standards	IEC 60255-5 and 60870-2-1
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50 Hz / 60 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 Hz / 60 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity

Standards	IEC 60255-6, 60255-22 (product standards) EN 6100-6-2 (generic standard) DIN 57435 / Part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 / Part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, frequency sweep, IEC 60255-22-3, IEC 61000-4-3 class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHZ
Irradiation with RF field, amplitude-modulated, single frequencies, IEC 60255-22-3, IEC 61000-4-3, class III	10 V/m; 80, 160, 450, 900 MHz, 80 % AM; duration > 10 s
Irradiation with RF field, pulse-modulated, single frequencies, IEC 60255-22-3, IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % PM
Fast transients interference, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5, installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2kV; 12 Ω, 9 µF Differential (transversal) mode: 1kV; 2 Ω, 18 µF
Analog inputs, binary inputs, binary outputs	Common (longitude) mode: 2kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz

Technical data

Electrical tests (cont'd)

EMC tests for interference immunity (cont'd)

Magnetic field with power frequency IEC 61000-4-8, IEC 60255-6 class IV	30 A/m continuous; 300 A/m for 3 s; 50 Hz, 0.5 mT; 50 Hz
Oscillatory surge withstand capability, ANSI/IEEE C37.90.1	2.5 kV (peak); 1 MHz; $\tau = 15$ µs; Damped wave; 400 surges per second; duration 2 s; $R_i = 200\ \Omega$
Fast transient surge withstand capability, ANSI/IEEE C37.90.1	4 kV; 5/50 ns; 5 kHz; burst 15 ms; repetition rate 300 ms; both polarities; duration 1 min.; $R_i = 80\ \Omega$
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, $R_i = 200\ \Omega$

EMC tests for interference emission (type test)

Standard	EN 50081-* (generic standard)
Conducted interference, only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strenght IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests

Vibration, shock stress and seismic vibration

<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration frequency sweep 1 octave/min. 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60255-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 15 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal acceleration 10 g, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F

Humidity

Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Yearly average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; condensation not permitted

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits ("Low voltage" Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Technical data

Functions

Differential protection

General

Pickup values

Differential current $I_{\text{DIFF}} > / I_{\text{Nobj}}$	0.05 to 2.00	(steps 0.01)
High-current stage $I_{\text{DIFF}} >> / I_{\text{Nobj}}$	0.5 to 35.0 or deactivated	(steps 0.1) (stage ineffective)
Pickup on switch-on (factor of $I_{\text{DIFF}} >$)	1.0 to 2.0	(steps 0.1)
Add-on stabilization on external fault ($I_{\text{STAB}} >$ set value) $I_{\text{add-on}} / I_{\text{Nobj}}$ action time	2.00 to 15.00 2 to 250 cycles or deactivated	(steps 0.01) (steps 1 cycle) (effective until dropoff)
Tolerances (at preset parameters)		
$I_{\text{DIFF}} >$ stage and characteristic	5 % of set value	
$I_{\text{DIFF}} >>$ stage	5 % of set value	

Time delays

Delay of $I_{\text{DIFF}} >$ stage $T_{\text{I-DIFF}>}$	0.00 to 60.00 s or deactivated	(steps 0.01 s) (no trip)
Delay of $I_{\text{DIFF}} >>$ stage $T_{\text{I-DIFF}>>}$	0.00 to 60.00 s or deactivated	(steps 0.01 s) (no trip)
Time tolerance	1 % of set value or 10 ms	
The set times are pure delay times		

Transformers

Harmonic stabilization

Inrush restraint ratio (2^{nd} harmonic) $I_{\text{2fN}}/I_{\text{fN}}$	10 to 80 %	(steps 1 %)
Stabilization ratio further (n-th) harmonic (optional 3^{rd} or 5^{th}) $I_{\text{nfN}}/I_{\text{fN}}$	10 to 80 %	(steps 1 %)
Crossblock function max. action time for crossblock	Can be activated / deactivated 2 to 1000 AC cycles or 0 (crossblock deactivated) or deactivated (active until dropout)	 (steps 1 cycle)

Operating times

Pickup time/dropout time with single-side infeed

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
$I_{\text{DIFF}} >$, min.	38	35
$I_{\text{DIFF}} >>$, min.	19	17
Dropout time (in ms), approx.	35	30
7UT 613/63x		
$I_{\text{DIFF}} >$, min.	30	27
$I_{\text{DIFF}} >>$, min.	11	11
Dropout time (in ms), approx.	54	46
Dropout ratio, approx.	0.7	

Current matching for transformers

Vector group adaptation	0 to 11 (x 30 °) (steps 1)
Star-point conditioning	Earthed or non-earthed (for each winding)

Generators, motors, reactors

Operating times

Pickup time/dropout time with single-side infeed

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
$I_{\text{DIFF}} >$, min.	38	35
$I_{\text{DIFF}} >>$, min.	19	17
Dropout time (in ms), approx.	35	30
7UT 613/63x		
$I_{\text{DIFF}} >$, min.	30	27
$I_{\text{DIFF}} >>$, min.	11	11
Dropout time (in ms), approx.	54	46
Dropout ratio, approx.	0.7	

Busbars, short lines

Differential current monitor

Steady-state differential current monitoring $I_{\text{DIFF mon}}/I_{\text{Nobj}}$	0.15 to 0.80	(steps 0.01)
Delay of blocking with differential current monitoring $T_{\text{DIFF mon}}$	1 to 10 s	(steps 1 s)

Feeder current guard

Trip release by feeder current guard $I_{\text{guard}}/I_{\text{Nobj}}$	0.20 to 2.00 or 0 (always released)	(steps 0.01)

Operating times

Pickup time/dropout time with single-side infeed

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
$I_{\text{DIFF}} >$, min.	25	25
$I_{\text{DIFF}} >>$, min.	19	17
Dropout time (in ms), approx.	30	30
7UT 613/63x		
$I_{\text{DIFF}} >$, min.	11	11
$I_{\text{DIFF}} >>$, min.	11	11
Dropout time (in ms), approx.	54	46
Dropout ratio, approx.	0.7	

Technical data

Restricted earth-fault protection

Multiple availability		2 times (option)
Settings		
Differential current	$I_{REF}>/I_{Nobj}$	0.05 to 2.00 (steps 0.01)
Limit angle	φ_{REF}	110 ° (fixed)
Time delay	T_{REF}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)

The set times are pure delay times

Operating times

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
At 1.5 · setting value $I_{REF}>$, approx.	40	38
At 2.5 · setting value $I_{REF}>$, approx.	37	32
Dropout time (in ms), approx.	40	40
7UT 613/63x		
At 1.5 · setting value $I_{REF}>$, approx.	35	30
At 2.5 · setting value $I_{REF}>$, approx.	33	29
Dropout time (in ms), approx.	26	23

Dropout ratio, approx. 0.7

Overcurrent-time protection for phase and residual currents

Multiple availability		3 times (option)
Characteristics		
Definite-time stages (DT)		$I_{Ph}>>$, $3I_0>>$, $I_{Ph}>$, $3I_0>$
Inverse-time stages (IT)		I_P, $3I_{0P}$
Acc. to IEC		Inverse, very inverse, extremely inverse, long-time inverse
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse
		Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)		Acc. to ANSI with disk emulation
Current stages		
High-current stages	$I_{Ph}>>$	0.10 to 35.00 A 1) (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IPh}>>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0>>$	0.05 to 35.00 A 1) (steps 0.01 A) or deactivated (stage ineffective)
	$T_{3I0}>>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stages	$I_{Ph}>$	0.10 to 35.00 A 1) (steps 0.01 A) or deactivated (stage ineffective)
	T_{IPh}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0>$	0.05 to 35.00 A 1) (steps 0.01 A) or deactivated (stage ineffective)
	$T_{3I0}>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A 1) (steps 0.01 A)
Acc. to IEC	T_{IP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A 1) (steps 0.01 A)
	T_{3I0P}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A 1) (steps 0.01 A)
Acc. to ANSI	D_{IP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A 1) (steps 0.01 A)
	D_{3I0P}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)

Current stages (cont'd)

Tolerances		
Definite time	Currents Times	3 % of set value or 1 % of rated current 1 % of set value or 10 ms
Inverse time	Currents	Pickup at $1.05 \le I/I_P \le 1.15$; or $1.05 \le I/3I_{0P} \le 1.15$
Acc. to IEC	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \le I/I_P \le 20$ and $T_{IP}/s \ge 1$; or $2 \le I/3I_{0P} \le 20$ and $T_{3I0P}/s \ge 1$
Acc. to ANSI	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \le I/I_P \le 20$ and $D_{IP}/s \ge 1$; or $2 \le I/3I_{0P} \le 20$ and $D_{3I0P}/s \ge 1$

The set definite times are pure delay times.

Operating times of the definite-time stages

Pickup time/dropout time phase current stages

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT612		
Without inrush restraint, min.	20	18
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
7UT613/6x		
Without inrush restraint, min.	11	11
With inrush restraint, min.	33	29
Dropout time (in ms), approx.	35	35

Pickup time/dropout time residual current stages

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
Without inrush restraint, min.	40	35
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
7UT613/6x		
Without inrush restraint, min.	21	19
With inrush restraint, min.	31	29
Dropout time (in ms), approx.	45	43

Dropout ratios

Current stages	Approx. 0.95 for $I/I_N \ge 0.5$

Inrush blocking

Inrush blocking ratio (2nd harmonic)	I_{2fN}/I_{fN}	10 to 45 % (steps 1 %)
Lower operation limit		I > 0.2 A 1)
Max. current for blocking		0.30 to 25.00 A 1) (steps 0.01 A)
Crossblock function between phases max. action time for crossblock		Can be activated/deactivated 0.00 to 180 s (steps 0.01 A)

---

1) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.

Technical data

Overcurrent-time protection for earth current

Multiple availability		3 times (option)
Characteristics		
Definite-time stages (DT)		$I_E >>$, $I_E >$
Inverse-time stages (IT)		I_{EP}
Acc. to IEC		Inverse, very inverse, extremely inverse, long-time inverse
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)		Acc. to ANSI with disk emulation
Current stages		
High-current stage	$I_E >>$	0.05 to 35.00 A 1) (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IE} >>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stage	$I_E >$	0.05 to 35.00 A 1) (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IE} >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_{EP}	0.05 to 4.00 A 1) (steps 0.01 A)
Acc. to IEC	T_{IEP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_{EP}	0.05 to 4.00 A 1) (steps 0.01 A)
Acc. to ANSI	D_{IEP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
Tolerances		
Definite time	Currents	3 % of set value or 1 % of rated current
	Times	1 % of set value or 10 ms
Inverse time	Currents	Pickup at $1.05 \leq I/I_{EP} \leq 1.15$
Acc. to IEC	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \leq I/I_{EP} \leq 20$ and $T_{IEP}/s \geq 1$
Acc. to ANSI	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \leq I/I_{EP} \leq 20$ and $D_{IEP}/s \geq 1$

The set definite times are pure delay times.

Operating times of the definite-time stages

Pickup time/dropout time

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
Without inrush restraint, min.	20	18
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
7UT613/63x		
Without inrush restraint, min.	11	11
With inrush restraint, min.	33	29
Dropout time (in ms), approx.	35	35

Dropout ratios

Current stages	Approx. 0.95 for $I/I_N \geq 0.5$

Inrush blocking

Inrush blocking ratio (2^{nd} harmonic) I_{2fN}/I_{fN}	10 to 45 %	(steps 1 %)
Lower operation limit	$I > 0.2$ A 1)	
Max. current for blocking	0.30 to 25.00 A 1)	(steps 0.01 A)

Dynamic cold-load pickup for overcurrent-time protection

Time control		
Start criterion		Binary input from circuit-breaker auxiliary contact or current criterion (of the assigned side)
CB open time	$T_{CB\ open}$	0 to 21600 s (= 6 h) (steps 1 s)
Active time	$T_{Active\ time}$	1 to 21600 s (= 6 h) (steps 1 s)
Accelerated dropout time	$T_{Stop\ time}$	1 to 600 s (= 10 min) (steps 1 s) or deactivated (no accelerated dropout)
Setting ranges and changeover values		
Dynamic parameters of current pickup and delay times or time multipliers		Setting ranges and steps are the same as for the functions to be influenced

Single-phase overcurrent-time protection

Current stages		
High-current stage	$I >>$	0.05 to 35.00 A 1) (steps 0.01 A) 0.003 to 1.500 A 2) (steps 0.001 A) or deactivated (stage ineffective)
	$T_I >>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stage	$I >$	0.05 to 35.00 A 1) (steps 0.01 A) 0.003 to 1.500 A 2) (steps 0.001 A) or deactivated (stage ineffective)
	$T_I >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Tolerances	Currents	3 % of set value or 1 % of rated current at I_N = 1 A or 5 A; 5 % of set value or 3 % of rated current at I_N = 0.1 A
	Times	1 % of set value or 10 ms

The set definite times are pure delay times.

Operating times

Pickup time/dropout time

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT612		
Minimum	20	18
Dropout time (in ms), approx.	30	27
7UT613/63x		
Minimum	14	13
Dropout time (in ms), approx.	25	22

Dropout ratios

Current stages	Approx. 0.95 for $I/I_N \geq 0.5$

1) Secondary values based on I_N = 1 A;
for I_N = 5 A they must be multiplied by 5.

2) Secondary values for high-sensitivity current input I_8, independent of rated current.

Technical data

Unbalanced load protection (Negative-sequence protection)

Characteristics

Definite-time stages	(DT)	$I_2>>, I_2>$	
Inverse-time stages Acc. to IEC	(IT)	I_{2P} Inverse, very inverse, extremely inverse	
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse	
Reset characteristics	(IT)	Acc. to ANSI with disk emulation	
Operating range		0.1 to 4 A 1)	

Current stages

High-current stage	$I_2>>$ $T_{I2}>>$	0.10 to 3.00 A 1) 0.00 to 60.00 s or deactivated (no trip)	(steps 0.01 A) (steps 0.01 s)
Definite-time stage	$I_2>$ $T_{I2}>$	0.10 to 3.00 A 1) 0.00 to 60.00 s or deactivated (no trip)	(steps 0.01 A) (steps 0.01 s)
Inverse-time stages Acc. to IEC	I_{2P} T_{I2P}	0.10 to 2.00 A 1) 0.05 to 3.20 s or deactivated (no trip)	(steps 0.01 A) (steps 0.01 s)
Inverse-time stages Acc. to ANSI	I_{2P} D_{I2P}	0.10 to 2.00 A 1) 0.50 to 15.00 s or deactivated (no trip)	(steps 0.01 A) (steps 0.01 s)
Tolerances Definite-time	Currents Times	3 % of set value or 1 % of rated current 1 % of set value or 10 ms	
Inverse time Acc. to IEC	Currents Times	Pickup at 1.05 $\leq I/I_{EP} \leq$ 1.15 5 % ± 15 ms at f_N = 50/60 Hz for 2 $\leq I/I_{EP} \leq$ 20 and T_{IEP}/s $\geq$ 1	
Acc. to ANSI	Times	5 % ± 15 ms at f_N = 50/60 Hz for 2 $\leq I/I_{EP} \leq$ 20 and D_{IEP}/s $\geq$ 1	

The set definite times are pure delay times.

Operating times of the definite-time stages

Pickup time/dropout time

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT612		
Minimum	50	45
Dropout time (in ms), approx.	30	30
7UT613/63x		
Minimum	41	34
Dropout time (in ms), approx.	23	20

Dropout ratios

Current stages	Approx. 0.95 for $I_2/I_N \geq 0.5$

Thermal overload protection

Overload protection using a thermal replica

Multiple availability		2 times (option)	

Setting ranges

Factor k acc. IEC 60255-8		0.10 to 4.00	(steps 0.01)
Time constant	τ	1.0 to 999.9 min	(steps 0.1 min)
Cooling down factor at motor stand-still (for motors)	$K\tau$-factor	1.0 to 10.0	(steps 0.1)
Thermal alarm stage	$\Theta_{alarm}/\Theta_{trip}$	50 to 100 % referred to trip temperature rise	(steps 1 %)
Current-based alarm stage	I_{alarm}	0.10 to 4.00 A 1)	(steps 0.01 A)
Start-up recognition (for motors)	$I_{start-up}$	0.60 to 10.00 A 1) or deactivated (no start-up recognition)	(steps 0.01 A)
Emergency start run-on time (for motors)	T_{run-on}	10 to 15000 s	(steps 1 s)

Overload protection using a thermal replica (cont'd)

Tripping characteristics

Tripping characteristic for $I/(k \cdot I_N) \leq 8$

$$t = \tau \cdot I_n \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

t	Tripping time
τ	Heating-up time constant
I	Actual load current
I_{pre}	Preload current
k	Setting factor IEC 60255-8
I_N	Rated current of the protected object

Dropout ratios

Θ/Θ_{trip}	Dropout at Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
I/I_{alarm}	Approx. 0.97

Tolerances

(with one 3-phase measuring location)

Referring to k · I_N	3 % or 10 mA 1); class 3 % acc. IEC 60255-8
Referring to tripping time	3 % or 1 s at f_N = 50/60 Hz for $I/(k \cdot I_N) > 1.25$

Frequency influence referring to k · I_N

In the range 0.9 $\leq f/f_N \leq$ 1.1	1 % at f_N = 50/60 Hz

Hot-spot calculation and determination of the ageing rate

Thermo-box
(temperature monitoring box)

Number of measuring points	From 1 thermo-box (up to 6 temperature sensors) or from 2 thermo-boxes (up to 12 temperature sensors)	
For hot spot calculation *one* temperature sensor must be connected.		

Cooling

Cooling method	ON (oil natural) OF (oil forced) OD (oil directed)	
Oil exponent Y	1.6 to 2.0	(steps 0.1)
Hot spot to top-oil gradient H_{gr}	22 to 29	(steps 1)

Annunciation thresholds

Warning temperature hot spot	98 to 140 °C 208 to 284 °F	(steps 1 °C) (steps 1 °F)
Alarm temperature hot spot	98 to 140 °C 208 to 284 °F	(steps 1 °C) (steps 1 °F)
Warning ageing rate	0.125 to 128.000	(steps 0.001)
Alarm ageing rate	0.125 to 128.000	(steps 0.001)

---

1) Secondary values based on I_N = 1 A;
for I_N = 5 A they must be multiplied by 5.

Technical data

Thermo-boxes for overload protection

Thermo-boxes (connectable)	1 or 2
Number of temperature sensors per thermo-box	Max. 6
Measuring type	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Annuciation thresholds	
For each measuring point:	
Warning temperature (stage 1)	-50 to 250 °C (steps 1 °C) -58 to 482 °F (steps 1 °F) or deactivated (no warning)
Alarm temperature (stage 2)	-50 to 250 °C (steps 1 °C) -58 to 482 °F (steps 1 °F) or deactivated (no alarm)

Breaker failure protection

Multiple availability	2 times (option)
Setting ranges	
Current flow monitoring	0.04 to 1.00 A [1] (steps 0.01 A) for the respective side
Dropoff to pickup ratio	Approx. 0.9 for $I \geq 0.25$ A [1]
Pickup tolerance	5 % of set value or 0.01 A [1]
Breaker status monitoring	Binary input for CB auxiliary contact
Starting conditions	
For breaker failure protection	Internal trip External trip (via binary input)
Times	
Pickup time	Approx. 2 ms (7UT613/63x) and approx. 3 ms (7UT612) with measured quantities present; Approx. 20 ms after switch-on of measured quantities, f_N = 50/60 Hz

Reset time (incl. output relay), approx.	50 Hz	60 Hz
7UT612	30 ms	30 ms
7UT613/63x	25 ms	25 ms

Delay times for all stages	0.00 to 60.00 s; deactivated (steps 0.01 s)
Time tolerance	1 % of setting value or 10 ms

Overexcitation protection (Volt / Hertz) (7UT613 / 633 only)

Setting ranges	
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Pickup threshold V/f>>-stage	1 to 1.4 (steps 0.01)
Time delays T	0 to 60 s (steps 0.01 s) or deactivated
Characteristic values of V/f and assigned times t (V/f)	1.05/1.1/1.15/1.2/1.25/1.3/1.35/1.4 0 to 20000 s (steps 1 s)
Cooling down time $T_{Cooling}$	0 to 20000 s (steps 1 s)

Times (in ms) (alarm and V/f>>-stage)	50 Hz	60 Hz
Pickup times at 1.1 of set value, approx.	36	31
Drop-off times, approx.	28	23

Drop-off ratio (alarm, trip)	0.95
Tolerances	
V/f-Pickup	3 % of set value
Time delays T	1 % or 10 ms
Thermal characteristic (time)	5 % rated to V/f or 600 ms

Undervoltage protection (definite-time and inverse-time function) (ANSI 27)

Setting range	
Undervoltage pickup $V<$, $V<<$, $V_p<$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time multiplier T_M	0.1 to 5 s (steps 0.01 s)
Times	
Pickup time $V<$, $V<<$	Approx. 50 ms
Drop-off time $V<$, $V<<$	Approx. 50 ms
Drop-off ratio $V<$, $V<<$, $V_p<$	1.01 or 0.5 V
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Inverse-time characteristic	1 % of measured value of voltage

Overvoltage protection (ANSI 59)

Setting ranges	
Overvoltage pickup $V>$, $V>>$ (maximum phase-to-phase voltage or phase-to-earth-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Drop-off times $V>$, $V>>$	Approx. 50 ms
Drop-off ratio $V>$, $V>>$	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms

Frequency protection (ANSI 81)

Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	3 stages 0 to 100 s, 1 stage up to 600 s
Undervoltage blocking $V_1<$	(steps 0.01 s) 10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms
Drop-off times $f>$, $f<$	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V_1<$	Approx. 1.05
Tolerances	
Frequency	10 mHz (at $V>$ 0.5 V_N)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Reverse-power protection (ANSI 32R)

Setting ranges	
Reverse power $P_{Rev.}>/S_N$	- 0.5 to - 30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.}>$	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.}>$	0.25 % S_N ± 3 % set value
Time delays T	1 % or 10 ms

[1] Secondary values based on I_N = 1 A;
for I_N = 5 A they must be multiplied by 5.

Technical data

Forward-power protection (ANSI 32F)

Setting ranges	
Forward power $P_{\text{Forw.}<}/S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{\text{Forw.}>}/S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{\text{Forw.}<}$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{\text{Forw.}>}$	Approx. 0.9 or – 0.5 % of S_N
Tolerances	
Active power $P_{\text{Forw.}<}$, $P_{\text{Forw.}>}$	0.25 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at accurate measuring 0.5 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at fast measuring
Time delays T	1 % or 10 ms

External trip commands

Binary inputs

Number of binary inputs for direct tripping	2
Operating time	Approx. 12.5 ms min. Approx. 25 ms typical
Dropout time	Approx. 25 ms
Delay time	0.00 to 60.00 s (steps 0.01 s)
Expiration tolerance	1 % of set value or 10 ms

The set definite times are pure delay times.

Transformer annunciations

External annunciations	Buchholz warning Buchholz tank Buchholz tripping

Measured quantities supervision

Current symmetry (for each measurement location)	$\lvert I_{min}\rvert$ / $\lvert I_{max}\rvert$ < BAL. FAKT. I if I_{max} / I_N > BAL. I LIMIT / I_N
BAL. FAKT. I	0.10 to 0.90 (steps 0.01)
BAL. I LIMIT	0.10 to 1.00 A [1] (steps 0.01 A)
Voltage symmetry (if voltages applied)	$\lvert V_{min}\rvert / \lvert V_{max}\rvert$ < BAL. FAKT. if $\lvert V_{max}\rvert$ > BALANCE V-LIMIT
Voltage sum (if voltages applied)	$\lvert \underline{V}_{L1+}\ \underline{V}_{L2+}\ \underline{V}_{L3-}\ \text{kV} \cdot \underline{V}_{EN}\rvert > 25\ \text{V}$
Current phase sequence	$\underline{I}_{L1}$ before $\underline{I}_{L2}$ before $\underline{I}_{L3}$ (clockwise) or $\underline{I}_{L1}$ before $\underline{I}_{L3}$ before $\underline{I}_{L2}$ (counter-clockwise) if $\lvert\underline{I}_{L1}\rvert$, $\lvert\underline{I}_{L2}\rvert$, $\lvert\underline{I}_{L3}\rvert$ > 0.5 I_N
Voltage phase sequence (if voltages applied)	$\underline{V}_{L1}$ before $\underline{V}_{L2}$ before $\underline{V}_{L3}$ (clockwise) or $\underline{V}_{L1}$ before $\underline{V}_{L3}$ before $\underline{V}_{L2}$ (counter-clock) if $\lvert\underline{V}_{L1}\rvert$, $\lvert\underline{V}_{L2}\rvert$, $\lvert\underline{V}_{L3}\rvert$ > 40 V/√3
Broken wire	Unexpected instantaneous current value and current interruption or missing zero crossing

Fuse failure monitor

	detects failure of the measured voltage

Trip circuit supervision

Trip circuits

Number of supervised trip circuits	1
Operation of each trip circuit	With 1 binary input or with 2 binary inputs

Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59,81)

N°. of selectable stages	12
Operating modes / measuring quantities	Measurement location or side selectable
3-phase	I, I_1, I_2, $3I_0$, V, V_1, V_2, V_0, P, Q, cos φ
1-phase	I, I_E, $I_{E\ sens.}$, V, P, Q, cos φ
Without fixed phase relation	f, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current I, I_1, I_2, $3I_0$, I_E	0.05 to 35 A (steps of 0.01 A)
Sens. earth curr. $I_{E\ sens.}$	0.001 to 1.5 A (steps of 0.001 A)
Voltages V, V_1, V_2, V_0	1 to 170 V (steps of 0.1 V)
Displacement voltage V_E	1 to 200 V (steps of 0.1 V)
Power P, Q	1.6 to 3000 W (steps of 0.1 W)
Power P, Q (side)	0.01 to 17 P/S_N, Q/S_N, (steps of 0.01)
Power factor (cos φ)	- 0.99 to + 0.99 (steps of 0.01)
Frequency f_N = 50/60 Hz	10 to 66 Hz (steps of 0.01 Hz)
Pickup delay time	0 to 60 s (steps of 0.01 s)
Trip delay time	0 to 3600 s (steps of 0.01 s)
Dropout delay time	0 to 60 s (steps of 0.01 s)
Times	On request (see Manual)
Dropout times	On request (see Manual)
Tolerances	On request (see Manual)

Additional functions

Operational measured values

– Operational measured values of currents, 3-phase for each side and measurement location	I_{L1}; I_{L2}; I_{L3} in A primary and secondary and % of I_N
Tolerance at I_N = 1 or 5 A	1 % of measured value or 1 % of I_N
Tolerance at I_N = 0.1 A	2 % of measured value or 2 % of I_N
– Operational measured values of currents, 3-phase for each side and measurement location	$3I_0$; I_1; I_2 in A primary and secondary and % of I_N
Tolerance	2 % of measured value or 2 % of I_N
– Operational measured values of currents	
1-phase for each measurement location	in A primary and secondary and % of I_N
Tolerance at I_N = 1 or 5 A	1 % of measured value or 1 % of I_N
Tolerance at I_N = 0.1 A	2 % of measured value or 2 % of I_N
For high-sensitivity inputs	in A primary and secondary
Tolerance	1 % of measured value or 2 mA

	Feeder	Further	High-sensitivity
7UT612	I_1 to I_7	I_7 to I_8	I_8
7UT613	I_1 to I_9	I_{x1} to I_{x3}	I_{x3}
7UT633	I_1 to I_9	I_{x1} to I_{x3}	I_{x3}
7UT635	I_1 to I_{12}	I_{x1} to I_{x4}	I_{x3}, I_{x4}

– Phase angles of currents, 3-phase for each measurement location	φ (I_{L1}); φ (I_{L2}); φ (I_{L3}) in °, referred to φ (I_{L1})
Tolerance	1 ° at rated current

Technical data

Operational measured values (cont'd)

– Phase angles of currents, 7UT612 7UT613 7UT633 7UT635	 φ (I_1) to φ (I_8) φ (I_1) to φ (I_9), φ (I_{x1}) to φ (I_{x3}) φ (I_1) to φ (I_9), φ (I_{x1}) to φ (I_{x4}) φ (I_1) to φ (I_{12}), φ (I_{x1}) to φ (I_{x4})
1-phase for each measurement location Tolerance	in °, referred to φ (I_1) 1 ° at rated current
– Operational measured values of voltages (7UT613/633 only)	in kV primary and V secondary and % of V_N
3-phase (if voltage applied) Tolerance Tolerance 1-phase (if voltage applied) Tolerance	V_{L1-E}, V_{L2-E}, V_{L3-E}, V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, 0.2 % of measured value or ± 0.2 V V_1, V_2, V_0, 0.4 % of measured value or ± 0.4 V V_{EN} or V_4 0.2 % of measured value or ± 0.2 V
– Phase angles of voltages (7UT613/633 only, if voltages applied) Tolerance	φ (V_{L1-E})), φ (V_{L2-E}), φ (V_{L3-E})), φ (V_4), φ (V_{EN}) 1 ° at rated voltage
– Operational measured values of frequency Range Tolerance	f in Hz and % of f_N 10 to 75 Hz 1 % within range f_N ± 10 % and $I \geq I_N$
– Operational measured values of power	

	S	P	Q
7UT612	x	–	–
7UT613	x	x	x
7UT633	x	x	x
7UT635	x	–	–

S (apparent power)	Applied or rated voltage
P (active power)	Only if voltage applied, 7UT613/633 only
Q (reactive power)	Only if voltage applied, 7UT613/633 only, in kVA; MVA; GVA primary
– Operational measured value of power factor	cos φ (p.f.) Only if voltage applied, 7UT613/633 only
– Overexcitation Tolerance	V / f Only if voltage applied, 7UT613/633 only 2 % of measured value
– Operational measured values for thermal value	Θ_{L1}; Θ_{L2}; Θ_{L3}; Θ_{res}, referred to tripping temperature rise Θ_{trip}
– Operational measured values (Overload protection acc. to IEC 60354)	$\Theta_{thermo-box1}$ to $\Theta_{thermo-box12}$ in °C or °F relative aging rate, load reserve
– Measured values of differential protection Tolerance (with preset values)	$I_{DIFF\ L1}$; $I_{DIFF\ L2}$; $I_{DIFF\ L3}$; $I_{REST\ L1}$; $I_{REST\ L2}$; $I_{REST\ L3}$ in % of operational rated current 2 % of measured value or 2 % of I_N (50/60 Hz) 3 % of measured value or 3 % of I_N (16.7 Hz)
– Measured values of restricted earth-fault protection Tolerance (with preset values)	$I_{DIFFREF}$; $I_{RestREF}$ in % of operational rated current 2 % of measured value or 2 % of I_N (50/60 Hz) 3 % of measured value or 3 % of I_N (16.7 Hz)

Max. / Min. / Mean report

Report of measured values	With date and time from all sides and measurement locations
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./max./mean values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component) I_2 (negative-sequence component), $3I_0$, $I_{DIFF\ L1}$, $I_{DIFF\ L2}$, $I_{DIFF\ L3}$, $I_{RESTR.L1}$, $I_{RESTR.L2}$, $I_{RESTR.L3}$
Min./max./mean values for voltages	V_{L1-E}, V_{L2-E}, V_{L3-E} V_1 (positive-sequence component) V_2 (negative-sequence component) V_0, V_E, V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
Min./max./mean values for power	S, P, Q, cos φ, frequency
Min./max. for mean values	see above

Fault event log

Storage of the messages of the last 8 faults	With a total of max. 200 messages

Fault recording

Number of stored fault records	Max. 8			
Storage period (start with pickup or trip)	Max. 5 s for each fault, Approx. 5 s in total			
	7UT 612	613	633	635
Sampling rate at f_N = 50 Hz	600 Hz	800 Hz	800 Hz	800 Hz
Sampling rate at f_N = 60 Hz	720 Hz	960 Hz	960 Hz	960 Hz

Switching statistics

Number of trip events caused by 7UT6	
Total of interrupted currents caused by 7UT6	Segregated for each pole, each side and each measurement location
Operating hours Criterion	Up to 7 decimal digits Excess of current threshold

Real-time clock and buffer battery

Resolution for operational messages	1 ms
Resolution for fault messages	1 ms
Buffer battery	3 V/1 Ah, type CR 1/2 AA Self-discharging time approx. 10 years

Time synchronization

Operating modes:	
Internal	Internal via RTC
IEC 60870-5-103	External via system interface (IEC 60870-5-103)
Time signal IRIG B	External via IRIG B
Time signal DCF77	External, via time signal DCF77
Time signal synchro-box	External, via synchro-box
Pulse via binary input	External with pulse via binary input

Selection and ordering data

Description	Order No.	Order Code
7UT612 differential protection relay for transformers, generators, motors and busbars Housing 1/3 x 19"; 3 BI, 4 BO, 1 live status contact, 7 I, I_{EE} 1)	*7UT612☐-☐☐☐☐☐-☐☐A0*	☐☐☐

Rated current		
I_N = 1 A	*1*	
I_N = 5 A	*5*	

Rated auxiliary voltage (power supply, binary inputs)		
24 to 48 V DC, binary input threshold 17 V 2)	*2*	
60 to 125 V DC 3), binary input threshold 17 V 2)	*4*	
110 to 250 V DC, 115/230 V AC, binary input threshold 73 V 2)	*5*	

Unit design		
For panel surface mounting, two-tier terminals on top and bottom	*B*	
For panel flush mounting, plug-in terminals (2/3-pole AMP connector)	*D*	
For panel flush mounting, screw-type terminals, (direct wiring/ring lugs)	*E*	

Region-specific default settings/function and language settings		
Region DE, 50/60 Hz, IEC/ANSI, language German; selectable	*A*	
Region World, 50/60 Hz, IEC/ANSI, language English (GB); selectable	*B*	
Region US, 60/50 Hz, ANSI/IEC, language English (US); selectable	*C*	
Region World, 50/60 Hz, IEC/ANSI, language Spanish; selectable	*E*	

System interface (Port B) on rear		
No system interface	*0*	
IEC 60870-5-103 protocol, electrical RS232	*1*	
IEC 60870-5-103 protocol, electrical RS485	*2*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
PROFIBUS-FMS Slave, electrical RS485	*4*	
PROFIBUS-FMS Slave, optical, single loop, ST connector 4)	*5*	
PROFIBUS-FMS Slave, optical, double loop, ST connector 4)	*6*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, optical 820 nm, double loop, ST connector 4)	*9*	*L 0 B*
MODBUS, electrical RS485	*9*	*L 0 D*
MODBUS, optical 820 nm, ST connector 4)	*9*	*L 0 E*
DNP 3.0, electrical RS485	*9*	*L 0 G*
DNP 3.0, optical 820 nm, ST connector 4)	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Etherent, optical, double, LC connector (EN 100) 5)	*9*	*L 0 S*

See next page

1) Sensitivity selectable normal/high.

2) The binary input thresholds are selectable in two stages by means of jumpers.

3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

4) With surface-mounting housing: only RS485 interface available.

5) If position 9 = "B" (surface-mounting housing), please order relay with electrical Ethernet interface and use a separate FO switch.

Selection and ordering data

Description	Order No.
7UT612 differential protection relay for transformers, generators, motors and busbars	*7UT612☐ - ☐☐☐☐☐-☐☐A0*
DIGSI 4/browser/modem interface (Port C) on rear/temperature monitoring box connection	
No DIGSI 4 port	*0*
DIGSI 4/browser, electrical RS232	*1*
DIGSI 4/browser or temperature monitoring box[1], electrical RS485	*2*
DIGSI 4/browser or temperature monitoring box[1], 820 nm fiber optic, ST connector	*3*
Functions	
Measured values/monitoring functions	
Basic measured values	*1*
Basic measured values, transformer monitoring functions (connection to thermo-box/hot spot acc. to IEC, overload factor)	*4*
Differential protection + basic functions	
Differential protection for transformer, generator, motor, busbar (87) Overload protection for one winding (49), Lockout (86) Overcurrent-time protection (50/51): $I>$, $I>>$, I_P (inrush stabilization) Overcurrent-time protection (50N/51N): $3I_0>$, $3I_0>>$, $3I_{0P}$ (inrush stabilization) Overcurrent-time protection earth (50G/51G): $I_E>$, $I_E>>$, I_{EP} (inrush stabilization)	*A*
Differential protection + basic functions + additional functions	
Restricted earth fault protection, low impedance (87N) Restricted earth fault protection, high impedance (87N without resistor and varistor), O/C 1-phase Trip circuit supervision (74TC), breaker failure protection (50BF), unbalanced load protection (46)	*B*

---

[1] External temperature monitoring box required.

Selection and ordering data

Description	Order No.	Order Code
7UT613 differential protection relay for transformers, generators, motors and busbars Housing 1/2 x 19"; 5 BI, 8 BO, 1 live status contact, 11 I, I_{EE}[1]	*7UT613□-□□□□□-□□□□*	*□□□*
Rated current		
$I_N = 1$ A	*1*	
$I_N = 5$ A	*5*	
Rated auxiliary voltage (power supply, binary inputs)		
24 to 48 V DC, binary input threshold 17 V[2]	*2*	
60 to 125 V DC[3], binary input threshold 17 V[2]	*4*	
110 to 250 V DC[1], 115/230 V AC, binary input threshold 73 V[2]	*5*	
110 to 250 V DC[1], 115/230 V AC, binary input threshold 154 V[2]	*6*	
Unit design		
Surface-mounting housing with two-tier terminals	*B*	
Flush-mounting housing with plug-in terminals	*D*	
Flush-mounting housing with screw-type terminals	*E*	
Region-specific default settings/language settings		
Region DE, 50/60 Hz, IEC/ANSI, language German; selectable	*A*	
Region World, 50/60 Hz, IEC/ANSI, language English (GB); selectable	*B*	
Region US, 60/50 Hz, ANSI/IEC, language English (US); selectable	*C*	
Region World, 50/60 Hz, IEC/ANSI, language French; selectable	*D*	
Region World, 50/60 Hz, IEC/ANSI, language Spanish; selectable	*E*	
System interface (Port B) on rear		
No system interface	*0*	
IEC 60870-5-103 protocol, electrical RS232	*1*	
IEC 60870-5-103 protocol, electrical RS485	*2*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
PROFIBUS-FMS Slave, electrical RS485	*4*	
PROFIBUS-FMS Slave, optical, single ring, ST connector[4]	*5*	
PROFIBUS-FMS Slave, optical, double ring, ST connector[4]	*6*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector[4]	*9*	*L 0 B*
MODBUS, electrical RS485	*9*	*L 0 D*
MODBUS, optical 820 nm, ST connector[4]	*9*	*L 0 E*
DNP 3.0, electrical RS485	*9*	*L 0 G*
DNP 3.0, optical 820 nm, ST connector[4]	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Etherent, optical, double, LC connector (EN 100)[5]	*9*	*L 0 S*

see next page

---

1) Sensitivity selectable normal/high.

2) The binary input thresholds are selectable in two stages by means of jumpers.

3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

4) With surface-mounting housing: only RS485 interface available.

5) If position 9 = "B" (surface-mounting housing), please order relay with electrical Ethernet interface and use a separate FO switch.

Selection and ordering data

Description	Order No.	Order Code
7UT613 differential protection relay for transformers, generators, motors and busbars	*7UT613☐-☐☐☐☐☐ - ☐☐☐☐*	*☐☐☐*

Port C and Port D

Port C: DIGSI 4/modem, electrical RS232; Port D: empty	1	
Port C: DIGSI 4/modem/thermo-box, electrical RS485; Port D: empty	2	
Port C and Port D installed	9	M ☐☐

Port C (service interface)

DIGSI 4/modem, electrical RS232	1
DIGSI 4/modem/thermo-box, electrical RS485	2

Port D (additional interface)

Thermo-box, optical 820 nm, ST connector	A
Thermo-box, electrical RS485	F

Measured values/monitoring functions

Basic measured values	1
Extended measured values, min./max. values, mean values	2
Extended measured values, min./max., mean values, transformer monitoring functions (connection to thermo-box/hot spot, overload factor)	4

Differential protection + basic functions

Differential protection for transformer, generator, motor, busbar (87) Overload protection according to IEC for one side (49) Lock out (86) Overcurrent-time protection phases (50/51): $I>$, $I>>$, I_P (inrush stabilization) Overcurrent-time protection 3 I_0 (50N/51N): 3 $I_0>$, 3 $I_0>>$, 3 I_{0P} (inrush stabilization) Overcurrent-time protection earth (50G/51G): $I_E>$, $I_E>>$, I_{EP} (inrush stabilization)	A

Differential protection + basic functions + additional current functions

Restricted earth-fault protection, low impedance (87N) Restricted earth-fault protection, high impedance (87N without resistor and varistor), O/C 1-phase Trip circuit supervision (74TC) Unbalanced load protection (46) Breaker failure protection (50BF) High-sensitivity overcurrent-time protection/tank leakage protection (64), O/C 1-phase	B

Additional voltage functions

Without voltage functions	A
With overexcitation protection and voltage/power/energy/measurement	B
With overexcitation protection and voltage/power/energy measurement + Over/undervoltage protection (59/27) + Frequency protection (81) + Directional power protection (32R/F) + Fuse failure monitor (60FL)	C

Additional functions (general)

Without	0
Multiple protection functions (50, 51, 50N/G, 87N, 50BF, 49)1)	1
Flexible protection functions	2
Multiple + flexible protection functions	3

---

1) Available if selected on position 14.

Selection and ordering data

Description	Order No.	Order Code
7UT63☐ differential protection relay for transformers, generators, motors and busbars, graphic display	7UT63☐☐-☐☐☐☐☐-☐☐☐☐	☐☐☐
Housing, inputs and outputs		
Housing 1/1 x 19”, 21 BI, 24 BO, 1 live status contact 12 current inputs (11 I, I_{EE}1)); 4 voltage inputs (1 x 3-phase + 1 x 1-phase)	3	
Housing 1/1 x 19”, 29 BI, 24 BO, 1 live status contact 16 current inputs (14 I, 2 I_{EE}1))	5	
Rated current		
$I_N = 1$ A	1	
$I_N = 5$ A	5	
Rated auxiliary voltage (power supply, binary inputs)		
24 to 48 V DC, binary input threshold 17 V2)	2	
60 to 125 V DC3), binary input threshold 17 V2)	4	
110 to 250 V DC1), 115/230 V AC, binary input threshold 73 V2)	5	
110 to 250 V DC1), 115/230 V AC, binary input threshold 154 V2)	6	
Unit design		
Surface-mounting with two-tier terminals	B	
Flush-mounting with plug-in terminals	D	
Flush-mounting with screw-type terminals	E	
Surface mounting with two-tier terminals, with 5 high-speed trip contacts	N	
Flush-mounting with plug-in terminals, with 5 high-speed trip contacts	P	
Flush-mounting with screw-type terminals, with 5 high-speed trip contacts	Q	
Region-specific default settings/language settings		
Region DE, 50/60 Hz, IEC/ANSI language German; selectable	A	
Region World, 50/60 Hz, IEC/ANSI language English (GB); selectable	B	
Region US, 60/50 Hz, ANSI/IEC language English (US); selectable	C	
Region World, 50/60 Hz, IEC/ANSI, language French; selectable	D	
Region World, 50/60 Hz, IEC/ANSI language Spanish; selectable	E	
System interface (Port B) on rear		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single ring, ST connector4)	5	
PROFIBUS-FMS Slave, optical, double ring, ST connector4)	6	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820, double ring, ST connector4)	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector4)	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector4)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)5)	9	L 0 S

see next page

1) Sensitivity selectable normal/high.

2) The binary input thresholds are selectable in two stages by means of jumpers.

3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

4) With surface-mounting housing: only RS485 interface available.

5) If position 9 = “B” (surface-mounting housing), please order relay with electrical Ethernet interface and use a separate FO switch.

Selection and ordering data

Description	Order No.	Order Code
7UT63☐ differential protection relay for transformers, generators, motors and busbars, graphic display	*7UT63☐☐-☐☐☐☐☐-☐☐☐☐*	*☐☐☐*
Port C and Port D		
Port C: DIGSI 4/modem, electrical RS232; Port D: empty	1	
Port C: DIGSI 4/modem/thermo-box, electrical RS485; Port D: empty	2	
Port C and Port D installed	9	M ☐☐
Port C (service interface)		
DIGSI 4/modem, electrical RS232		1
DIGSI 4/modem/thermo-box, electrical RS485		2
Port D (additional interface)		
Thermo-box, optical 820 nm, ST connector		A
Thermo-box, electrical RS485		F
Measured values/monitoring functions		
Basic measured values	1	
Extended measured values, min./max. values, mean values	2	
Extended measured values, min./max. values, mean values, transformer monitoring functions (connection to thermo-box/hot spot, overload factor)	4	
Differential protection + basic functions		
Differential protection for transformer, generator, motor, busbar (87) Overload protection according to IEC for one side (49) Lock out (86) Overcurrent-time protection phases (50/51): $I>$, $I>>$, I_P (inrush stabilization) Overcurrent-time protection 3 I_0 (50N/51N): 3 $I_0>$, 3 $I_0>>$, 3 I_{0P} (inrush stabilization) Overcurrent-time protection earth (50G/51G): $I_E>$, $I_E>>$, I_{EP} (inrush stabilization)	A	
Differential protection + basic functions + additional current functions		
Restricted earth-fault protection, low impedance (87N) Restricted earth-fault protection, high impedance (87N without resistor and varistor), O/C 1-phase Trip circuit supervision (74TC) Unbalanced load protection (46) Breaker failure protection (50BF) High-sensitivity overcurrent-time protection/tank leakage protection (64), O/C 1-phase	B	
Additional voltage functions (only with 7UT633)		
Without voltage functions	A	
With overexcitation protection and voltage/power/energy/measurement	B	
With overexcitation protection and voltage/power/energy measurement + Over/undervoltage protection (59/27) + Frequency protection (81) + Directional power protection (32R/F) + Fuse failure monitor (6FL)	C	
Additional functions (general)		
Without	0	
Multiple protection functions (50, 51, 50N/G, 87N, 50BF, 49)[1]	1	
Flexible protection functions	2	
Multiple + flexible protection functions	3	

---

1) Available if selected on position 14

Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection relays running under MS Windows (Windows 2000/XP Professional Edition), device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)		
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)		7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)		7XS5402-0AA00
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator		7XS5403-0AA00
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		7XS5460-0AA00
SIGRA 4		
(generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format) running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.		7XS5410-0AA00
Connecting cable		
Cable between PC/notebook (9-pin connector) and protection relay (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		7XV5100-4
Cable between thermo-box and relay		
- length 5 m / 16.4 ft		7XV5103-7AA05
- length 25 m / 82 ft		7XV5103-7AA25
- length 50 m / 164 ft		7XV5103-7AA50
Voltage transformer miniature circuit-breaker		
Rated current 1.6 A; Thermal overload release 1.6 A; Overcurrent trip 6 A		3RV1611-1AG14
Temperature monitoring box with 6 thermal inputs		
For SIPROTEC units		
With 6 temperature sensors and	24 to 60 V AC/DC	7XV5662-2AD10
RS485 interface	90 to 240 V AC/DC	7XV5662-5AD10
Manual for 7UT612		
English		C53000-G1176-C148-1
Manual for 7UT6		
English V4.0		C53000-G1176-C160-1
English V4.6		C53000-G1176-C160-2

Accessories

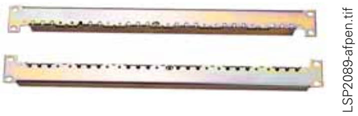


Fig. 8/34 Mounting rail for 19" rack

Fig. 8/35
2-pin connector

Fig. 8/36
3-pin connector

Fig. 8/37
Short-circuit link for
current contacts

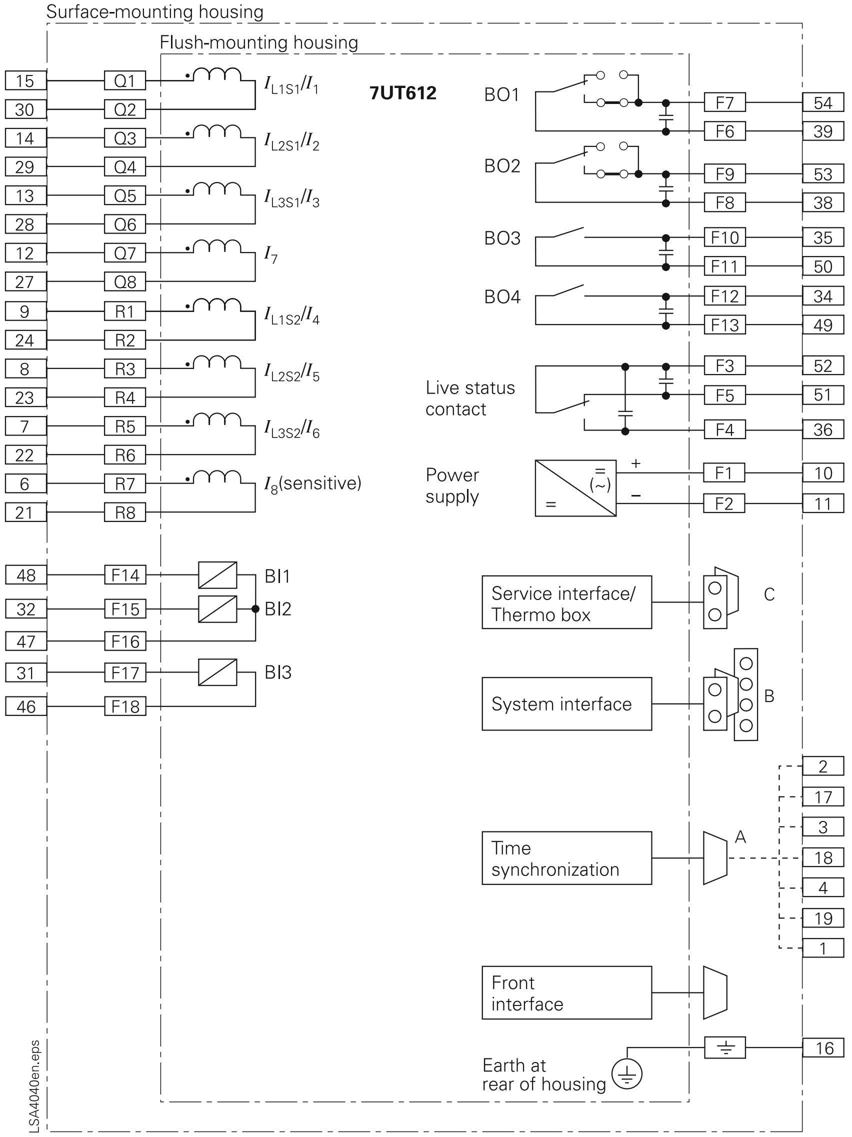
Fig. 8/38
Short-circuit link
for voltage
contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	8/35
	3-pin	C73334-A1-C36-1	1	Siemens	8/36
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP [1]	
		0-827396-1	1	AMP [1]	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP [1]	
		0-827397-1	1	AMP [1]	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP [1]	
		0-163084-2	1	AMP [1]	
Crimping tool	For Type III+	0-539635-1	1	AMP [1]	
	and matching female	0-539668-2		AMP [1]	
	For CI2	0-734372-1	1	AMP [1]	
	and matching female	1-734387-1		AMP [1]	
19" mounting rail		C73165-A63-D200-1	1	Siemens	8/34
Short-circuit links	For current contacts	C73334-A1-C33-1	1	Siemens	8/37
	For voltage contacts	C73334-A1-C34-1	1	Siemens	8/38
Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens	
	small	C73334-A1-C32-1	1	Siemens	

---

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram



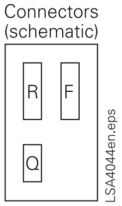
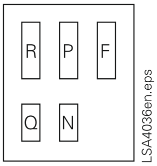


Fig. 8/39 Connection diagram

Connection diagram

Connectors (schematic)



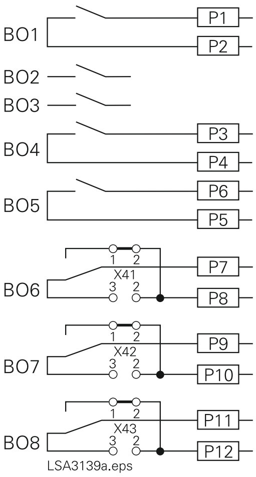


Fig. 8/40a
Additional setting by jumpers:
Separation of common circuit of fast BO1 to BO5 with jumpers X80, X81, X82. Switching of fast BO7, BO8 as NO contact or NC contact with jumpers X41, X42, X43.

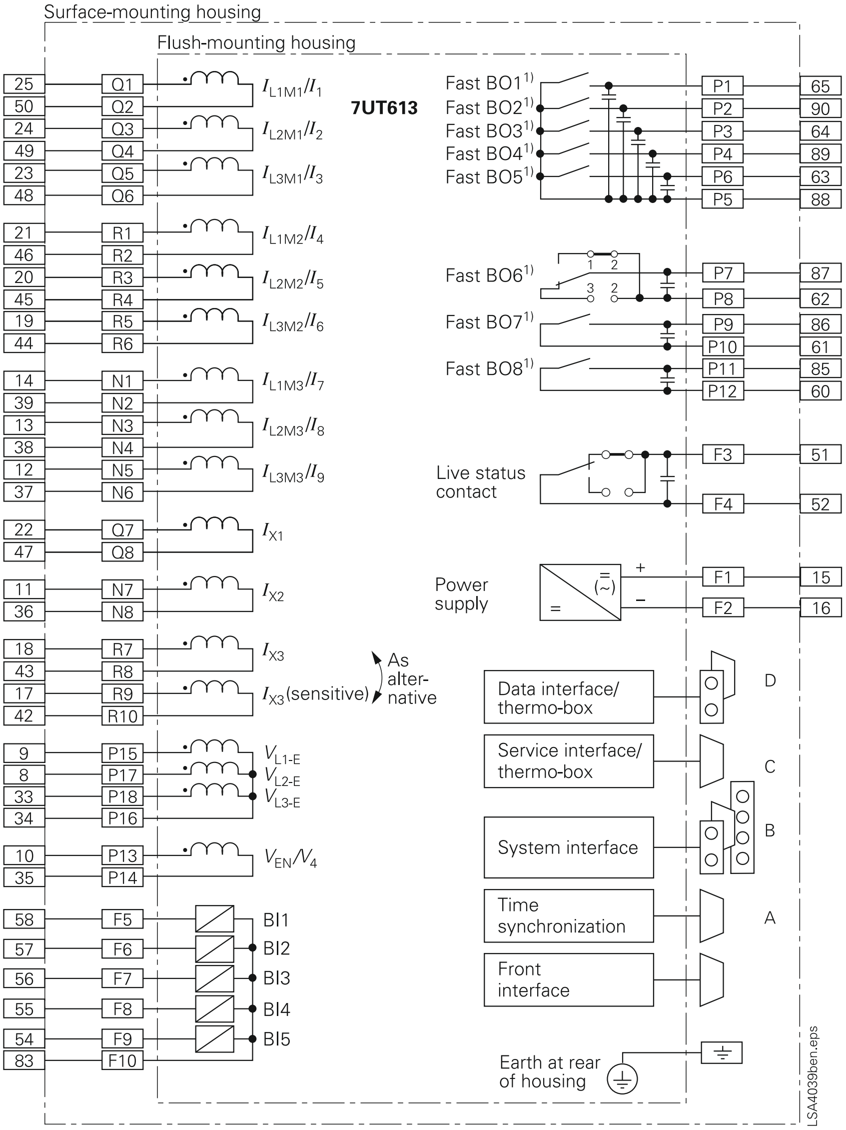
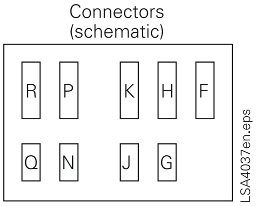


Fig. 8/40 Connection diagram 7UT613

---

1) Configuration of binary outputs up to hardware-version .../CC
For advanced flexibility see Fig. 8/40a.

Connection diagram



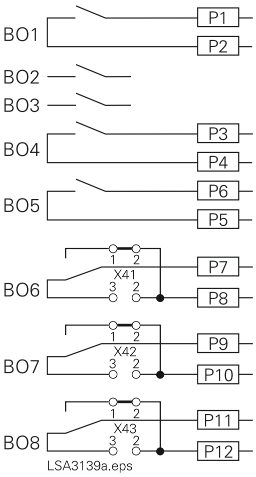


Fig. 8/41a
Additional setting by jumpers: Separation of common circuit of fast BO1 to BO5 with jumpers X80, X81, X82. Switching of fast BO7, BO8 as NO contact or NC contact with jumpers X41, X42, X43.

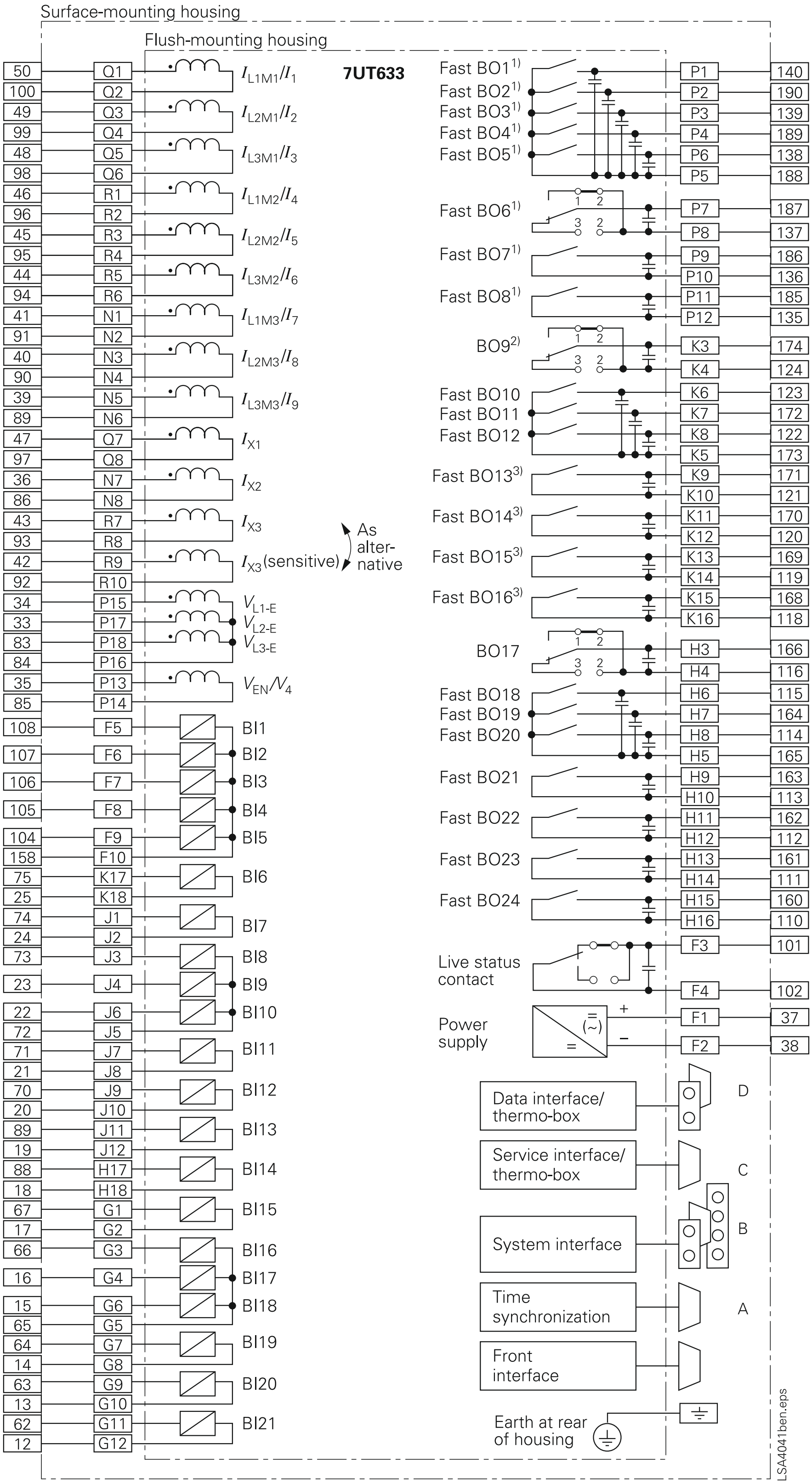


Fig. 8/41 Connection diagram 7UT63

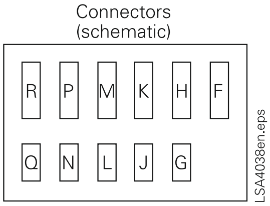
---

1) Configuration of binary outputs up to hardware-version .../CC
For advanced flexibility see Fig. 8/41a.

2) High-speed contacts (option), NO only

3) High-speed contacts (option)

Connection diagram



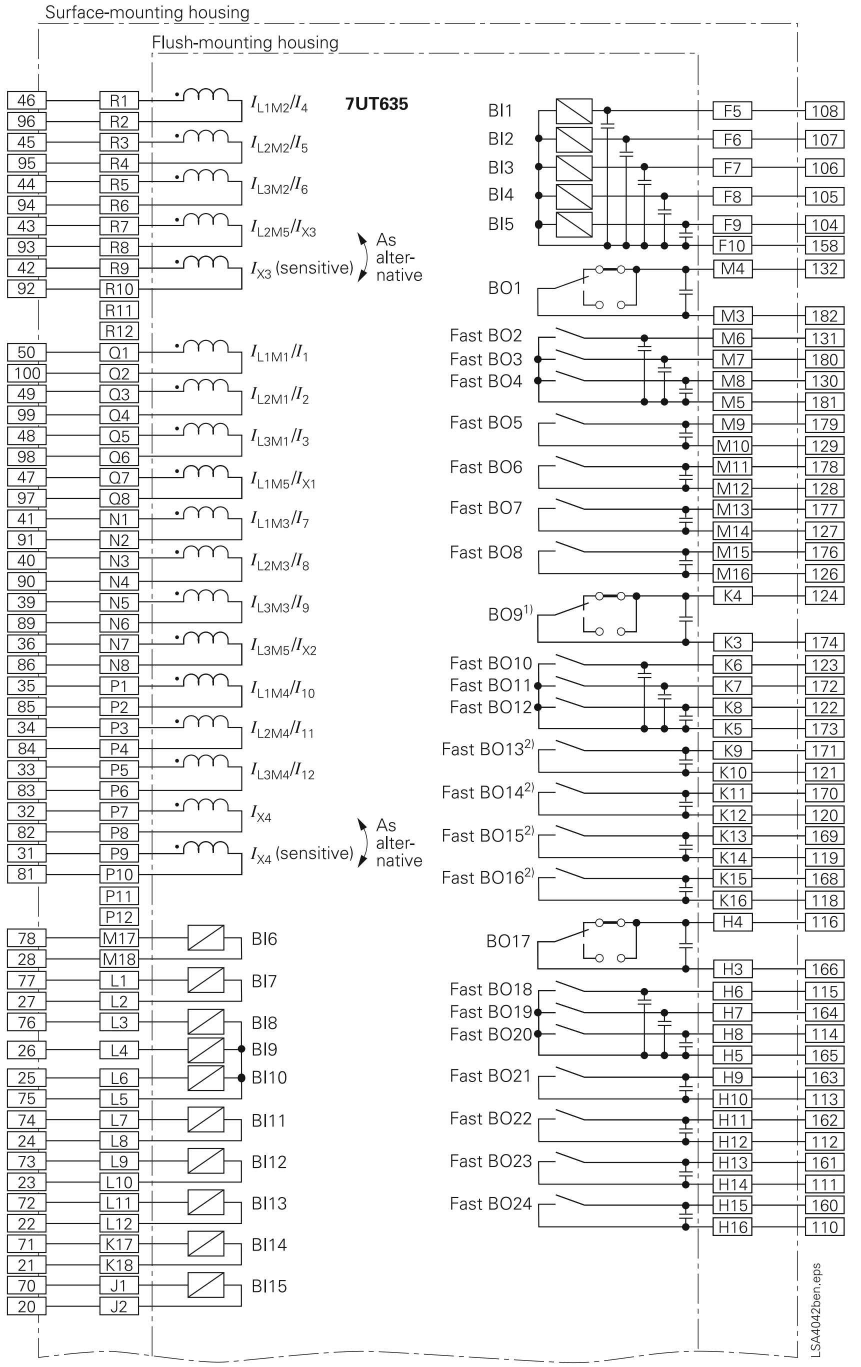


Fig. 8/42 Connection diagram 7UT635
part 1; continued on following page

---

1) High-speed contacts (option), NO only

2) High-speed contacts (option)

Connection diagram

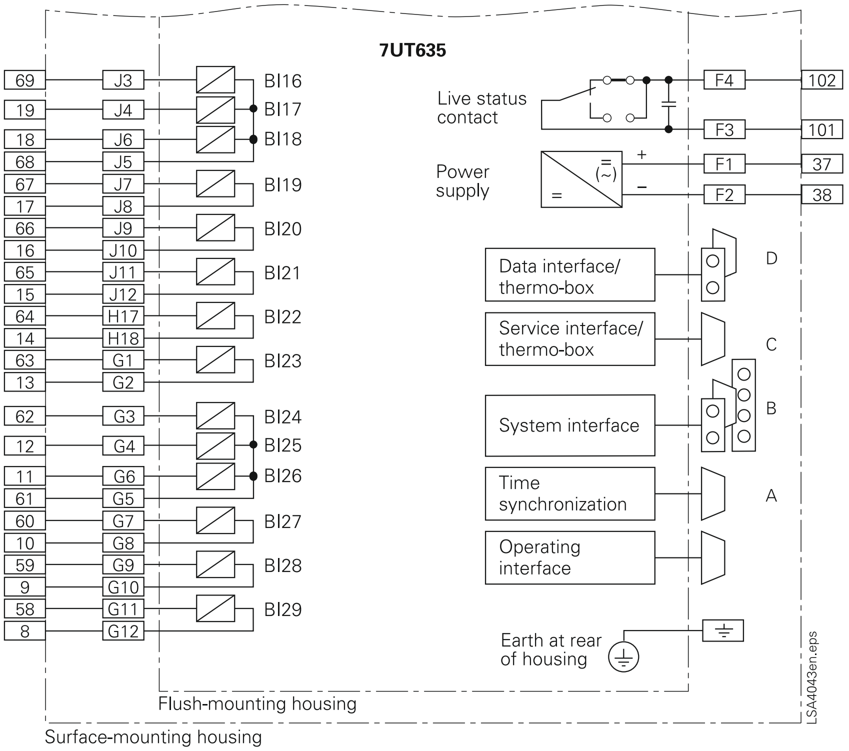


Fig. 8/43 Connection diagram 7UT635 part 2

Busbar Differential Protection

SIPROTEC 7SS60 Centralized Numerical Busbar Protection

Fig. 9/1 7SS601 measuring system

Description

The SIPROTEC 7SS60 system is an inexpensive numerical differential current protection for busbars in a centralized configuration.

It is suitable for all voltage levels and can be adapted to a large variety of busbar configurations with an unlimited number of feeders. The components are designed for single busbars, 1½-breaker configurations and double busbars with or without couplers.

Different primary CT ratios can be matched by using appropriate windings of the input current transformers.

The use of matching transformers allows phase-selective measurement. Single-phase measurement can be achieved by using summation current transformers.

Function overview

Features

- Optimized for single busbar and 1½ circuit-breaker configurations
- Suitable for double busbars with or without couplers
- Separate check zone possible
- Short trip times
- Unlimited number of feeders
- Matching of different primary CT ratios
- Differential current principle
- Low-impedance measuring method
- Numerical measured-value processing
- Suitable for all voltage levels
- Low demands on CTs thanks to additional restraint
- Measured-value acquisition via summation current transformer or phase-selective matching transformers
- Maintained TRIP command (lockout function)
- Centralized, compact design
- Combinative with separate breaker failure protection

Monitoring functions

- Primary current transformers including supply leads
- Operational measured values: Differential and restraint current
- Self-supervision of the relay
- 30 event logs
- 8 fault logs
- 8 oscillographic fault records

Communication interface

- RS485 interface for local and remote operation with DIGSI

Hardware

- Concept of modular components
- Reduced number of module types
- Auxiliary voltage 48 V DC to 250 V DC
- 7SS601 measuring system in 1⁄6 19-inch housing 7XP20
- Peripheral components in ½ 19-inch housing 7XP20

Front design

- Display for operation and measured values
- 6 LEDs for local indication

Application

The 7SS60 system is an easily settable numerical differential current protection for busbars.

It is suitable for all voltage levels and can be adapted to a large variety of busbar configurations. The components are designed for single busbars, 1½-breaker configurations and double busbars with or without couplers.

The use of matching transformers allows phase-selective measurement.

Single-phase measurement can be achieved by using summation current transformers.

The 7SS60 is designed to be the successor of the 7SS1 static busbar protection. The existing summation current or matching transformers can be reused for this protection system.

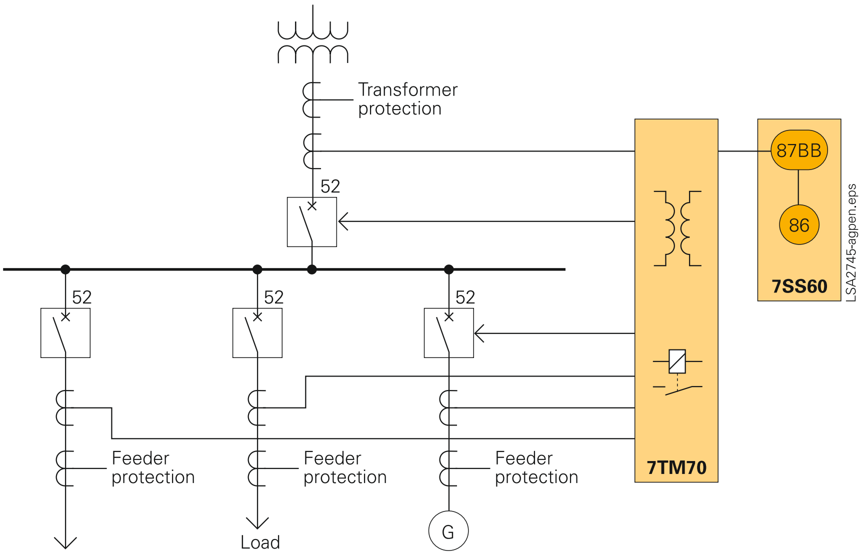


Fig. 9/2 Basic connection scheme 7SS60

Construction/Functions

Design

The 7SS60 compactly-built protection system contains all components for:

- Measured-value acquisition and evaluation
- Operation and LC display
- Annunciation and command output
- Input and evaluation of binary signals
- Data transmission via the RS485 interface with bus capability
- Auxiliary voltage supply

The 7SS60 system comprises the following components:

- 7SS601 measuring system and the peripheral modules
- 7TM70 restraint/command output module
- 7TR71 isolator replica/preference module
- 7TS72 command output module

The number of modules required is determined by the substation configuration and the measuring principle used (summation current transformers or phase-selective measurement). The 7SS601 measuring system is accommodated in a separate housing (1/6 19-inch 7XP20) that is suited for panel flush mounting or cubicle mounting. The 7XP2040 peripheral module housing has a width of ½ 19 inches and can hold up to four peripheral modules. It is suited for panel flush mounting or cubicle mounting and has plug-on connectors fitted at the rear.

The primary current transformers are connected to summation current transformers of type 4AM5120-3DA/4DA or to matching transformers of type 4AM5120-1DA/2DA. With a rated current of 1 or 5 A, the current output at these transformers is 100 mA. This output current is fed onto the 7SS601 measuring system (for differential current formation) and onto the 7TM70 restraint units (for restraint current formation). The summated restraint current is fed onto the 7SS601 measuring system as well.

Functions of the components

- The 7SS601 measuring system comprises:
  - One measuring input for acquisition and processing of the differential and the restraint current
  - 3 binary inputs for acquisition of information, e.g. a blocking condition
  - 2 command relays for activation of other, feeder-specific command relays on the 7TM70 and 7TS72 peripheral modules.

In circuits with summation current transformer, one 7SS601 measuring system is required per protected zone. For phase-selective measurement, one 7SS601 measuring system is required per phase and protected zone.

- 7TM70 restraint/command output module
  This module contains 5 current transformers with rectifiers for the formation of the restraint current. It has also 5 command relays with 2 NO contacts each for output of a direct TRIP command to the circuit-breakers.
- 7TR71 isolator replica/preference module
  This module enables the two bus isolators to be detected in a double busbar. The feeder current is assigned to the corresponding measuring system on the basis of the detected isolator position.
  The module is also designed for an additional function. In the case of a double busbar system, for example, where both bus isolators of a feeder are closed at a time, no selective protection of the two busbars is possible. During this state, one of the two measuring systems is given priority. The module 7TR71 appropriately assigns feeder currents to the corresponding measuring system 7SS601.
  The module also contains an auxiliary relay with two changeover contacts.
- 7TS72 command output module
  The 7TM70 contains 5 trip relays with 2 NO contacts each. If more trip contacts are needed, the 7TS72 module can be used, providing 8 relays with 2 NO contacts each.


LSP2383-afp.tif

Fig. 9/3 Housing for peripheral modules (front cover removed)


LSP2803.tif

Fig. 9/4 Rear view

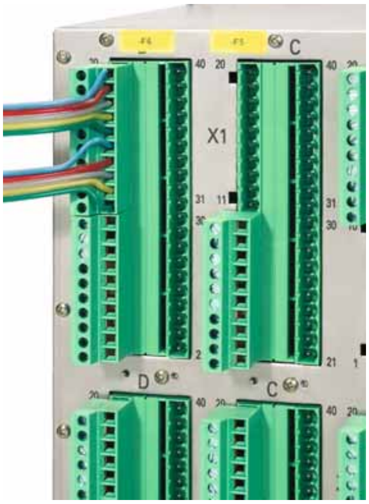

LSP2804.tif

Fig. 9/5 Rear view detail

Protection functions

Measuring principles

The feeder currents can be measured and processed according to different principles.

- Summation current transformer principle
  In the summation current transformer variant, the three secondary currents of the primary CTs are fed onto the three primary windings of the summation current transformers with a winding ratio of n1:n2:n3 = 2:1:3. According to the expected fault currents two different circuits for connecting the summation current transformer are possible. For power systems with low-resistance or solid earthing of the starpoint, the 1-phase earth-faults are sufficiently high to use the circuit with normal sensitivity (see Fig. 9/7). An increased sensitivity for earth-faults can be achieved by use of a circuit according to Fig. 9/8. With a symmetrical, three-phase current of 1 x I_N, the secondary current of the summation current transformers is 100 mA.
  Different primary CT transformation ratios can usually be compensated directly by appropriate selection of the summation CT primary windings. Where the circuit conditions do not allow this, additional matching transformers, such as the 4AM5272-3AA, should be used, preferably in the form of autotransformers (see Fig. 9/9: Protection with summation current transformer and matching transformers). The autotransformer circuit reduces the total burden for the primary CTs.

- Phase-selective measurement
  In this variant, each phase current is measured separately. To do so, each of the secondary currents of the primary transformers is fed onto a matching transformer. This transformer allows, if its primary windings are selected accordingly, to generate a normalized current from a variety of different primary CT transformation ratios (see Fig. 9/10: Phase-selective measurement). With a primary current of 1 x I_N, the secondary current of the matching transformers is 100 mA.

Function principle of the differential protection

The main function of the 7SS60 protection system is a busbar protection that operates with the differential current measuring principle. Its algorithm relies on Kirchhoff's current law, which states that in fault-free condition the vectorial sum I_d of all currents flowing into an independent busbar section must be zero. Some slight deviations from this law may be caused by current transformer error, inaccuracies in the matching of the transformation ratios and measuring inaccuracies. Further errors, which may be due to e.g. transformer saturation in case of high-current external short-circuits, are counteracted by a load-dependent supplementary restraint.

The restraint current I_R is derived from the load condition. This restraint current is formed as the summated magnitudes of all currents. The differential and the restraint current are fed into the 7SS601 measuring system (see Fig. 9/6: Block diagram). With double busbars or sectionalized busbars, one measuring system 7SS601 (summation CT), respectively 3 measuring systems (phase-selective measurement) will be used for each selective section. The module 7TS71 (isolator replica/preference) appropriately assigns feeder currents to the corresponding measuring system 7SS601.

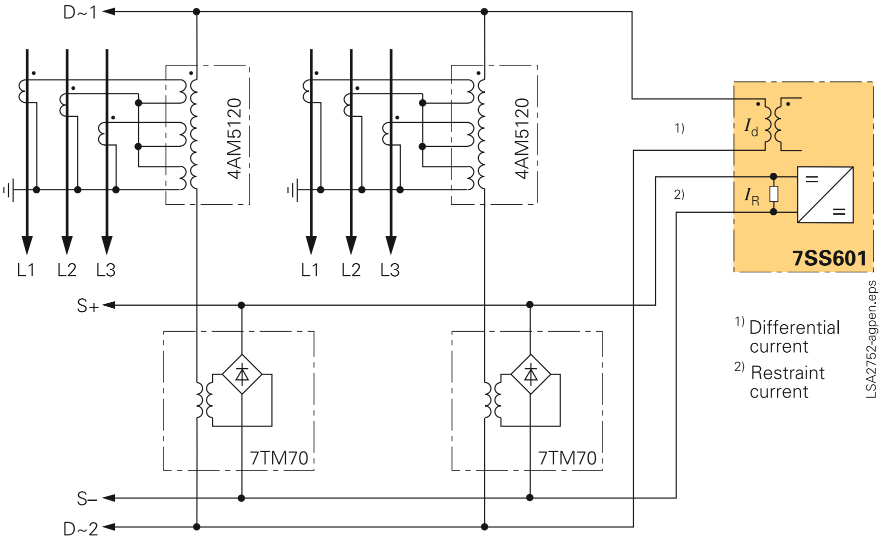


Fig. 9/6 Block diagram: Acquisition of measured values

Typical connections

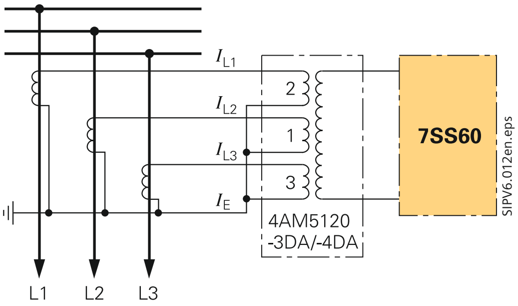


Fig. 9/7 Protection with summation current transformer (L1-L2-L3 circuit)

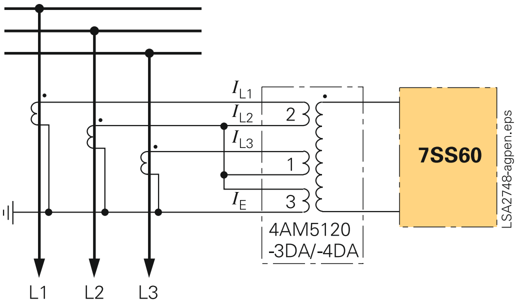


Fig. 9/8 Protection with summation current transformer (L1-L3-N circuit)

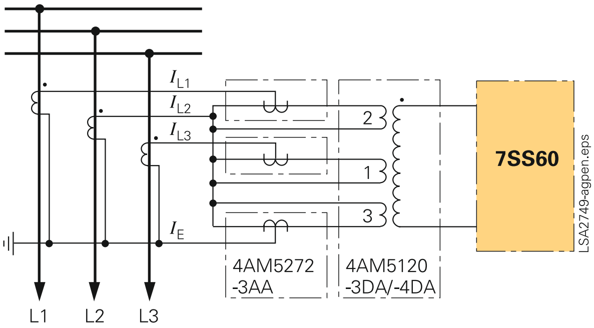


Fig. 9/9 Protection with summation current transformer and matching transformers

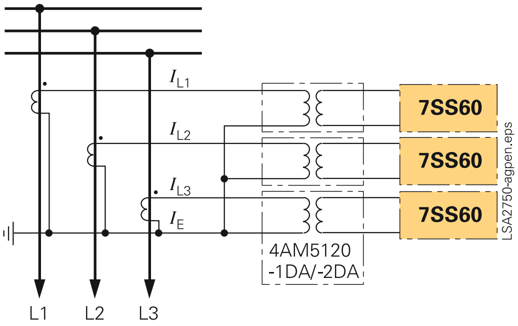


Fig. 9/10 Phase-selective measurement

Protection functions/Functions

Pickup characteristic of the differential protection

The characteristic can be set in the parameters for $I_d >$ (pickup value) and for the k factor which considers the linear and non-linear current transformer errors. Differential currents above the set characteristic lead to tripping.

Current transformer monitoring

An independent sensitive differential current monitoring with its parameter $I_{d\ thr}$ detects faults (short-circuits, open circuit) of current transformers and their wiring even with load currents. The affected measuring system is blocked and an alarm is given. By this, the stability of the busbar protection is ensured in case of external faults.

Trip command lockout (with manual reset)

Following a trip of the differential protection, the TRIP command can be kept (sealed-in). The circuit-breakers are not reclosed until the operator has obtained information on the fault; the command must be manually reset by pressing a key or by a binary input.

The logical state of the TRIP command is buffered against a loss of the auxiliary power supply, so that it is still present on restoration of the auxiliary voltage supply.

Test and commissioning aids

The protection system provides user support for testing and commissioning. It has a wide range of integrated aids that can be activated from the keypad or from a PC using the DIGSI program. For some tests a codeword must be entered.
The following test aids are available:

- Display of operational measured values
- Interrogation of status of binary inputs and LED indicators
- Blocking of the TRIP function during testing

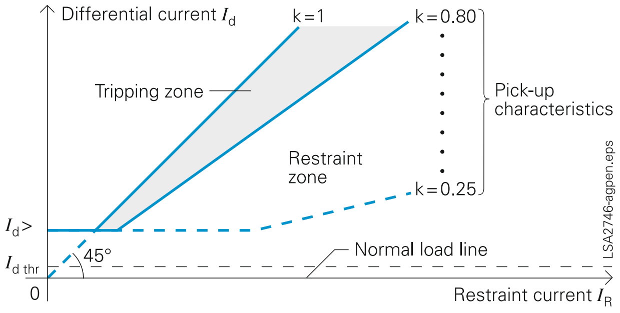


Fig. 9/11 Tripping characteristic

Communication/Functions

Serial data transmission

The device is equipped with an RS485 interface. The interface has bus capability and allows a maximum of 32 units to be connected via a serial two-wire interface. A PC can be connected to the interface via an RS232↔RS485 converter, so that configuration, setting and evaluation can be performed comfortably via the PC using the DIGSI operating program. The PC can also be used to read out the fault record that is generated by the device when a fault occurs.

With RS485↔820 nm optical converters, which are available as accessories (7XV5650, 7XV5651), an interference-free, isolated connection to a control center or a DIGSI-based remote control unit is possible; this allows to design low-cost stations concepts that permit e.g. remote diagnosis.

Comfortable setting

The parameter settings are made in a menu-guided procedure from the integrated operator panel and the LC display. It is, however, more comfortable to use a PC for this purpose, together with the standard DIGSI operating program.

Fault recording

If a fault leads to a trip, a fault record is generated, in which the differential and the restraint current are recorded with a sampling frequency of 2 kHz. In addition, signals are stored as binary traces, which represent internal device states or binary input states. Up to eight fault records can be stored. When a ninth fault occurs, the oldest record is overwritten. A total storage capacity of 7 s is available. The most recent 2.5 s are buffered against power failure.

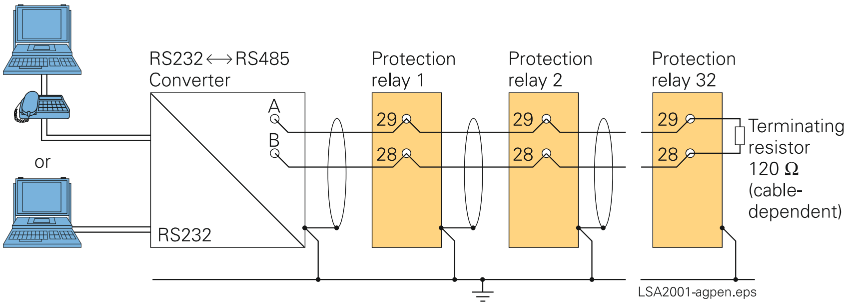


Fig. 9/12 Communication scheme

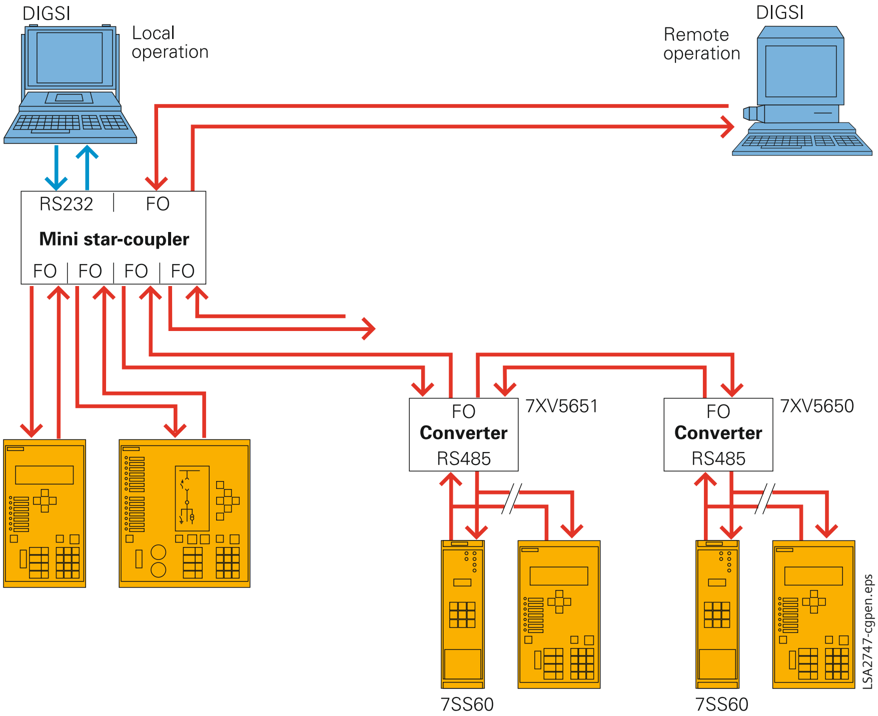


Fig. 9/13 Communication scheme

Technical data

7SS60 measuring system

Measuring input I_d

Rated current	100 mA
Rated frequency	50/60 Hz settable, 16.7 Hz
Dynamic overload capacity (pulse current)	250 x I_N one half cycle
Thermal overload capacity (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
Isolating voltage	2.5 kV (r.m.s.)
Measuring range for operational measured values	0 to 240 %
Measuring dynamics	100 x I_N without offset 50 x I_N with full offset

Measuring input I_R

Rated current	1.9 mA
Dynamic overload capability (pulse current)	250 x I_N for 10 ms
Thermal overload capability (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
Isolating voltage	2.5 kV (r.m.s.)
Measuring dynamics	0 to 200 x I_N

Auxiliary voltage

Via integrated DC/DC converter Rated auxiliary voltage V_{aux} (permissible voltage)	24/48 V DC 60/110/125 V DC 220/250 V DC 115 V AC	(19 to 58 V DC) (48 to 150 V DC) (176 to 300 V DC) (92 to 133 V AC)
Superimposed AC voltage (peak-to-peak)	≤ 15 % of rated voltage	
Power consumption	Quiescent Energized	Approx. 3 W Approx. 5 W
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms at V_{aux} ≥ 100 V DC ≥ 20 ms at V_{aux} ≥ 48 V DC	

Binary inputs

Number	3 (marshallable)
Operating voltage range	24 to 250 V DC
Current consumption when energized	Approx. 2.5 mA Independent of operating voltage
Pickup threshold	Can be changed by setting jumpers
Rated aux. voltage 48/60 V DC	
V_{pickup}	≥ 17 V DC
$V_{drop\text{-}off}$	< 8 V DC
Rated aux. voltage 110/125/220/250 V DC	
V_{pickup}	≥ 74 V DC
$V_{drop\text{-}off}$	< 45 V DC
Max. voltage	300 V DC

Command contacts

Number of relays	1 (2 NO contacts) 1 (1 NO contact)
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	
Continuous	5 A
0.5 s	30 A

Signal contacts

Number of relays	3 (2 marshallable)
Contacts	2 changeover contacts and 1 NO contact (can be changed to NC by jumper)
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	
Continuous	5 A
0.5 s	30 A

Serial interface

Standard	Isolated RS485
Test voltage	3.5 kV DC
Connection	Data cable at housing terminals, 2 data lines For connection of a personal computer or similar Cables must be shielded, and shields must be earthed.
Transmission rate	As delivered 9600 baud min. 1200 baud, max. 19200 baud

Unit design

Housing 7XP20	$^1/_6$ 19"
Dimensions	See part 15
Weight	Approx. 4.0 kg
Degree of protection according to IEC 60529-1	
For the unit	IP 51
For operator protection	IP 2X

Technical data

Functions

Differential current protection

Setting ranges for pickup threshold	
Differential current I_d>	0.20 to 2.50 I_{NO}
Restraint factor	0.25 to 0.80
Tolerance of pickup value	
Differential current I_d>	± 5 % of setpoint
Minimum duration of trip command	0.01 to 32.00 s (in steps of 0.01 s)
Time delay of trip	0.00 to 10.00 s (in steps of 0.01 s)
Times	
Minimum tripping time 50/60 Hz1)	10 ms
Typical tripping time 50/60 Hz1)	12 ms (rapid measurement) 40 ms (repeated measurement)
Minimum tripping time 16.7 Hz1)	12 ms
Typical tripping time 16.7 Hz1)	14 ms (rapid measurement) 40 ms (repeated measurement)
Reset time 2)	28 ms at 50 Hz 26 ms at 60 Hz 70 ms at 16.7 Hz
Differential current supervision	
Pickup threshold	0.10 to 1.00 I_{NO}

Lockout function

Lockout seal-in of trip command	Until reset
Reset	By binary input and/or local operator panel

Additional functions

Operational measured values	
Operating currents	I_d, I_R
Measuring range	0 to 240 % I_{NO}
Tolerance	5 % of rated value
Fault logging	Buffered storage of the annunciations of the last 8 faults
Time stamping	
Resolution for operational annunc.	1 ms
Resolution for fault annunciation	1 ms
Fault recording (max. 8 fault)	Buffered against voltage failure (last 2.5 s)
Recording time (from fault detection)	Max. 7.1 s total Pre-trigger and post-fault time can be set
Max. length per record	0.2 to 5.0 s (in steps of 0.01 s)
Pre-trigger time	0.05 to 1.5 s (in steps of 0.01 s)
Post-fault time	0.01 to 1.5 s (in steps of 0.01 s)
Sampling frequency	2 kHz

Peripheral modules

7TM700 restraint/command output module

Measuring input I_R

Number of restraint units	5
Rated current	100 mA
Rated frequency	16.7, 50, 60 Hz
Dynamic overload capacity (pulse current)	250 x I_N one half cycle
Thermal overload capacity (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous

Auxiliary voltage (7TM700)

Rated auxiliary voltage V_{aux} (permitted voltage range)	48/60 V DC (38 to 72 V DC) 110/125 V DC (88 to 150 V DC) 220/250 V DC (176 to 300 V DC) Settable As delivered: 220/250 V DC

Command contacts (7TM700)

Number of relays	5
Contacts per relay	2 NO contacts
For short-term operation < 10 s 3)	
Pickup time	Approx. 7 ms
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible currents	
Continuous	5 A
0.5 s	30 A
Weight	Approx. 2.0 kg

7TR710 isolator replica/preferential treatment module

NOTE: The module 7TR710 can be used to implement 2 different functions: isolator replica or preferential treatment

Isolator replica

Number of feeders (single busbar and double busbar)	1
Number of isolators per feeder	2

Preferential treatment

Number of preferential treatment circuits	2
Number of contacts per preferential treatment	3 changeover contacts
Switching time	< 20 ms
Number of auxiliary relays	1
Contacts of auxiliary relay	2 changeover contacts

Auxiliary voltage

Rated auxiliary voltage V_{aux} (permissible voltage range)	48/60 V DC (38 to 72 V DC) 110/125 V DC (88 to 150 V DC) 220/250 V DC (176 to 300 V DC) Depending on the design

Relay contacts

Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	
Continuous	5 A
0.5 s	10 A
Weight	Approx. 0.6 kg

---

1) Each additional intermediate relay increases the tripping time by 7 ms.

2) Each additional intermediate relay increases the reset time by 8 ms.

3) Limited by the continuous power dissipation of the device.

Technical data

Peripheral modules (cont'd)

7TS720 command output module

Auxiliary voltage

Rated auxiliary voltage V_{aux} (permissible voltage range)	48/60 V 110/125 V 220/250 V	(38 to 72 V DC) (88 to 150 V DC) (176 to 300 V DC)
	Settable As delivered: 220/250 V DC	

Command contacts

Number of relays	8
Contacts per relay	2 NO contacts
For short term operation < 10 s (1)	
Pickup time	Approx. 7 ms
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	
Continuous	5 A
0.5 s	30 A
Weight	Approx. 0.5 kg

7SS601 measuring system

Current connections (terminals 1 to 6)

Screw-type terminals (ring-type cable lug)	For bolts of 6 mm
Max. outside diameter	13 mm
Type	e.g. PDIG of AMP
For conductor cross-sections of	2.7 to 6.6 mm^2 AWG 12 to 10
In parallel double leaf-spring-crimp contact for conductor cross-sections of	2.5 to 4.0 mm^2 AWG 13 to 11
Max. tightening torque	3.5 Nm

Control connections (terminals 7 to 31)

Screw-type terminals (ring-type cable lug)	For 4 mm bolts
Max. outside diameter	9 mm
Type	e.g. PDIG of AMP
For conductor cross-sections of	1.0 to 2.6 mm^2 AWG 17 to 13
In parallel double leaf-spring-crimp contact for conductor cross-sections of	0.5 to 2.5 mm^2 AWG 20 to 13
Max. tightening torque	1.8 Nm

Connectors with screw-type terminals

Type	COMBICON system of PHOENIX CONTACT Front-MSTB 2.5/10-ST-5.08
For conductor cross-sections of	0.2 to 2.5 mm^2 (rigid and flexible) AWG 24 to 12 0.25 to 2.5 mm^2 (with end sleeve)
Multiple conductor connection (2 conductors of same cross-section)	0.2 to 1.0 mm^2 (rigid) 0.2 to 1.5 mm^2 (flexible) 0.25 to 1.0 mm^2 (flexible with end sleeve, without plastic collar) 0.5 to 1.5 mm^2 (flexible with TWIN end sleeve with plastic collar)
Stripping length	7 mm
Recommended tightening torque	0.5 to 0.6 Nm

Unit design

Housing 7XP204	½ 19"
Dimensions	See part 15
Weight	Approx. 3.5 kg
Degree of protection according to IEC 60529-1	
For the device	IP 51 (front panel) IP 20 (rear)
For the operator protection	IP 2X (if all connectors and blanking plates are fitted)

Matching transformers

4AM5120-1DA00-0AN2

For connection to current transformers with a rated current I_N of		1 A					
Rated frequency f_N		45-60 Hz					
Winding		A-B	B-C	D-E	E-F	G-H	H-J
Number of turns			Y-Z				
		1	2	4	8	16	32
			500				
Max. current, continuous	A	6.8	6.8	6.8	6.8	6.8	6.8
Max. voltage	V		0.85				
		0.4	0.8	1.6	3.2	6.4	12.8
			200				
Max. burden	VA	1.0					

4AM5120-2DA00-0AN2

For connection to current transformers with a rated current I_N of		5 A			
Rated frequency f_N		45-60 Hz			
Winding		A-B	B-C	D-E	E-F
Number of turns					Y-Z
		1	2	4	8
					500
Max. current, continuous	A	26	26	26	26
Max. voltage	V				0.85
		0.4	0.8	1.6	3.2
					200
Max. burden	VA	1.2			

---

1) Limited by the continuous power dissipation of the device.

Technical data

Summation current matching transformers

4AM5120-3DA00-0AN2

For connection to current transformers with a rated current I_N of		1 A							
Rated frequency f_N		45-60 Hz							
Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z
Number of turns		3	6	9	18	24	36	90	500
Max. current, continuous	A	4	4	4	4	4	4	2	0.85
Max. voltage	V	1.2	2.4	3.6	7.2	9.6	14.4	36	200
Max. burden	VA	1.8							

4AM5120-4DA00-0AN2

For connection to current transformers with a rated current I_N of		5 A							
Rated frequency f_N		45-60 Hz							
Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z
Number of turns		1	2	3	4	6	8	12	500
Max. current, continuous	A	17.5	17.5	17.5	17.5	17.5	17.5	8.0	0.85
Max. voltage	V	0.4	0.8	1.2	1.6	2.4	3.2	4.8	200
Max. burden	VA	2.5							

Matching transformer

4AM5272-3AA00-0AN2

Multi-tap auxiliary current transformer to match different c.t. ratios									
Rated frequency f_N		45-60 Hz							
Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	P-Q
Number of turns		1	2	7	16	1	2	7	16
Max. current, continuous	A	6	6	6	1.2	6	6	6	1.2
Max. voltage	V	4	8	28	64	4	8	28	64
resistance	Ω	0.018	0.035	0.11	1.05	0.018	0.035	0.11	1.05

Electrical tests

Specifications

Standards: IEC 60255-5; ANSI/IEEE C37.90.0

Insulation tests

High voltage test (routine test), measuring input I_d and relay outputs	2.5 kV (r.m.s.); 50 Hz
High voltage test (routine test), auxiliary voltage input and RS485 interface, binary inputs and measuring input I_R	3.5 kV DC
Impulse voltage test (type test), all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses in intervals of 5 s

EMC tests for interference immunity; type tests

Standard	IEC 60255-6, IEC 60255-22 (international product standards) EM 50082-2 (technical generic standard) DIN VDE 57435 part 303 (German product standard for protection devices)
High-frequency test IEC 60255-22-1, DIN 57435 part 303; class III	2.5 kV (peak); 1 MHz; t = 15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2; IEC 61000-4-2; class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report); class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m; 900 MHz; repetition frequency 200 Hz; ED 50 %
Fast transient disturbance/bursts IEC 60255-22-4; IEC 61000-4-4; class III	4 kHz; 5/50 ns; 5 kHz, burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5, installation, class III	Auxiliary voltage: Longitudinal test: 2 kV; 12 Ω; 9 µF Transversal test: 1 kV; 2 Ω; 18 µF Measuring inputs, binary inputs and relay outputs: Longitudinal test: 2 kV; 42 Ω; 0.5 µF Transversal test: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6; class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8; class IV IEC 60255-6	30 A/m; continuous; 300 A/m for 3 s; 50 Hz; 0.5 mT
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz; damped wave; 50 surges per s; duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s; both polarities; duration 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 61000-4-12 IEC 60694	2.5 kV (peak, alternating polarity); 100 kHz; 1, 10 and 50 MHz; damped wave; R_i = 50 Ω

EMC tests for interference emission; type test

Standard	EN 50081-* (technical generic standard)
Conducted interference voltage on lines only auxiliary voltage, EN 55022, DIN VDE 0878 part 22, IEC CISPR 22	150 kHz to 30 MHz, limit value, class B
Radio interference field strength EN 55011; DIN VDE 0875 part 11, IEC CISPR 11	30 to 1000 MHz, limit value, class A

Technical data

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21-1 IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz, ± 0.075 mm amplitude 60 to 150 Hz; 1 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal
Horizontal axis	1 to 8 Hz: ± 3.5 mm amplitude 8 to 35 Hz: 1 *g* acceleration
Vertical axis	1 to 8 Hz: ± 1.5 mm amplitude 8 to 35 Hz: 0.5 *g* acceleration
	Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude 8 to 150 Hz: 2 *g* acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*; duration 16 ms 1000 shocks in each direction of the 3 orthogonal axes

Climatic stress test

Temperatures	
Standards	IEC 60255-6
Permissible ambient temperatures – In service	-20 to +45/55 °C
– During storage	-25 to +55 °C
– During transport	-25 to +70 °C
Storage and transport with standard works packing	
Humidity	
Standards	IEC 60068-2-3
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 30 days in the year up to 95 % relative humidity; condensation not permissible!

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.
Centralized numerical busbar protection 7SS60 *Measuring system 50, 60, 16.7 Hz*	*7SS601☐-☐☐A☐0-0AA0*
Rated current/frequency	
100 mA; 50/60 Hz AC	*0*
100 mA; 16.7 Hz AC	*6*
Rated auxiliary voltage	
24 to 48 V DC	*2*
60 to 125 V DC	*4*
220 to 250 V DC	*5*
Unit design	
Housing 7XP20 1/6 19-inch, for panel flush mounting or cubicle mounting	*E*
Measuring system	
Standard	*0*
Stabilizing/command output module	
5 stabilizing CTs, 5 relays with 2 NO contacts 48/60 V DC, 110/125 V DC, 220/250 V DC settable	*7TM7000-0AA00-0AA0*
Isolator replica/preference module	*7TR7100-☐AA00-0AA0*
48 to 60 V DC	*3*
110 to 125 V DC	*4*
220 to 250 V DC	*5*
Command output module	
8 relays with 2 NO contacts 48/60 V DC, 110/125 V DC, 220/250 V DC settable	*7TS7200-0AA00-0AA0*
Housing ½ 19-inch for peripheral modules 7SS60	
For panel flush mounting or cubicle mounting	*7XP2041-2MA00-0AA0*

Accessories

Copper interconnecting cable	
PC (9-pole socket) and converter/protection relay	*7XV5100-2*
Connector adapter	
9 pin female / 25 pin male	*7XV5100-8H*
RS232 - RS485 converter	
With power supply unit for 230 V AC	*7XV5700-0AA00*
With power supply unit for 110 V AC	*7XV5700-1AA00*
Converter	
Full duplex fiber-optic cable – RS485 Auxiliary voltage: 24 V DC to 250 V DC, 110/230 V DC	
Line converter ST connector	*7XV5650-0BA00*
Cascada converter ST connector	*7XV5651-0BA00*
Connector for peripheral modules, as spare part	*W73078-B9005-A710*
Extraction tool for connector	*W73078-Z9005-A710*
Test adapter	*7XV6010-0AA00*
Angle bracket (set)	*C73165-A63-D200-1*

Accessories

Description	Order No.
Summation current matching transformer	
1 A, 50/60 Hz	4AM5120-3DA00-0AN2
5 A, 50/60 Hz	4AM5120-4DA00-0AN2
Matching transformer	
1 A, 50/60 Hz	4AM5120-1DA00-0AN2
5 A, 50/60 Hz	4AM5120-2DA00-0AN2
1 A, 5 A, 50/60 Hz	4AM5272-3AA00-0AN2
Manual 7SS60	
English	E50417-G1176-C132-A3

Connection diagrams

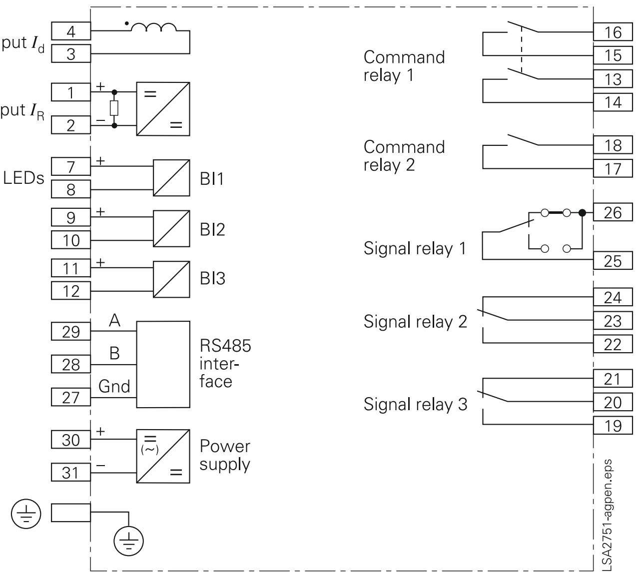


Fig. 9/14 Connection diagram for 7SS601

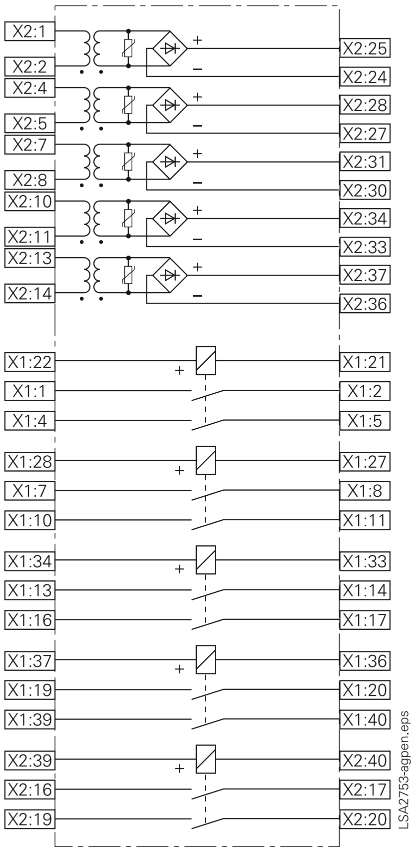


Fig. 9/15 Connection diagram for 7TM700

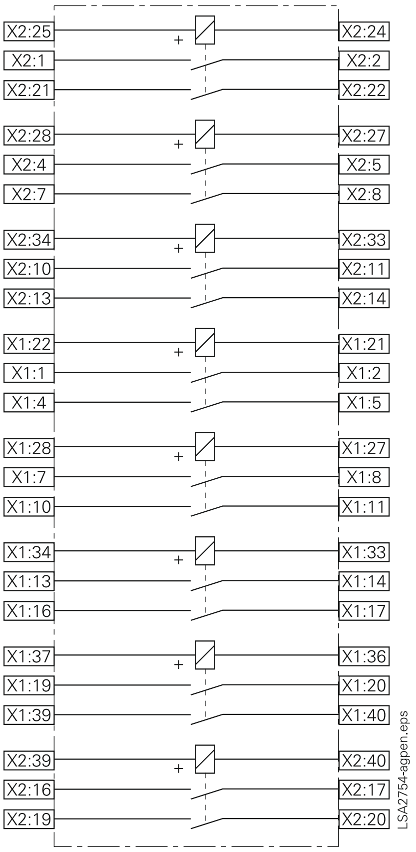


Fig. 9/16 Connection diagram for 7TS720

Connection diagram

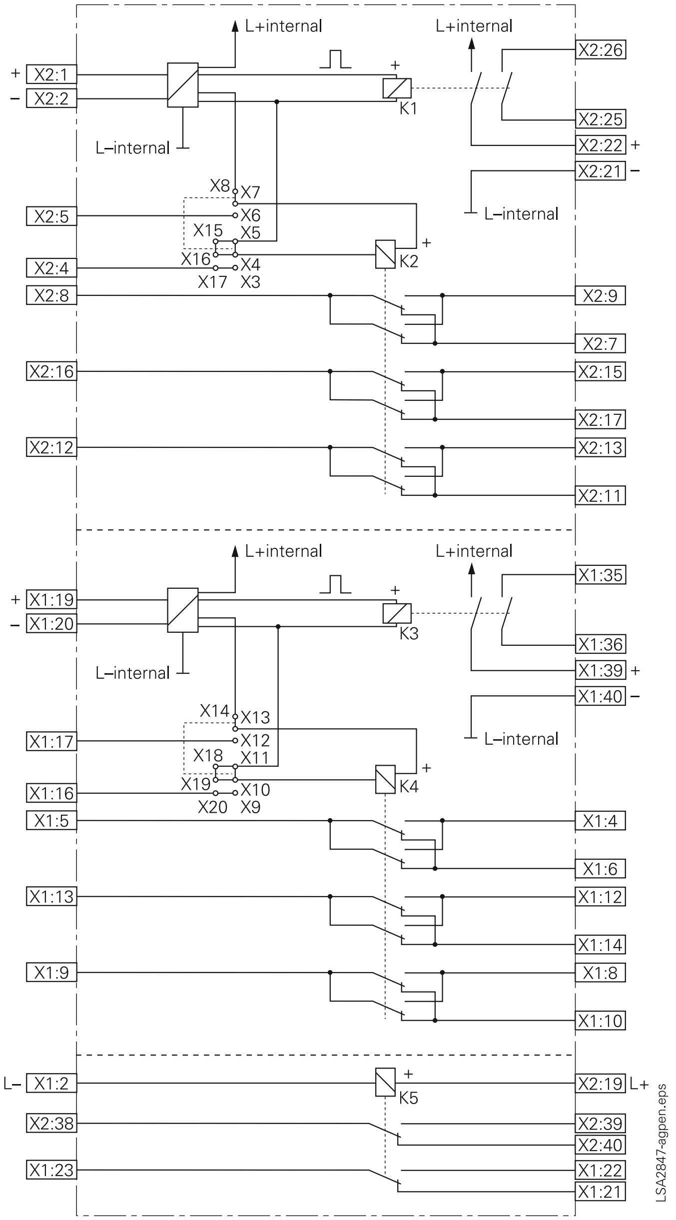


Fig. 9/17 Block diagram of 7TR710

SIPROTEC 4 7SS52 Distributed Numerical Busbar and Breaker Failure Protection

Fig. 9/18 SIPROTEC 4 7SS52 busbar protection system

Description

The SIPROTEC 7SS52 numerical protection is a selective, reliable and fast protection for busbar faults and breaker failure in medium, high and extra-high voltage substations with various possible busbar configurations.

The protection is suitable for all switchgear types with iron-core or linearized current transformers. The short tripping time is especially advantageous for applications with high fault levels or where fast fault clearance is required for power system stability.

The modular hardware allows the protection to be optimally matched to the busbar configuration. The decentralized arrangement allows the cabling costs in the substation to be drastically reduced. The 7SS52 busbar protection caters for single, double or triple busbar systems with or without and quadruple busbar systems without transfer bus with up to: 48 bays,
16 bus couplers, and 24 sectionalizing disconnectors and 12 busbar sections.

Function overview

Busbar protection functions

- Busbar differential protection
- Selective zone tripping
- Very short tripping time (<15 ms)
- Extreme stability against external fault, short saturation-free time (≥ 2 ms)
- Phase-segregated measuring systems
- Integrated check zone
- 48 bays can be configured
- 12 busbar sections can be protected
- Bay-selective intertripping

Breaker failure protection functions

- Breaker failure protection (single-phase with/without current)
- 5 operation modes, selectable per bay
- Separate parameterization possible for busbar and line faults
- Independently settable delay times for all operation modes
- 2-stage operation bay trip repeat/trip busbar
- Intertrip facility (via teleprotection interface)
- “Low-current” mode using the circuit-breaker auxiliary contacts

Additional protection functions

- End-fault protection with intertrip or bus zone trip
- Backup overcurrent protection per bay unit (definite-time or inverse-time)
- Independent breaker failure protection per bay unit

Features

- Distributed or centralized installation
- Easy expansion capability
- Integrated commissioning aids
- Centralized user-friendly configuration / parameterization with DIGSI
- Universal hardware

Communication interfaces

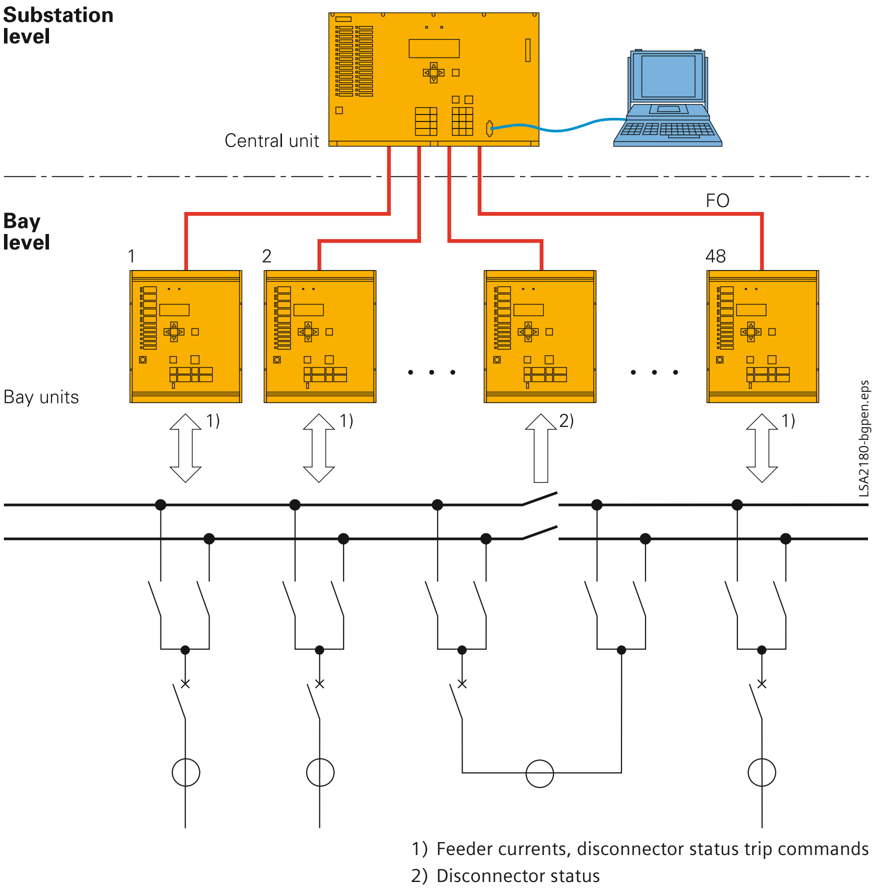
- FO interface
  – IEC 60870-5-103 protocol
- Electrical interface
  – IEC 61850 protocol
  with EN 100 module (firmware V4.6)

Application

The 7SS52 distributed numerical busbar and breaker failure protection system is a selective, reliable and fast protection for busbar faults and breaker failure in medium, high and extra-high voltage substations with various possible busbar configurations. The protection is suitable for all switchgear types with iron-core or linearized current transformers. The short tripping time is especially advantageous for applications with high fault levels or where fast fault clearance is required for power system stability.

The modular hardware design allows the protection system to be optimally matched to the busbar configuration.

The distributed arrangement allows the cabling costs between bay and substation to be drastically reduced. The 7SS52 busbar protection caters for single, double, triple and quadruple busbar systems with or without transfer bus with up to:
- 48 bays
- 16 bus couplers
- 24 sectionalizing disconnectors
- 12 busbar sections



1) Feeder currents, disconnector status trip commands
2) Disconnector status

Fig. 9/19 Distributed system structure

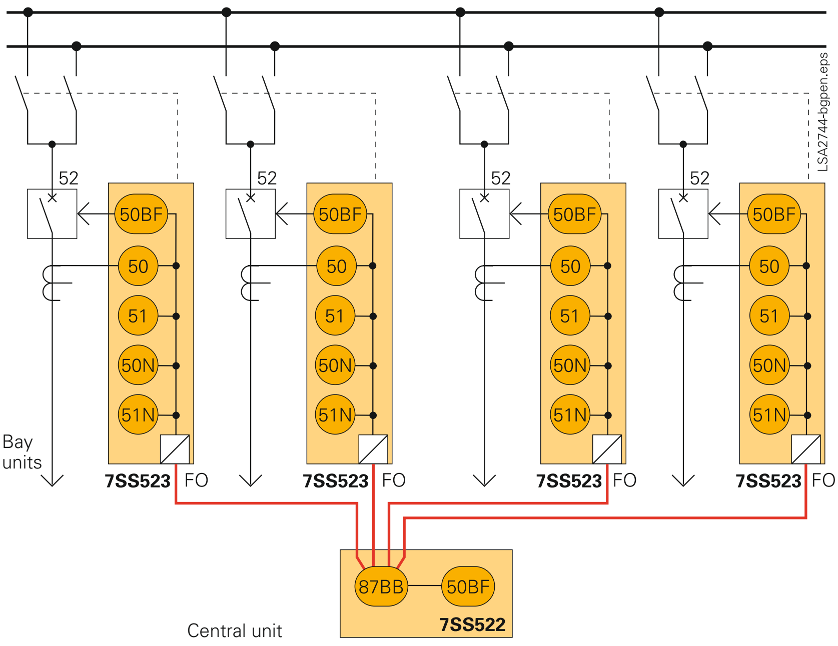


Fig. 9/20 Protection functions of the central unit and the bay units

Construction

The distributed bay units measure the 3 phase currents in each bay. The rated input current is 1 or 5 A and therefore eliminates the need for interposing current transformers. The disconnector status, breaker failure protection triggering, bay out-of- service and other bay status information is derived via marshallable binary inputs in the bay units. The complete information exchange is conveyed to the central unit via a fiber-optic interface. The bay unit also has an interface on the front side for connection to a PC for operation and diagnosis. The trip and intertrip commands are issued via trip contacts in the bay units. The 7XP20 standard housing is available in a flush or surface mounting version (7SS523).

The central unit is connected to the bay units via fiber-optic communication links. The connection is built up in a star configuration. The central unit also contains serial ports for system configuration via PC or communication with a substation control system, an integrated LC Display with keypad and marshallable binary inputs, LEDs and alarm relays. The central unit is available in a 19" SIPAC module rack version for either cubicle or wall mounting.

Because of its modular hardware design, it is easy to adapt the central unit to the substation or to expand it with further modules each being connected with up to 8 bay units.

Each bay unit and the central unit has its own internal power supply.


LSP2377-afpen.tif

Fig. 9/21 7SS522 Central unit
Front view of SIPAC subrack version


LSP2515.tif

Fig. 9/22 7SS522 Central unit
Rear view


LSP2076-afp.tif

Fig. 9/23 7SS523 Bay unit
Front view of panel/flush/cubicle mounting unit


LSP2516.tif

Fig. 9/24 7SS525 Bay unit
Front view of panel/flush/cubicle mounting unit

Protection functions

Busbar protection

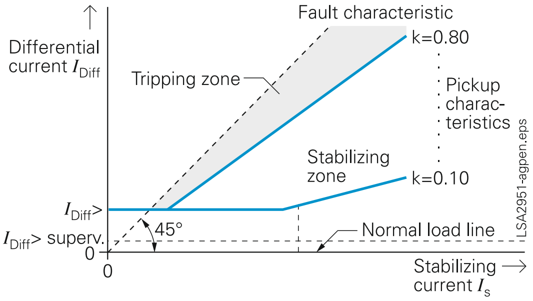
The main function of the 7SS52 is busbar protection, and has the following characteristics:

- Evaluation of differential currents, with stabilization by through-currents based on the proven performance of the Siemens busbar protection 7SS1 and 7SS50/51, currently in service worldwide
- Selective busbar protection for busbars with up to 12 busbar sections and 48 bays
- Integrated "check zone" (evaluation of all busbar section currents without use of the disconnector replica)
- Very short tripping time (15 ms typical)
- Selective detection of short-circuits, also for faults on the transfer bus, with transfer trip to the remote end.
- Detection and clearance of faults between the current transformer and the circuit-breaker via current measurement and selective unbalancing.
- Tripping only when all three fault detection modules recognize a busbar fault (2 measurement processors and check zone processor)
- No special CT requirements (stability is guaranteed, even when the CTs saturate after 2 ms)
- Selective output tripping relays per feeder in bay units.

Mode of operation

The 7SS52 protection relay offers complete numerical measured-value processing from sampling to digital conversion of the measured variables through to the circuit-breaker tripping decision. The bay units dispose of sufficient powerful contacts to directly trip the circuit-breaker.

For each busbar section and for all three phases, two independent processors execute the protection algorithm on alternate data samples. Based on the proven performance of the 7SS1 and 7SS50/51, this method of measurement ensures highest stability even in case of high short-circuit currents and CT saturation.



The pickup characteristic can be set independently for selective busbar protection, for the "check zone" and for the breaker failure protection.

Fig. 9/25
Standard characteristic

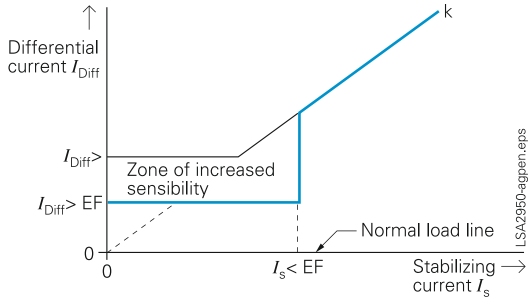


Fig. 9/26
Earth-fault characteristic

In addition, an disconnector status independent check-zone measurement is executed on a further processor thus increasing the protection against unwanted operation. All three processors must reach a trip decision independently before the trip command is released.

The disconnector status is monitored using normally open and normally closed contacts to enable plausibility checks for both status and transition time. The contact monitoring voltage is also supervised.

In case of an auxiliary voltage failure in the bay, the latest disconnector status is stored and a bay-selective indication of the failure is issued.

The assignment of the feeder currents to the corresponding busbar systems is controlled by software via the disconnector replica. The disconnector replica is applied for both busbar protection and breaker failure protection.

The integrated breaker failure protection function provides phase-segregated two-stage operation (bay-specific trip repeat, trip bus section). Alternatively, an external breaker failure protection relay can issue its trip commands via the disconnector replica in the 7SS52.

Breaker failure protection

The 7SS52 protection includes an integrated breaker failure protection with the following features:

- Five breaker failure protection modes that are selectable:

  1. Following the issue of a trip signal from a feeder protection, the busbar protection monitors the drop-off of the trip signal. If the feeder current is not interrupted before a set time delay the polarity of the feeder current is reversed, which results in a differential current in the corresponding section of the bus protection. For this function, a separate parameter set is used.

  2. Following a trip signal from a feeder protection, a trip signal will be output after a settable time delay from the 7SS52 protection to the corresponding feeder circuit-breaker. If this second trip signal is also unsuccessful, the unbalancing procedure according to mode 1) as described above will take place.

  3. With external stand-alone breaker failure protection, the disconnector replica of the 7SS52 may be used to selectively trip the busbar section with the faulty circuit-breaker.

Protection functions

4. Following a trip signal from the feeder protection, the 7SS52 monitors the drop-off of the trip signal. If, after a settable time, the current does not fall below a settable limiting value, busbar-selective feeder trip commands are issued with the help of the disconnector replica within the 7SS52.

5. Following a trip signal from a feeder protection, a trip signal will be output after a settable time delay from the 7SS52 protection to the corresponding feeder circuit-breaker. If this second trip signal is also unsuccessful, the tripping as described under 4) will take place.

- For single-pole or multi-pole starting, delay times are available.
- Breaker failure detection following a busbar fault by comparison of the measured current with a set value.
- For all modes of breaker failure protection, a transfer trip command output contact is provided for each feeder to initiate remote tripping.

Sensitive tripping characteristic

In some applications, e.g. within resistive earthed networks, single-phase short-circuit currents are limited to rated current values. In order to provide a busbar protection for these cases, an independent characteristic is available. This characteristic presents separate parameters for the pickup threshold, as well as for a limitation of efficiency. The activation of the characteristic takes place by means of a binary input in the central unit, e.g. by recognizing a displacement voltage.

End-fault protection

The location of the current transformer normally limits the measuring range of the busbar protection. When the circuit-breaker is open, the area located between the current transformer and the circuit-breaker can be optimally protected by means of the end-fault protection. In the event of a fault, depending on the mounting position of the current transformer, instantaneous and selective tripping of the busbar section or intertripping of the circuit-breaker at the opposite end occurs.

Backup protection

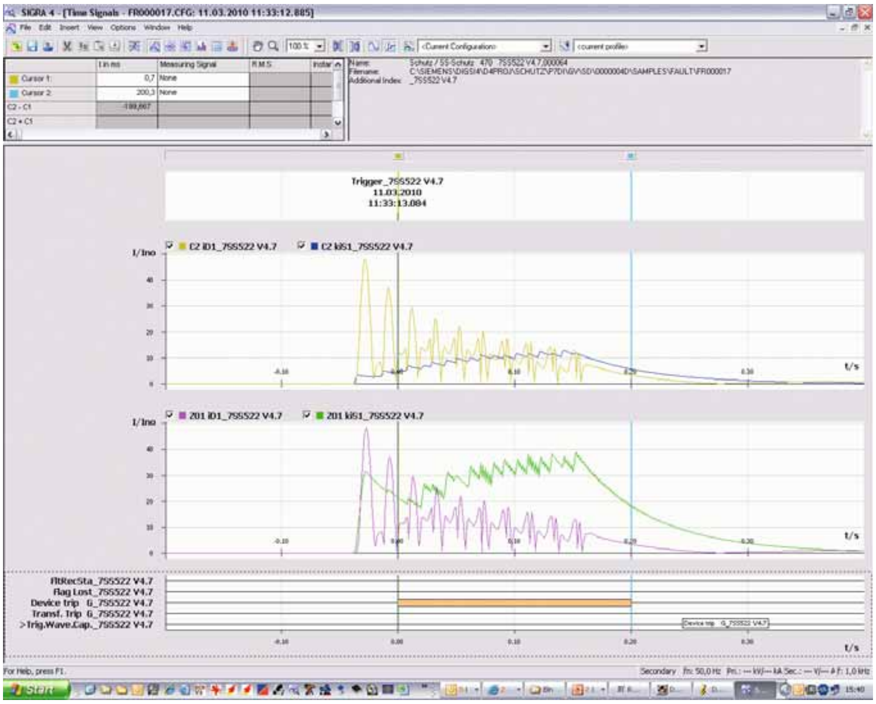
As an option, a two-stage backup protection, independent of the busbar protection is included in every bay unit. This backup protection is completed by means of a breaker failure protection. The parametrization and operation can be carried out in the central unit or locally in each bay unit with the DIGSI operating program.

Disconnector replica

The disconnector replica is used for both the busbar protection and the breaker failure protection.

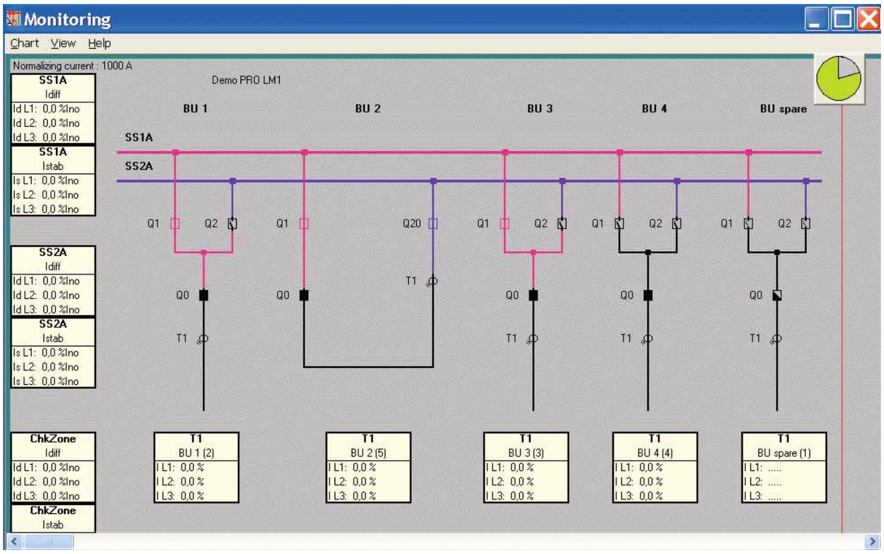
The following features characterize the disconnector replica function:

- Includes up to 48 bays and 12 busbar sections
- Integrated bi-stable disconnector status characteristic (status stored on loss of auxiliary power).



SIPV6.101en.tif

Fig. 9/27 Fault record



Normalizing current : 1000 A

SS1A Idiff
Id L1: 0,0 %Ino
Id L2: 0,0 %Ino
Id L3: 0,0 %Ino

SS1A Istab
Is L1: 0,0 %Ino
Is L2: 0,0 %Ino
Is L3: 0,0 %Ino

SS2A Idiff
Id L1: 0,0 %Ino
Id L2: 0,0 %Ino
Id L3: 0,0 %Ino

SS2A Istab
Is L1: 0,0 %Ino
Is L2: 0,0 %Ino
Is L3: 0,0 %Ino

ChkZone Idiff
Id L1: 0,0 %Ino
Id L2: 0,0 %Ino
Id L3: 0,0 %Ino

ChkZone Istab

T1 BU 1 (2)
I L1: 0,0 %
I L2: 0,0 %
I L3: 0,0 %

T1 BU 2 (5)
I L1: 0,0 %
I L2: 0,0 %
I L3: 0,0 %

T1 BU 3 (3)
I L1: 0,0 %
I L2: 0,0 %
I L3: 0,0 %

T1 BU 4 (4)
I L1: 0,0 %
I L2: 0,0 %
I L3: 0,0 %

T1 BU spare (1)
I L1: .....
I L2: .....
I L3: .....

SIPV6.100en.tif

Fig. 9/28 DIGSI plant monitoring

Protection functions/Functions

- Disconnector transition time monitoring.
- By the assignment "NOT open = closed", the disconnector is taken to be CLOSED during the transition time. Accurate matching of the disconnector auxiliary contacts with the main contact is not required.
- Menu-guided graphic configuration with DIGSI operating program.
- LEDs in the bay modules indicate the actual status of the busbar disconnector.
- Dynamic visualization of the substation with DIGSI on the central unit.

Tripping command/reset

The tripping output processing for the 7SS52 protection has the following features:

- Bay-selective tripping by bay units
- Settings provided for overcurrent release of the tripping command (to enable selective tripping of infeeding circuits only)
- Settable minimum time for the trip command.
- Current-dependent reset of the tripping command.

Disturbance recording

The digitized measured values from the phase currents and the differential and stabilizing currents of the busbar sections and check zone are stored following a trip decision by the 7SS52 or following an external initiation via a binary input. Pre-trigger and post-fault times with regard of the trip command can be set. Up to 8 fault recordings are stored in the 7SS52. The fault records may be input to a PC connected to the central unit, using the menu-guided DIGSI operating program. Then, the SIGRA graphics program makes it possible to easily analyze the fault recordings.

Marshallable tripping relays, binary inputs, alarm relays and LEDs

The bay units are equipped with marshallable command relays for direct circuit-breaker tripping. For each bay there are 9 (7SS523) or 8 (7SS525) duty contacts available.

For user-specific output and indication of events, 16 alarm relays and 32 LEDs in the central unit are freely marshallable.

Several individual alarms may be grouped together.

The central unit has marshallable binary inputs with:

- Reset of LED display
- Time synchronization
- Blocking of protection functions

The bay units have marshallable binary inputs:

- Disconnector status closed/open
- Phase-segregated start of circuit-breaker failure protection
- Release of circuit-breaker failure protection
- Release of TRIP command
- Circuit-breaker auxiliary contacts
- Bay out of service
- Test of circuit-breaker tripping

Measurement and monitoring functions

In the 7SS52 protection relay, a variety of measurement and monitoring functions is provided for commissioning and maintenance. These functions include:

- Measurement and display of the phase currents of the feeders in the central unit and bay units.
- Measurement and display (on the integrated LCD or PC) of the differential and stabilizing currents of all measuring systems in the central unit and the bay units.
- Monitoring of busbar-selective and phase-segregated differential currents with busbar-selective blocking/alarming
- Monitoring of the differential currents of the check zone with alarming/blocking
- Phase-segregated trip test including control of feeder circuit-breaker (by central or bay unit)
- Removal of a bay from the busbar measurement processing during feeder service and maintenance via central or bay units (bay out of service)
- Blocking of breaker failure protection or tripping command for testing purposes.
- Disconnector replica freezing (maintenance) with alarm indication ("Disconnector switching prohibition").
- Cyclic tests of measured-value acquisition and processing and trip circuit tests including coils of the command relays.

Event recording

The 7SS52 protection provides complete data for analysis of protection performance following a trip or any other abnormal condition and for monitoring the state of the relay during normal service.

Up to 200 operational events and 80 fault annunciations with a resolution of one millisecond may be stored in two independent buffers:

- Operational indications
  This group includes plant/substation operation events, for example disconnector switching, disconnector status discrepancies (transition time limit exceeded, loss of auxiliary voltage, etc.) or event/alarm indications
- Tripping following a busbar short-circuit fault or circuit-breaker failure.

Protection functions/Functions

Settings

A PC can be connected to the operator interface located at the front panel or the rear of the central unit. An operating program is available for convenient and clear setting, fault recording and evaluation as well as for commissioning. All settings of the busbar or breaker failure protection, as well as settings of additional functions such as backup protection, need only be parameterized at the central unit. Settings at the bay units are not necessary.
With the help of the integrated keypad and display on the central unit, all setting parameters may be read out.
Keypad, display (7SS523) and the front side interface of the bay units serve for commissioning, display of operational values and diagnosis.
All parameters are written into nonvolatile memories to ensure that they are retained even during loss of auxiliary voltage.

Configuration, visualization

The configuration of the 7SS52 is effected by means of a graphics-orientated editor included in the DIGSI operation program. For frequently used bay types, a symbol library is available. Enhancements can be easily effected anytime.
A graphical configuration visualizes the states of the disconnector position, the circuit-breaker and measuring values.

Self-monitoring

Hardware and software are continuously monitored and any irregularity is immediately detected and alarmed. The self-monitoring feature improves both the reliability and the availability of the 7SS52. The following quantities are monitored:

- The current transformer circuits
- The analog-to-digital conversion
- All internal supply voltages
- The program memory
- The program running times by a watch dog function
- The disconnector status
- The three channel tripping circuit

Maximum lifetime and reliability

The hardware of the 7SS52 units is guaranteed by more than 20 years of experience in numerical protection design at Siemens. The number of components employed is reduced through use of a powerful microprocessor in conjunction with highly-integrated components, thus enhancing the reliability. The experience gained by Siemens in production of over 1 million numerical protection units has been incorporated in the software design. The most modern manufacturing methods together with effective quality control ensure high reliability and a long service life.

Battery monitoring

The internal battery is used to back-up the clock and memory for storage of switching statistics, status and fault indications and fault recording, in the event of a power supply failure. The processor checks its capacity at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated. Routine replacement is therefore not necessary. All setting parameters are stored in the Flash-EPROM, and therefore not lost if the power supply or the battery fails.

Functions for testing and commissioning

The 7SS52 offers auxiliary functions for commissioning. The physical status of all binary inputs and output relays of the central unit can be displayed and directly altered to facilitate testing.

All measured values can be clearly depicted by means of DIGSI and simultaneously displayed in different windows as primary or percentage values.

The 7SS52 units are provided with a circuit-breaker test function. Single-pole and three-pole TRIP commands can be issued.

Data transmission lockout

Data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test mode

During commissioning, a test mode can be selected; all indications then have a test mode suffix for transmission to the control system.

Communication

Serial communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication "circuit-breaker TRIP" to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.

Local and remote communication

The 7SS52 central unit provides several serial communication interfaces for various tasks:

- Front interface for connecting a PC
- Rear-side service interface (always provided) for connection to a PC, either directly or via a modern
- System interface for connecting to a control system via IEC 60870-5-103 protocol.
- System interface (EN 100 module) for connecting to a control system via IEC 61850 protocol
- Time synchronization via IRIG-B/DCF/system interface

Serial front interface (central unit and bay units)

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Communication (continued)

Rear-mounted interfaces (central unit only)

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. The interface modules support the following applications:

- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS85 or an optical interface.
- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.

System interface

Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.

IEC 61850 protocol (retrofittable)

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. By means of this protocol, information can also be exchanged directly between protection units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

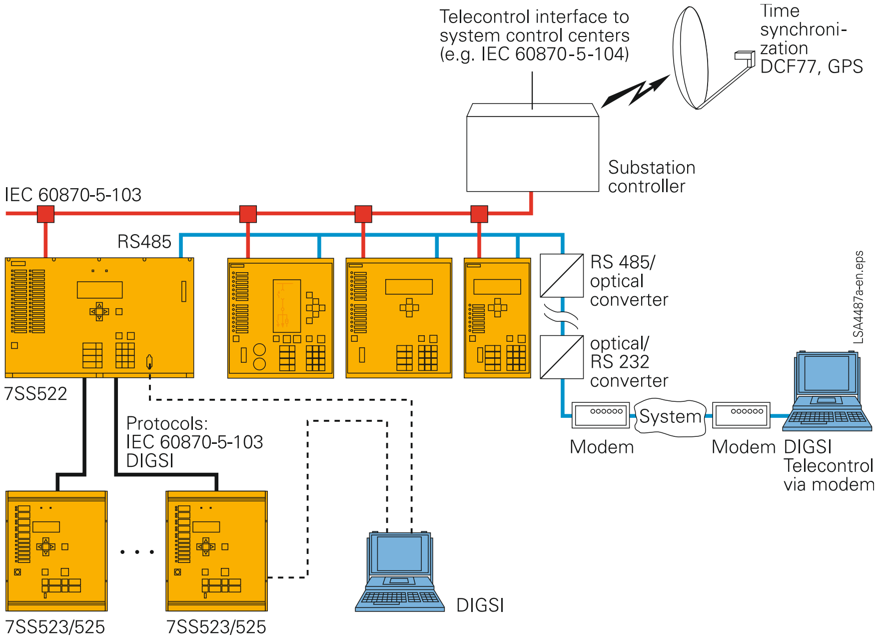


Fig. 9/29 Communication structure with DIGSI and IEC 60870-5-103

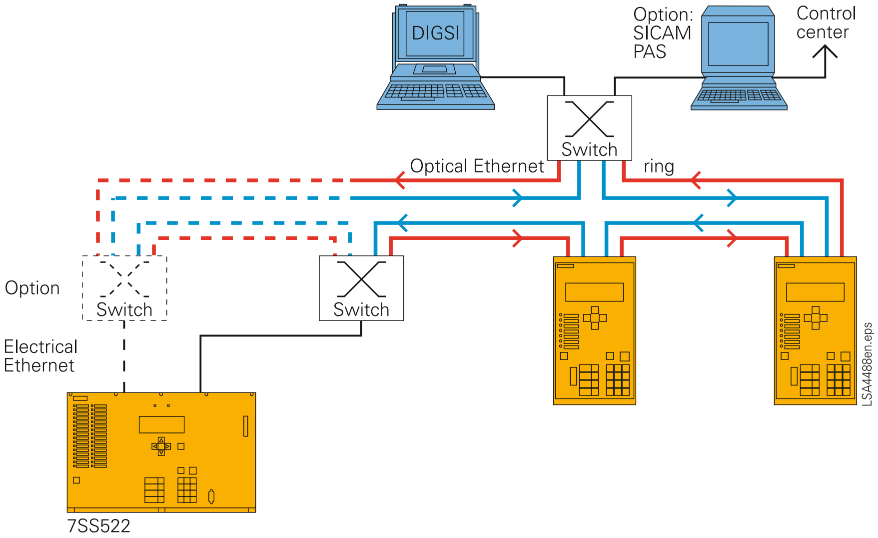


Fig. 9/30 Communication structure for station bus with Ethernet and IEC 61850, FO ring

Time synchronization

The battery-backed clock of the 7SS52 central unit can be synchronized via:

- DCF 77 signal via time synchronization receiver
- IRIG-B satellite signal via time synchronization receiver
- Minute-pulse via binary input
- System interface by the substation control, e.g. SICAM

Date and time with milliseconds resolution is assigned to every indication. The synchronization of the 7SS52 bay units is automatically effected with the central unit.

Technical data

General unit data

Input circuits

Rated current I_N		1 or 5 A	
Rated frequency f_N		50/60 Hz	
Thermal overload capability in current path	Continuous 10 s 1 s	4 x I_N 10 x I_N 100 x I_N	
Dynamic overload capability		250 x I_N	
Burden of current inputs	At $I_N = 1$ A At $I_N = 5$ A	< 0.1 VA < 0.2 VA	

Auxiliary voltage

Rated auxiliary voltage V_{aux}	Central unit	48/60, 110/125, 220/250 V DC	
Rated auxiliary voltage V_{aux}	Bay unit	48, 60 to 250 V DC	
Permissible tolerance V_{aux}		–20 to +20 %	
Maximum ripple		≤ 15 %	
Power consumption		Configuration dependent	
Central unit	Quiescent Energized	30 to 50 W 35 to 65 W	
Bay unit		7SS523	7SS525
	Quiescent Energized	12 W 16 W	10 W 14 W
Max. bridging time during loss of voltage supply		> 50 ms at $V_{aux} \geq 60$ V	

Binary inputs

		7SS523	7SS525
Number of binary inputs	Bay unit Central unit	20 12	10
Voltage range		24 to 250 V DC	
Current consumption		Approx. 1.5 mA/input	

Alarm/event contacts

Central unit			
Number of relays	Marshallable Fixed	16 (each 1 NO contact) 1 (2 NC contacts)	
Switching capacity	Make/Break	20 W/VA	
Switching voltage		250 V AC/DC	
Permissible current		1 A	
Bay unit		7SS523	7SS525
Number of relays	Marshallable Fixed	1 (1 NO contact) 1 (2 NC contacts)	1 (1 NO contact) 1 (1 NC contacts)
Switching capacity	Make/Break	20 W/VA	
Switching voltage		250 V AC/DC	
Permissible current		1 A	

Command contacts

Number of relays (bay unit)		7SS523	7SS525
		4 (each 2 NO contacts) 1 (1 NO contact)	3 (each 2 NO contacts) 2 (1 NO contact)
Switching capacity	Make Break	1000 W/VA 30 W/VA	
Switching voltage		250 V AC/DC	
Permissible current	Continuous 0.5 s	5 A 30 A	

LEDs

Central unit		
Operation indication	Green	1
Device failure	Red	1
Marshallable	Red	32
Bay unit		
Operation indication	Green	1
Device failure	Red	1
Indications	Green Red	5 (7SS523)/– (7SS525) 11 (7SS523)/1 (7SS525)

Control, displays

Central unit	
LC Display	4 lines x 20 characters
Membrane keyboard	24 keys
Bay unit (7SS523)	
LC Display	4 lines x 16 characters
Membrane keyboard	12 keys

Serial interfaces

Central unit

PC interface (front)	
Connection, electrical	SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 115000 baud
System interface IEC 60870-5-103 (rear)	
Connection, optical electrical	ST connectors SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 115000 baud
System interface IEC 61850 (rear)	
Connection, electrical with EN 100 module	RJ45 connector
Baud rate	up to 100 Mbaud
Service interface (rear)	
Connection, optical electrical	ST connectors SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 115000 baud

Bay unit

PC interface (front)	
Connection, electrical	SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 19200 baud

Central/bay unit

Interface for high-speed data communication	
Connection	ST connectors
Fiber-optic cable	Glass fiber 62.5/125 µm
Optical wavelength	820 nm
Permissible cable attenuation	Max. 8 dB
Transmission distance	Max. 1.5 km

Technical data

Unit design (degree of protection according to EN 60529)

Central unit		
Cubicle	IP 54	
Housing for wall mounting	IP 55	
SIPAC subrack	IP 20	
Bay unit	7SS523	7SS525
Housing	IP 51	IP 20
Terminals	IP 21	
Weight at max. configuration Central unit		
SIPAC subrack	14.3 kg	
Surface-mounting housing	43.0 kg	
Bay unit	7SS523	7SS525
Flush mounting	8.1 kg	5.5 kg
Surface mounting	11.8 kg	

Electrical tests

Specification

Standards	IEC 60255-5, DIN 57435 part 303
High-voltage test (routine test), except DC voltage supply input	2 kV (r.m.s.), 50 Hz
High-voltage test (routine test), only DC voltage supply input	2.8 kV DC
Impulse voltage test (type test), all circuits, class III	5 kV (peak), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type test

Standards	IEC 60255-6, IEC 60255-22 (international product standard), EN 50082-2 (European generic standard for industrial environment), VDE 0435 part 303 (German product standard)
High-frequency test with 1 MHz interference IEC 60255-2-1, class III and VDE 0435 part 303, class III	2.5 kV (peak), 1 MHz, $\tau = 15$ µs, 400 surges/s, duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV and IEC 61000-4-2, class IV	8 kV contact discharge, 15 kV air discharge, both polarities, 150 pF, $R_I = 330\ \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3, class III	10 V/m, 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, AM 80 %, 1 kHz
Irradiation with radio-frequency field, pulse-modulated ENV 50204, class III	10 V/m, 900 MHz, repetition rate 200 Hz, duty cycle 50 %
Fast transients interference/bursts IEC 60255-22-4, class IV; IEC 61000-4-4, class IV; IEC 60801-4	4 kV, 5/50 ns, 5 kHz, burst length = 15 ms, repetition rate 300 ms, both polarities, $R_I = 50\ \Omega$, duration 1 min
Line-conducted disturbances induced by radio-frequency fields, amplitude-modulated IEC 61000-4-6, class III	10 V, 150 kHz to 80 MHz, AM 80 %, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous, 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz

EMC tests for interference emission; type test

Standard	EN 50081-2 (European generic standard for industrial environment)
Conducted interference voltage, auxiliary voltage CISPR 11, EN 55011 and VDE 0875 part 11	150 kHz to 30 MHz, limit class B
Radio interference field strength CISPR 11, EN 55011 and VDE 0875 part 11	30 to 1000 MHz, limit class B

Mechanical stress tests

Specification

Standards	IEC 60255-21-1, IEC 6068-2
Permissible mechanical stress	
During service	10 to 60 Hz, 0.035 mm amplitude 60 to 500 Hz, 0.5 g acceleration
During transport	5 to 8 Hz, 7.5 mm amplitude 8 to 500 Hz, 2 g acceleration

Climatic stress tests

Temperatures

Standard	IEC 60255-6
Permissible ambient temperature	
– In service	–10 °C to +55 °C (bay unit) – 5 °C to +55 °C (central unit)
– For storage	–25 °C to +70 °C
– During transport	–25 °C to +70 °C
– During start-up	–10 °C to +55 °C (bay unit) 0 °C to +55 °C (central unit)

Humidity

Standards	IEC 60068-2-3
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation not permissible!

Busbar configuration

Quadruple or triple busbar with transfer busbar;	
Number of bays	48
Number of bus sections	12
Number of bus couplers	16
Number of sectionalizers	24
Number of coupler bus sections	12

Busbar protection

Tripping characteristics	
Setting ranges	
Overcurrent I/I_{NO} 1)	0.2 to 4 (in steps of 0.01)
Stabilizing factor k for busbar-selective protection	0.1 to 0.8 (in steps of 0.01)
Stabilizing factor k for check zone	0 to 0.8 (in steps of 0.01)
Tripping time	
Typical trip time	15 ms
Differential current monitoring	
Setting ranges	
Current limit I/I_{NO} 1)	0.05 to 0.8 (in steps of 0.01)
Time delay	1 to 10 s (in steps of 1 s)

1) I_{NO} = highest c.t. ratio.

Technical data

Breaker failure protection

Tripping	
Setting ranges	
Overcurrent I/I_N	0.05 to 2 (in steps of 0.01)
Stabilizing factor k	0 to 0.8 (in steps of 0.01)
Time delay for unbalancing / $I >$ query	0.05 to 10 s (in steps of 0.01 s)
Time delay for TRIP repeat	0.00 to 10 s (in steps of 0.01 s)

Modes of operation

Individually selectable per feeder:

- $I >$ query
- TRIP repeat (1/3-phase) with $I >$ query
- Unbalancing (1-stage BF)
- Unbalancing with TRIP repeat (1/3-phase, 2-stage BF)
- TRIP by external BF protection (tripping via disconnector replica of busbar protection)
- Plus for each mode (except for TRIP by external BF): low-current mode
- Plus for modes with TRIP repeat: pulse mode

Breaker failure protection for busbar short-circuit	
Setting value	
Overcurrent I/I_N	0.05 to 2 (in steps of 0.01)
Time delay	0.05 to 10.00 s (in steps of 0.01 s)

General data of the protection system

Min. time of TRIP commands	
Setting range	
Current threshold for command reset I/I_N	0.02 to 1 s (in steps of 0.01 s) 0.05 to 2 (in steps of 0.10)
Overcurrent release of TRIP commands	
Setting range	0 to 25 (in steps of 0.01)
Disconnector transition time	
Setting range	1 to 180 s (in steps of 0.01 s)

Overcurrent protection in the bay unit

Characteristics	Definite-time or inverse-time overcurrent protection
Setting ranges	
High-set stage; $I >>$ (phase) I/I_N	0.05 to 25.00 (in steps of 0.01)
High-set stage; $I_E >>$(earth) I/I_N	0.05 to 25.00 (in steps of 0.01)
Trip time delays; $T_I >>$, $T_{IE} >>$	0.00 to 60.00 s or ∞
Definite-time overcurrent protection	
Overcurrent stage; $I >$ (phase) I/I_N	0.05 to 25.00 (in steps of 0.01)
Overcurrent stage; $I_E >$ (earth) I/I_N	0.05 to 25.00 (in steps of 0.01)
Trip time delays; $T_I >$, $T_{IE} >$	0.00 to 60.00 s or ∞
Inverse-time overcurrent protection	
Inverse time O/C stage; I_p (phase) I/I_N	0.10 to 4.00 (in steps of 0.01)
Inverse time O/C stage; I_E (earth) I/I_N	0.10 to 4.00 (in steps of 0.01)
Trip time delays; T_{Ip}, T_{IE}	0.00 to 10.00 s or ∞
Characteristics	Inverse (IEC 60255-3 type A) Very inverse (IEC 60255-3 type B) Extremely inverse (IEC 60255-3 type C)

1) I_{NO} = normalizing current.

Additional functions

Self-diagnosis

Current monitoring per feeder
Auxiliary voltage monitoring
Cyclic test
Check of the data transmission between central unit and bay units
Memory tests

Operational measured values: Central unit

Feeder currents	I_{L1}; I_{L2}; I_{L3} in A primary and in % I_N
Range	0 to 1000 % I_N
Tolerance	typically 2 % of measured value
Differential and restraint (stabilizing) currents of all bus sections (separate for ZPS-BSZ1 and ZPS-BSZ2)	I_{dL1}; I_{dL2}; I_{dL3} I_{sL1}; I_{sL2}; I_{sL3} in % I_N
Range	0 to 1000 % I_N

Operational measured values: Bay unit

Feeder currents	I_{L1}; I_{L2}; I_{L3}; I_E in A primary and in % I_N
Range	0 to 6 000 % I_N
Tolerance	typically 2 % of measured value
Differential and restraint (stabilizing) currents	I_{dL1}; I_{dL2}; I_{dL3} I_{sL1}; I_{sL2}; I_{sL3}
Range	0 to 6 000 % I_N
Frequency	f in Hz ($I > 0.1$ I_N)
Range	$f_N \pm 5$ Hz
Tolerance	0.1 Hz

Event recording: Central unit

Storage of the last 200 operational events and 80 fault events

Event recording: Bay unit

Storage of the last 50 operational events and 100 fault events

Fault recording: Central unit

Resolution	1 ms at 50 Hz; 0.83 ms at 60 Hz
Storage time (from busbar TRIP or external initiation by binary input)	– 500 to + 500 ms at 50 Hz – 416 to + 416 ms at 60 Hz (up to 8 fault records)

Fault recording: Bay unit

Resolution	1 ms at 50 Hz; 0.83 ms at 60 Hz
Storage time (from busbar TRIP or external initiation by binary input)	– 500 to + 500 ms at 50 Hz – 416 to + 416 ms at 60 Hz (up to 8 fault records)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonisation of the laws the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).
This unit conforms to the international standard IEC 60255 and the German standard DIN 57435/Part 303 (corresponding to VDE 0435 part 303).
The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Order code
7SS522 distributed busbar/breaker failure protection	*7SS52☐0-☐☐☐☐☐-☐☐A0*	*☐☐☐*
Central unit		
Central unit 50/60 Hz	*2*	
Rated auxiliary voltage		
48, 60 V DC	*3*	
110, 125 V DC	*4*	
220, 250 V DC	*5*	
Unit design		
In subrack ES902C	*A*	
Regional presettings/regional functions and languages		
Region DE, language German (language can be selected)	*A*	
Region World, language English (UK) (language can be selected)	*B*	
Region US, language English (US) (language can be selected)	*C*	
Region FR, language French (language can be selected)	*D*	
Region World, language Spanish (language can be selected)	*E*	
Region World, language Italian (language can be selected)	*F*	
Region World, language Russian (language can be selected)	*G*	
System interface		
Without	*0*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	*9*	*L 0 R*
Service interface (on rear of relay)		
DIGSI 4/modem, electrical RS232	*1*	
DIGSI 4/modem, electrical RS485	*2*	
DIGSI 4/modem, optical 820 nm, ST connector	*3*	
Additional functions		
without	*1*	
with cross stabilisation	*2*	
Equipped for		
8 bays	*A*	
16 bays	*B*	
24 bays	*C*	
32 bays	*D*	
40 bays	*E*	
48 bays	*F*	

Description	Order No.
7SS523 distributed busbar/breaker failure protection	*7SS52☐☐-☐☐A01-☐AA1*
Bay unit, frequency, housing, binary inputs and outputs	
Bay unit, 50/60 Hz, housing 1/2 x 19", 20 BI, 6 BO, 2 live status contacts	*3*
Rated current	
1 A	*1*
5 A	*5*
Rated auxiliary voltage	
48 V DC	*2*
60 to 250 V DC	*5*
Unit design	
7XP2040-2 for flush mounting or cubicle mounting	*C*
7XP2040-1 for surface mounting	*D*
7XP2040-2 for flush mounting without glass cover	*E*
Additional functions	
Without additional functions	*0*
With overcurrent-time protection	*1*

Selection and ordering data

Description	Order No.
7SS525 distributed busbar/breaker failure protection *Bay unit, frequency 50/60 Hz;* *Housing 1/3 x 19"; 10 BI, 6 BO, 1 live status contact*	*7SS525☐-☐☐A01-☐AA1*
Rated current at 50/60 Hz	
1 A	*1*
5 A	*5*
Rated auxiliary voltage at converter	
48 to 250 V DC	*5*
Unit design	
7XP2040-2 for panel flush mounting or cubicle mounting without glass cover	*F*
Additional functions	
Without additional functions	*0*
With overcurrent-time protection	*1*

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection relays running under MS Windows (version Windows 2000/XP Professional Edition) device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CDC Editor (logic editor), Display Editor (editor for default and control displays), and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM (contained in DIGSI 4, but can be ordered additionally)	*7XS5410-0AA00*
Connection cable Cable between PC/notebook (9-pin connector) and protection relay (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Manual 7SS52 V4.7/V3.3 English	*C53000-G1176-C182-5*

Connection diagram

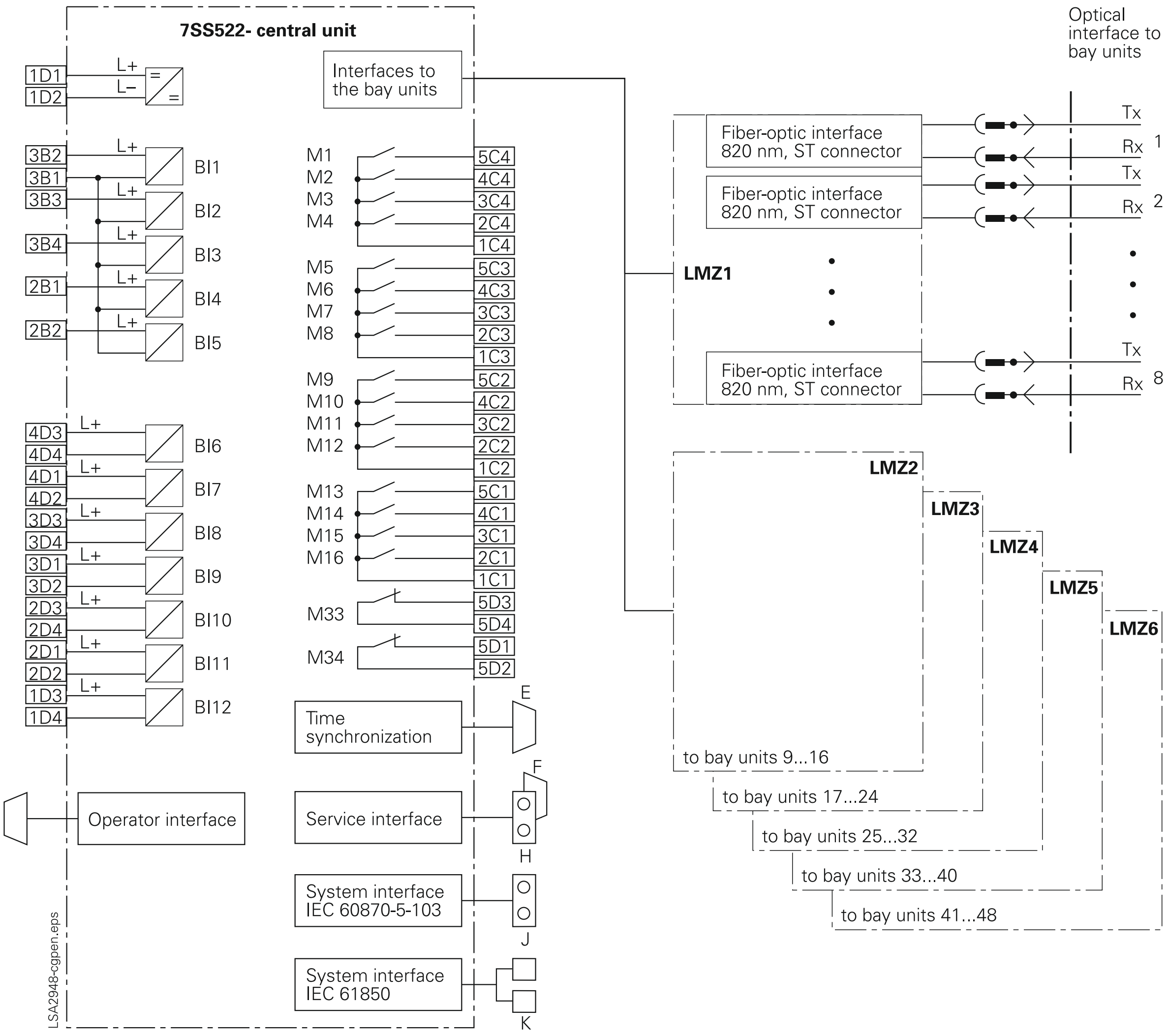


Fig. 9/31 Connection diagram 7SS522

Connection diagram

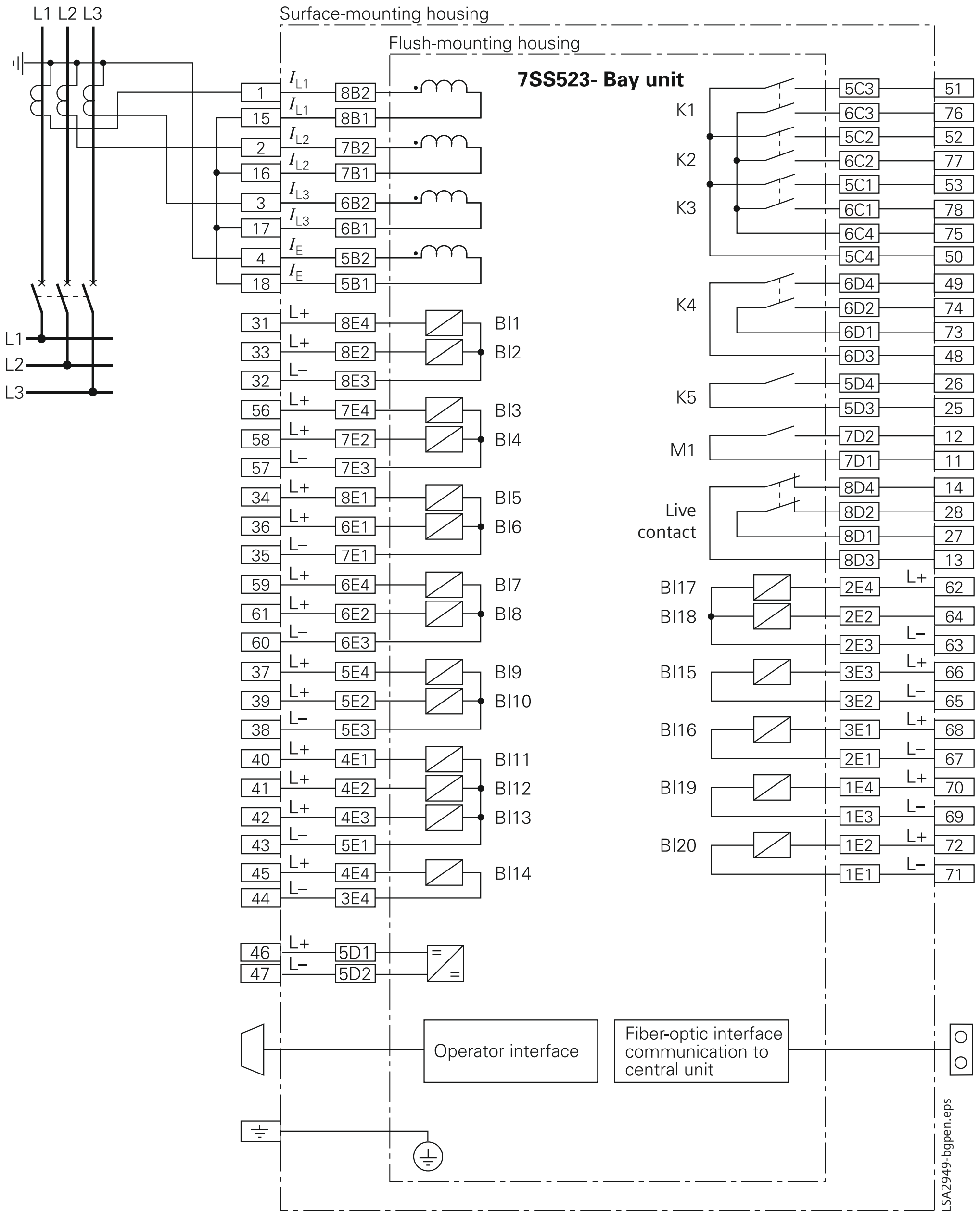


Fig. 9/32 Connection diagram 7SS523

Connection diagram

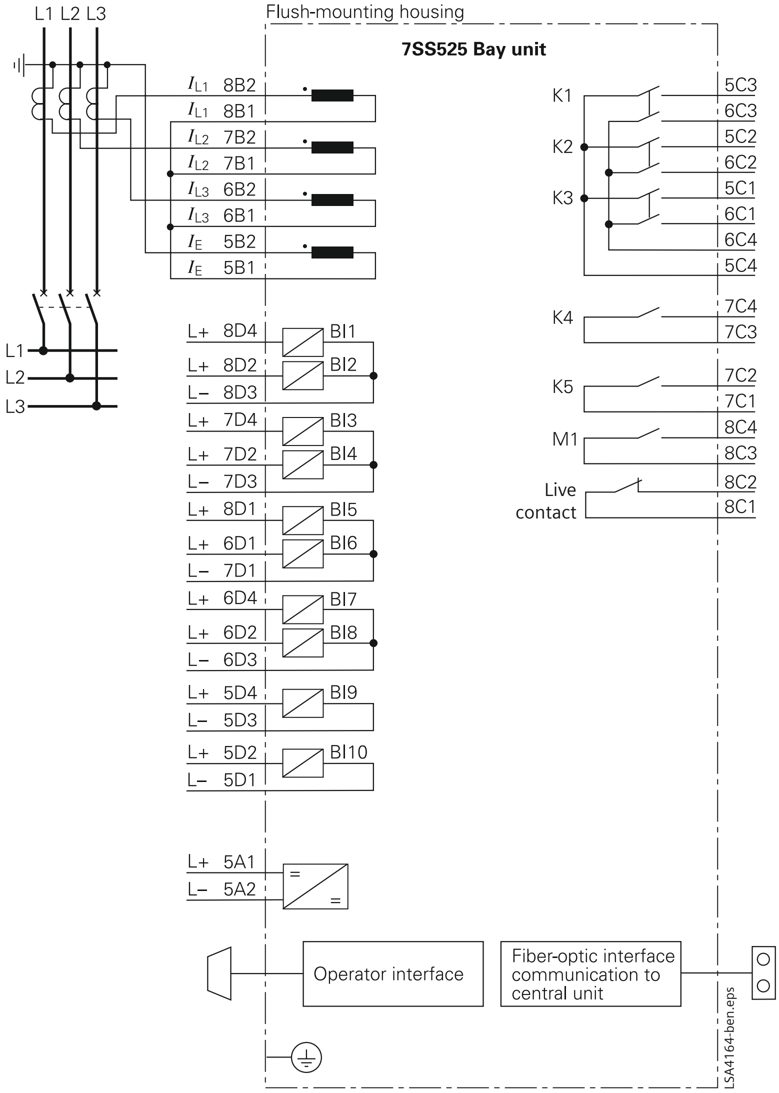


Fig. 9/33 Connection diagram 7SS525

Relays for Various Protection Applications

SIPROTEC 4 7VK61
Breaker Management Relay

Fig. 10/1
SIPROTEC 4 7VK61 breaker management relay

Description

The SIPROTEC 4 breaker management relay 7VK61 is a highly flexible auto-reclosure, synchro-check and circuit-breaker failure protection unit.

This unit is used for the single and three-pole auto-reclosure of a circuit-breaker, after this circuit-breaker has tripped due to a fault. The synchro-check function ensures that the two circuits being reconnected by closing the circuit-breaker are within a defined safe operating state before the CLOSE command is issued.
The 7VK61 is also applicable as circuit-breaker failure protection. A breaker failure occurs when the circuit-breaker fails to correctly open and clear the fault after single or three-pole trip commands have been issued by the protection. It is then necessary to trip the relevant busbar zone (section) to ensure fault clearance.
Together with the above-mentioned protection functions, the following additional functions of the 7VK61 can be applied: end-fault protection, pole-discrepancy protection, overvoltage protection and undervoltage protection. As a member of the numerical SIPROTEC 4 relay family, it also provides control and monitoring functions and therefore supports the user with regard to a cost-effective power system management.

Function overview

Protection functions

- Single and/or three-pole auto-reclosure
- Synchro-check with live/dead line/bus measurement
- Closing under asynchronous conditions (consideration of CB operating time)
- Circuit-breaker failure protection with two stages (single and three-pole with/without current)
- End-fault protection
- Pole-discrepancy protection
- Overvoltage/undervoltage protection

Control function

- Commands f. ctrl. of CB and isolators

Monitoring functions

- Operational measured values
- Self-supervision of the relay
- Event buffer and fault protocols
- Oscillographic fault recording
- Monitoring of CB auxiliary contacts
- Switching statistics

Features

- All functions can be used separately
- Initiation/start by phase-segregated or 3-pole trip commands
- Auto-reclosure for max. 8 reclose cycles
- Evolving/sequential trip recognition
- Auto-reclosure with ADT, DLC, RDT
- Synchro-check with ΔV, $\Delta\varphi$, Δf measurement
- Breaker failure protection with highly secure 2-out-of-4 current check detectors
- Breaker failure protection with short reset time and negligible overshoot time

Communicatlon interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  – IEC 61850 Ethernet
  – IEC 60870-5-103 protocol
  – PROFIBUS-FMS/-DP
  – DNP 3.0
- Rear-side service/modem interface
- Time synchronization via
  – IRIG-B or DCF77 or system interface

Application

The 7VK61 provides highly flexible breaker management. It applies to single-breaker, ring-bus, and 1½ breaker installations. The auto-reclosure, synchronism-check, breaker failure protection and voltage protection functions can be used separately or combined. Therefore the current and voltage transformer connection can be selected according to the required application.

The auto-reclosure function closes the circuit-breaker after this circuit-breaker has tripped due to a fault. The check-synchronism function ensures that the two circuits being reconnected by closing the circuit-breaker are within a defined safe operating state before the CLOSE command is issued.

The numerical 7VK61 relay provides rapid backup fault clearance in case the circuit-breaker nearest to the fault fails to respond to a TRIP command. It is suitable for power systems of all voltage levels with single and/or three-pole circuit-breaker operation. The initiation signal can be issued from any protection or supervision equipment. Information from the circuit-breaker auxiliary contact is only required for the breaker failure protection during faults which produce little or no fault current flow, for instance due to a trip from the power transformer Buchholz protection.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user with regard to a cost-effective power system management. The security and reliability of the power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control.

If the requirements for protection, control and interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.
The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

ANSI	
50BF	Breaker-failure protection
59/27	Overvoltage/undervoltage protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)

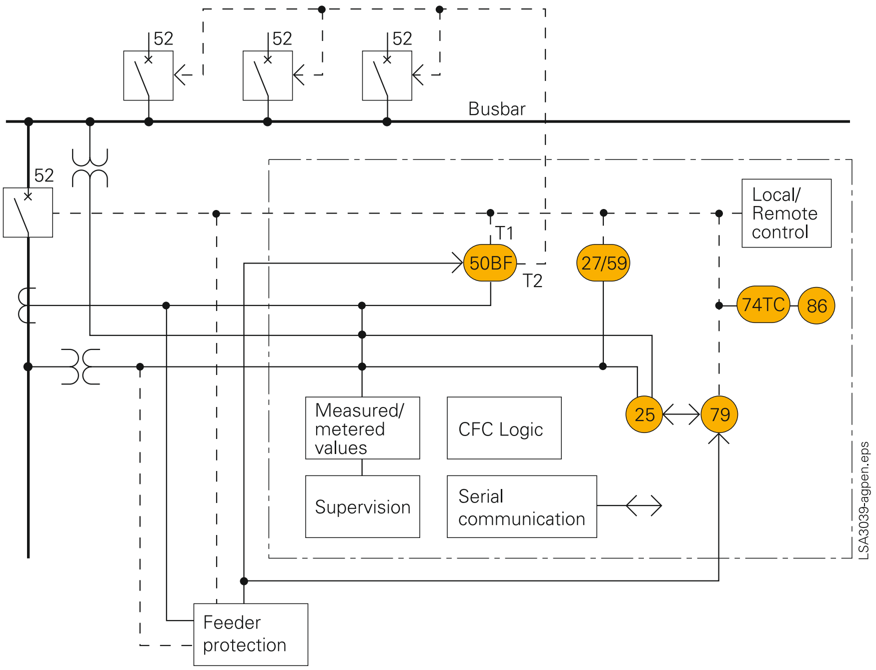


Fig. 10/2 Application and function diagram

Construction

Connection technique and housing with many advantages

1/3 and 1/2-rack sizes are available as housing widths of the SIPROTEC 4 7VK61 relays, referred to a 19" modular frame system. This means that previous models can always be replaced. The height is a uniform 255 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below the housing in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

LSP2174-afp.tif

Fig. 10/3
Flush-mounting housing with screw-type terminals

LSP2166-afp.tif

Fig. 10/4
Rear view of flush-mounting housing with covered connection terminals and wirings

LSP2219-afp.eps

Fig. 10/5
Surface-mounting housing with screw-type terminals, example 7SA63

LSP2237-afp.tif

Fig. 10/6
Communication interfaces in a sloped case in a surface-mounting housing

Protection functions

Auto-reclosure (ANSI 79)

The 7VK61 relay is equipped with an auto-reclose function (AR). Usually the auto-reclosure interacts with the feeder protection via binary inputs and outputs.

The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts.

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

The 7VK61 allows the line-side voltages to be evaluated. A number of voltage-dependent supplementary functions are thus available:

- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure in case that the synchronism check can not be used).
- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no teleprotection method is employed: when faults within the zone extension of a distance feeder protection but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped, that the fault has been cleared by the protection on the faulted downstream feeder and that reclosure with reduced dead time may take place.

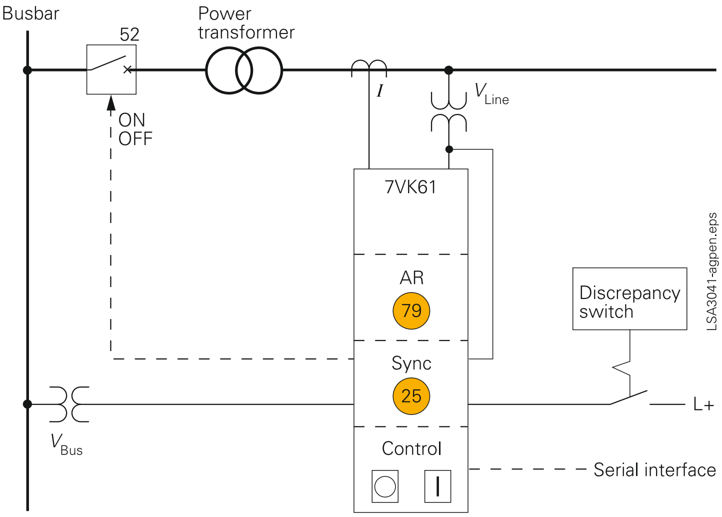


Fig. 10/7 Auto-reclosure and synchro-check with voltage measurement across a power transformer

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism, the function releases the CLOSE command. Consideration of the duration of the CB operating time before issuing the CLOSE command (especially important under asynchronous conditions and when several circuit-breakers with different operating times are to be operated by one single relay).

In addition, reclosing can be enabled for different criteria, e.g., when the busbar or line are not carrying a voltage (dead line or dead bus).

Breaker failure protection (ANSI 50BF)

The 7VK61 relay incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or the busbar trip command will be generated. The breaker failure protection will usually be initiated by external feeder protection relays via binary input signals. Trip signals from the internal auto-reclosure logic or from the voltage protection can start the breaker failure protection as well.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

The 7VK61 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input (not in conjunction with syncho-check) or be derived from the phase voltages.
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7VK61 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Protection functions

End-fault protection

When the circuit-breaker is open, the area located between the current transformer and the circuit-breaker can be optimally protected by means of the end-fault protection. In the event of a fault, an independently settable time delay is started after a valid initiation has been received and the circuit-breaker auxiliary contacts indicate an open circuit-breaker position, with current still flowing (see Fig. 10/8). Depending on the mounting position of the current transformer, instantaneous tripping of the busbar section or intertripping of the circuit-breaker at the opposite end occurs.

Pole-discrepancy protection

This function ensures that any one or two poles of a circuit-breaker do not remain open for longer than an independently settable time (i.e. unsymmetrical conditions). This time stage is initiated when current (above the set value) is flowing in any 1 or 2 phases, but not in all 3 phases. Additionally, the circuit-breaker auxiliary contacts (if connected) are interrogated and must show the same condition as the current measurement. Should this time delay expire, then a three-pole trip command is issued. This function is normally used when single-pole auto-reclosing is applied.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted. The trip circuit supervision function requires one or two independent potential-free binary inputs per trip circuit. To make existing (non potential-free) binary inputs potential-free, external optocoupler modules can be applied.

Lockout (ANSI 86)

Under certain operating conditions, it is advisable to block CLOSE commands after a final TRIP command of the relay has been issued. Only a manual ‘Reset’ command unblocks the CLOSE command. The 7VK61 is equipped with such an interlocking logic.

Monitoring functions

The 7VK61 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.
If all voltages are connected, the relay will detect secondary voltage interruptions by means of the integrated fuse failure monitor. Immediate alarm and blocking of the synchronism check and dead line check is provided for all types of secondary voltage failures. Additional measurement supervision functions are

- Symmetry of voltages and currents (in case of appropriate transformer connection)
- Broken-conductor supervision (if current transformers are connected)
- Summation of currents and voltages (in case of appropriate transformer connection)
- Phase-sequence supervision (if three voltage transformers are connected)

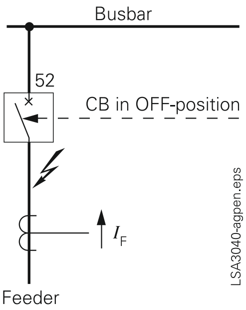


Fig. 10/8
End-fault between circuit-breaker and current transformer

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication "circuit-breaker TRIP" to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the unit which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

7VK61 units are always fitted with a rear-side hardwired service interface, optionally as RS232 or RS485. In addition to the front-side operator interface, a PC can be connected here either directly or via a modem.

Time synchronization interface

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should a unit fail, there is no effect on the communication with the rest of the system.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc.) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this Standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also be possible with DIGSI.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays.
IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide. Supplements for the control function are defined in the manufacturer-specific part of this standard.

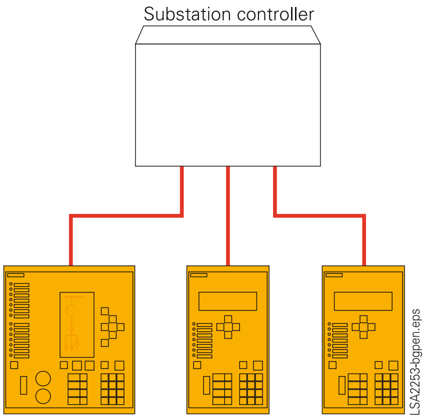


Fig. 10/9
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

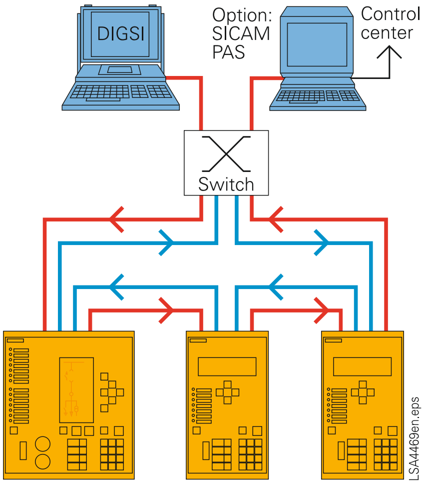


Fig. 10/10
Bus structure for station bus with Ethernet and IEC 61850 with fiber-optic ring

Communication

PROFIBUS-DP

PROFIBUS-DP is an industrial communications standard and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 10/14).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus.

With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI can also be used via the same station bus.

Fig. 10/11 820 nm fiber-optic communication module

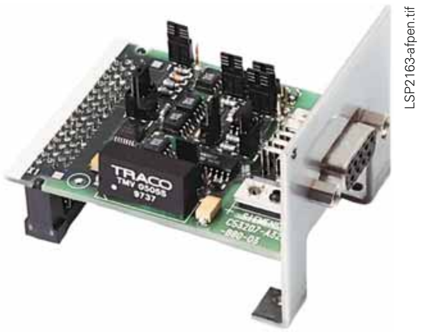


Fig. 10/12 RS232/RS485 electrical communication module

Fig. 10/13 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

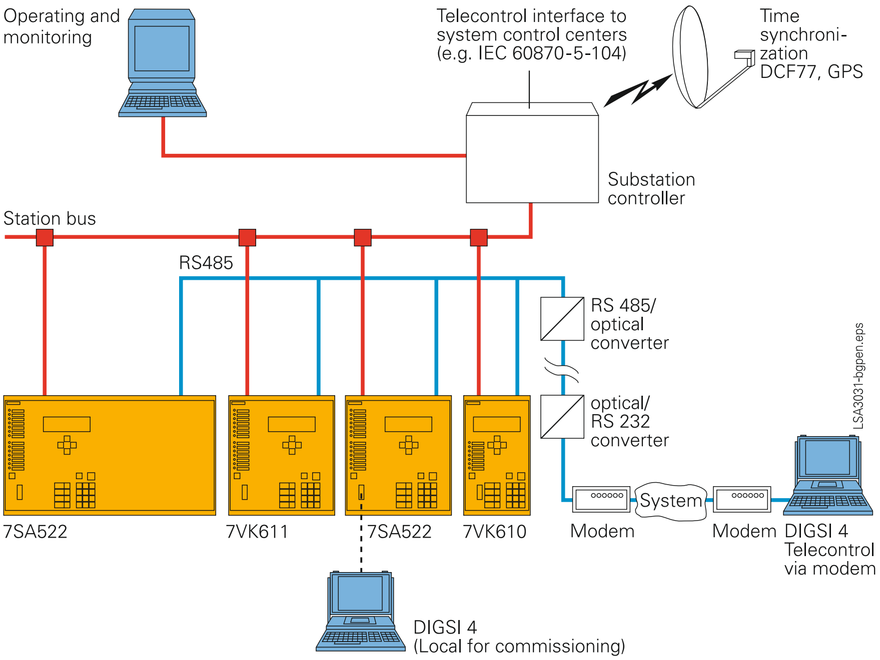


Fig. 10/14 Communication

Typical connection

Connection for current and voltage transformers

With the transformer connection as shown in Fig. 10/15, it is possible to use the complete scope of functions of 7VK61, i.e. breaker failure protection, synchronism check with 3-phase dead line check (with or without auto-reclosure), complete measured value monitoring, voltage protection, and the complete range of operational measured values.

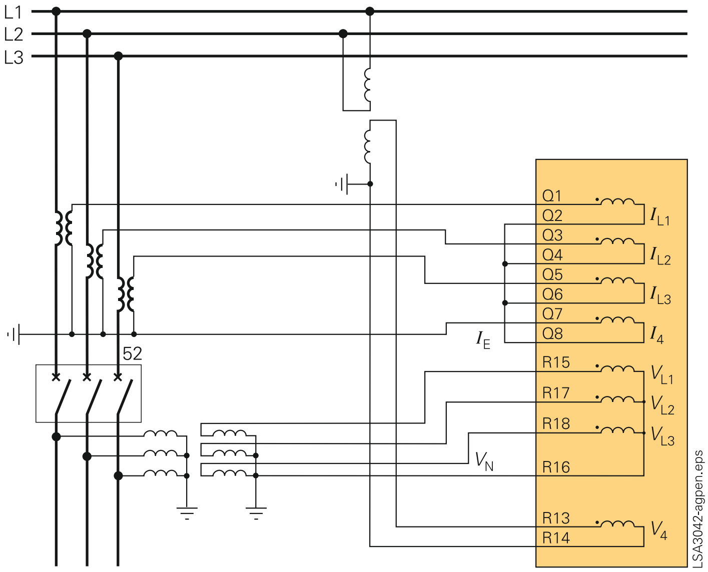


Fig. 10/15
Complete connection of all current and voltage transformers

Alternative: Connection for current transformers only

The connection for current transformers only provides breaker failure protection and current operational measured values.

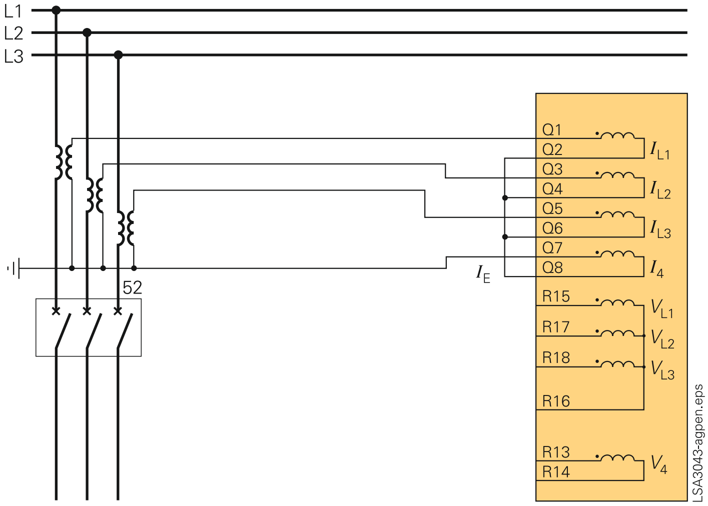


Fig. 10/16
Typical current transformer connection for breaker failure protection

Typical connection

Alternative: Connection for two voltage transformers

In case of a connection for two voltage transformers, synchro-check and two operational measured voltages, and additionally synchro-check measured values are applicable. Dead line check is performed for the connected line voltage only.

Note: Please connect the two voltages always to the terminals R15/R16 and R13/R14 with the appropriate polarity. The setting address 106 "Voltage transformer" must then be set to "single-phase". The terminals R17 and R18 must not be connected.

The connection of the voltage $V_{L1\text{-}L2}$ as shown in Fig. 10/17 is just an example: any other of the shown combinations is possible for synchronization.

The two voltage transformer connection can also be combined with the current transformer connection according to Fig. 10/16.

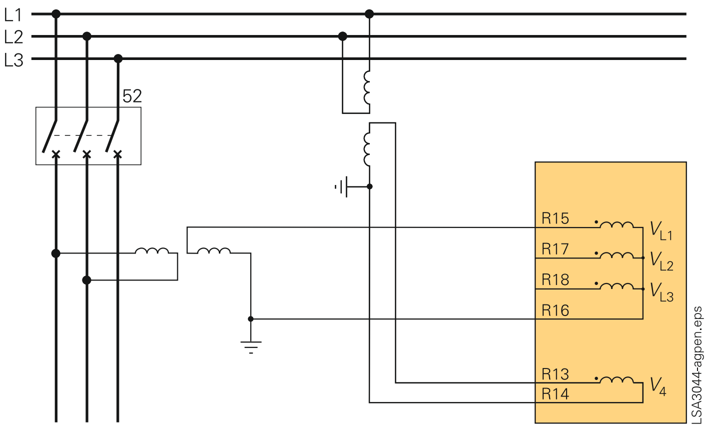


Fig. 10/17
Typical voltage transformer connection for synchro-check with single voltage dead line check

Technical data

General unit data

Analog inputs

Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage V_{nom}	80 to 125 V (selectable)
Power consumption	
With I_{nom} = 1 A	Approx. 0.05 VA
With I_{nom} = 5 A	Approx. 0.30 VA
Voltage inputs	≤ 0.10 VA
Overload capacity of current circuit	
Thermal (r.m.s.)	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (peak value)	1250 A (half cycle)
Thermal overload capacity of voltage circuit	230 V continuous

Auxiliary voltage

Rated voltages	24, 48 V DC 60, 125 V DC 110, 250 V DC and 115, 230 V AC (50/60 Hz)
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Quiescent	Approx. 5 W
Energized	Approx. 8 W to 14 W, depending on design
Bridging time during failure of the auxiliary voltage	
For V_{aux} = 48 V and V_{aux} ≥ 110 V	≥ 50 ms
For V_{aux} = 24 V and V_{aux} = 60 V	≥ 20 ms

Binary inputs

Quantity	
7VK610	7
7VK611	20
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	19 or 88 V or 176 V DC, bipolar
Functions are freely assignable	
Minimum pickup voltage	19 or 88 V or 176 V DC, bipolar
Ranges are settable by means of jumpers for each binary input	(3 operating ranges)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time >60 ms

Output contacts

"Unit ready" contact (live status contact)	1 NC/NO contact1)
Command/indication relay	
Quantity	
7VK610	5 NO contacts,
7VK611	14 NO contacts, 4 NC/NO contacts1)
NO/NC contact	
Switching capacity	
Make	1000 W / VA
Break, contacts	30 VA
Break, contacts (for resistive load)	40 W
Break, contacts (for τ = L/R ≤ 50 ms)	25 VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx.	
NO contact	8 ms
NO/NC contact (selectable)	8 ms
Fast NO contact	5 ms

LEDs

Quantity	
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	
7VK610	7
7VK611	14

Unit design

Housing	7XP20
Dimensions	Refer to part 15 for dimension drawings
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 20 with terminal cover put on
Weight	
Flush-mounting housing	
1/3 x 19"	5 kg
1/2 x 19"	6 kg
Surface-mounting housing	
1/3 x 19"	9.5 kg
1/2 x 19"	11 kg

---

1) Can be set via jumpers.

Technical data

Serial interfaces

Operating interface, *front of unit for DIGSI 4*

Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1

Time synchronization DCF77/ IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Service/modem interface for DIGSI 4 / modem / service

Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

System interface

	IEC 61850 Ethernet IEC 60870-5-103 protocol PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 38400 baud
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Dielectric test	500 V / 50 Hz
Baud rate	Max. 12 Mbaud
Distance	1000 m at 93.75 kbaud; 100 m at 12 Mbaud
PROFIBUS fiber-optic	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM1)
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	500 kB/s 1.6 km 1500 kB/s 530 m

Electrical tests

Specifications

Standards	IEC 60255 (product standards) IEEE C37.90.0/.1/.2 VDE 0435 For further standards see "Individual tests"

Insulation tests

Standards	IEC 60255-5 and 60870-2-1
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J, 3 positive and 3 negative impulses in intervals of 5 s

EMC tests for noise immunity; *type tests*

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 Part 301, DIN VDE 0435-110
High-frequency test IEC 60255-22-1 class III and VDE 0435 Part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with HF field, IEC 60255-22-3 class III IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz 10 V/m; 1.4 to 2 GHz; 80 % AM; 1 kHz
Irradiation with HF field, IEC 60255-22-31, IEC 61000-4-3	Class III, 10 V/m
Amplitude-modulated	80; 160; 450; 900 MHz; 80 % AM 1kHz; duration >10 s
Pulse-modulated	900 MHz, 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min

---

1) Conversion with external OLM
Fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order Code L0A (DP RS485) or 9 and Order Code L0G (DNP 3.0) and additionally a suitable external repeater.

Technical data

EMC tests for noise immunity; type tests (cont'd)

High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω; 9 µF Differential (transversal) mode:1 kV; 2 Ω: 18 uF
Measurement inputs, binary inputs, binary output relays	Common (longitudinal) mode: 2 kV; 42 Ω; 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability, IEEE C37.90.1	2.5 kV (peak); 1 MHz; $\tau = 50$ µs; 400 surges per second, duration 2 s, $R_i = 200\ \Omega$
Fast transient surge withstand capability, IEEE C37.90.1	4 kV; 5/50 ns; 5 kHz burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; duration 1 min
Radiated electromagnetic interference IEEE C37.90.2	35 V/m; 25 to 1000 MHz,
Damped oscillation IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200\ \Omega$

EMC tests for interference emission; type tests

Standard	EN 61000-6-3 (generic standard)
Conducted interference voltage on lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B
Harmonic currents on the network lead at 230 V AC, IEC 61000-3-2	Class A limits are observed
Voltage fluctuations and flicker on the network incoming feeder at 230 V AC, IEC 61000-3-3	Limits are observed

Mechanical stress test

Vibration, shock stress and seismic vibration

<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests

Standard	IEC 60255-6
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.

Technical data

Functions

Auto-reclosure (ANSI 79)

Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1- or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{1\text{-ph}}$, $T_{3\text{-ph}}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (steps 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage $_{\text{PH-E}}$	30 to 90 V (steps 1 V)
Dead line voltage $_{\text{PH-E}}$	2 to 70 V (steps 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 1 V

Synchro-check (ANSI 25)

Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	
With auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1°)
Max. duration of synchronization	0.01 to 600 s (steps 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (steps 0.01 s)
Minimum measuring time	Approx. 80 ms
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 1 V

Breaker failure protection (ANSI 50BF)

Number of stages	2
Pickup of current element	0.05 to 20 A $_{(1A)}$ / 0.25 to 100 A $_{(5A)}$ (step 0.01 A)
Time delays $T1_{\text{1phase}}$, $T1_{\text{3phase}}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Dropout (overshoot) time, internal	≤ 15 ms, typical; 25 ms, max.
End-fault protection	For fault between open CB and CT, with intertrip to the remote line end
Pole discrepancy supervision	Initiation if not all CB poles are closed or open
Monitoring time	0 to 30 s (steps 0.01 s) or deactivated
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms

Voltage protection (ANSI 59, 27)

Operating modes	Local tripping and/or carrier trip for remote end

Overvoltage protection

Pickup values $V_{\text{PH-E}}>>$, $V_{\text{PH-E}}>$ (phase-earth overvoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_{\text{PH-PH}}>>$, $V_{\text{PH-PH}}>$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_0>>$, $3V_0>$ ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values $V_1>>$, $V_1>$ (positive-sequence overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $V_2>>$, $V_2>$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)

Undervoltage protection

Pickup values $V_{\text{PH-E}}<<$, $V_{\text{PH-E}}<$ (phase-earth undervoltage)	1 to 100 V (step 0.1 V)
Pickup values $V_{\text{PH-PH}}<<$, $V_{\text{PH-PH}}<$ (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_1<<$, $V_1<$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio (settable)	1.01 to 1.20 (step 0.01)

Time delays

Time delay for all stages	0 to 100 s (step 0.01 s) or deactivated
Command / pickup time	Approx. 34 ms at $f_{\text{nom}} = 50$ Hz Approx. 30 ms at $f_{\text{nom}} = 60$ Hz
Tolerances	
Voltage limit values	≤ 3 % of setting value or 1 V
Time stages	1 % of setting value or 10 ms

Trip circuit supervision (ANSI 74TC)

Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (steps 1 s)

Technical data

Additional functions

Operational measured values

Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; I_1; I_2
Tolerances	Typ. 0.3 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{Phase\text{-}Earth}$; 3 x $V_{Phase\text{-}Phase}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}
Tolerances	Typ. 0.25 % of indicated measured value or 0.01 % V_{nom}
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert\cos\varphi\rvert = 0.7$ to 1 and V/V_{nom}, $I/I_{nom} = 50$ to 120 %	Typical ≤ 1%
Q: for $\lvert\sin\varphi\rvert = 0.7$ to 1 and V/V_{nom} , $I/I_{nom} = 50$ to 120 %	Typical ≤ 1%
S: for V/V_{nom}, $I/I_{nom} = 50$ to 120 %	Typical ≤ 1%
Frequency	f
Tolerance	≤ 10 mHz
Power factor	PF
Tolerance for $\lvert\cos\varphi\rvert = 0.7$ to 1	Typical ≤ 0.02

Energy meters

Four-quadrant meters	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance	
for $\lvert\cos\varphi\rvert > 0.7$ and $V >$ 50 % V_{nom} and $I >$ 50 % I_{nom}	5 %

Oscillographic fault recording

Analog channels	3 x I_{Phase}, $3I_0$ 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	> 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40

Control

Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys, control keys (if available)
Remote control	Control protection, DIGSI, pilot wires

Further additional functions

Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Phase sequence Fuse failure monitor
Indications	Power direction
Operational indications	Buffer size 200
System disturbance indication	Storage of indications of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, CB test, status display of binary inputs, setting of output relays, generation of indications for testing serial interfaces
Phase rotation adjustment	Clockwise or anti-clockwise

CE conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23/EEC).

This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directive and with the standard EN 60255-6 for the low-voltage directive.

This device is designed and produced for industrial use.

The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

Selection and ordering data

Description	Order No.	Order code
7VK61 breaker management relay	*7VK61☐☐ – ☐☐☐☐☐ – 4Y☐0*	*☐☐☐*
Housing, binary inputs (BI) and outputs (BO)		
Housing 1/3 19”, 7 BI, 6 BO incl. 1 live-status contact,	0	
Housing 1/2 19”, 20 BI, 19 BO incl. 1 live-status contact	1	
Measuring inputs (4 x V, 4 x I)		
I_{ph} = 1 A, I_e = 1 A (min. = 0.05 A) 1)	1	
I_{ph} = 5 A, I_e = 5 A (min. = 0.25 A) 1)	5	
Rated auxiliary voltage (power supply, threshold of binary inputs)		
24 to 48 V DC, binary input threshold 19 V 3)	2	
60 to 125 V DC 2), binary input threshold 19 V 3)	4	
110 to 250 V DC 2), 115 to 230 V AC, binary input threshold 88 V 3)	5	
220 to 250 V DC 2), 115 to 230 V AC, binary input threshold 176 V 3)	6	
Unit version		
For panel flush mounting	A	
For panel surface mounting	E	
Region-specific default settings/language settings and functions versions		
Region DE, language: German, selectable	A	
Region World, language: English, selectable	B	
Region US, language:US-English, selectable	C	
Region FR, language: French, selectable	D	
Region World, language: Spanish, selectable	E	
Region World, language: Italian, selectable	F	
Port B system interface		
Empty	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, double ring, ST connector 4)	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm , double ring, ST connector 4)	9	L 0 B
DNP 3.0, RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector 4)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector 5)	9	L 0 S
Port C service interface		
DIGSI 4/modem, electrical RS232	1	
DIGSI 4/modem, electrical RS485	2	

Functions

Breaker failure protection 1-/3-pole or 3-pole only	Auto-reclosure 1-/3-pole or 3-pole only and synchro-check	Over/Undervoltage protection	Order No.
■			C
■		■	D
	■		N
	■	■	P
■	■		Q
■	■	■	R

1) Rated current can be selected by means of jumpers.

2) Transition between the 3 auxiliary ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in 3 steps by means of jumpers.

4) Optical interfaces are not available with surface mounting housings (position 9 = E). Please order the version with RS485 interface and a separate electrical/optical converter.

5) For surface-mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA 4 (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
Manual for 7VK61 For the latest version please visit	www.siemens.com/siprotec

Fig. 10/18 Mounting rail for 19" rack

Fig. 10/19
2-pin connector

Fig. 10/20
3-pin connector

Fig. 10/21
Short-circuit link for current contacts

Fig. 10/22
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	10/19
	3-pin	C73334-A1-C36-1	1	Siemens	10/20
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For type III+	0-539635-1	1	AMP 1)	
	and matching female	0-539668-2		AMP 1)	
	for CI2	0-734372-1	1	AMP 1)	
	and matching female	1-734387-1		AMP 1)	
19" mounting rail		C73165-A63-D200-1	1	Siemens	10/18
Short-circuit links	For current terminals	C73334-A1-C33-1	1	Siemens	10/21
	For other terminals	C73334-A1-C34-1	1	Siemens	10/22
Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens	10/4
	small	C73334-A1-C32-1	1	Siemens	10/4

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

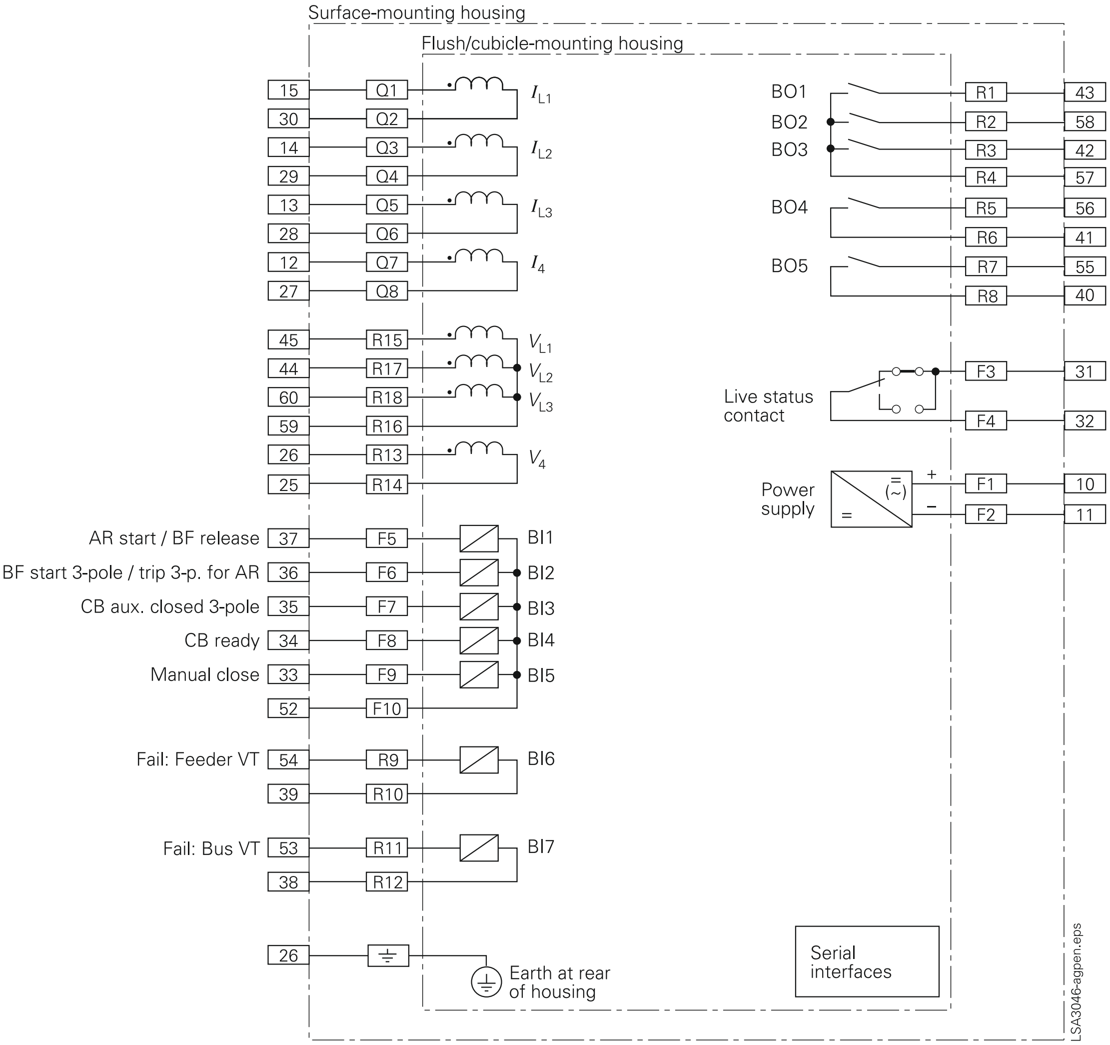


Fig. 10/23
Connection diagram 7VK610, 1/3 x 19″ housing

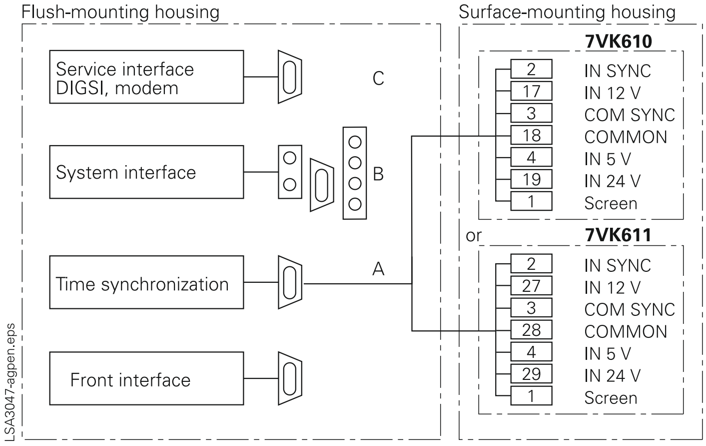


Fig. 10/24
Serial interfaces

Connection diagram

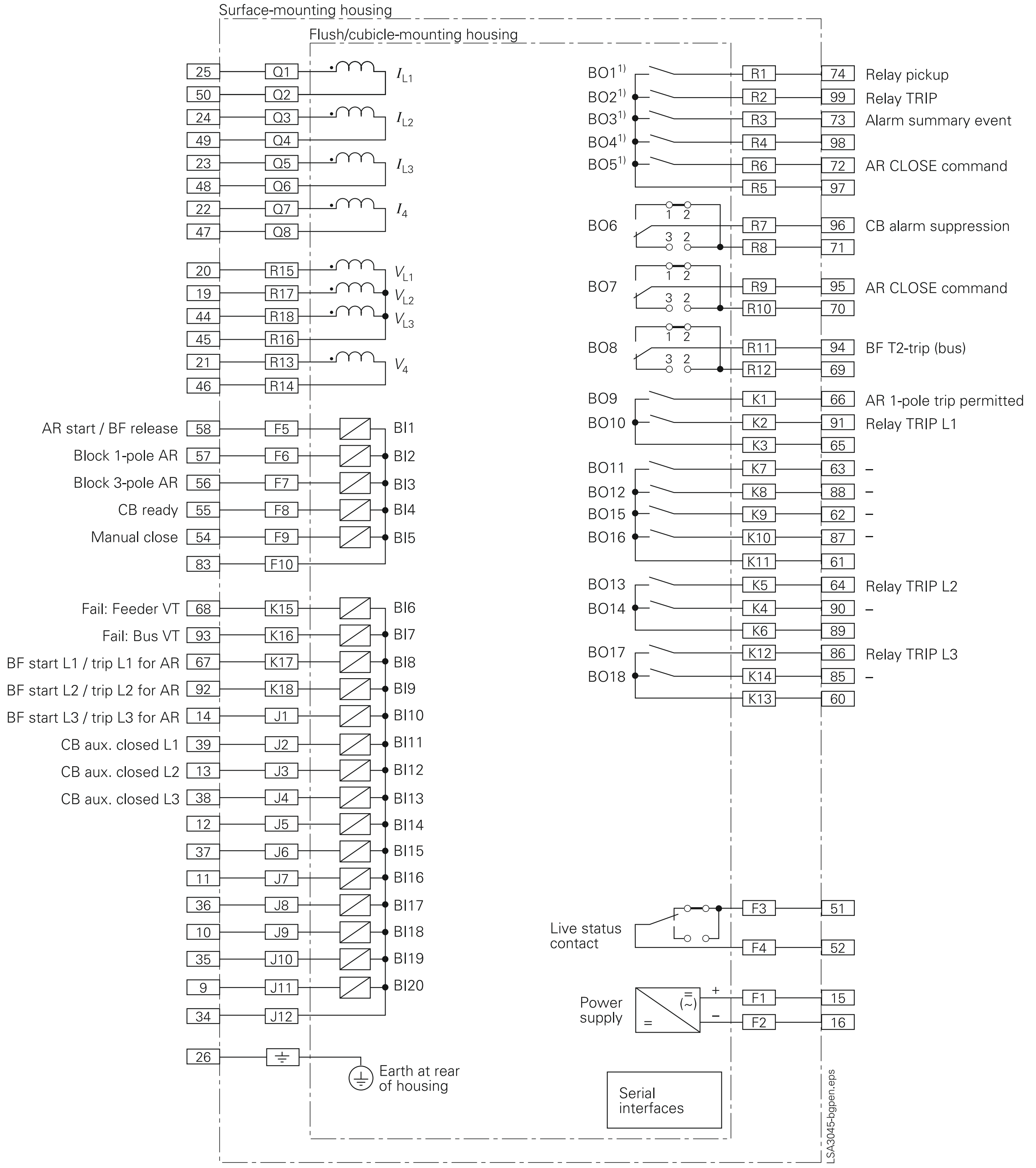


Fig. 10/25
Connection diagram 7VK611, 1/2 x 19" housing

---

1) Fast relay

SIPROTEC 7SV600
Numerical Circuit-Breaker Failure Protection Relay

LSP2001-afpen.tif

Fig. 10/26
SIPROTEC 7SV600
numerical circuit- breaker
failure protection relay

Description

The SIPROTEC 7SV600 is a numerical relay used for circuit-breaker failure protection. A failure occurs when the circuit-breaker fails to correctly open and clear the fault after single or three-pole trip commands have been issued by the protection unit. It is then necessary to trip the relevant busbar zone (section) to ensure fault clearance.

Generally, the monitoring of the current is sufficient as the criterion for the indication that the circuit-breaker has successfully cleared the fault ("current condition"). However, under certain fault conditions (e.g. overvoltage), little or no current may flow, making the measurement of current unreliable for indication of the circuit-breaker status ("no current condition"). The 7SV600 operates correctly for both these conditions. The relay is suitable for use at all voltage levels and in all applications. The current transformers can either be of the closed iron core or linear type. The relay can be incorporated in conventional switchgear systems and modem substation control systems e.g. SICAM.

Function overview

Protection functions

- Circuit-breaker failure protection (single or three-pole with/without current)
- Independently settable delay times for operation with and without current
- Single or two-stage time delay of the busbar trip command
- Re-trip (cross trip) stage (1^{st} stage of the 2-stage operation)
- Intertrip facility (via teleprotection interface)
- End-fault protection with intertrip
- "No current" control using the circuit-breaker auxiliary contacts

Features

- Highly sensitive current detection
- 2-out-of-4 check of the current detectors
- Short reset time, negligible overshoot time
- Can be initiated by phase-segregated or common-phase trip commands
- End-fault protection
- Assignable output relays, LEDs and binary inputs

Monitoring functions

- Monitoring of circuit-breaker auxiliary contacts
- Operational current measured values
- Self-supervision of the relay
- Event buffer
- Fault protocols
- Oscillographic fault recording

Communication interfaces

- 1 x RS485 interface
  – IEC 60870-5-103 protocol
  – DIGSI

Hardware

- Digital inputs:
  – 3 binary inputs
- Digital outputs:
  – 4 output relays

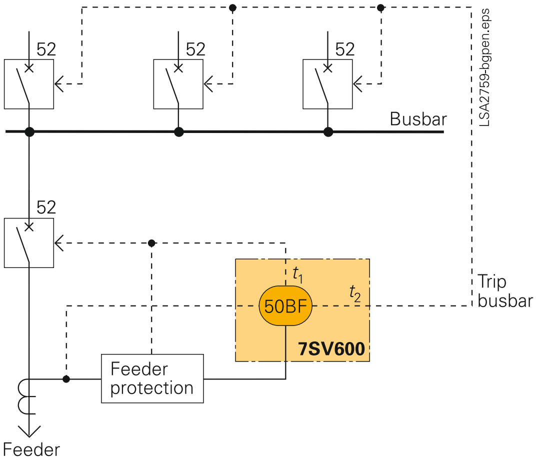
Front design

- Display for operation and measured values
- 6 LEDs for local alarm

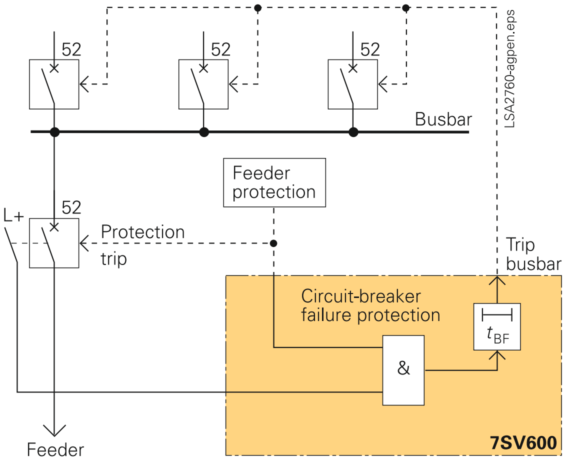
Application

The numerical circuit-breaker failure protection relay 7SV600 provides rapid backup fault clearance instruction to the associated circuit-breakers in case the circuit-breaker nearest to the fault fails to respond.

It is suitable for power systems of all voltage levels. The initiation signal can be derived from any protection or supervision equipment or, in case of manual opening, from the control discrepancy switch of the breaker. Information from the circuit-breaker auxiliary contact is required for the breaker failure protection to function during faults which produce little or no current flow (possible only with common-phase initiation).



Simplified application diagram of circuit-breaker failure protection.



Simplified application diagram of circuit-breaker failure protection by means of a circuit-breaker auxiliary contact.

Fig. 10/27 Typical applications

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485)
- Power supply

The rated CT currents applied to the SIPROTEC 7SV600 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Three different housings are available. The flush-mounting versions have terminals accessible from the rear. The surface-mounting version has terminals accessible from the front.

Fig. 10/28
Rear view of surface-mounting housing

Protection functions

The breaker failure protection can operate single-stage or two-stage. When used as single-stage protection, the bus trip command is given to the adjacent circuit-breakers if the protected feeder breaker fails. When used as two-stage protection, the first stage can be used to repeat the trip command to the relevant feeder breaker, normally on a different trip coil, if the initial trip command from the feeder protection is not successful. The second stage will result in a bus trip to the adjacent breakers, if the command of the first stage is not successful.

The bus trip command from the breaker failure protection can be routed to all circuit-breakers linked to the same busbar (section) as the breaker that failed. It can also be transmitted to the remote end by means of a suitable communication link (e.g. PLC, radio wave, or optical fiber).

The isolator replica which is necessary in case of multiple busbar sections is not part of the 7SV600 relay.

The current level is monitored in each of the three phases against a set threshold. In addition, the zero-sequence component or the negative-sequence component of the phase currents derived by symmetrical component analysis is monitored. This ensures high security against malfunction by use of a 2-out-of-4 check of the current detectors.

The version with phase-segregated initiation enables reliable breaker failure detection even during single-pole auto-reclose cycles, provided the phase-segregated trip signals of the feeder protection are connected to the 7SV600.

If the protected circuit-breaker is not operational (e.g. air pressure failure or spring not charged), instantaneous bus trip of the adjacent circuit-breakers can be achieved following a feeder protection trip, provided the relay is informed via binary input of the breaker status (possible only for common-phase initiation).

An end-fault protection function is integrated in the 7SV600 relay. An end fault is a short-circuit located between the circuit-breaker and the current transformer set of the feeder. For this fault, current flow is detected, although the auxiliary contacts of the breaker indicate open breaker poles. A command signal is generated which can be transmitted to the remote-end breaker (possible only for common-phase initiation).

Special measures are taken to prevent malfunction of the relay. Besides the mentioned 2-out-of-4 check of the current detection elements, the trip signals of the feeder protection can be connected in a redundant manner, so that they can be checked for plausibility (possible only for common-phase initiation).

Continuous monitoring of the measured values permits rapid annunciation of any fault in the instrument transformer circuits. Continuous plausibility monitoring of the internal measured value processing circuits and monitoring of the auxiliary voltages to ensure that they remain within tolerance are obviously inherent features.

Serial data transmission

A PC can be connected to ease setup of the relay using the Windows-based program DIGSI which runs under MS-Windows.

It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and the operational event buffer. As an option, a system interface is available.

The SIPROTEC 7SV600 transmits a subset of data via IEC 60870-5-103 protocol:

- General fault detection of the device
- General trip of the device
- Current in phase L2 [%] =
- Breaker failure trip T1 (local trip)
- Breaker failure trip T2 (busbar trip)
- Circuit-breaker defective: Trip
- Trip by end-fault protection
- Trip by monitoring current symmetry
- Breaker failure protection is active

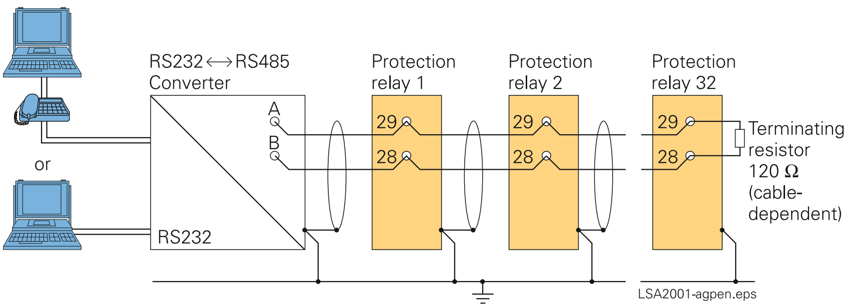


Fig. 10/29
Wiring communication RS485
For convenient wiring of the RS485 bus,
use bus cable system 7XV5103 (see part 13 of this catalog)

Connection diagrams

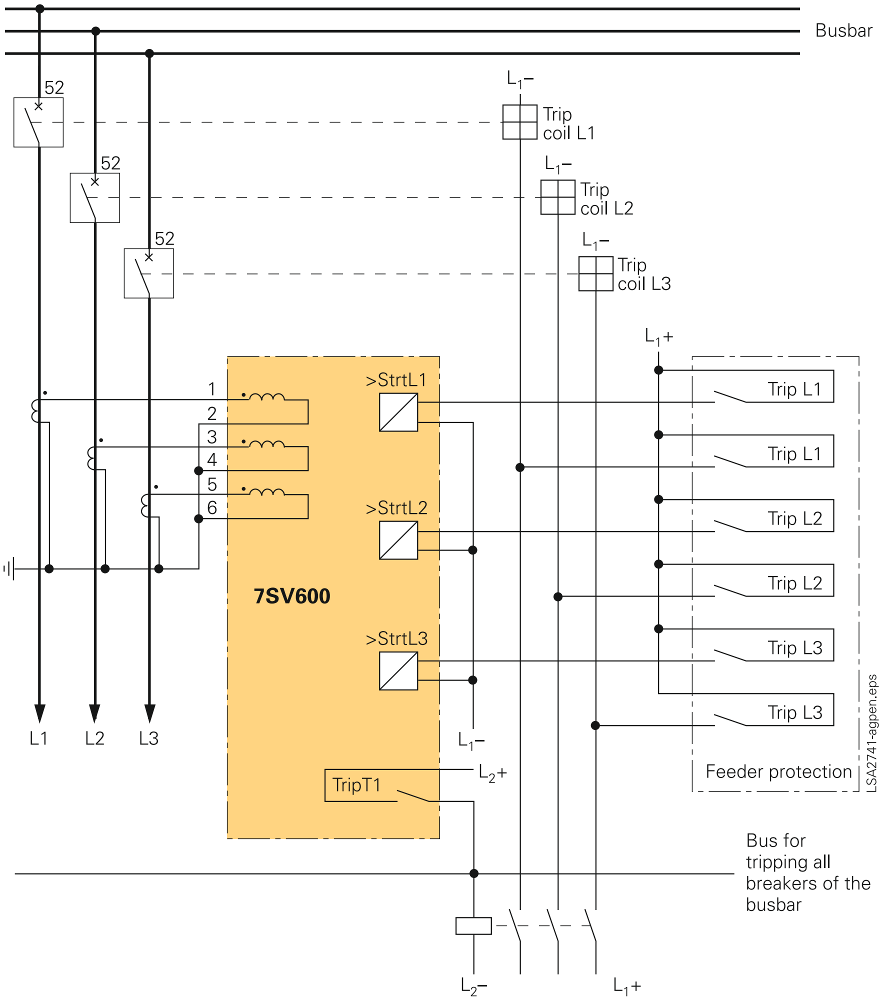


Fig. 10/30
Connection example for single-stage breaker failure protection with phase-segregated initiation

Connection diagrams

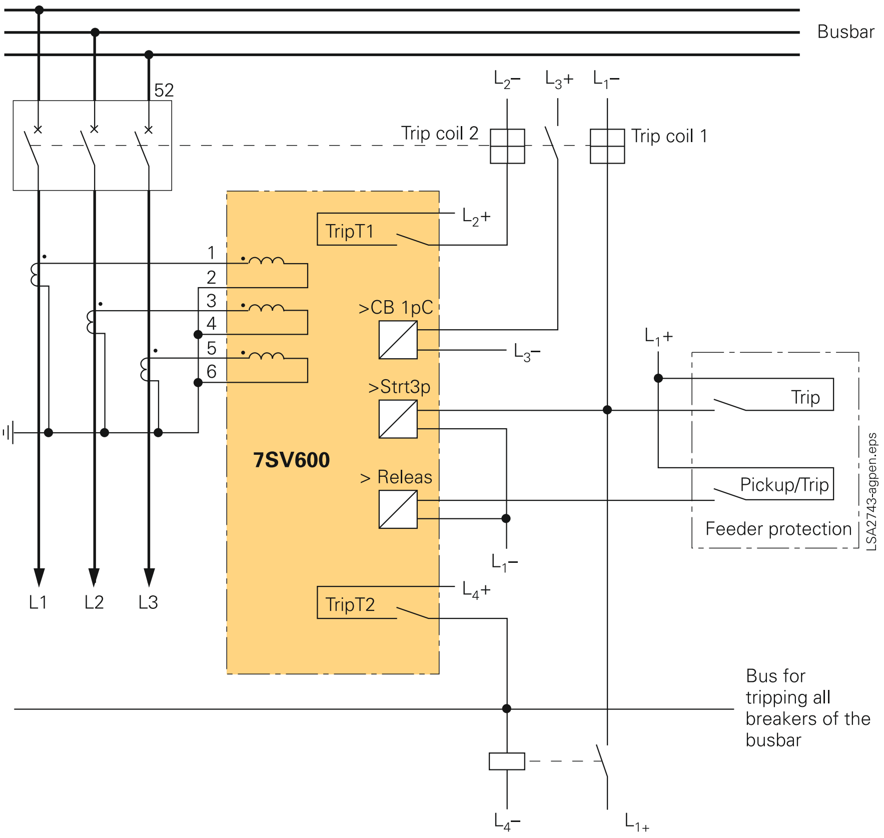


Fig. 10/31
Connection example for 2-stage breaker failure protection, common phase initiation, CB interrogation

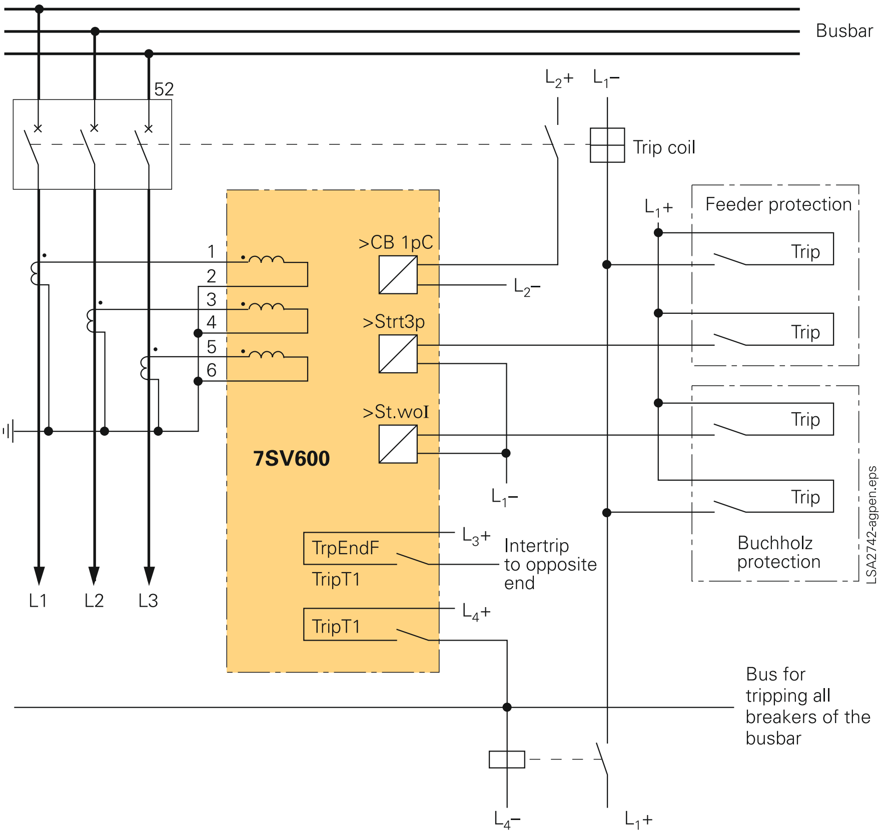


Fig. 10/32
Connection example for single-stage breaker failure protection with common phase initation and Buchholz protection, CB interrogation is imperative; additional intertrip signal to the opposite line end in case of breaker failure or end fault

Technical data

General unit data

Measuring circuits

Rated current I_N	1 to 5 A
Rated frequency f_N can be parameterized	50 or 60 Hz (selectable)
Power consumption of current inputs	
At $I_N = 1$ A	< 0.1 VA
At $I_N = 5$ A	< 0.2 VA
Overload capability current path,	
Thermal (r.m.s.)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
Dynamic (pulse current)	250 x I_N one half cycle

Auxiliary voltage

Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{Aux} DC	24 / 48 V DC 60 / 110 / 125 V DC 220 / 250 V DC
Permissible variations	19 to 58 V DC 48 to 150 V DC 176 to 300 V DC
Superimposed	
AC voltage	≤ 12 % at rated voltage
Peak-to-peak	≤ 6 % at limits of admissible voltage
Power consumption	
Quiescent	Approx. 2 W
Energized	Approx. 4 W
Bridging time during failure/short-circuit of auxiliary voltage	≥ 50 ms at $V_{rated} \geq 110$ V DC ≥ 20 ms at $V_{rated} \geq 24$ V DC
Rated auxiliary voltage V_{Aux}	115 V AC, 50/60 Hz 230 V AC, 50/60 Hz
Permissible variations	92 to 133 V AC 184 to 265 V AC

Heavy duty (command) contacts

Command (trip) relays, number	2 (can be marshalled)
Contacts per relays	2 NO
Switching capacity	
Make	1000 W / VA
Break	30 W / VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 s

Signal contacts

Signal/alarm relays	2 (can be marshalled)
Contact per relays	1 CO
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V
Permissible current	5 A

Binary inputs

Number	3 (can be marshalled)
Rated operating voltage	24 to 250 V DC
Current consumption	Approx. 2.5 mA, independent of operating voltage
Pick-up threshold	selectable by plug-in jumpers
Rated aux. voltage	$V_{pickup} \geq 17$ V DC
24/48/60 V DC	$V_{drop-off} < 8$ V DC
Rated aux. voltage	$V_{pickup} \geq 74$ V DC
110/125/220/250 V DC	$V_{drop-off} < 45$ V DC

Unit design

Housing	7XP20
Dimensions	Refer to part 15 for dimension drawings
Weight	
In housing for surface mounting	Approx. 4.5 kg
In housing for flush mounting	Approx. 4.0 kg
Degree of protection acc. to EN 60529	
Housing	IP 51
Terminals	IP 21

Serial interface

Isolated	
Standard	RS485
Test voltage	2.8 kV DC
Connection	Data cable on terminals, two data wires, one frame reference, for connection of a personal computer or similar; core pairs with shield, shield must be earthed; communication possible via modem
Baud rate	As delivered 9600 baud min. 1200 baud; max. 19200 baud

Electrical tests

Specifications

Standards	IEC 60255-5; ANSI/IEEE C37.90.0

Insulation tests

High voltage test (routine test) except DC voltage supply input and RS485	2 kV (r.m.s.); 50 Hz
High voltage test (routine test) only DC voltage supply input and RS485	2.8 kV DC
High voltage test (type test)	
Between open contacts of trip relays	1.5 kV (r.m.s.), 50 Hz
Between open contacts of alarm relays	1 kV (r.m.s.), 50 Hz
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s

Technical data

EMC tests for noise immunity; type tests

Standards: IEC 60255-6, IEC 60255-22 (product standards);
EN 50082-2 (generic standard) VDE 0435, part 303

High frequency IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; τ =15 µs; 400 shots/s; duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with radio-frequency field, non-modulated; IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated; IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with radio-frequency field, pulse-modulated; IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients/bursts IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV; 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; duration 1 min
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV	30 A/m continuous; 300 A/m for 3 s; 50 Hz
IEC 60255-6	0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak); 1 to 1.5 MHz, decaying oscillation; 50 surges per s; duration 2 s; $R_i = 150\ \Omega$ to $200\ \Omega$
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV; 10/150 ns; 50 surges per s; both polarities; duration 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m; 25 to 1000 MHz; amplitude and pulse modulated
High frequency test document 17C (SEC) 102	2.5 kV (peak, alternating polarity); 100 kHz, 1 MHz, 10 and 50 MHz, decaying oscillation; $R_i = 50\ \Omega$

EMC tests for interference emission; type tests

Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage	150 to 30 MHz
CISPR 22, EN 55022	Limit class B
Radio interference field strength CISPR 11, EN 55011	30 to 1000 MHz Limit class A

Mechanical stress tests

Vibration, shock stress and seismic vibration

<u>During operation</u>

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude; 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine Acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes

<u>During transportation</u>

Standard	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine Acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine Acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Technical data

Climatic stress tests

Temperatures

Permissible temperature during service	–20 °C to +70 °C (> 55 °C decreased display contrast)
Recommended temperature during service	–5 °C to +55 °C
Permissible temperature during storage	–25 °C to +55 °C
Permissible temperature during transport Storage and transport with standard works packaging!	–25 °C to +70 °C

Humidity

Permissible humidity We recommend that all units are installed such that they are not subjected to direct sunlight, nor to large temperature fluctuations which may give rise to condensation.	Mean value per year ≤ 75 % relative humidity; on 30 days per year 95 % relative humidity; condensation not permissible!

Service conditions

The relay is designed for use in industrial environment, for installation in standard relay rooms and compartments so that with proper installation electromagnetic compatibility (EMC) is ensured. The following should also be heeded:

- All contactors and relays which operate in the same cubicle or on the same relay panel as the digital protection equipment should, as a rule, be fitted with suitable spike quenching elements.
- All external connection leads in substations from 100 kV upwards should be shielded with a shield capable of carrying power currents and earthed at both sides. No special measures are normally necessary for substations of lower voltages.
- The shield of the RS485 cable must be earthed.
- It is not permissible to withdraw or insert individual modules under voltage. In the withdrawn condition, some components are electrostatically endangered; during handling the standards for electrostatically endangered components must be observed. The modules are not endangered when plugged in.

WARNING! The relay is not designed for use in residential, commercial or light-industrial environment as defined in EN 50081.

Functions

Breaker supervision

Current detection	
Setting range	0.05 x I_N to 4.00 x I_N (steps 0.01 x I_N)
Drop-off ratio	Approx. 0.9
Tolerance	0.01 x I_N or 5 % of set value
Initiation conditions	
Depending on ordered version	Phase-segregated initiation (single-pole trip from feeder protection) or common-phase initiation (three-pole trip from feeder protection) and common-phase initiation (three-pole trip from non-short-circuit protection)
Times	
Pickup time	Approx. 15 ms with measured quantities present Approx. 25 ms after switch-on of measured quantities
Drop-off time with sinusoidal measured quantities	≤ 10 ms
Drop-off time maximum	≤ 25 ms
Delay times for all time stages	0.00 s to 32.00 s (steps 0.01 ms) or deactivated
Delay time tolerance	1 % of set value or 10 ms
The set times are pure delay times.	

Additional functions

Operational value measurements

Operational current values	I_{L1}; I_{L2}; I_{L3}
Measurement range	0 % to 240 % I_N
Tolerance	3 % of rated value or of measured value

Steady-state measured value supervision

Current unbalance	I_{max} / I_{min} > symmetry factor as long as $I > I_{limit}$

Fault event data storage

Storage of annunciations of the last eight faults with max. 30 messages each	

Time assignment

Resolution for operational annunciations	1 s
Resolution for fault event annunciations	1 ms
Max. time deviation	0.01 %

Data storage for fault recording (max. 8 fault events)

Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 to 5.00 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (steps 0.01 s)
Post-fault time T_{post}	0.05 to 0.50 s (steps 0.01 s)
Sampling rate	1 instantaneous value per ms at 50 Hz 1 instantaneous value per 0.83 ms at 60 Hz

Selection and ordering data

Description	Order No.
7SV600 numerical circuit-breaker failure protection relay	*7SV600☐-☐☐A00-☐DA0*
Rated current; rated frequency	
1 A; 50/60 Hz	1
5 A; 50/60 Hz	5
Rated auxiliary voltage	
24, 48 V DC	2
60, 110, 125 V DC	4
220, 250 V DC / 115 V AC, 50/60 Hz	5
230 V AC, 50/60 Hz	6
Unit design	
For panel surface mounting with terminals on both sides	B
For panel surface mounting with terminals at top and bottom	D
For panel flush mounting/cubicle mounting	E
Options	
For common phase initiation	0
For common phase initiation or phase-segregated initiation	1

Accessories

DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (version Windows 2000/XP Professional Edition) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
*RS232 (V.24)↔RS485 converter**	*7XV5700-☐☐☐00*
Plug-in auxiliary power supply unit 220 V/50 Hz AC	0
Plug-in auxiliary power supply unit 110 V/60 Hz AC	1
With RS485 connecting cable for 7SJ6, 7RW6, 7SD6, 7SV6	A
With RS485 connecting cable with 9-pin connector for SIMEAS Q	B
With RS485 connecting cable with plug connector for SIMEAS T	C
Without RS232 connecting cable	A
With RS232 connecting cable 7XV5100-2 for PC/notebook, 9-pin connector (female)	B
With RS232 adapter, 25-pin connector (male) to 9-pin connector (female) for connection to notebook/PC	C
Converter full-duplex fiber-optic cable - RS485 With power supply 24 - 250 V DC and 110/230 V AC	*7XV5650-0BA00*
Manual for 7SV600 For the latest version please visit	*www.siemens.com/siprotec*

---

*) RS485 bus system up to 115 kbaud
RS485 bus cable and adaptor
7XV5103-☐AA☐☐; see part 13.

Connection diagram

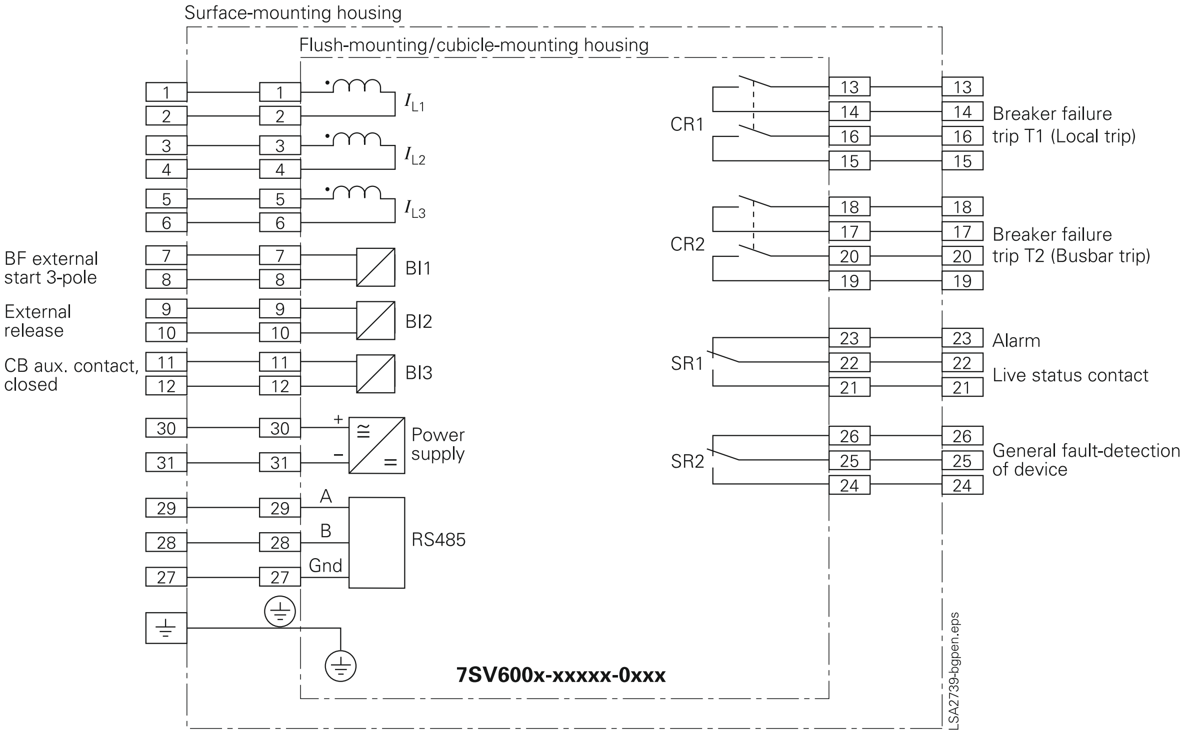


Fig. 10/33
General connection diagram of 7SV600 with presettings for common phase initiation

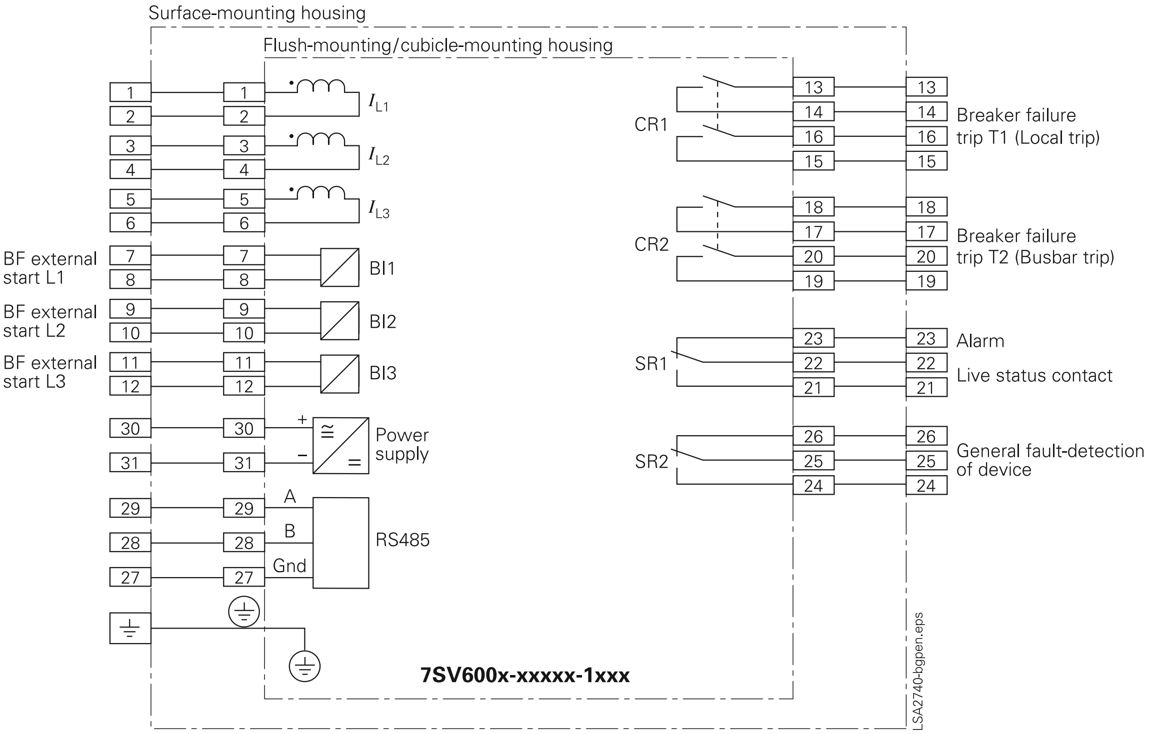


Fig. 10/34
General connection diagram of 7SV600 with presettings for phase-segregated initiation

SIPROTEC 7SN60 Transient Earth-Fault Protection Relay

Fig. 10/35
SIPROTEC 7SN60
transient earth-fault relay

Description

The highly sensitive 7SN60 transient earth-fault relay determines the direction of transient and continuous earth faults in systems with isolated neutral, in systems with high-impedance resistive earthing and in compensated systems. Continuous earth faults are indicated with a delay, either in conjunction with a transient earth fault and subsequently persisting displacement voltage, or with just the displacement voltage present.

Function overview

Protection functions

- Units for panel surface mounting or flush mounting in 7XP20 housing, with terminals on the side or terminals on the top/bottom
- Both fault directions indicated by LEDs and signaled by relays
- High pickup sensitivity due to separate detection and evaluation of total current and displacement voltage
- 1 A and 5 A rated current selectable for current transformer matching
- 16 selectable pickup thresholds for detection of transients in the current path, even with higher steady-state total currents of 10 to 300 mA
- Fixed pickup threshold of 5 V for detection of transients in the voltage path, even in the case of higher steady-state displacement voltages
- 4 selectable pickup thresholds for evaluation of the displacement voltage of 10 to 50 V
- Optional suppression of switching operations by evaluation of the displacement voltage after a switching-induced transient has occured
- Wide-range power supply for connection to 110/230 V AC systems, 60 to 250 V DC station batteries or 100 V DC voltage transformers without switchover or 24 to 60 V DC
- Binary inputs for remote reset and blocking with extremely wide input voltage range of 24 to 250 V DC
- Automatic reset of direction indications and signals after 3 or 10 s (selectable)
- Automatic reset in case of intermittent earth faults only after the last earth-fault, i.e. the correct indication and signal of the first earth fault is preserved
- Detection of the displacement voltage and earth-fault indication/signal, independent of a transient fault detection
- Signaling and indication of a continuous earth fault possible only in the forward direction
- Fault indication if sensitivity is set too high

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Power supply

The rated CT currents applied to the SIPROTEC 7SN60 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Three different housings are available. The flush-mounting/cubicle-mounting housings have terminals accessible from the rear. The surface-mounting housing has terminals either on the side or on the top and bottom.


LSP2002-afpen.tif

Fig. 10/36 Rear view

Protection functions

Earth-fault directional determination

The highly sensitive 7SN60 transient earth-fault relay determines the direction of transient and continuous earth faults in systems with isolated neutral, in systems with high-impedance resistive earthing and in compensated systems.

Continuous earth faults are indicated with a delay, either in conjunction with a transient earth fault and subsequently persisting displacement voltage, or with just the displacement voltage present.

In the event of an earth fault, the neutral-point voltage to earth can be as high as the full-phase voltage.

The phase-to-earth capacitances of the non-earth-faulted phases are charged via the transformer inductance.

This charging process is bound up with a strong current surge (starting oscillation).

The amplitude of this current surge depends on the expands of the system and on the contact resistance values at the earth-fault location.

This current flows via the phase-to-earth capacitances of the unaffected lines to earth, enters the earth-faulted phase via the earth-fault location and flows back from there to the feeding transformer.

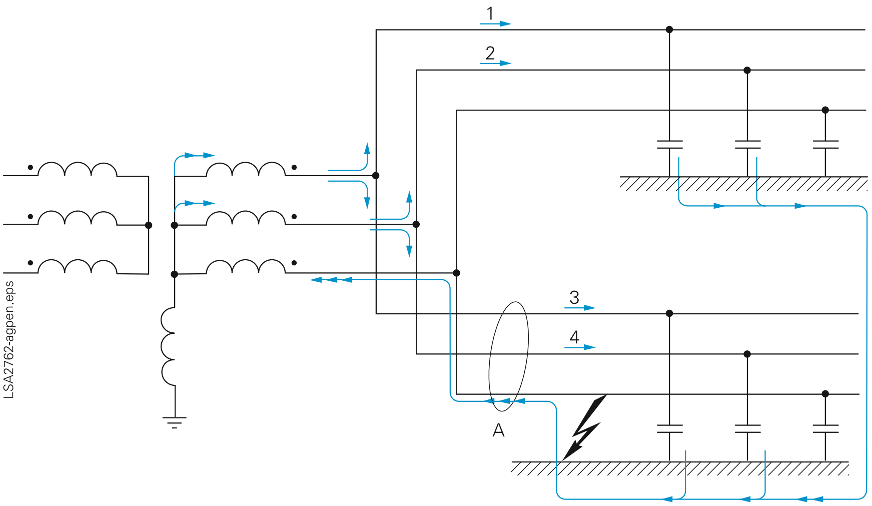
Thus the direction of the earth-fault induced current surge is identical to that of the short-circuit current at the same location.

At measuring point A, as a result of the transformer summation circuit, the earth current of the faulted line is not included in the measurement, as this current portion flows through the summation transformer of the relevant Holmgreen circuit and back, thereby canceling itself out.

It is the total of the capacitive earth currents from the non-faulted system which has an effect. In the diagram they are summated on the upper line. The capacitive currents of the non-faulted lines 1, 3 and 2, 4 accumulate vectorially, which explains why only three arrows instead of four are shown at the measuring point A.

With a transient earth fault, the equalizing current forming a damped oscillation of 100 to more than 1000 Hz decays after only a few periods.

The displacement voltage V_{EM} thereupon also returns to zero. In earthed systems this takes place after a number of periods (decay of the Petersen coil - earth capacitance oscillation circuit); in non-earthed systems this occurs after a very short time.



LSA2762-agpen.eps

Fig. 10/37 Fault currents in the system

Protection functions

In the case of a continuous earth fault, the equalizing current in the non-earthed system changes into the mostly capacitive continuous earth current or, in compensated systems, into the relatively low residual active current.

For the directional determination, the direction of the first transient of neutral current and displacement voltage is considered.

The relay indicates the direction of the transient earth fault by LEDs (red = forward direction, yellow = reverse direction) and the relevant signaling relay pickups.

Continuous earth faults are indicated after a settable time by an LED on the relay and signaled by a signaling relay.

Detection of the fault location

If the system is of radial configuration, the red lamp immediately indicates the faulted line.

If one of the lines consists of several sections, the fault is upstream of the last red lamp.

The transient earth-fault relay can also be used without restrictions in any type of meshed systems. Transient earth-fault relays distributed at suitable points throughout the system allow detection of the earth-fault location from the directional indications.

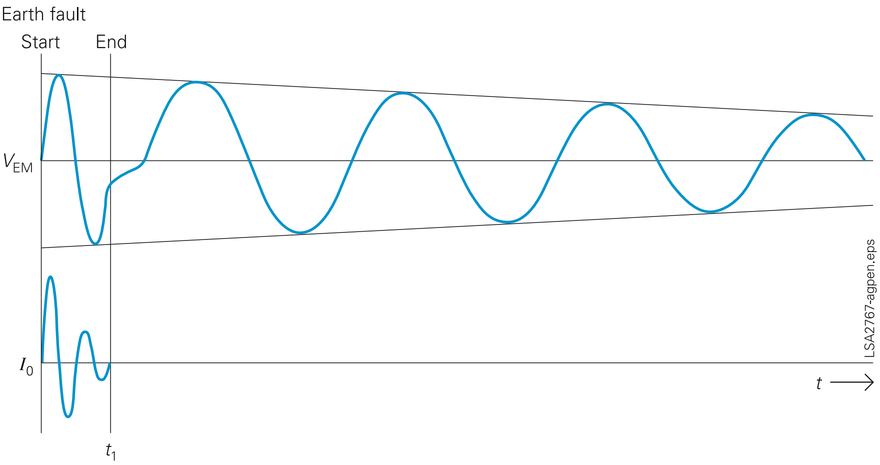


Fig. 10/38 Neutral current and displacement voltage

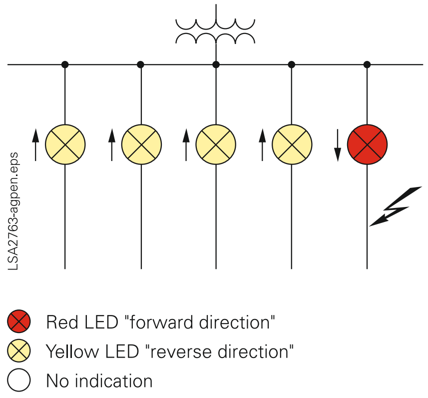


Fig. 10/39 Radial system

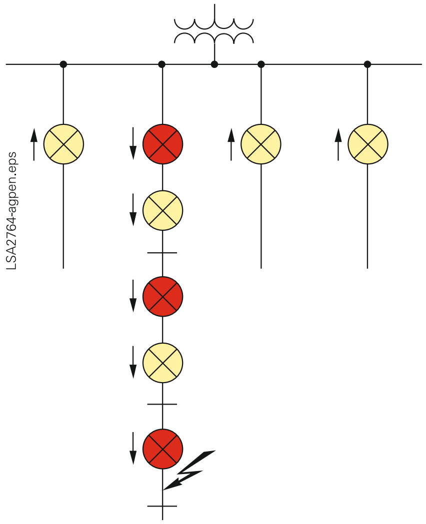


Fig. 10/40 Cascaded radial system

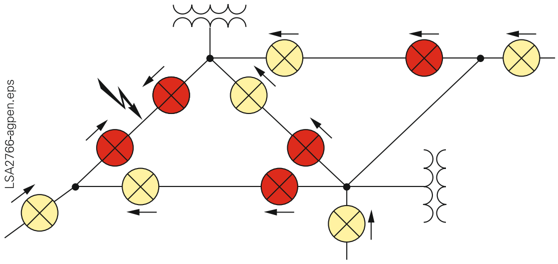


Fig. 10/41 Meshed system

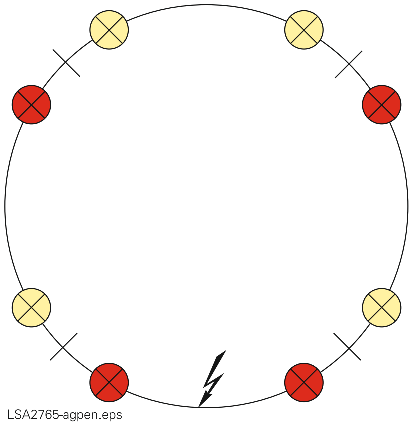


Fig. 10/42 Ring system

Typical connection

Connection of the current and voltage transformers

Figures 10/43 and 10/44 show the connection of the current and voltage transformer set in Holmgreen circuit.

In Fig. 10/43, the star point at the line-side of the CT must be connected to terminal 1 while the star point at the busbar side of the CTs must be connected to terminal 2.

The three phase voltages V_{L1}, V_{L2} and V_{L3} are connected to terminals 7, 8, 9 respectively. The earthed star point of the voltage transformer is connected to terminal 10.

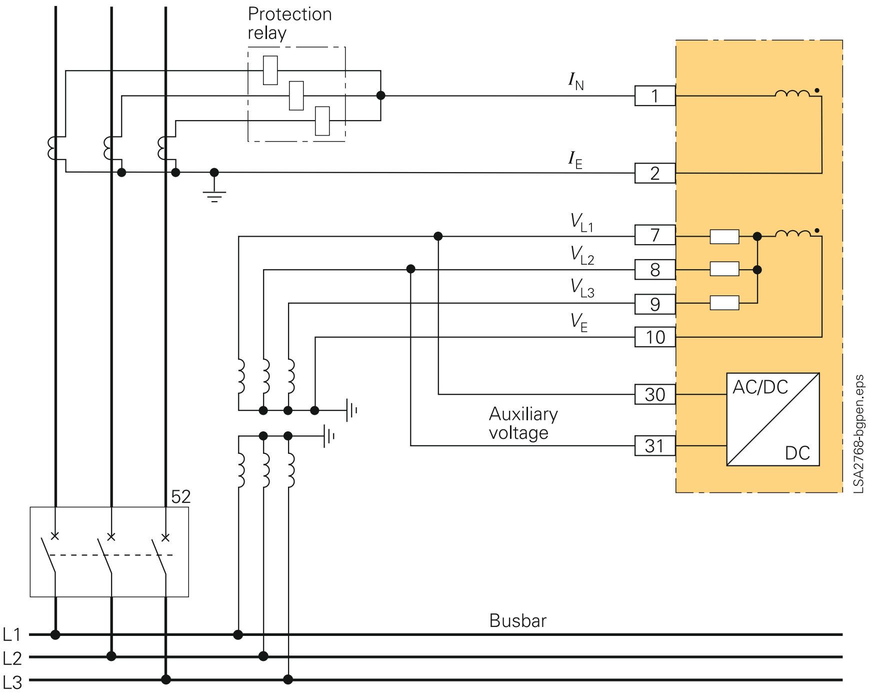


Fig. 10/43 Connection of transformers and auxiliary power supply for panel flush-mounting housing and panel surface-mounting housing (terminals on the side)

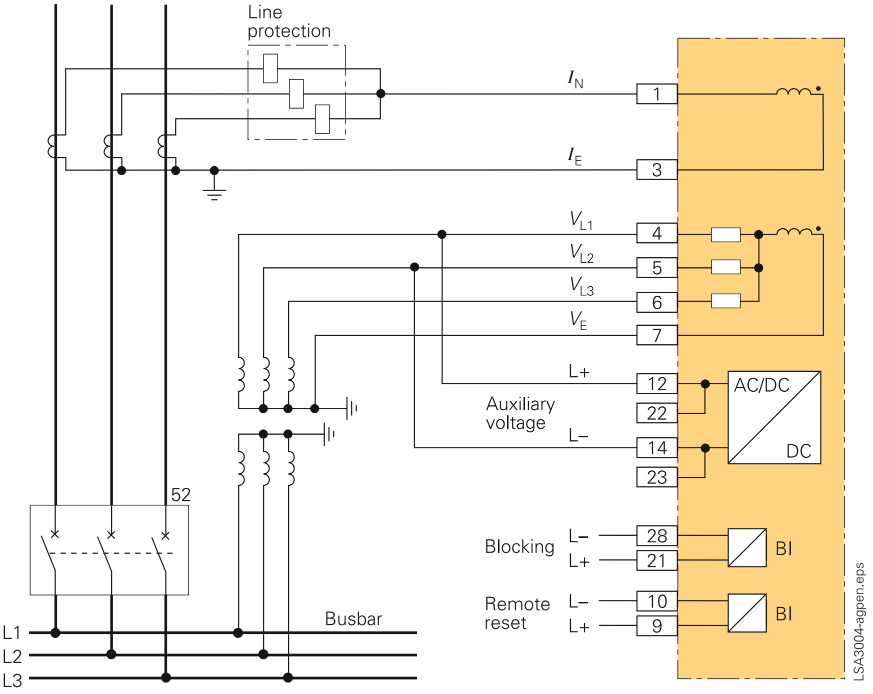


Fig. 10/44 Connection of transformers and auxiliary power supply for panel surface-mounting housing (terminals on the top/bottom)

Technical data

General unit data		
Measuring circuit		
Rated current I_0	1 or 5 A	
Input impedance Z at 50 Hz and I_N	< 0.05 Ω	
Rated voltage V_N	100/110 V AC	
Rated frequency f_N	50 Hz (16.7 Hz)	
Thermal rating		
- In voltage path, continuous	140 V AC	
- In current path, continuous	4 x I_N	
10 s	30 x I_N	
1 s (at 1 A)	100 x I_N	
1 s (at 5)	300 A	
Auxiliary voltage		
Rated auxiliary voltage V_{aux}	60 – 250 V DC and 100 – 230 V AC without switchover	
Power consumption at	Quiescent	Energized
60 V DC	3.1 W	4.5 W
110 V DC	3.0 W	4.5 W
220 V DC	3.6 W	4.6 W
250 V DC	3.7 W	4.8 W
100 V AC	2.9 VA	4.2 VA
110 V AC	3.0 VA	4.2 VA
230 V AC	4.6 VA	5.8 VA
Binary inputs		
Input voltage for blocking and remote reset input	24 - 250 V DC	
Pickup thresholds for		
– Blocking X30 pin 1-2, remote reset X31 pin 1-2	Approx. 19 V	
– Blocking X30 pin 2-3, remote reset X31 pin 2-3	Approx. 75 V	
Signaling relays		
Number of relays, forward or reverse direction	2 NO contacts	
Number of relays, continuous earth-fault signal	1 NO contact	
Number of relays, alarm	1 NC contact	
Switching capacity Make (all relays)	1000 W/VA	
Switching capacity Break (all relays)	30 W/VA	
Switching voltage	250 V AC/DC	
Permissible switching current		
Continuous	5 A	
0.5 s	30 A	
Unit design		
Housing, dimensions	SIPROTEC housing of 1/6 width Refer to part 15 for dimension drawings	
For flush mounting, terminals at the top/bottom	6 current / 25 voltage terminals	
For panel surface mounting, terminals on the side	6 current / 25 voltage terminals	
Weight	Approx. 4 kg	
Standards		
DIN VDE 0435, Part 303 and IEC 60255-5		

Selection and ordering data

Description	Order No.
7SN60 transient earth-fault protection relay	*7SN6000-☐☐A00*
In SIPROTEC housing 1/6 width Rated frequency 50 Hz	
Rated auxiliary voltage	
60 - 250 V DC and 100 - 230 V AC without switchover	*0*
24 - 48 V DC	*1*
For panel surface mounting with terminals on the side	*B*
For panel surface mounting with terminals at top/bottom part	*D*
For panel flush mounting or cubicle mounting	*E*

Connection diagram

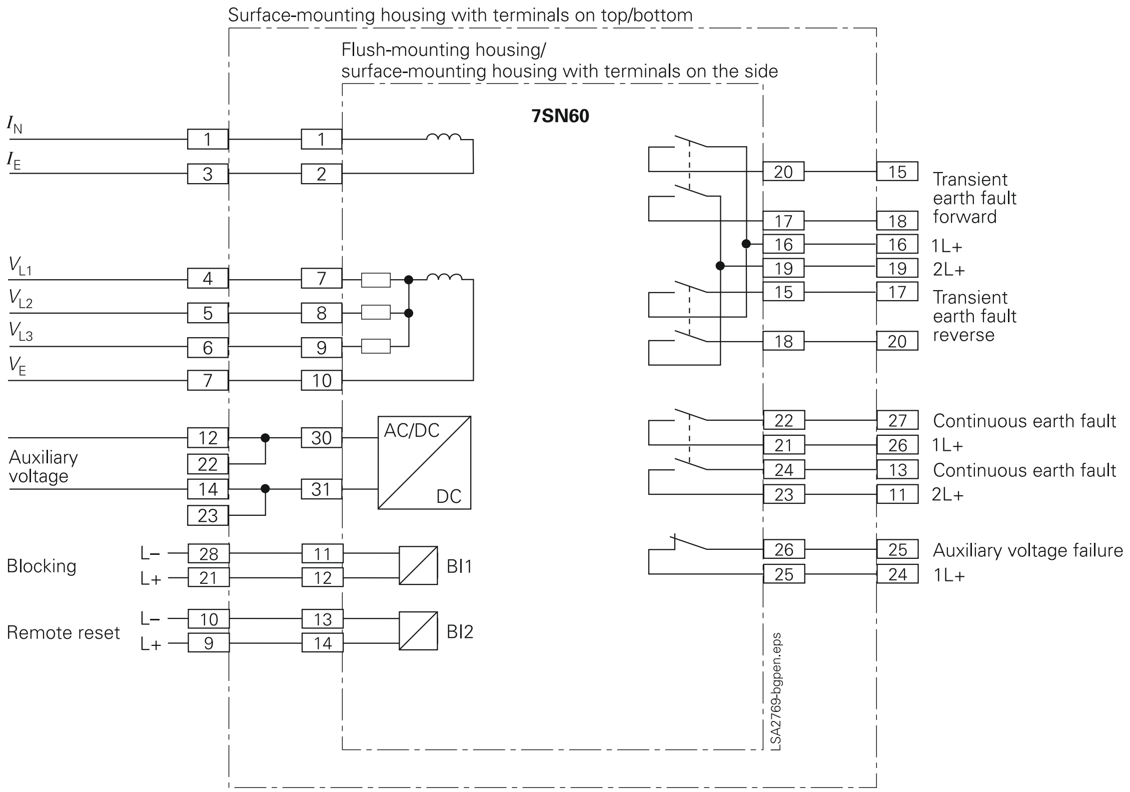
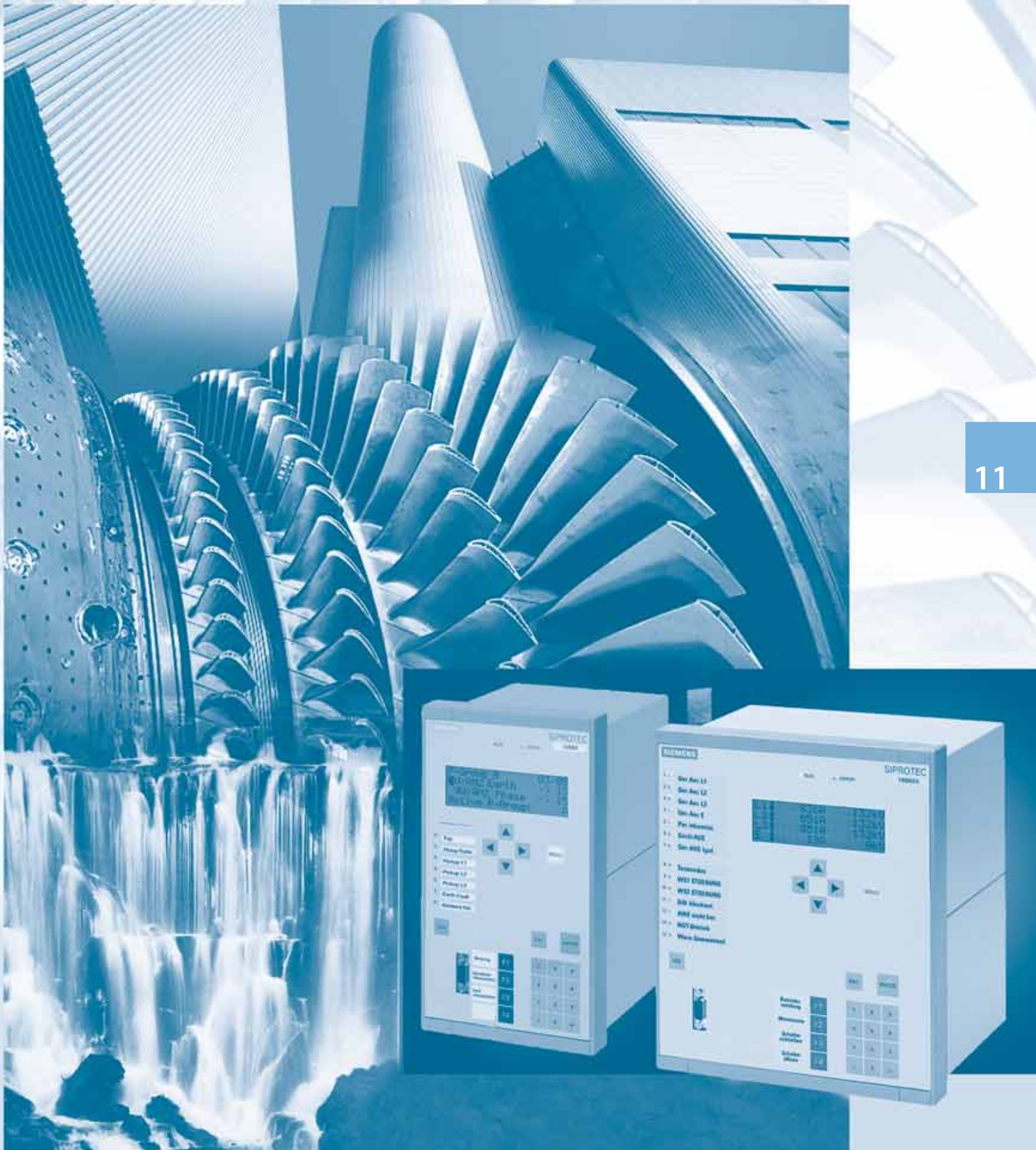


Fig. 10/45 Connection diagram

Generator Protection



SIPROTEC 4 7UM61 Multifunction Generator and Motor Protection Relay

LSP2176-afpen.tif

Fig. 11/1 SIPROTEC 4 7UM61 multifunction generator and motor protection relay

Description

The SIPROTEC 4 7UM61 protection relays can do more than just protect. They also offer numerous additional functions. Be it earth faults, short-circuits, overloads, overvoltage, overfrequency or underfrequency, protection relays assure continued operation of power stations. The SIPROTEC 4 7UM61 protection relay is a compact unit which has been specially developed and designed for the protection of small and medium-sized generators. They integrate all the necessary protection functions and are particularly suited for the protection of :

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Diesel generator stations
- Gas-turbine power stations
- Industrial power stations
- Conventional steam power stations.

The device can also be used for protecting synchronous and asynchronous motors.

The integrated programmable logic functions (continuous function chart CFC) offer the user high flexibility so that adjustments can easily be made to the varying power station requirements, on the basis of special system conditions.

The flexible communication interfaces are open for modern communication architectures with the control system.

Function overview

Basic version

- Stator earth-fault protection
- Sensitive earth-fault protection
- Stator overload protection
- Overcurrent-time protection (either definite-time or inverse-time)
- Definite-time overcurrent-time protection, directional
- Undervoltage and overvoltage protection
- Underfrequency and overfrequency protection
- Reverse power protection
- Overexcitation protection
- External trip coupling

Standard version

Scope of basic version plus:

- Forward-power protection
- Underexcitation protection
- Negative-sequence protection
- Breaker failure protection

Full version

Scope of standard version plus:

- Inadverdent energization protection
- 100 % - stator earth-fault protection with 3rd harmonic
- Impedance protection

Asynchronous motor

Scope of standard version plus

- Motor starting time supervision
- Restart inhibit (without underexcitation protection)

Monitoring functions

- Trip circuit supervision
- Fuse failure monitor
- Operational measured values $V, I, f, \ldots$
- Every metering value W_p, W_q
- Time metering of operation hours
- Self-supervision of relay
- 8 oscillographic fault records

Communication interfaces

- System interface
  - IEC 60870-5-103 protocol
  - PROFIBUS-DP
  - MODBUS RTU
  - DNP 3.0

Application

The 7UM6 protection relays of the SIPROTEC 4 family are compact multifunction units which have been developed for small to medium-sized power generation plants. They incorporate all the necessary protective functions and are especially suitable for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Power generation with diesel generators
- Gas turbine power stations
- Industrial power stations
- Conventional steam power stations.

They can also be employed for protection of motors and transformers.

The numerous other additional functions assist the user in ensuring cost-effective system management and reliable power supply. Measured values display current operating conditions. Stored status indications and fault recording provide assistance in fault diagnosis not only in the event of a disturbance in generator operation.

Combination of the units makes it possible to implement effective redundancy concepts.

Protection functions

Numerous protection functions are necessary for reliable protection of electrical machines. Their extent and combination are determined by a variety of factors, such as machine size, mode of operation, plant configuration, availability requirements, experience and design philosophy.

This results in multifunctionality, which is implemented in outstanding fashion by numerical technology.

In order to satisfy differing requirements, the combination of functions is scalable (see Table 11/1). Selection is facilitated by division into groups.

Protection functions	**Abbreviation**	**ANSI No.**	**Generator**			
			Basic	**Standard**	**Full**	**Motor async.**
Stator earth-fault protection non-directional, directional	$V_0>$, $3I_0>$ $\backslash(V_0, 3I_0)$	59N, 64G 67G	X	X	X	X
Sensitive earth-fault protection (also rotor earth-fault protection)	$I_{EE}>$	50/51GN (64R)	X	X	X	X
Stator overload protection	I^2t	49	X	X	X	X
Definite-time overcurrent protection with undervoltage seal-in	$I> +V<$	51	X	X	X	X
Definite-time overcurrent protection, directional	$I>>$, Direc.	50/51/67	X	X	X	X
Inverse-time overcurrent protection	$t = f(I)+V<$	51V	X	X	X	X
Overvoltage protection	$V>$	59	X	X	X	X
Undervoltage protection	$V<$	27	X	X	X	X
Frequency protection	$f<$, $f>$	81	X	X	X	X
Reverse-power protection	$-P$	32R	X	X	X	X
Overexcitation protection (Volt/Hertz)	V/f	24	X	X	X	
Fuse failure monitor	V_2/V_1, I_1/I_2	60FL	X	X	X	X
External trip coupling (7UM611/612)	Incoup.		2/4	2/4	2/4	2/4
Trip circuit supervision (7UM612)	T.C.S.	74TC	X	X	X	X
Forward-power protection	$P>$, $P<$	32F		X	X	X
Underexcitation protection	1/xd	40		X	X	
Negative-sequence protection	$I_2>$, $t = f(I_2)$	46		X	X	X
Breaker failure protection	$I_{min}>$	50BF		X	X	X
Inadvertent energization protection	$I>$, $V<$	50/27			X	
100 %-stator-earth-fault protection with 3rd harmonics	$V_{0(3rd\ harm)}$	59TN 27TN (3rd h.)			X	
Impedance protection with ($I >+V<$)-pickup	$Z<$	21			X	
Motor starting time supervision	$I_{an}^2 t$	48			X	X
Restart inhibit for motors	I^2t	49 Rotor			X	X
External temperature monitoring through serial interface	ϑ (Thermo-box)	38	X	X	X	X
Rate-of-frequency-change protection[1)]	$df/dt >$	81R	X	X	X	X
Vector jump supervision (voltage)[1)]	$\Delta\varphi >$		X	X	X	X

Table 11/1 Scope of functions of the 7UM61

Generator Basic

One application is concentrated on small generators or as backup protection for larger generators. The function mix is also an effective addition to transformer differential protection with parallel-connected transformers. The functions are also suitable for system disconnection.

Generator Standard

This function mix is recommended for generator outputs exceeding 1 MVA.
It is also suitable for protection of synchronous motors.
Another application is as backup protection for the larger block units.

Generator Full

Here, all protection functions are available and are recommended from generator outputs exceeding 5 MVA. Backup protection for the larger block units is also a recommended application.

Asynchronous motor

This protection function mix is recommended for motors up to 1 - 2 MW.
It offers a wide frequency operating range from 11 Hz to 69 Hz. When an infeed is switched, the protection adapts to the changed voltage and frequency.

---

1) Available as an option (please refer to Order No., position 15).

Application

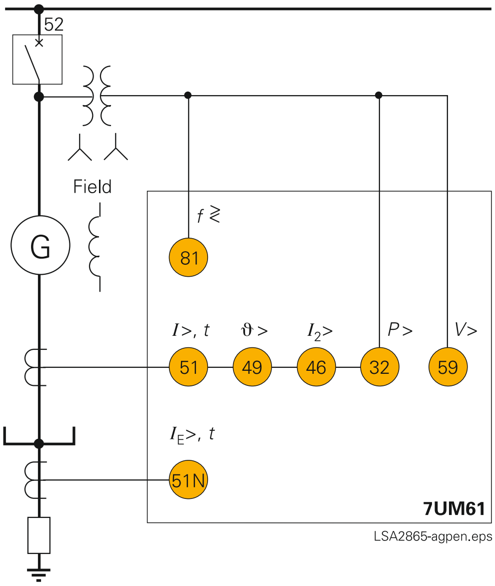


Fig. 11/2

Construction

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control. Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays were a major design aim. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

The 7UM611 is configured in 1/3 19 inch, and the 7UM612 in 1/2 19 inch width. This means that the units of previous models can be replaced. The height throughout all housing width increments is 243 mm.

All wires are connected directly or by means of ring-type cable lugs.

Alternatively, versions with plug-in terminals are also available. These permit the use of prefabricated cable harnesses.

In the case of panel surface mounting, the connecting terminals are in the form of screw-type terminals at top and bottom. The communication interfaces are also arranged on the same sides.

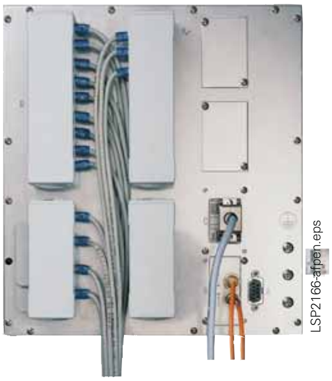


Fig. 11/3
Rear view with wiring terminal safety cover and serial interface

Protection functions

Definite-time overcurrent protection I>, I>> (ANSI 50, 51, 67)

This protection function comprises the short-circuit protection for the generator and also the backup protection for upstream devices such as transformers or power system protection.

An undervoltage stage at *I*> maintains the pickup when, during the fault, the current falls below the threshold. In the event of a voltage drop on the generator terminals, the static excitation system can no longer be sufficiently supplied. This is one reason for the decrease of the short-circuit current.

The *I*>> stage can be implemented as high-set instantaneous trip stage. With the integrated directional function it can be applied for generators without star point CT (see Figure 11/4).

Inverse-time overcurrent protection (ANSI 51V)

This function also comprises short-circuit and backup protection and is used for power system protection with current-dependent protection devices.

IEC and ANSI characteristics can be selected (Table 11/2).

The current function can be controlled by evaluating the generator terminal voltage.

The "controlled" version releases the sensitive set current stage.

With the "restraint" version, the pickup value of the current is lowered linearly with decreasing voltage.

The fuse failure monitor prevents unwanted operation.

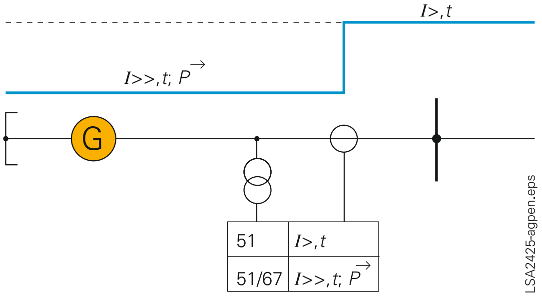


Fig. 11/4
Protection with current transformer on terminal side

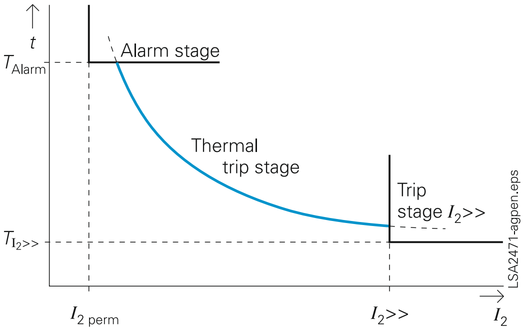


Fig. 11/5
Characteristic of negative-sequence protection

Stator overload protection (ANSI 49)

The task of the overload protection is to protect the stator windings of generators and motors from high, continuous overload currents. All load variations are evaluated by the mathematical model used. The thermal effect of the r.m.s. current value forms the basis of the calculation. This conforms to IEC 60255-8. In dependency of the current the cooling time constant is automatically extended. If the ambient temperature or the temperature of the coolant are injected via PROFIBUS-DP, the model automatically adapts to the ambient conditions; otherwise a constant ambient temperature is assumed.

Negative-sequence protection (ANSI 46)

Asymmetrical current loads in the three phases of a generator cause a temperature rise in the rotor because of the negative sequence field produced.

This protection detects an asymmetrical load in three-phase generators. It functions on the basis of symmetrical components and evaluates the negative sequence of the phase currents. The thermal processes are taken into account in the algorithm and form the inverse characteristic. In addition, the negative sequence is evaluated by an independent stage (alarm and trip) which is supplemented by a time-delay element (see Figure 11/5).

Available inverse-time characteristic

Characteristics	ANSI / IEEE	IEC 60255-3
Inverse	●	●
Moderately inverse	●	
Very inverse	●	●
Extremely inverse	●	●
Definite inverse	●	

Table 11/2

Protection functions

Underexcitation protection (ANSI 40) (Loss-of-field protection)

Derived from the generator terminal voltage and current, the complex admittance is calculated and corresponds to the generator diagram scaled in per unit. This protection prevents damage due to loss of synchronism resulting from underexcitation. The protection function provides three characteristics for monitoring static and dynamic stability. In the event of exciter failure, fast response of the protection can be ensured via binary input. This input releases a timer with a short time delay.

The straight-line characteristics allow the protection of the generator diagram to be optimally adapted (see Fig. 11/6). The per-unit-presentation of the diagram allows the setting values to be directly read out.

The positive-sequence systems of current and voltage are used to calculate the admittance. This ensures that the protection always operates correctly even with asymmetrical network conditions.

If the voltage deviates from the rated voltage, the admittance calculation has the advantage that the characteristics move in the same direction as the generator diagram.

Reverse-power protection (ANSI 32R)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails because then the drive power is taken from the network. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical network faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (±) of the active power can be reversed via parameters.

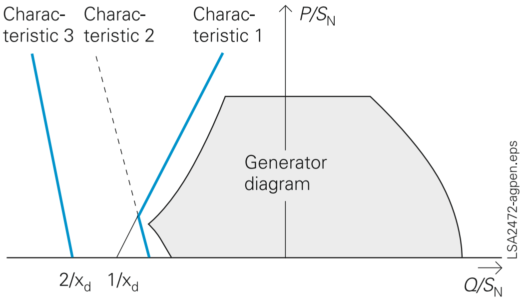


Fig. 11/6
Characteristic of underexcitation protection

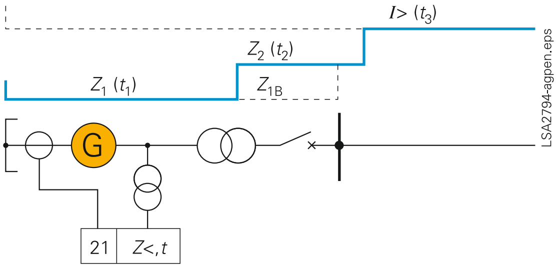


Fig. 11/7
Grading of impedance protection

Forward-power protection (ANSI 32F)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors threshold beyond one limit value while another stage monitors threshold below another limit value. The power is calculated using the positive-sequence component of current and voltage.

Impedance protection (ANSI 21)

This fast short-circuit protection protects the generator, the generator transformer and is a backup protection for the power system. This protection has two settable impedance stages; in addition, the first stage can be switched over via binary input. With the circuit-breaker in “open” position (see Fig. 11/7) the impedance measuring range can be extended. The overcurrent pickup element with undervoltage seal-in ensures a reliable pickup and the loop selection logic a reliable detection of the faulty loop. With this logic it is possible to perform a correct measurement via the unit transformer.

Undervoltage protection (ANSI 27)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-earth voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by earth-faults. This function is implemented in two stages.

Protection functions

Frequency protection (ANSI 81)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Overexcitation protection Volt/Hertz (ANSI 24)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to *V*/*f*) in generators or transformers, which leads to thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via seven points derived from the manufacturer data.

In addition, a definite-time alarm stage and an instantaneous stage can be used.

For calculation of the *V*/*f* ratio, frequency and also the highest of the three line-to-line voltages are used. The frequency range that can be monitored comprises 11 to 69 Hz.

Stator earth-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)

Earth faults manifest themselves in generators that are operated in isolation by the occurrence of a displacement voltage. In case of unit connections, the displacement voltage is an adequate, selective criterion for protection.

For the selective earth-fault detection, the direction of the flowing earth current has to be evaluated too, if there is a direct connection between generator and busbar.

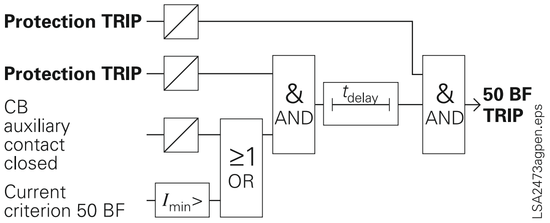


Fig. 11/8

Logic diagram of breaker failure protection

The protection relay measures the displacement voltage at a VT located at the transformer star point or at the broken delta-winding of a VT. As an option, it is also possible to calculate the zero-sequence voltage from the phase-to-earth voltages. Depending on the load resistor selection, 90 to 95 % of the stator winding of a generator can be protected.

A sensitive current input is available for earth-current measurement. This input should be connected to a core-balance current transformer. The fault direction is deduced from the displacement voltage and earth current. The directional characteristic (straight line) can be easily adapted to the system conditions. Effective protection for direct connection of a generator to a busbar can therefore be established. During start-up, it is possible to switch over from the directional to the displacement voltage measurement via an externally injected signal.

Depending on the protection setting, various earth-fault protection concepts can be implemented with this function (see Figs. 11/17 to 11/21).

Sensitive earth-fault protection (ANSI 50/51GN, 64R)

The sensitive earth-current input can also be used as separate earth-fault protection. It is of two-stage form. Secondary earth currents of 2 mA or higher can be reliably handled.

Alternatively, this input is also suitable as rotor earth-fault protection. A voltage with rated frequency (50 or 60 Hz) is connected in the rotor circuit via the interface unit 7XR61. If a higher earth current is flowing, a rotor earth fault has occurred. Measuring-circuit monitoring is provided for this application (see Figure 11/20).

100 % stator earth-fault protection with 3 harmonic (ANSI 59TN, 27TN (3H.))

Owing to the design, the generator produces a 3rd harmonic that forms a zero system. It is verifiable by the protection on a broken delta winding or on the neutral transformer. The magnitude of the voltage amplitude depends on the generator and its operation.

In the event of an earth fault in the vicinity of the neutral point, there is a voltage displacement in the 3rd harmonic (dropping in the neutral point and rising at the terminals).

Depending on the connection, the protection must be set in either undervoltage or overvoltage form. It can also be delayed. So as to avoid overfunction, the active power and the positive-sequence voltage act as enabling criteria.

The final protection setting can be made only by way of a primary test with the generator.

Breaker failure protection (ANSI 50BF)

In the event of scheduled downtimes or a fault in the generator, the generator can remain on line if the circuit-breaker is defective and could suffer substantial damage.

Breaker failure protection evaluates a minimum current and the circuit-breaker auxiliary contact. It can be started by internal protective tripping or externally via binary input. Two-channel activation avoids overfunction (see Figure 11/8).

Protection functions

Inadvertent energization protection (ANSI 50, 27)

This protection has the function of limiting the damage of the generator in the event of an unintentional switch-on of the circuit-breaker, whether the generator is standing still or rotating without being excited or synchronized. If the power system voltage is connected, the generator starts as an asynchronous machine with a large slip and this leads to excessively high currents in the rotor.

A logic circuit consisting of sensitive current measurement for each phase, measured value detector, time control and blocking as of a minimum voltage, leads to an instantaneous trip command. If the fuse failure monitor responds, this function is ineffective.

Starting time supervision (motor protection only) (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups, which might occur as a result of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked.

The tripping time is dependent on the square of the start-up current and the set start-up time (Inverse Characteristic). It adapts itself to the start-up with reduced voltage. The tripping time is determined in accordance with the following formula:

$$t_{\mathrm{Trip}} = \left(\frac{I_{\mathrm{start}}}{I_{\mathrm{rms}}}\right)^2 \cdot t_{\mathrm{start\ max}}$$

t_{Trip}	Tripping time
I_{start}	Permissible start-up current
$t_{\mathrm{start\ max}}$	Permissible start-up time
I_{rms}	Measured r.m.s. current value

Calculation is not started until the current I_{rms} is higher than an adjustable response value
(e.g. 2 $I_{\mathrm{N,\ MOTOR}}$).

If the permissible locked-rotor time is less than the permissible start-up time (motors with a thermally critical rotor), a binary signal is set to detect a locked rotor by means of a tachometer generator. This binary signal releases the set locked-rotor time, and tripping occurs after it has elapsed.

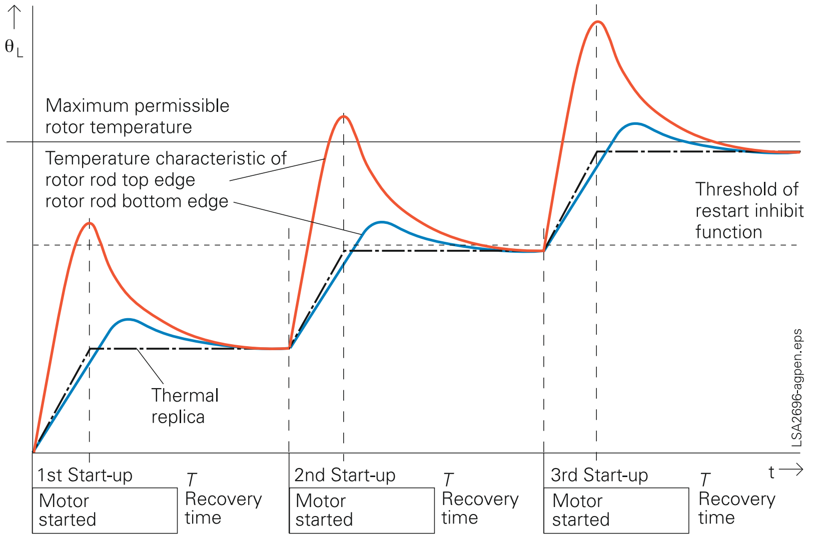


Fig. 11/9 Temperature characteristic at rotor and thermal replica of the rotor (multiple start-ups)

Restart inhibit for motors (ANSI 66, 49Rotor)

When cold or at operating temperature, motors may only be connected a certain number of times in succession. The start-up current causes heat development in the rotor which is monitored by the restart inhibit function.

Contrary to classical counting methods, in the restart inhibit function the heat and cooling phenomena in the rotor are simulated by a thermal replica. The rotor temperature is determined on the basis of the stator currents. Restart inhibit permits restart of the motor only if the rotor has enough thermal reserve for a completely new start. Fig. 11/9 illustrates the thermal profile for a permissible triple start out of the cold state. If the thermal reserve is too low, the restart inhibit function issues a blocking signal with which the motor starting circuit can be blocked. The blockage is cancelled again after cooling down and the thermal value has dropped below the pickup threshold.

As the fan provides no forced cooling when the motor is off, it cools down more slowly. Depending on the operating state, the protection function controls the cooling time constant. A value below a minimum current is an effective changeover criterion.

System disconnection

Take the case of in-plant generators feeding directly into a system. The incoming line is generally the legal entity boundary between the system owner and the in-plant generator. If the incoming line fails as the result of auto-reclosure, for instance, a voltage or frequency deviation may occur depending on the power balance at the feeding generator. Asynchronous conditions may arise in the event of connection, which may lead to damage on the generator or the gearing between the generator and the turbine. Besides the classic criteria such as voltage and frequency, the following two criteria are also applied (vector jump, rate-of-frequency-change protection).

Rate-of-frequency-change protection (ANSI 81)

The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed so that it reacts to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

Protection functions

Vector jump

Monitoring the phase angle in the voltage is a criterion for identifying an interrupted infeed. If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

External trip coupling

For recording and processing of external trip information, there are 2 (for 7UM611) or 4 (for 7UM612) binary inputs. They are provided for information from the Buchholz relay or generator-specific commands and act like a protective function. Each input initiates a fault event and can be individually delayed by a timer.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Phase rotation reversal

If the relay is used in a pumped-storage power plant, matching to the prevailing rotary field is possible via a binary input (generator/motor operation via phase rotation reversal).

2 pre-definable parameter groups

In the protection, the setting values can be stored in two data sets. In addition to the standard parameter group, the second group is provided for certain operating conditions (pumped-storage power stations). It can be activated via binary input, local control or DIGSI 4.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Fuse failure and other monitoring

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions.

The positive and negative-sequence system (voltage and current) are evaluated.

Filter time

All binary inputs can be subjected to a filter time (indication suppression).

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program during commissioning is particularly advantageous.

Rear-mounted interfaces

Two communication modules on the rear of the unit incorporate optional equipment complements and permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces (electrical or optical) and protocols (IEC 60870, PROFIBUS, DIGSI).

The interfaces make provision for the following applications:

Service interface

In the RS485 version, several protection units can be centrally operated with DIGSI 4. By using a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned substations.

System interface

This is used to communicate with a control or protection and control system and supports, depending on the module connected, a variety of communication protocols and interface designs.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for communication with protection relays.

IEC 60870-5-103 is supported by a number of protection unit manufacturers and is used worldwide.

The generator protection functions are stored in the manufacturer-specific, published part of the protocol.

PROFIBUS-DP

PROFIBUS is an internationally standardized communication protocol (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world.

With the PROFIBUS-DP, the protection can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and information from or to the logic (CFC).

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any faults.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

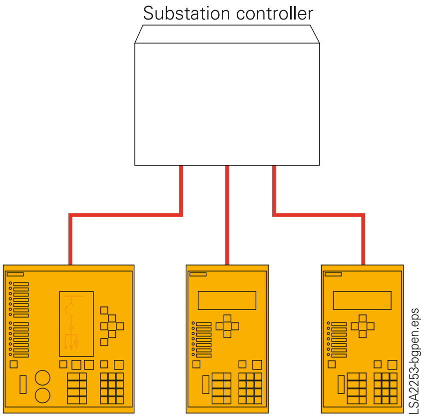


Fig. 11/10
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

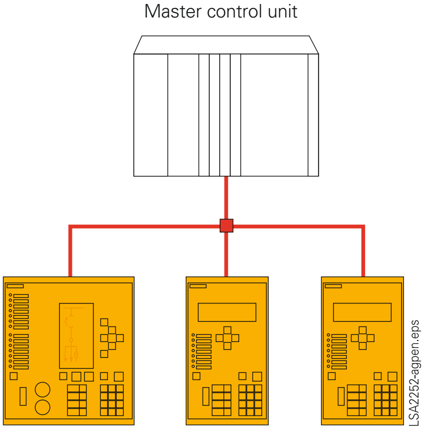


Fig. 11/11
PROFIBUS: RS485 copper conductors

Communication

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit.

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

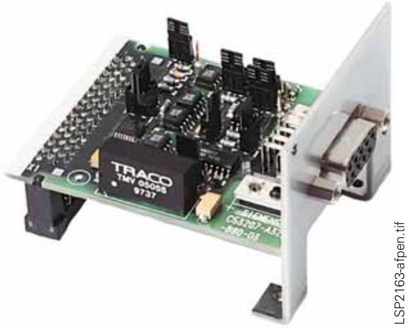


Fig. 11/12

RS232/RS485
Electrical communication module

LSP2163-afpen.tif

Fig. 11/13

820 nm fiber-optic
communication module

LSP2162-afpen.tif

Fig. 11/14

PROFIBUS communication module,
optical, double-ring

LSP2164-afpen.tif

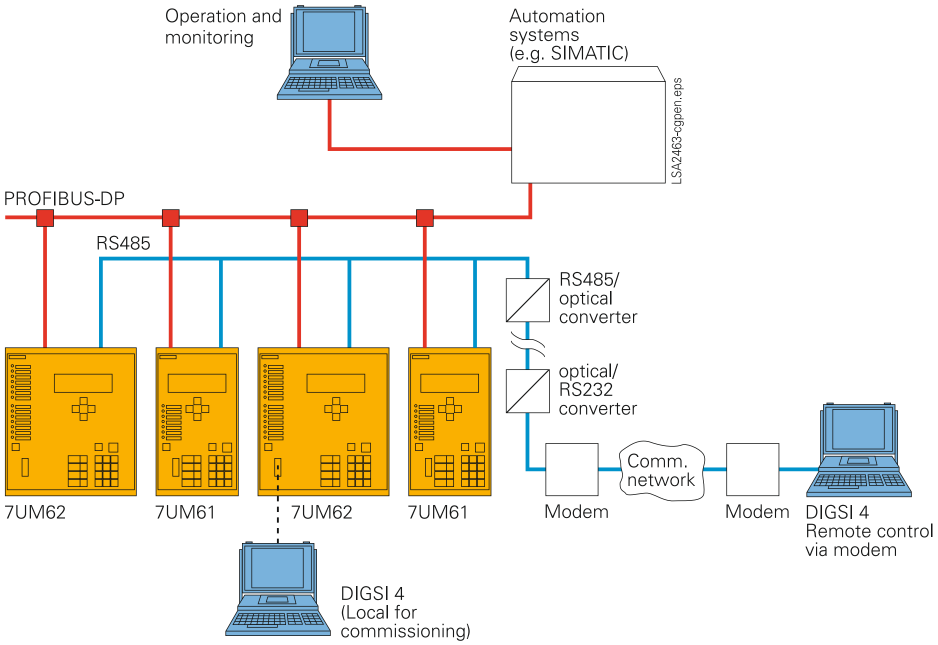


Fig. 11/15

System solution: Communication

Typical connections

Direct generator - busbar connection

Fig. 11/16 illustrates the recommended standard connection if several generators supply one busbar. Phase-to-earth faults are disconnected by employing the directional earth-fault criterion. The earth-fault current is driven through the cables of the system. If this is not sufficient, an earthing transformer connected to the busbar supplies the necessary current (maximum approximately 10 A) and permits a protection range of up to 90 %. The earth-fault current should be detected by means of core-balance current transformers in order to achieve the necessary sensitivity. The displacement voltage can be used as earth-fault criterion during starting operations until synchronization is achieved.

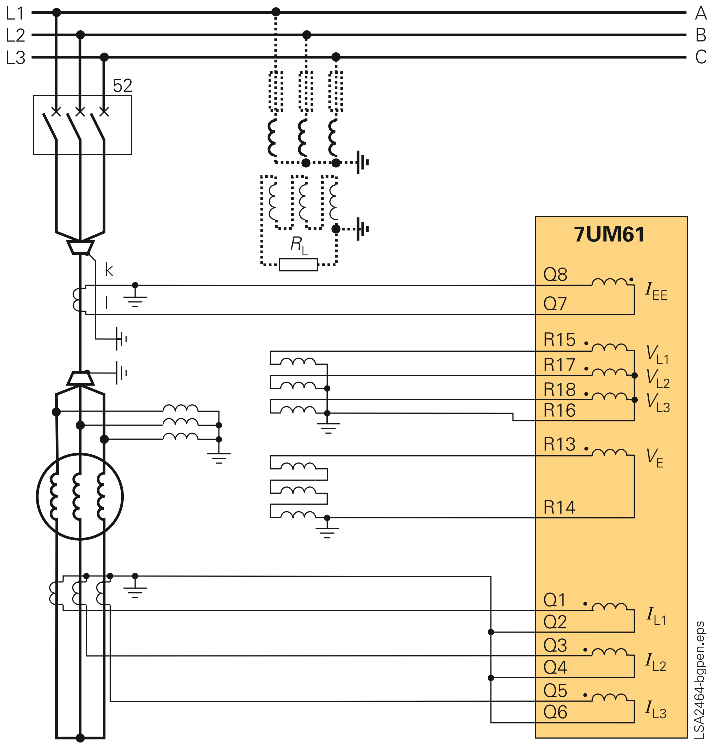


Fig. 11/16

Direct generator - busbar connection with low-resistance earthing

If the generator neutral point has low-resistance earthing, the connection illustrated in Fig. 11/17 is recommended. In the case of several generators, the resistance must be connected to only one generator, in order to prevent circulating currents (3rd harmonic).

For selective earth-fault detection, the earth-current input should be looped into the common return conductor of the two current transformer sets (differential connection). The current transformers must be earthed at only one point. The displacement voltage V_E is utilized as an additional enabling criterion.

Balanced current transformers are desirable with this form of connection. In the case of higher generator power (for example, I_N approximately 2000 A), current transformers with a secondary rated current of 5 A are recommended.

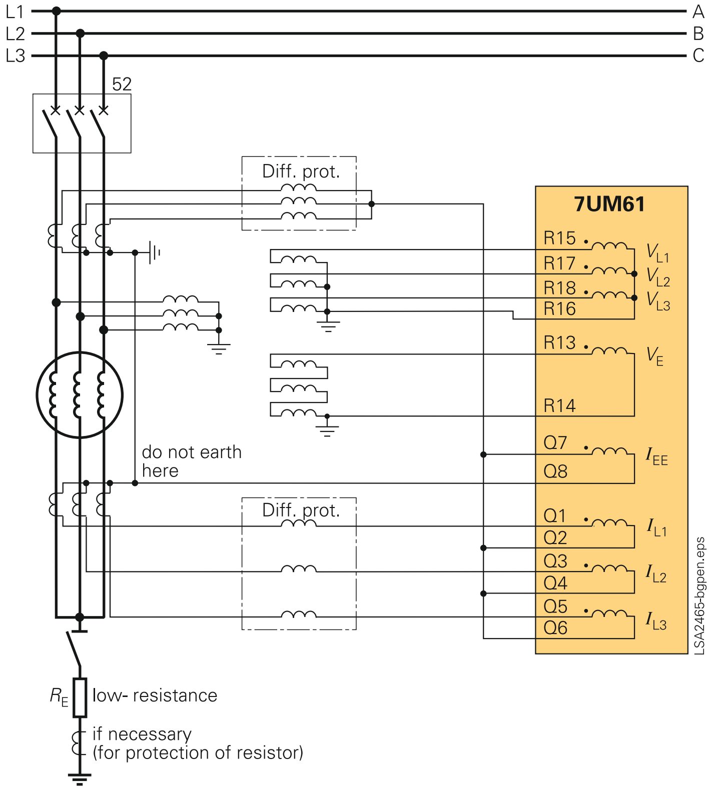


Fig. 11/17

Typical connections

Direct generator - busbar connection with high-resistance generator neutral earthing

With this system configuration, selective earth-fault detection is implemented on the basis of the lower fault currents through the differential connection of core-balance current transformers (see Figure 11/18). Secondary-side earthing must be effected at only one core-balance current transformer. The displacement voltage is to be utilized additionally as enable criterion.

The load resistor takes the form either of primary or of secondary resistor with neutral transformer. In the case of several generators connected to the busbar, again only one generator will be earthed via the resistor.

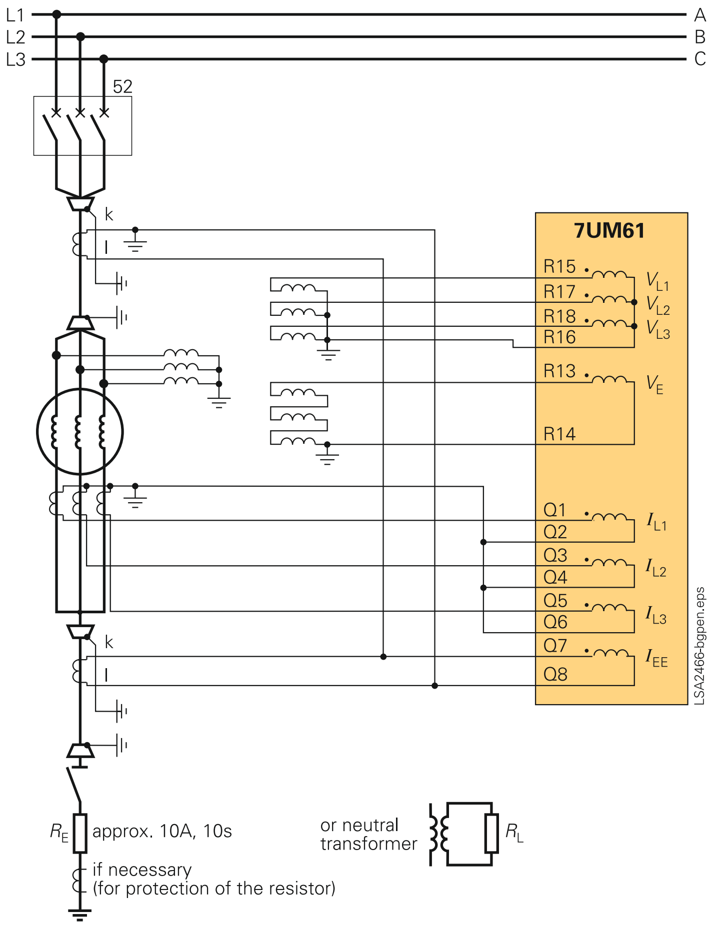


Fig. 11/18

Unit connection with isolated star point

This configuration of unit connection is a variant to be recommended (see Figure 11/19). Earth-fault detection is effected by means of the displacement voltage. In order to prevent unwanted operation in the event of earth faults in the system, a load resistor must be provided at the broken delta winding. Depending on the plant (or substation), a voltage transformer with a high power (VA) may in fact be sufficient. If not, an earthing transformer should be employed. The available measuring winding can be used for the purpose of voltage measurement.

Rotor earth-fault protection can be implemented with the unassigned earth-fault current input. The 7XR61 coupling unit must be used for this purpose.

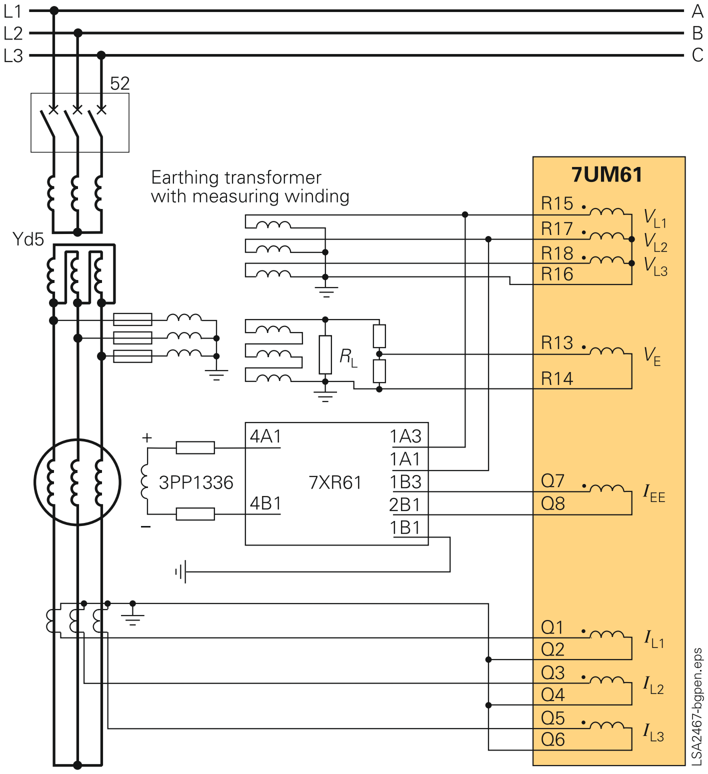


Fig. 11/19

Typical connections

Unit connection with neutral transformer

With this system configuration, disturbance voltage reduction and damping in the event of earth faults in the generator area are effected by a load resistor connected to generator neutral point. The maximum earth-fault current is limited to approximately 10 A. Configuration can take the form of a primary or secondary resistor with neutral transformer. In order to avoid low secondary resistance, the transformation ratio of the neutral transformer should be low. The higher secondary voltage can be reduced by means of a voltage divider.

Electrically, the circuit is identical to the configuration in Figure 11/19.

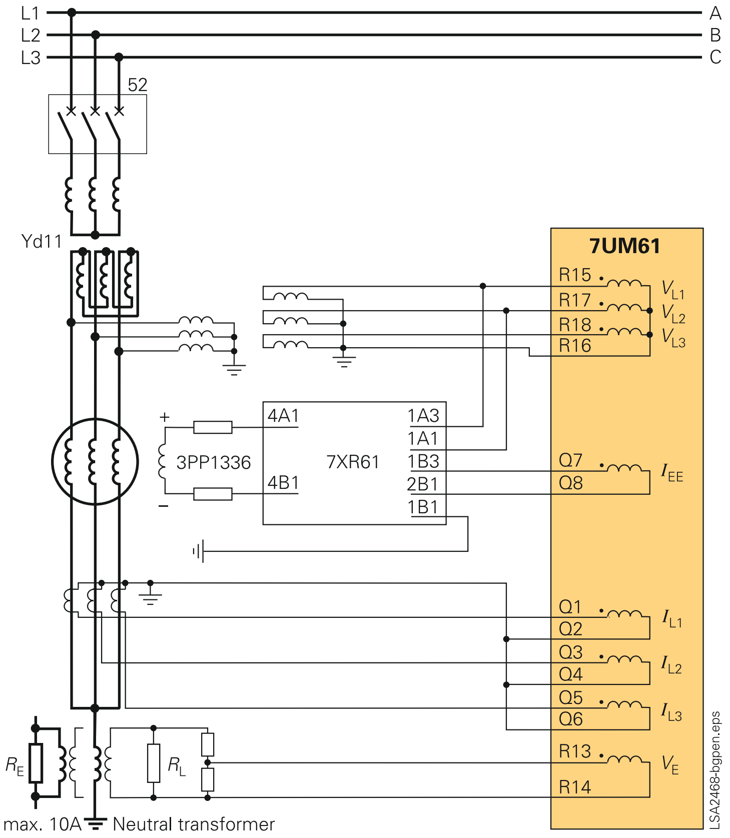


Fig. 11/20

Connection with low-voltage generators

As is generally known, the low-voltage system is solidly earthed, so that the generator neutral point is connected to earth (see Figure 11/21). With this configuration, there is the risk that, as a result of the 3rd harmonics forming a zero phase-sequence system, circulating currents will flow via the N-conductor. This must be limited by the generator or system configuration (reactor).

Otherwise, connection corresponds to the customary standard. In the case of residual current transformer design, it has to be ensured that the thermal current limit (1 s) of the I_{EE} input is restricted to 300 A.

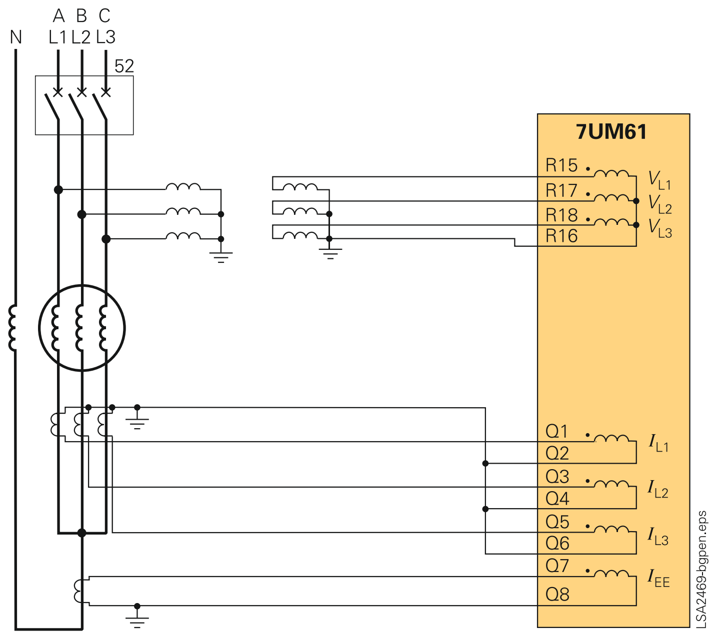


Fig. 11/21

Typical connections

Connection of an asynchronous motor

The figure shows the standard connection of motors of medium capacity (500 kW to <(1-2) MW). In addition to the short-circuit protection, an earth-fault protection (V_E; I_E inputs) is available.

As the busbar voltage is being monitored, starting of the motor is prevented if the voltage is too low or - in case of failure of infeed - the motor circuit-breaker is opened. Here, the wide range of frequency is advantageous. For the detection of temperatures, 2 thermo-boxes (temperature monitoring boxes) can be connected via a serial interface.

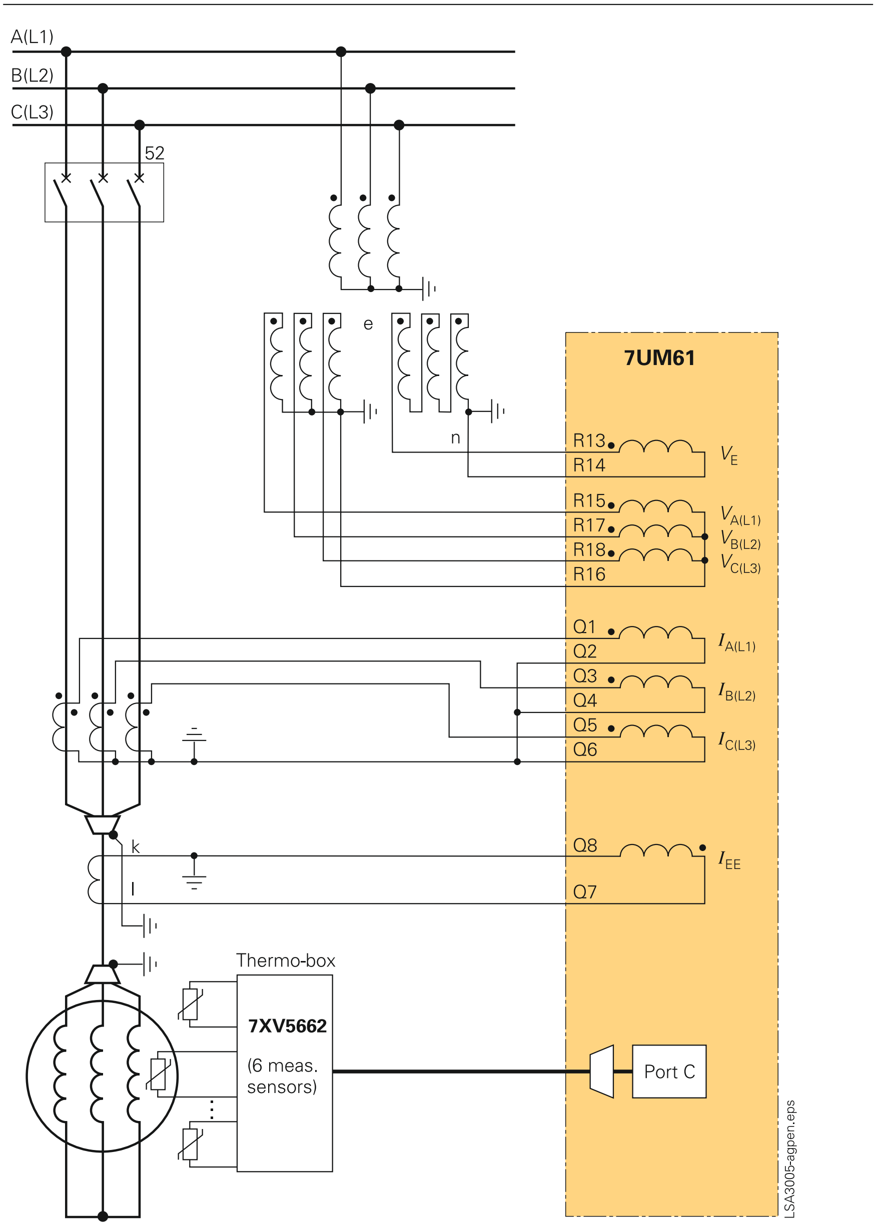


Fig. 11/22

Typical connections

Voltage transformer in open delta connection (V-connection)

Protection can also be implemented on voltage transformers in open delta connection. Figure 11/23 shows the connection involved. If necessary, the operational measured values for the phase-to-earth voltages can be slightly asymmetrical. If this is disturbing, the neutral point (R16) can be connected to earth via a capacitor.

In the case of open delta connection, it is not possible to calculate the displacement voltage from the secondary voltages. It must be passed to the protection relay along a different path (for example, voltage transformer at the generator neutral point or from the earthing transformer).

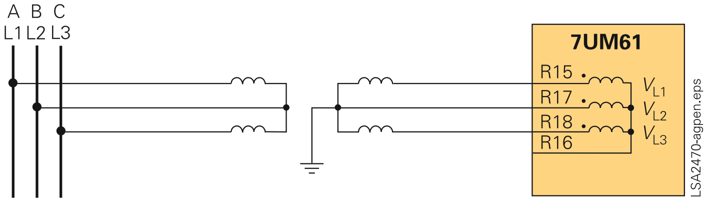


Fig. 11/23

Connection with two current transformers

This configuration is to be found in older systems with insulated or high-resistance star point. This connection is illustrated in Fig. 11/24. In the protection unit, the secondary currents are represented correctly and, in addition, the positive and the negative-sequence system are correctly calculated. Limits of application occur in the case of low-resistance and solid earthing.

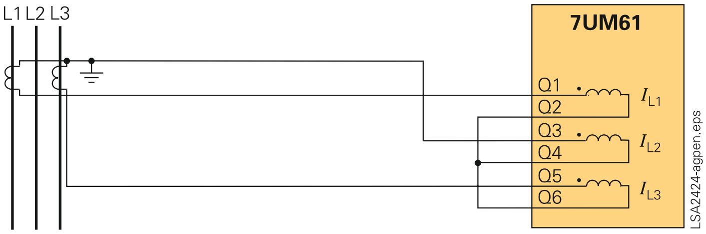


Fig. 11/24

Technical data

Hardware

Analog inputs

Rated frequency	50 or 60 Hz
Rated current I_N	1 or 5 A
Earth current, sensitive I_{Emax}	1.6 A
Rated voltage V_N	100 to 125 V
Power consumption	
With $I_N = 1$ A	Approx. 0.05 VA
With $I_N = 5$ A	Approx. 0.3 VA
For sensitive earth current	Approx. 0.05 VA
Voltage inputs (with 100 V)	Approx. 0.3 VA
Capability in CT circuits	
Thermal (r.m.s. values)	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak)	250 I_N (one half cycle)
Earth current, sensitive	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (peak)	750 A (one half cycle)
Capability in voltage paths	230 V continuous

Auxiliary voltage

Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V/230 V AC with 50/60 Hz
Permitted tolerance	–20 to +20 %
Superimposed (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	
7UM611	Approx. 4 W
7UM612	Approx. 4.5 W
During pickup with all inputs and outputs activated	
7UM611	Approx. 9.5 W
7UM612	Approx. 12.5 W
Bridging time during auxiliary voltage failure	
at V_{aux} = 48 V and $V_{aux} \geq$ 110 V	≥ 50 ms
at V_{aux} = 24 V and V_{aux} = 60 V	≥ 20 ms

Binary inputs

Number	
7UM611	7
7UM612	15
3 pickup thresholds	10 to 19 V DC or 44 to 88 V DC
Range is selectable with jumpers	88 to 176 V DC 1)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

---

1) Not valid for the CPU board.

Output relays

Number	
7UM611	12 (1 NO, 1 optional as NC, via jumper)
7UM612	20 (1 NO, 2 optional as NC, via jumper)
Switching capacity	
Make	1000 W / VA
Break	30 VA
Break (for resistive load)	40 W
Break (for L/R ≤ 50 ms)	25 VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds

LEDs

Number	
RUN (green)	1
ERROR (red)	1
Assignable LED (red)	
7UM611	7
7UM612	14

Unit design

7XP20 housing	For dimensions see dimension drawings, part 15
Degree of protection acc. to EN 60529	
For surface-mounting housing	IP 51
For flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 2x with terminal cover put on
Weight	
Flush mounting housing	
7UM611 (1/3 x 19″)	Approx. 5.5 kg
7UM612 (1/2 x 19″)	Approx. 7 kg
Surface mounting housing	
7UM611 (1/3 x 19″)	Approx. 7.5 kg
7UM612 (1/2 x 19″)	Approx. 12 kg

Technical data

Serial interfaces

Operating interface for DIGSI 4

Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector
Baud rate	4800 to 115200 baud

Time synchronization IRIG-B / DCF 77 signal (Format IRIG-B000)

Connection	9-pin subminiature connector, terminal with surface-mounting housing
Voltage levels	Selectable 5 V or 12 V or 24 V

Service/modem interface for DIGSI 4/modem/service

Isolated RS232/RS485	9-pin subminiature connector
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
Fiber-optic cable	Integrated ST-connector
Optical wavelength	$\lambda = 820$ nm
Permissible path attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Bridgeable distance	Max. 1.5 km

System interface IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU

Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 115200 baud
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Test voltage	500 V / 50 Hz
Baud rate	Max. 12 Mbaud
Distance	1000 m at 93.75 kBaud; 100 m at 12 Mbaud
PROFIBUS fiber-optic	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[1]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	$\lambda = 820$ nm
Permissible path attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	1.6 km (500 kB/s) 530 m (1500 kB/s)

Electrical tests

Specifications

Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below.

Insulation tests

Standards	IEC 60255-5
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) RS485/RS232 rear side communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for noise immunity; type test

Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak value), 1 MHz; $\tau = 15$ ms, 400 pulses per s; duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated, IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min

---

1) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order code L0A (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Technical data

EMC tests for noise immunity; type tests

High-energy surge voltages (SURGE), IEC 61000-4-5 Installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω, 9 µF Differential (transversal) mode: 1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	Common (longitudinal) mode: 2 kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; Duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; Duration 2 s ; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

EMC tests for interference emission; type tests

Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Technical data

Climatic stress tests

Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	–25 °C to +85 °C / –13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	–20 °C to +70 °C / –4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	–5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	–25 °C to +55 °C / –13 °F to +131 °F
– Limiting temperature during transport	–25 °C to +70 °C / –13 °F to +158 °F
Humidity	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permitted

Functions

General

Frequency range	11 to 69 Hz

Definite-time overcurrent protection, directional (ANSI 50, 51, 67)

Setting ranges	
Overcurrent $I>$, $I>>$	0.1 to 8 A (steps 0.01 A); 5 times at I_N = 5 A
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1 V)
Seal-in time of $V<$	0.1 to 60 s (steps 0.01 s)
Angle of the directional element (at $I>$)	– 90 ° to + 90 ° (steps 1 °)
Times	
Pickup time $I>$, $I>>$	
At 2 times of set value	Approx. 35 ms
At 10 times of set value	Approx. 25 ms
Drop-off time $I>$, $I>>$	Approx. 50 ms
Drop-off ratio	$I>$: 0.95; $I>>$: 0.9 to 0.99 (steps 0.01)
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Current pickup (starting) $I>$, $I>>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Angle of the directional element	1 °
Time delays	1 % or 10 ms

Inverse-time overcurrent protection (ANSI 51V)

Setting ranges	
Pickup overcurrent I_P	0.1 to 4 A (steps 0.01 A); 5 times at I_N = 5 A
Time multiplier IEC-characteristics T	0.05 to 3.2 s (steps 0.01 s) or indefinite
Time multiplier ANSI-characteristics D	0.5 to 15 (steps 0.01) or indefinite
Undervoltage release $V<$	10 to 125 V (steps 0.1 V)
Trip characteristics	
IEC	Normal inverse; very inverse; extremely inverse
ANSI	Inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Pickup threshold	Approx. 1.1 I_P
Drop-off threshold	Approx. 1.05 I_P for $I_P/I_N \geq 0.3$
Tolerances	
Pickup threshold I_P	1 % of set value 10/50 mA
Pickup threshold $V<$	1 % of set value or 0.5 V
Time for $2 \leq I/I_P \leq 20$	5 % of nominal value + 1 % current tolerance or 40 ms

Stator overload protection, thermal (ANSI 49)

Setting ranges	
Factor k according to IEC 60255-8	0.5 to 2.5 (steps 0.01)
Time constant	30 to 32000 s (steps 1 s)
Time delay factor at standstill	1 to 10 (steps 0.01)
Alarm overtemperature $\Theta_{Alarm}/\Theta_{Trip}$	70 to 100 % related to the trip temperature (steps 1 %)
Overcurrent alarm stage I_{Alarm}	0.1 to 4 A (steps 0.01 A); 5 times at I_N = 5 A
Temperature at I_N	40 to 200 °C (steps 1 °C) or 104 to 392 °F (steps 1 °F)
Scaling temperature of cooling medium	40 to 300 °C (steps 1 °C) or 104 to 572 °F (steps 1 °F)
Reset time at emergency start	20 to 150000 s (steps 1 s)
Drop-off ratio	
Θ/Θ_{Trip}	Drop-off with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.95
Tolerances	
Regarding k x I_P	2 % or 10/50 mA; class 2 % according to IEC 60255-8
Regarding trip time	3 % or 1 s: class 3 % according to IEC 60255-8 for $I/(k\ I_N)$>1.25

Technical data

Negative-sequence protection *(ANSI 46)*

Setting ranges	
Permissible negative sequence I_2 perm. $/I_N$	3 to 30 % (steps 1 %)
Definite time trip stage $I_2>>/I_N$	10 to 100 % (steps 1 %)
Time delays T_{Alarm}; $T_{I2>>}$	0 to 60 s (steps 0.01 s) or indefinite
Negative-sequence factor k	2 to 40 s (steps 0.1 s)
Cooling down time $T_{Cooling}$	0 to 50000 s (steps 1 s)
Times	
Pickup time (definite stage)	Approx. 50 ms
Drop-off time (definite stage)	Approx. 50 ms
Drop-off ratios I_2 perm.; $I_2>>$	Approx. 0.95
Drop-off ratio thermal stage	Drop-off at fall below of I_2 perm.
Tolerances	
Pickup values I_2 perm.; $I_2>>$	3 % of set value or 0.3 % negative sequence
Time delays	1 % or 10 ms
Thermal characteristic Time for $2 \leq I_2/I_2$ perm. ≤ 20	5 % of nominal value +1 % current tolerance or 600 ms

Underexcitation protection *(ANSI 40)*

Setting ranges	
Conductance thresholds 1/xd characteristic (3 characteristics)	0.25 to 3.0 (steps 0.01)
Inclination angle $\alpha_1, \alpha_2, \alpha_3$	50 to 120 ° (steps 1 °)
Time delay T	0 to 50 s (steps 0.01 s) or indefinite
Times	
Stator criterion 1/xd characteristic; α	Approx. 60 ms
Undervoltage blocking	Approx. 50 ms
Drop-off ratio	
Stator criterion 1/xd characteristic; α	Approx. 0.95
Undervoltage blocking	Approx. 1.1
Tolerances	
Stator criterion 1/xd characteristic	3 % of set value
Stator criterion α	1 ° electrical
Undervoltage blocking	1 % or 0.5 V
Time delays T	1 % or 10 ms

Reverse-power protection *(ANSI 32R)*

Setting ranges	
Reverse power $P_{Rev.>}/S_N$	–0.5 to –30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.>}$	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.>}$	0.25 % $S_N \pm 3$ % set value
Time delays T	1 % or 10 ms

Forward-power protection *(ANSI 32F)*

Setting ranges	
Forward power $P_{Forw.<}/S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{Forw.>}/S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{Forw.<}$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{Forw.>}$	Approx. 0.9 or –0.5 % of S_N
Tolerances	
Active power $P_{Forw.<}$, $P_{Forw.>}$	0.25 % $S_N \pm 3$ % of set value at $Q < 0.5\ S_N$ at accurate measuring 0.5 % $S_N \pm 3$ % of set value at $Q < 0.5\ S_N$ at fast measuring
Time delays T	1 % or 10 ms

Impedance protection *(ANSI 21)*

Setting ranges	
Overcurrent pickup $I>$	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$A
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1V)
Impedance Z1 (related to I_N =1 A)	0.05 to 130 Ω (steps 0.01 Ω)
Impedance Z1B (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Impedance Z2 (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Shortest tripping time	Approx. 40 ms
Drop-off time	Approx. 50 ms
Drop-off ratio	
Overcurrent pickup $I>$	Approx. 0.95
Undervoltage seal-in $V<$	Approx. 1.05
Tolerances	
Overcurrent pickup $I>$	1 % of set value. 10/50 mA
Undervoltage seal-in $V<$	1 % of set value. or 0.5 V
Impedance measuring Z1, Z2	$\lvert\Delta Z/Z\rvert \leq 5$ % for $30° \leq \varphi_K \leq 90°$
Time delays T	1 % or 10 ms

Undervoltage protection *(ANSI 27)*

Setting range	
Undervoltage pickup $V<$, $V<<$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time $V<$, $V<<$	Approx. 50 ms
Drop-off time $V<$, $V<<$	Approx. 50 ms
Drop-off ratio $V<$, $V<<$	1.01 to 1.1 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Technical data

Overvoltage protection *(ANSI 59)*

Setting ranges	
Overvoltage pickup $V>$, $V>>$ (maximum phase-to-phase voltage or phase-to-earth-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup times $V>$, $V>>$	Approx. 50 ms
Drop-off times $V>$, $V>>$	Approx. 50 ms
Drop-off ratio $V>$, $V>>$	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms

Frequency protection *(ANSI 81)*

Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V_1<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms
Drop-off times $f>$, $f<$	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V_1<$	Approx. 1.05
Tolerances	
Frequency	10 mHz (at $V>$ 0.5 V_N)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Overexcitation protection (Volt/Hertz) *(ANSI 24)*

Setting ranges	
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Pickup threshold $V/f>>$-stage	1 to 1.4 (steps 0.01)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Characteristic values of V/f	1.1/1.15/1.2/1.25/1.3/1.35/1.4
and assigned times t(V/f)	0 to 20000 s (steps 1 s)
Cooling down time $T_{Cooling}$	0 to 20000 s (steps 1 s)
Times (Alarm and $V/f>>$-stage)	
Pickup times at 1.1 of set value	Approx. 60 ms
Drop-off times	Approx. 60 ms
Drop-off ratio (alarm, trip)	0.95
Tolerances	
V/f-pickup	3 % of set value
Time delays T	1 % or 10 ms
Thermal characteristic (time)	5 % rated to V/f or 600 ms

90 % stator earth-fault protection, non-directional, directional *(ANSI 59N, 64G, 67G)*

Setting ranges	
Displacement voltage $V_0>$	5 to 125 V (steps 0.1 V)
Earth current $3I_0>$	2 to 1000 mA (steps 1 mA)
Angle of direction element	0 to 360 ° (steps 1 °)
Time delays T	0 to 60 s (steps 0,01 s) or indefinite
Times	
Pickup times $V_0>$, $3I_0>$	Approx. 50 ms
Drop-off times $V_0>$/ $3I_0>$	Approx. 50 ms
Drop-off ratio $V_0>$, $3I_0>$	0.7
Drop-off difference angle	10 ° directed to power system
Tolerances	
Displacement voltage	1 % of set value or 0.5 V
Earth current	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms

Sensitive earth-fault protection *(ANSI 50/51GN, 64R)*

Setting ranges	
Earth current pickup $I_{EE}>$, $I_{EE}>>$	2 to 1000 mA (steps 1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Measuring circuit supervision $I_{EE}<$	1.5 to 50 mA (steps 0.1 mA)
Times	
Pickup times	Approx. 50 ms
Drop-off times	Approx. 50 ms
Measuring circuit supervision	Approx. 50 ms
Drop-off ratio $I_{EE}>$, $I_{EE}>>$	0.95 or 1 mA
Drop-off ratio measuring circuit supervision $I_{EE}<$	Approx. 1.1 or 1 mA
Tolerances	
Earth current pickup	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms

100 % stator earth-fault protection with 3 harmonics *(ANSI 59TN, 27TN (3 H.))*

Setting ranges	
Displacement voltage $V_{0\,(3^{rd}\,harm.)}>$, $V_{0\,(3^{rd}\,harm.)}<$	0.2 to 40 V (steps 0.1 V)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Active-power release	10 to 100 % (steps 1 %) or indefinite
Positive-sequence voltage release	50 to 125 V (steps 0.1 V) or indefinite
Times	
Pickup time	Approx. 80 ms
Drop-off time	Approx. 80 ms
Drop-off ratio	
Undervoltage stage $V_{0\,(3^{rd}\,harm.)}<$	Approx. 1.4
Overvoltage stage $V_{0\,(3^{rd}\,harm.)}>$	Approx. 0.6
Active-power release	Approx. 0.9
Positive-sequence voltage release	Approx. 0.95
Tolerances	
Displacement voltage	3 % of set value or 0.1 V
Time delay T	1 % or 10 ms

Technical data

Breaker failure protection (ANSI 50BF)

Setting ranges	
Current thresholds I>BF	0.04 to 1 A (steps 0.01 A)
Time delay BF-T	0.06 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup time	Approx. 50 ms
Drop-off time	Approx. 50 ms
Tolerances	
Current threshold I>BF/I_N	1 % of set value or 10/50 mA
Time delay T	1 % or 10 ms

Inadvertent energizing protection (ANSI 50, 27)

Setting ranges	
Current pickup I>>>	0.1 to 20 A (steps 0.1 A); 5 times at I_N= 5 A
Voltage release V_1<	10 to 125 V (steps 1 V)
Time delay	0 to 60 s (steps 0.01 s) or indefinite
Drop-off time	0 to 60 s (steps 0.01 s) or indefinite
Times	
Reaction time	Approx. 25 ms
Drop-off time	Approx. 35 ms
Drop-off ratio I>>>	Approx. 0.8
Drop-off ratio V_1<	Approx. 1.05
Tolerances	
Current pickup	5 % of set value or 20/100 mA
Undervoltage seal-in V_1<	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

External trip coupling

Number of external trip couplings	2 for 7UM611 4 for 7UM612

Trip circuit supervision (ANSI 74TC)

Number of supervised trip circuits (only 7UM612)	1

Starting time supervision for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{\text{Start max}}/I_N$	1.0 to 16 (steps 0.01)
Starting current pickup $I_{\text{Start, pickup.}}/I_N$	0.6 to 10 (steps 0.01)
Permissible starting time $T_{\text{Start max}}$	1.0 to 180 s (steps 0.1 s)
Permissible locked rotor time T_{Blocking}	0.5 to 120 s (steps 0.1 s) or indefinite
Times	Depending on the settings
Drop-off ratio	Approx. 0.95
Tolerances	
Current threshold	1 % of set value, or 1 % of I_N
Time delays T	5 % or 30 ms

Restart inhibit for motors (ANSI 66, 49 Rotor)

Setting ranges	
Motor starting current $I_{\text{Start max}}/I_N$	3.0 to 10.0 (steps 0.01)
Permissible starting time $T_{\text{Start max}}$	3.0 to 120.0 s (steps 0.1 s)
Rotor temperature equalization time $T_{\text{Equali.}}$	0 to 60.0 min (steps 0,1 min)
Minimum restart inhibit time $T_{\text{Restart, min}}$	0.2 to 120.0 min (steps 0.1 min)
Permissible number of warm starts n_W	1 to 4
Difference between warm and cold starts n_K-n_W	1 to 2
Extensions of time constants (running and stop)	1.0 to 100.0
Tolerances	
Time delay T	1 % or 0.1 ms

Rate-of-frequency-change protection (ANSI 81R)

Setting ranges	
Steps, selectable +df/dt >; - df/dt	4
Pickup value df/dt	0.2 to 10 Hz/s (steps 0.1 Hz/s);
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Times	
Pickup times df/dt	Approx. 200 ms
Drop-off times df/dt	Approx. 200 ms
Drop-off ratio df/dt	Approx. 0.95 or 0.1 Hz/s
Drop-off ratio V<	Approx. 1.05
Tolerances	
Rate-of-frequency change	Approx. 0.1 Hz/s at V> 0.5 V_N
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Vector jump supervision (voltage)

Setting ranges	
Stage $\Delta\varphi$	0.5 ° to 15 ° (steps 0.1 °)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Tolerances	
Vector jump	0.3 ° at V> 0.5 V_N
Undervoltage blocking	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

Incoupling of temperature via serial interface (thermo-box) (ANSI 38)

Number of measuring sensors	6 or 12
Temperature thresholds	40 to 250 °C or 100 to 480 °F (steps 1 °C or 1 °F)
Sensor types	Pt100; Ni 100, Ni 120

Technical data

Operational measured values

Description	Primary; secondary or per unit (%)
Currents	I_{L1}; I_{L2}; I_{L3}; I_{EE}; I_1; I_2
Tolerance	0.2 % of measured values or ± 10 mA ± 1 digit
Voltages	V_{L1}; V_{L2}; V_{L3}; V_E; V_{L12}; V_{L23}; V_{L31}; V_1; V_2
Tolerance	0.2 % of measured values or ± 0.2 V ± 1 digit
Impedance	R, X
Tolerance	1 %
Power	S; P; Q
Tolerance	1 % of measured values or ± 0.25 % S_N
Phase angle	φ
Tolerance	<0.1 °
Power factor	cos φ (p.f.)
Tolerance	1 % ± 1 digit
Frequency	f
Tolerance	10 mHz at ($V > 0.5\ V_N$; 40 Hz $< f <$ 65 Hz)
Overexcitation	V/f;
Tolerance	1 %
Thermal measurement	Θ_{L1}; Θ_{L2}, Θ_{L3}, Θ_{I2}, $\Theta_{V/f}$,
Tolerance	5 %

Min./max. memory

Memory	Measured values with date and time
Reset manual	Via binary input Via key pad Via communication
Values	
Positive sequence voltage	V_1
Positive sequence current	I_1
Active power	P
Reactive power	Q
Frequency	f
Displacement voltage (3rd harmonics)	$V_{E(3^{rd}\text{ harm.})}$

Energy metering

Meter of 4 quadrants	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance	1 %

Fault records

Number of fault records	Max. 8 fault records
Instantaneous values	Max. 5 s
Storage time	Depending on the actual frequency
Sampling interval	(e. g. 1.25 ms at 50 Hz; 1.04 ms at 60 Hz))
Channels	v_{L1}, v_{L2}, v_{L3}, v_E; i_{L1}, i_{L2}, i_{L3}, i_{EE}
R.m.s. values	
Storage period	Max. 80 s
Sampling interval	Fixed (20 ms at 50 Hz; 16.67 ms at 60 Hz)
Channels	V_1, V_E, I_1, I_2, I_{EE}, P, Q, φ, f-f_n

Additional functions

Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits (criterion: current threshold)
Switching statistics	Number of breaker operation Phase-summated tripping current

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/ Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Order Code
7UM61 multifunction generator and motor protection relay	*7UM61□□-□□□□□-□□□0*	*□□□*
Housing, binary inputs and outputs		
Housing 1/3 19", 7 BI, 11 BO, 1 live status contact	1	
Housing 1/2 19", 15 BI, 19 BO, 1 live status contact	2	
Current transformer I		
1 A1)	1	
5 A1)	5	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V3)	2	
60 to 125 V DC2), threshold binary input 19 V3)	4	
110 to 220 V DC2), 115 to 230 V AC, threshold binary input 88 V3)	5	
Unit version		
For panel surface mounting, 2 tier screw-type terminals top/bottom	B	
For panel flush mounting, plug-in terminals (2-/3- pin connector)	D	
Flush-mounting housing, screw-type terminal (direct connection, ring-type cable lugs)	E	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, IEC characteristics, language: German, (language can be selected)	A	
Region World, 50/60 Hz, IEC/ANSI characteristics, language: English (UK), (language can be selected)	B	
Region US, 60 Hz, ANSI characteristics, language: English (US), (language can be selected)	C	
System interface (rear of units)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-DP slave, electrical RS485	9	L 0 A
PROFIBUS-DP slave, optical 820 nm, double ring, ST connector*	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector*	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector*	9	L 0 H
DIGSI 4/modem interface (rear of unit)		
No interface	0	
DIGSI 4, electrical RS232	1	
DIGSI 4, temperature monitoring box, electrical RS485	2	
DIGSI 4, temperature monitoring box, optical 820 nm, ST connector	3	
Measuring functions		
Without	0	
Min./max. values, energy metering	3	
Functions		
Generator Basic	A	
Generator Standard	B	
Generator Full	C	
Motor, asynchronous	F	
Additional functions		
Without	A	
Network decoupling (df / dt and vector jump)	E	

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected in stages by means of jumpers.

4) For more detailed information on the functions see Table 11/1 on page 11/4.

* Not with position 9 = B; if 9 = "B", please order 7UM61 unit with RS485 port and separate fiber-optic converters.

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Profesional Edition device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4	
(generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable	
Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Coupling device for rotor earth-fault protection	*7XR6100-0CA00*
	Short code
Series resistor for rotor earth-fault protection (group: 013002)	*3PP1336-0DZ K2Y*
Resistor for stator earth-fault protection (voltage divider, 5 : 1) (group 013001)	*3PP1336-1CZ K2Y*
Temperature monitoring box (thermo-box)	
24 to 60 V AC/DC	*7XV5662-2AD10*
90 to 240 V AC/DC	*7XV5662-5AD10*
Manual for 7UM61	
English	*C53000-G1176-C127-2*

Accessories

Fig. 11/25 Mounting rail for 19" rack

Fig. 11/26
2-pin connector

Fig. 11/27
3-pin connector

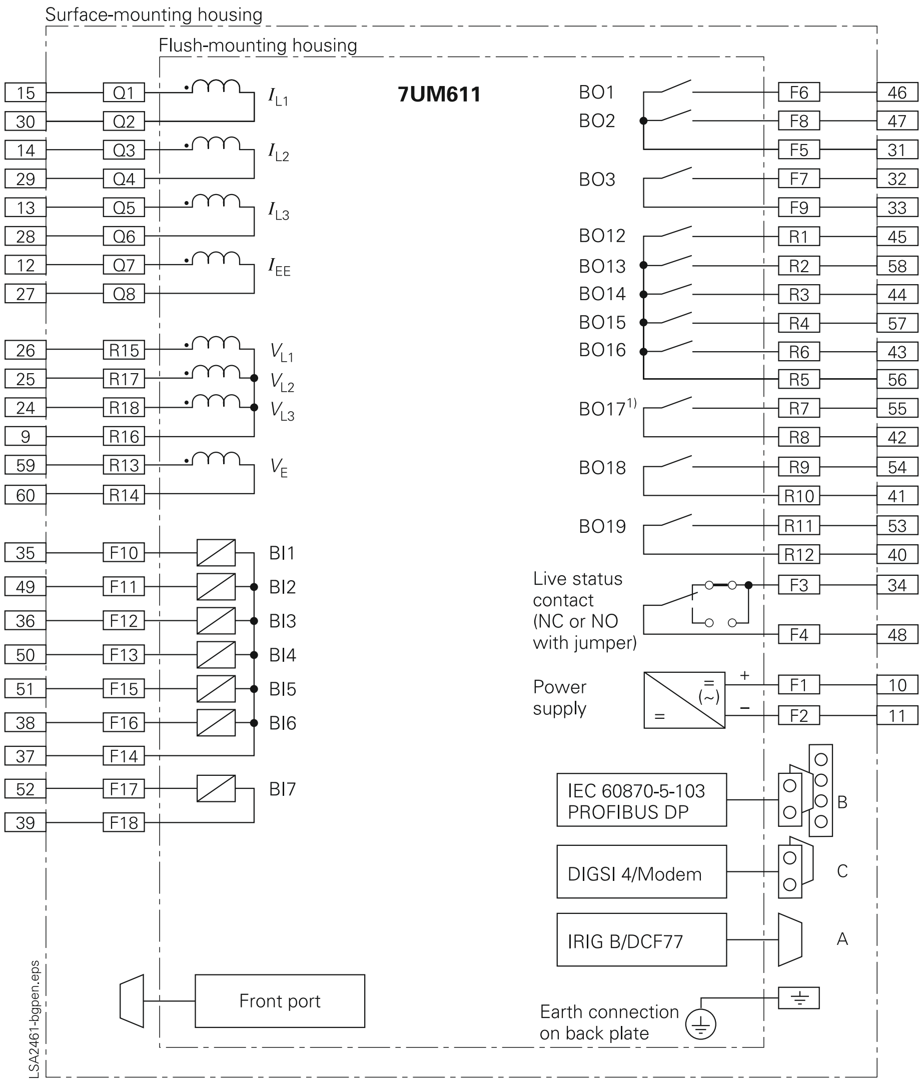
Fig. 11/28
Short-circuit link for current terminals

Fig. 11/29
Short-circuit link for voltage terminals/indications terminals

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	11/26
	3-pin	C73334-A1-C36-1	1	Siemens	11/27
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	0-539635-1	1	AMP 1)	
	and matching female	0-539668-2		AMP 1)	
	For CI2	0-734372-1	1	AMP 1)	
	and matching female	1-734387-1		AMP 1)	
Mounting rail		C73165-A63-D200-1	1	Siemens	11/25
Short-circuit links	For current terminals	C73334-A1-C33-1	1	Siemens	11/28
	For other terminals	C73334-A1-C34-1	1	Siemens	11/29
Safety cover for terminals	Large	C73334-A1-C31-1	1	Siemens	11/3
	Small	C73334-A1-C32-1	1	Siemens	11/3

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram, IEC

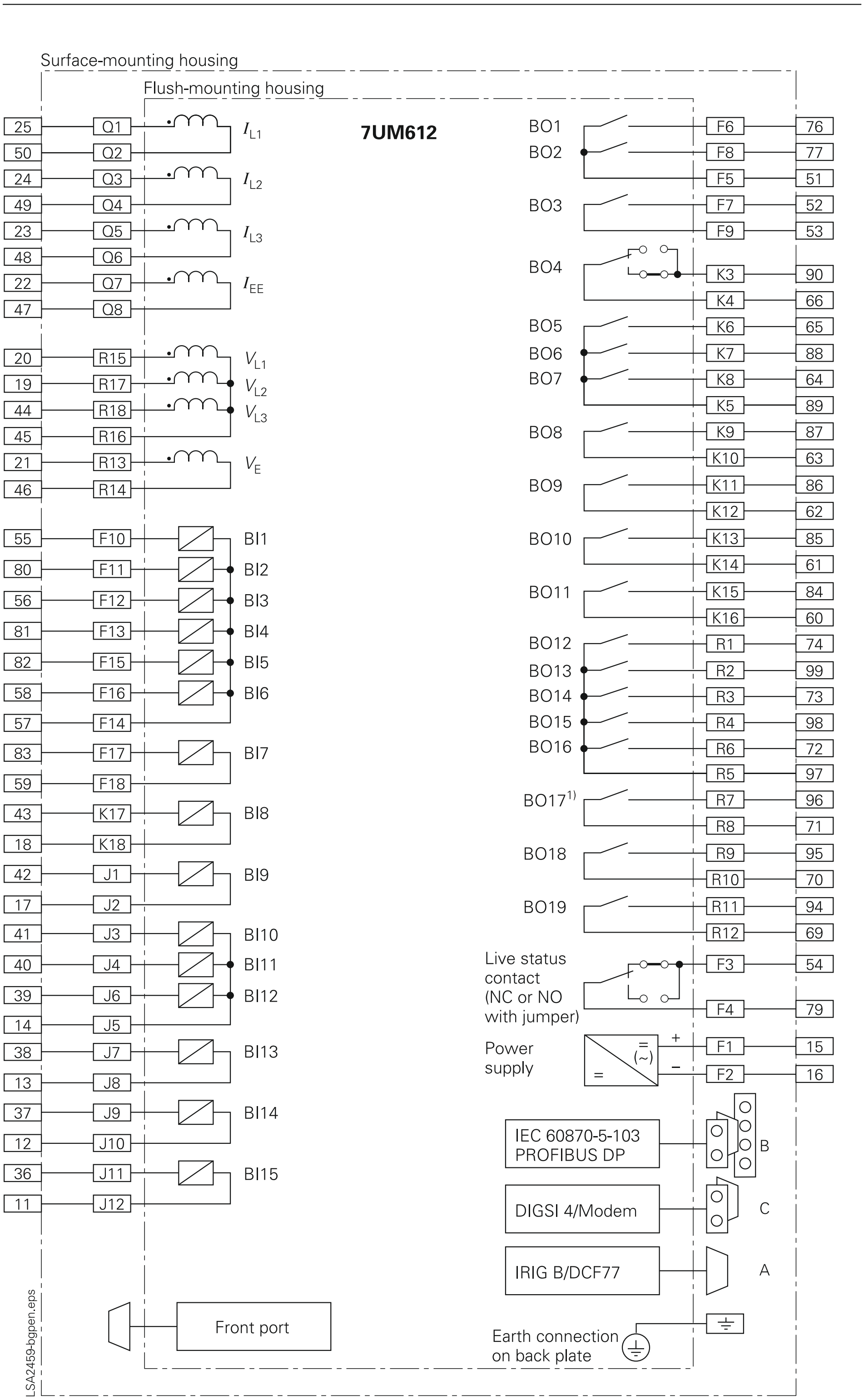


1) NO or NC with jumper possible.

Fig. 11/30

7UM611 connection diagram (IEC standard)

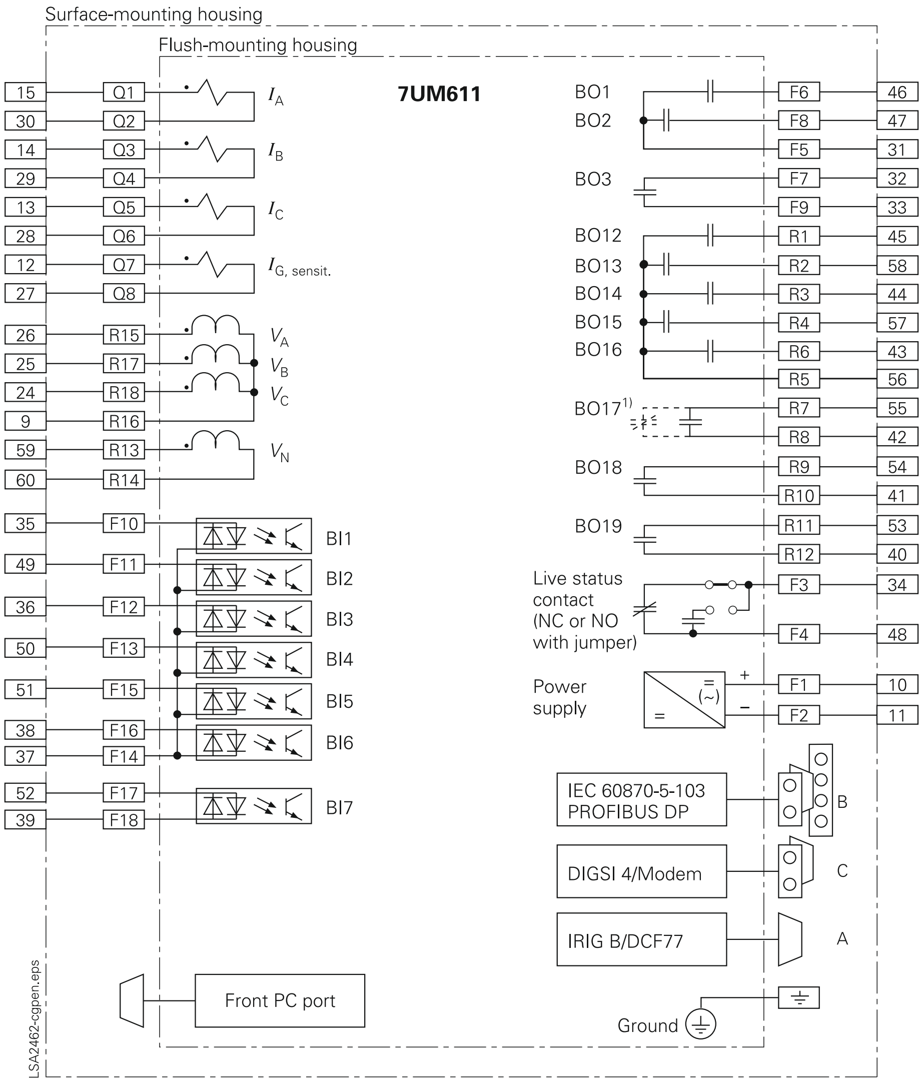
Connection diagram, IEC



1) NO or NC with jumper possible.

Fig. 11/31
7UM612 connection diagram (IEC standard)

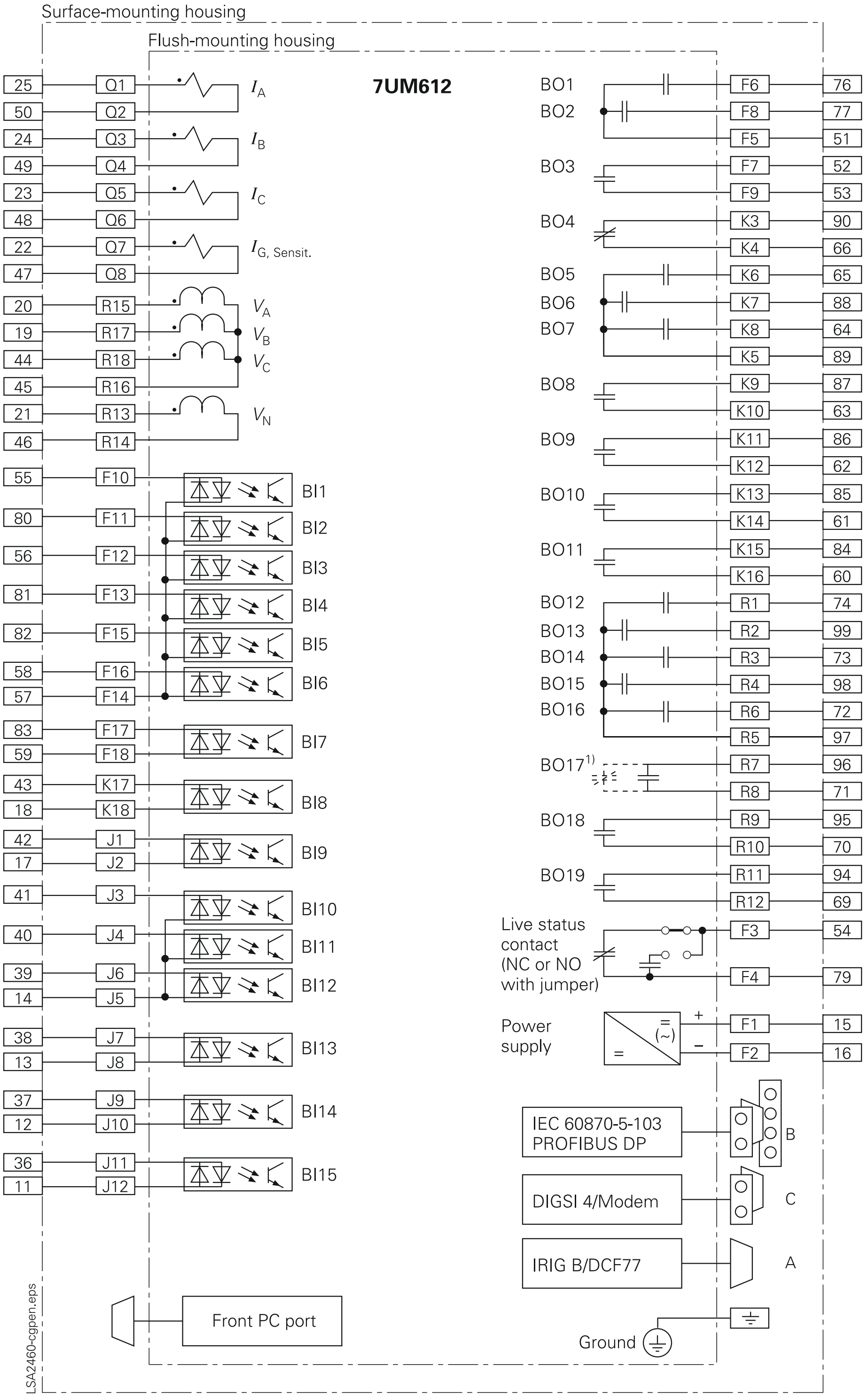
Connection diagram, ANSI



1) NO or NC with jumper possible.

Fig. 11/32
7UM611 connection diagram (ANSI standard)

Connection diagram, ANSI



1) NO or NC with jumper possible.

Fig. 11/33
7UM612 connection diagram (ANSI standard)

SIPROTEC 4 7UM62 Multifunction Generator, Motor and Transformer Protection Relay

Fig. 11/34 SIPROTEC 4 7UM62 multifunction protection relay for generators, motors and transformers

Description

The SIPROTEC 4 7UM62 protection relays can do more than just protect. They also offer numerous additional functions. Be it earth faults, short-circuits, overloads, overvoltage, overfrequency or underfrequency asynchronous conditions, protection relays assure continued operation of power stations. The SIPROTEC 4 7UM62 protection relay is a compact unit which has been specially developed and designed for the protection of small, medium-sized and large generators. They integrate all the necessary protection functions and are particularly suited for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Diesel generator stations
- Gas-turbine power stations
- Industrial power stations
- Conventional steam power stations.

The SIPROTEC 4 7UM62 includes all necessary protection functions for large synchronous and asynchronous motors and for transformers.

The integrated programmable logic functions (continuous function chart CFC) offer the user high flexibility so that adjustments can easily be made to the varying power station requirements on the basis of special system conditions.
The flexible communication interfaces are open for modern communication architectures with the control system.

The following basic functions are available for all versions:

Current differential protection for generators, motors and transformers, stator earth-fault protection, sensitive earth-fault protection, stator overload protection, overcurrent- time protection (either definite time or inverse time), definite-time overcurrent protection with directionality, undervoltage and overvoltage protection, underfrequency and overfrequency protection, overexcitation and underexcitation protection, external trip coupling, forward-power and reverse-power protection, negative-sequence protection, breaker failure protection, rotor earth-faults protection (f_n, R-measuring), motor starting time supervision and restart inhibit for motors.

Function overview

Standard version

Scope of basic version plus:

- Inadvertent energization protection
- 100 %-stator earth-fault protection with 3rd harmonic
- Impedance protection

Full version

Scope of standard version plus:

- DC voltage protection
- Overcurrent protection during start-ups
- Earth-current differential protection
- Out-of-step protection

Additional version

Available for each version:

- Sensitive rotor earth-fault protection (1-3 Hz method)
- Stator earth-fault protection with 20 Hz voltage
- Rate-of-frequency-change protection
- Vector jump supervision

Monitoring function

- Trip circuit supervision
- Fuse failure monitor
- Operational measured values V, I, f, …
- Energy metering values W_p, W_q
- Time metering of operating hours
- Self-supervision of relay
- 8 oscillographic fault records

Communication interfaces

- System interface
  - IEC 61850 protocol
  - IEC 60870-5-103 protocol
  - PROFIBUS-DP
  - MODBUS RTU
  - DNP 3.0

Hardware

- Analog inputs
- 8 current transformers
- 4 voltage transformers
- 7/15 binary inputs
- 12/20 output relays

Front design

- User-friendly local operation
- 7/14 LEDs for local alarm
- Function keys
- Graphic display with 7UM623

Application

The 7UM6 protection relays of the SIPROTEC 4 family are compact multifunction units which have been developed for small to medium-sized power generation plants. They incorporate all the necessary protective functions and are especially suitable for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Power generation with diesel generators
- Gas turbine power stations
- Industrial power stations
- Conventional steam power stations.

They can also be employed for protection of motors and transformers.

The numerous other additional functions assist the user in ensuring cost-effective system management and reliable power supply. Measured values display current operating conditions. Stored status indications and fault recording provide assistance in fault diagnosis not only in the event of a disturbance in generator operation.

Combination of the units makes it possible to implement effective redundancy concepts.

Protection functions

Numerous protection functions are necessary for reliable protection of electrical machines. Their extent and combination are determined by a variety of factors, such as machine size, mode of operation, plant configuration, availability requirements, experience and design philosophy.

This results in multifunctionality, which is implemented in outstanding fashion by numerical technology.

In order to satisfy differing requirements, the combination of functions is scalable (see Table 11/3). Selection is facilitated by division into five groups.

Generator Basic

One application concentrates on small and medium generators for which differential protection is required. The function mix is also suitable as backup protection. Protection of synchronous motors is a further application.

Generator Standard

In the case of medium-size generators (10 to 100 MVA) in a unit connection, this scope of functions offers all necessary protection functions. Besides inadvertent energization protection, it also includes powerful backup protection for the transformer or the power system. The scope of protection is also suitable for units in the second protection group.

Generator Full

Here, all protection functions are available and the main application focuses on large block units (more than 100 MVA). The function mix includes all necessary protection functions for the generator as well as backup protection for the block transformer including the power system. Additional functions such as protection during start-up for generators with starting converters are also included.

The scope of functions can be used for the second protection group, and functions that are not used, can be masked out.

Asynchronous motor

Besides differential protection, this function package includes all protection functions needed to protect large asynchronous motors (more than 1 MVA). Stator and bearing temperatures are measured by a separate thermo-box and are transmitted serially to the protection unit for evaluation.

Transformer

This scope of functions not only includes differential and overcurrent protection, but also a number of protection functions that permit monitoring of voltage and frequency stress, for instance. The reverse-power protection can be used for energy recovery monitoring of parallel-connected transformers.

Construction

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control.

Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays were a major design aim. The 7UM623 is equipped with a graphic display thus providing and depicting more information especially in industrial applications. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

The 7UM621 and 7UM623 are configured in 1/2 19 inches width. This means that the units of previous models can be replaced. The height throughout all housing width increments is 243 mm.

All wires are connected directly or by means of ring-type cable lugs. Alternatively, versions with plug-in terminals are also available. These permit the use of prefabricated cable harnesses.

In the case of panel surface mounting, the connecting terminals are in the form of screw-type terminals at top and bottom. The communication interfaces are also arranged on the same sides.

Fig. 11/35
Rear view with wiring terminal safety cover and serial interface

Protection functions

Protection functions	Abbre-viation	ANSI No.	Gene-rator Basic	Gene-rator Standard	Gene-rator Full	Motor Asyn-chronous	Trans-former
Current differential protection	Δ I	87G/87T/87M	X	X	X	X	X
Stator earth-fault protection non-directional, directional	V_0>, $3I_0$> \(V_0, $3I_0$)	59N, 64G 67G	X	X	X	X	X
Sensitive earth-fault protection (also rotor earth-fault protection)	I_{EE}>	50/51GN (64R)	X	X	X	X	X
Sensitive earth-fault prot. B (e.g. shaft current prot.)	I_{EE-B}> I_{EE-B}<	51GN	X	X	X	X	X
Stator overload protection	I^2t	49	X	X	X	X	X
Definite-time overcurrent prot. with undervolt. seal-in	I> +V<	51	X	X	X	X	X
Definite-time overcurrent protection, directional	I>>, Direc.	50/51/67	X	X	X	X	X
Inverse-time overcurrent protection	$t = f(I)$+V<	51V	X	X	X	X	X
Overvoltage protection	V>	59	X	X	X	X	X
Undervoltage protection	V<, $t = f$ (V)	27	X	X	X	X	X
Frequency protection	f<, f>	81	X	X	X	X	X
Reverse-power protection	-P	32R	X	X	X	X	X
Overexcitation protection (Volt/Hertz)	V/f	24	X	X	X	X	X
Fuse failure monitor	V_2/V_1, I_2/I_1	60FL	X	X	X	X	X
External trip coupling	Incoup.		4	4	4	4	4
Trip circuit supervision	T.C.S.	74TC	X	X	X	X	X
Forward-power protection	P>, P<	32F	X	X	X	X	X
Underexcitation protection (loss-of-field protection)	1/xd	40	X	X	X		
Negative-sequence protection	I_2>, $t = f(I_2)$	46	X	X	X	X	
Breaker failure protection	I_{min}>	50BF	X	X	X	X	X
Motor starting time supervision	$I_{start}{}^2t$	48	X	X	X	X	
Restart inhibit for motors	I^2t	66, 49 Rotor	X	X	X	X	
Rotor earth-fault protection (f_n, R-measuring)	R<	64R (f_n)	X	X	X		
Inadvertent energization protection	I>, V<	50/27		X	X		
100 % stator earth-fault protection with 3rd harmonics	$V_{0(3rd\ harm.)}$	59TN, 27TN 3rd h		X	X		
Impedance protection with (I>+V<) pickup	Z<	21		X	X		
Interturn protection	$U_{Interturn}$>	59N(IT)		X	X		
DC voltage / DC current time protection	V_{dc} > I_{dc} >	59N (DC) 51N (DC)			X		
Overcurrent protection during startup (for gas turbines)	I>	51			X		
Earth-current differential protection	ΔI_e	87GN/TN	X1)	X1)	X	X1)	X1)
Out-of-step protection	$\Delta Z/\Delta t$	78			X		
Rotor earth-fault protection (1-3 Hz square wave voltage)	R_{REF}<	64R (1–3 Hz)	X1)	X1)	X1)		
100 % stator earth-fault protection with 20 Hz voltage	R_{SEF}<	64G (100 %)	X1)	X1)	X1)		
Rate-of-frequency-change protection	df/dt >	81R	X1)	X1)	X1)	X1)	X1)
Vector jump supervision (voltage)	$\Delta\varphi$ >		X1)	X1)	X1)	X1)	X1)
Threshold supervision			X	X	X	X	X
Supervision of phase rotation	A, B, C	47	X	X	X	X	X
Undercurrent via CFC	I <	37	X	X	X	X	X
External temperature monitoring via serial interface	ϑ (Thermo-box)	38	X	X	X	X	X

Table 11/3 Scope of functions of the 7UM62

---

1) Optional for all function groups.

Protection functions

Current differential protection (ANSI 87G, 87M, 87T)

This function provides undelayed short-circuit protection for generators, motors and transformers, and is based on the current differential protection principle (Kirchhoff's current law).

The differential and restraint (stabilization) current are calculated on the basis of the phase currents. Optimized digital filters reliably attenuate disturbances such as aperiodic component and harmonics. The high resolution of measured quantities permits recording of low differential currents (10 % of I_N) and thus a very high sensitivity.

An adjustable restraint characteristic permits optimum adaptation to the conditions of the protected object. Software is used to correct the possible mismatch of the current transformers and the phase angle rotation through the transformer (vector group). Thanks to harmonic analysis of the differential current, inrush (second harmonic) and overexcitation (fifth harmonic) are reliably detected, and unwanted operation of the differential protection is prevented. The current of internal short-circuits is reliably measured by a fast measuring stage (I_{Diff}>>), which operates with two mutually complementary measuring processes. An external short-circuit with transformer saturation is picked up by a saturation detector with time and status monitoring. It becomes active when the differential current (I_{Diff}) moves out of the add-on restraint area.

If a motor is connected, this is detected by monitoring the restraint current and the restraint characteristic is briefly raised. This prevents false tripping in the event of unequal current transmission by the current transformers.

Figure 11/36 shows the restraint characteristic and various areas.

Earth-current differential protection (ANSI 87GN, 87TN)

The earth-current differential protection permits high sensitivity to single-pole faults. The zero currents are compared. On the one hand, the zero-sequence current is calculated on the basis of the phase currents and on the other hand, the earth current is measured directly at the star-point current transformer.

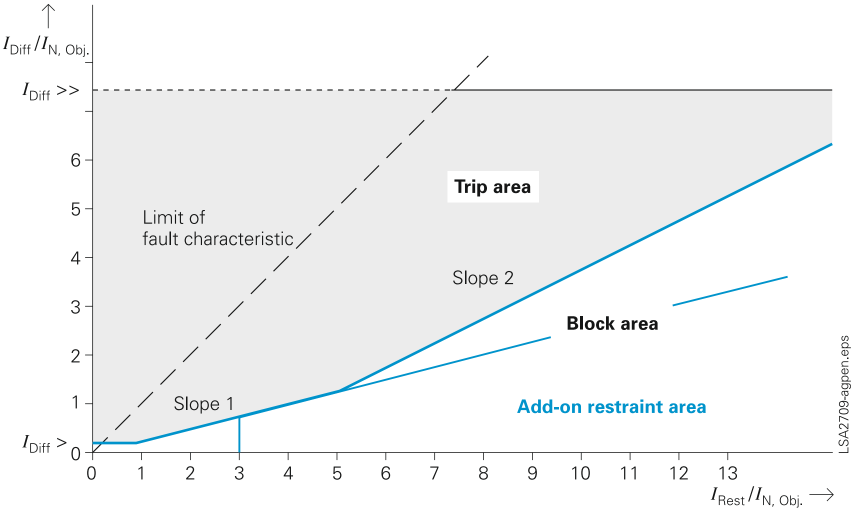


Fig. 11/36 Restraint characteristic of current differential protection

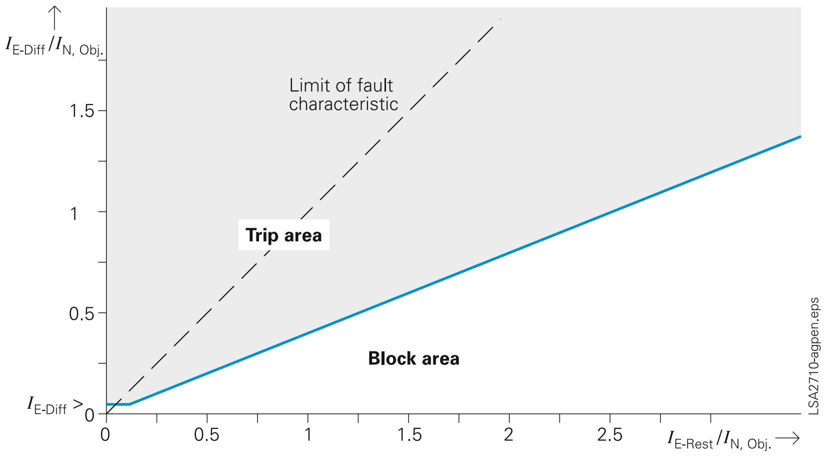


Fig. 11/37 Restraint characteristic of earth-current differential protection

The differential and restraint quantity is generated and fitted into the restraint characteristic (see Fig. 11/37).

DC components in particular are suppressed by means of specially dimensioned filters. A number of monitoring processes avoid unwanted operation in the event of external short-circuits. In the case of a sensitive setting, multiple measurement ensures the necessary reliability.

However, attention must be drawn to the fact that the sensitivity limits are determined by the current transformers.

The protection function is only used on generators when the neutral point is earthed with a low impedance. In the case of transformers, it is connected on the neutral side. Low impedance or solid earthing is also required.

Protection functions

Definite-time overcurrent protection $I>$, $I>>$ (ANSI 50, 51, 67)

This protection function comprises the short-circuit protection for the generator and also the backup protection for upstream devices such as transformers or power system protection.

An undervoltage stage at $I>$ maintains the pickup when, during the fault, the current drops below the threshold. In the event of a voltage drop on the generator terminals, the static excitation system can no longer be sufficiently supplied. This is one reason for the decrease of the short-circuit current.

The $I>>$ stage can be implemented as high-set instantaneous trip stage. With the integrated directional function it can be used as backup protection on the transformer high-voltage side. With the information of the directional element, impedance protection can be controlled via the CFC.

Inverse-time overcurrent protection (ANSI 51V)

This function also comprises short-circuit and backup protection and is used for power system protection with current-dependent protection devices.

IEC and ANSI characteristics can be selected (Table 11/4).

The current function can be controlled by evaluating the generator terminal voltage.

The “controlled” version releases the sensitive set current stage.

With the “restraint” version, the pickup value of the current is lowered linearly with decreasing voltage.

The fuse failure monitor prevents unwanted operation.

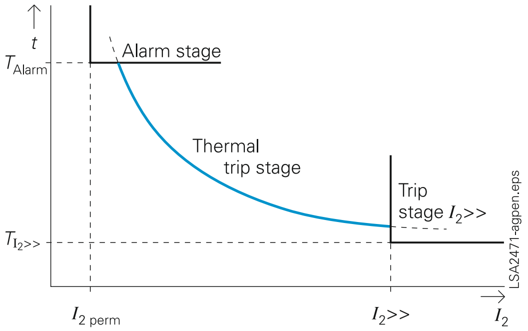


Fig. 11/38 Characteristic of negative-sequence protection

Stator overload protection (ANSI 49)

The task of the overload protection is to protect the stator windings of generators and motors from high, continuous overload currents. All load variations are evaluated by a mathematical model. The thermal effect of the r.m.s. current value forms the basis of the calculation.
This conforms to IEC 60255-8.
In dependency of the current, the cooling time constant is automatically extended. If the ambient temperature or the temperature of the coolant are injected via a transducer (TD2) or PROFIBUS-DP, the model automatically adapts to the ambient conditions; otherwise a constant ambient temperature is assumed.

Negative-sequence protection (ANSI 46)

Asymmetrical current loads in the three phases of a generator cause a temperature rise in the rotor because of the negative-sequence field produced.

This protection detects an asymmetrical load in three-phase generators. It functions on the basis of symmetrical components and evaluates the negative sequence of the phase currents. The thermal processes are taken into account in the algorithm and form the inverse characteristic. In addition, the negative sequence is evaluated by an independent stage (alarm and trip) which is supplemented by a time-delay element (see Figure 11/38). In the case of motors, the protection function is also used to monitor a phase failure.

Available inverse-time characteristics

Characteristics	ANSI	IEC 60255-3
Inverse	●	●
Moderately inverse	●	
Very inverse	●	●
Extremely inverse	●	●
Definite inverse	●	

Table 11/4

Underexcitation protection (Loss-of-field protection) (ANSI 40)

Derived from the generator terminal voltage and current, the complex admittance is calculated and corresponds to the generator diagram scaled in per unit. This protection prevents damage due to loss of synchronism resulting from underexcitation. The protection function provides three characteristics for monitoring static and dynamic stability. Via a transducer, the excitation voltage (see Figure 11/52) can be injected and, in the event of failure, a swift reaction of the protection function can be achieved by timer changeover.

The straight-line characteristics allow the protection to be optimally adapted to the generator diagram (see Figure 11/39). The per-unit-presentation of the diagram allows the setting values to be directly read out.

The positive-sequence systems of current and voltage are used to calculate the admittance. This ensures that the protection always operates correctly even with asymmetrical network conditions.

If the voltage deviates from the rated voltage, the admittance calculation has the advantage that the characteristics move in the same direction as the generator diagram.

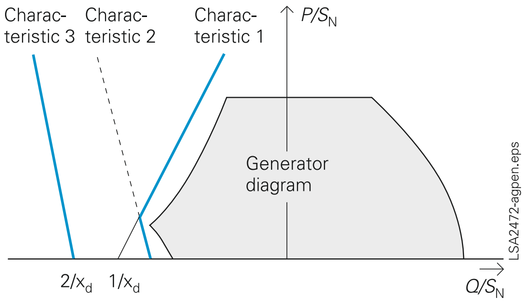


Fig. 11/39
Characteristic of underexcitation protection

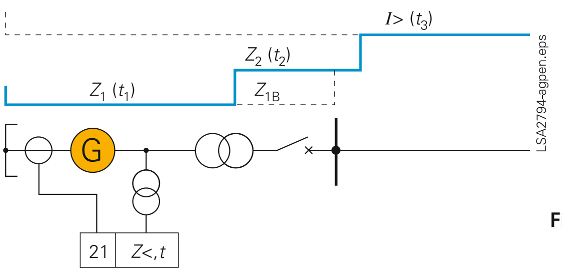


Fig. 11/40

Protection functions

Reverse-power protection (ANSI 32R)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical power system faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (±) of the active power can be reversed via parameters.

Forward-power protection (ANSI 32F)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors exceeding of a limit value, while another stage monitors falling below another limit value. The power is calculated using the positive-sequence component of current and voltage. The function can be used to shut down idling motors.

Impedance protection (ANSI 21)

This fast short-circuit protection protects the generator and the unit transformer and is a backup protection for the power system. This protection has two settable impedance stages; in addition, the first stage can be switched over via binary input. With the circuit-breaker in the “open” position the impedance measuring range can be extended (see Figure 11/40).

The overcurrent pickup element with undervoltage seal-in ensures a reliable pickup and the loop selection logic ensures a reliable detection of the faulty loop. With this logic it is possible to perform correct measurement via the unit transformer.

Undervoltage protection (ANSI 27)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-earth voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by earth faults. This function is implemented in two stages.

Frequency protection (ANSI 81)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Overexcitation protection Volt/Hertz (ANSI 24)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to *V*/*f*) in generators or transformers, which leads to thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via eight points derived from the manufacturer data.

In addition, a definite-time alarm stage and an instantaneous stage can be used. For calculation of the *V*/*f* ratio, frequency and also the highest of the three line-to-line voltages are used. The frequency range that can be monitored comprises 11 to 69 Hz.

Protection functions

90 % stator earth-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)

Earth faults manifest themselves in generators that are operated in isolation by the occurence of a displacement voltage. In case of unit connections, the displacement voltage is an adequate, selective criterion for protection.

For the selective earth-fault detection, the direction of the flowing earth current has to be evaluated too, if there is a direct connection between generator and busbar.

The protection relay measures the displacement voltage at a VT located at the transformer star point or at the broken delta winding of a VT As an option, it is also possible to calculate the zero-sequence voltage from the phase-to-earth voltages.

Depending on the load resistor selection, 90 to 95 % of the stator winding of a generator can be protected.

A sensitive current input is available for earth-current measurement. This input should be connected to a core-balance current transformer. The fault direction is deduced from the displacement voltage and earth current. The directional characteristic (straight line) can be easily adapted to the system conditions. Effective protection for direct connection of a generator to a busbar can therefore be established. During start-up, it is possible to switch over from the directional to the displacement voltage measurement via an externally injected signal.

Depending on the protection setting, various earth-fault protection concepts can be implemented with this function (see Figures 11/51 to 11/54).

Sensitive earth-fault protection (ANSI 50/51GN, 64R)

The sensitive earth-current input can also be used as separate earth-fault protection. It is of two-stage form. Secondary earth currents of 2 mA or higher can be reliably handled.

Alternatively, this input is also suitable as rotor earth-fault protection. A voltage with rated frequency (50 or 60 Hz) is connected in the rotor circuit via the interface unit 7XR61. If a higher earth current is flowing, a rotor earth fault has occurred. Measuring circuit monitoring is provided for this application (see Figure 11/56).

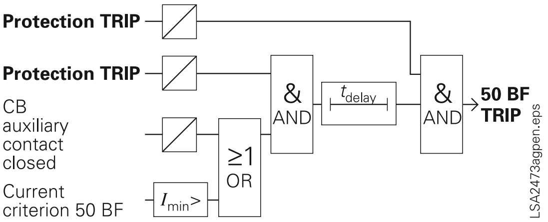


Fig. 11/41

Logic diagram of breaker failure protection

100 % stator earth-fault protection with 3. harmonic (ANSI 59TN, 27TN (3H.))

Owing to the creative design, the generator produces a 3^{rd} harmonic that forms a zero phase-sequence system. It is verifiable by the protection on a broken delta winding or on the neutral transformer. The magnitude of the voltage amplitude depends on the generator and its operation.

In the event of an earth fault in the vicinity of the neutral point, there is a change in the amplitude of the 3^{rd} harmonic voltage (dropping in the neutral point and rising at the terminals).

Depending on the connection the protection must be set either as undervoltage or overvoltage protection. It can also be delayed. So as to avoid overfunction, the active power and the positive-sequence voltage act as enabling criteria.

The picked-up threshold of the voltage stage is restrained by the active power. This increases sensitivity at low load.

The final protection setting can be made only by way of a primary test with the generator.

Breaker failure protection (ANSI 50BF)

In the event of scheduled downtimes or a fault in the generator, the generator can remain on line if the circuit-breaker is defective and could suffer substantial damage.

Breaker failure protection evaluates a minimum current and the circuit-breaker auxiliary contact. It can be started by internal protective tripping or externally via binary input. Two-channel activation avoids overfunction (see Figure 11/41).

Inadvertent energization protection (ANSI 50, 27)

This protection has the function of limiting the damage of the generator in the event of an unintentional switch-on of the circuit-breaker, whether the generator is standing still or rotating without being excited or synchronized. If the power system voltage is connected, the generator starts as an asynchronous machine with a large slip and this leads to excessively high currents in the rotor.

A logic circuit consisting of sensitive current measurement for each phase, measured value detector, time control and blocking as of a minimum voltage, leads to an instantaneous trip command. If the fuse failure monitor responds, this function is ineffective.

Rotor earth-fault protection (ANSI 64R)

This protection function can be realized in three ways with the 7UM62. The simplest form is the method of rotor-current measurement (see sensitive earth-current measurement).

Resistance measurement at system-frequency voltage

The second form is rotor earth resistance measurement with voltage at system frequency (see Fig. 11/56). This protection measures the voltage injected and the flowing rotor earth current. Taking into account the complex impedance from the coupling device (7XR61), the rotor earth resistance is calculated by way of a mathematical model. By means of this method, the disturbing influence of the rotor earth capacitance is eliminated, and sensitivity is increased. Fault resistance values up to 30 kΩ can be measured if the excitation voltage is without disturbances. Thus, a two-stage protection function, which features a warning and a tripping stage, can be realized. An additionally implemented undercurrent stage monitors the rotor circuit for open circuit and issues an alarm.

Protection functions

Resistance measurement with a square wave voltage of 1 to 3 Hz

A higher sensitivity is required for larger generators. On the one hand, the disturbing influence of the rotor earth capacitance must be eliminated more effectively and, on the other hand, the noise ratio with respect to the harmonics (e.g. sixth harmonic) of the excitation equipment must be increased. Injecting a low-frequency square wave voltage into the rotor circuit has proven itself excellently here (see Figure 11/57).

The square wave voltage injected through the controlling unit 7XT71 leads to permanent recharging of the rotor earth capacitance. By way of a shunt in the controlling unit, the flowing earth current is measured and is injected into the protection unit (measurement input). In the absence of a fault ($R_E \approx \infty$), the rotor earth current after charging of the earth capacitance is close to zero. In the event of an earth fault, the fault resistance including the coupling resistance (7XR6004), and also the injecting voltage, defines the stationary current. The current square wave voltage and the frequency are measured via the second input (control input). Fault resistance values up to 80 kΩ can be measured by this measurement principle. The rotor earth circuit is monitored for discontinuities by evaluation of the current during the polarity reversals.

100% stator earth-fault protection with 20 Hz injection (ANSI 64 G (100%))

Injecting a 20 Hz voltage to detect earth faults even at the neutral point of generators has proven to be a safe and reliable method. Contrary to the third harmonic criterion (see page 11/8), it is independent of the generator's characteristics and the mode of operation. Measurement is also possible during system standstill (Fig. 11/55).

This protection function is designed so as to detect both earth faults in the entire generator (genuine 100 %) and all electrically connected system components.

The protection unit measures the injected 20 Hz voltage and the flowing 20 Hz current. The disturbing variables, for example stator earth capacitance, are eliminated by way of a mathematical model, and the ohmic fault resistance is determined.

On the one hand, this ensures high sensitivity and, on the other hand, it permits use of generators with large earth capacitance values, e.g. large hydroelectric generators.

Phase-angle errors through the earthing or neutral transformer are measured during commissioning and are corrected in the algorithm.

The protection function has a warning and tripping stage. The measurement circuit is also monitored and failure of the 20 Hz generator is measured.

Independent of earth resistance calculation, the protection function additionally evaluates the amount of the r.m.s. current value.

Starting time supervision (motor protection only) (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups, which might occur as a result of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked.

The tripping time is dependent on the square of the start-up current and the set start-up time (Inverse Characteristic). It adapts itself to the start-up with reduced voltage. The tripping time is determined in accordance with the following formula:

$$t_{\text{Trip}} = \left(\frac{I_{\text{start}}}{I_{\text{rms}}}\right)^2 \cdot t_{\text{start max}}$$

t_{Trip}	Tripping time
I_{start}	Permissible start-up current
$t_{\text{start max}}$	Permissible start-up time
I_{rms}	Measured r.m.s. current value

Calculation is not started until the current I_{rms} is higher than an adjustable response value (e.g. 2 $I_{\text{N, MOTOR}}$).

If the permissible locked-rotor time is less than the permissible start-up time (motors with a thermally critical rotor), a binary signal is set to detect a locked rotor by means of a tachometer generator. This binary signal releases the set locked-rotor time, and tripping occurs after it has elapsed.

DC voltage time protection/DC current time protection (ANSI 59N (DC) 51N (DC))

Hydroelectric generators or gas turbines are started by way of frequency starting converters. An earth fault in the intermediate circuit of the frequency starting converter causes DC voltage displacement and thus a direct current. As the neutral or earthing transformers have a lower ohmic resistance than the voltage transformers, the largest part of the direct current flows through them, thus posing a risk of destruction from thermal overloading.

As shown in Fig. 11/55, the direct current is measured by means of a shunt transformer (measuring transducer) connected directly to the shunt. Voltages or currents are fed to the 7UM62 depending on the version of the measuring transducer. The measurement algorithm filters out the DC component and takes the threshold value decision. The protection function is active as from 0 Hz.

If the measuring transducer transmits a voltage for protection, the connection must be interference-free and must be kept short.

The implemented function can also be used for special applications. Thus, the r.m.s. value can be evaluated for the quantity applied at the input over a wide frequency range.

Overcurrent protection during start-up (ANSI 51)

Gas turbines are started by means of frequency starting converters. Overcurrent protection during start-up measures short-circuits in the lower frequency level (as from about 5 Hz) and is designed as independent overcurrent-time protection. The pickup value is set below the rated current. The function is only active during start-up. If frequencies are higher than 10 Hz, sampling frequency correction takes effect and the further short-circuit protection functions are active.

Out-of-step protection (ANSI 78)

This protection function serves to measure power swings in the system. If generators feed to a system short-circuit for too long, low frequency transient phenomena (active power swings) between the system and the generator may occur after fault clearing. If the center of power swing is in the area of the block unit, the "active power surges" lead to unpermissible mechanical stressing of the generator and the turbine.

As the currents and voltages are symmetrical, the positive-sequence impedance is calculated on the basis of their positive-sequence components and the impedance trajectory is evaluated. Symmetry is also monitored by evaluation of the negative-phase-sequence current. Two characteristics in the R/X diagram describe the active range (generator, unit transformer or power system) of the out-of-step protection. The associated counters are incremented depending on the range of the characteristic in which the impedance vector enters or departs. Tripping occurs when the set counter value is reached.

Protection functions

The counters are automatically reset if power swing no longer occurs after a set time. By means of an adjustable pulse, every power swing can be signaled. Expansion of the characteristic in the R direction defines the power swing angle that can be measured. An angle of 120 ° is practicable. The characteristic can be tilted over an adjustable angle to adapt to the conditions prevailing when several parallel generators feed into the system.

Inverse undervoltage protection (ANSI 27)

Motors tend to fall out of step when their torque is less than the breakdown torque. This, in turn, depends on the voltage. On the one hand, it is desirable to keep the motors connected to the system for as long as possible while, on the other hand, the torque should not fall below the breakdown level. This protection task is realized by inverse undervoltage protection. The inverse characteristic is started if the voltage is less than the pickup threshold V_P<. The tripping time is inversely proportional to the voltage dip (see equation). The protection function uses the positive-sequence voltage, for the protection decision.

$$t_{\mathrm{TRIP}} = \frac{1}{1 - \frac{V}{V_{\mathrm{p}}}} \cdot T_{\mathrm{M}}$$

t_{TRIP}	Tripping time
V	Voltage
V_{p}	Pickup value
T_{M}	Time multiplier

System disconnection

Take the case of in-plant generators feeding directly into a system. The incoming line is generally the legal entity boundary between the system owner and the in-plant generator. If the incoming line fails as the result of auto-reclosure, for instance, a voltage or frequency deviation may occur depending on the power balance at the feeding generator. Asynchronous conditions may arise in the event of connection, which may lead to damage on the generator or the gearing between the generator and the turbine. Besides the classic criteria such as voltage and frequency, the following two criteria are also applied: vector jump, rate-of-frequency-change protection.

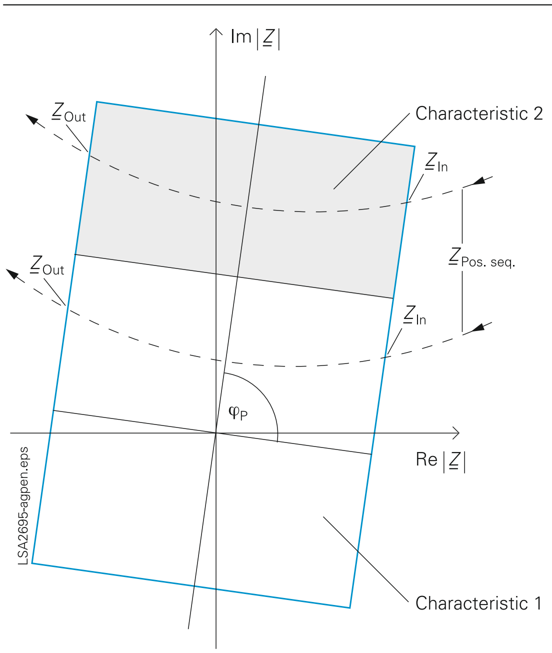


Fig. 11/42
Ranges of the characteristic and possible oscillation profiles.

Rate-of-frequency-change protection (ANSI 81)

The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed so that it reacts to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

Vector jump

Monitoring the phase angle in the voltage is a criterion for identifying an interrupted infeed. If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

Restart inhibit for motors (ANSI 66, 49Rotor)

When cold or at operating temperature, motors may only be connected a certain number of times in succession. The start-up current causes heat development in the rotor which is monitored by the restart inhibit function.

Contrary to classical counting methods, in the restart inhibit function the heat and cooling phenomena in the rotor are simulated by a thermal replica. The rotor temperature is determined on the basis of the stator currents. Restart inhibit permits restart of the motor only if the rotor has enough thermal reserve for a completely new start. Fig. 11/43 illustrates the thermal profile for a permissible triple start out of the cold state. If the thermal reserve is too low, the restart inhibit function issues a blocking signal with which the motor starting circuit can be blocked. The blockage is canceled again after cooling down and the thermal value has dropped below the pickup threshold.

As the fan provides no forced cooling when the motor is off, it cools down more slowly. Depending on the operating state, the protection function controls the cooling time constant. A value below a minimum current is an effective changeover criterion.

Sensitive earth-fault protection B (ANSI 51 GN)

The $I_{\mathrm{EE\text{-}B}}$ sensitive earth-fault protection feature of 7UM62 provides greater flexibility and can be used for the following applications:

- Any kind of earth-fault current supervision to detect earth faults (fundamental and 3$^{\mathrm{rd}}$ harmonics)
- Protection against load resistances
- Shaft current protection in order to detect shaft currents of the generator shaft and prevent that bearings take damage.

Protection functions

The sensitive earth-current protection $I_{\text{EE-B}}$ uses either the hardware input I_{EE1} or I_{EE2}. These inputs are designed in a way that allows them to cut off currents greater than 1.6 A (thermal limit, see technical data). This has to be considered for the applications or for the selection of the current transformers.

The shaft current protection function is of particular interest in conjunction with hydro-electric generators. Due to their construction, the hydroelectric generators have relatively long shafts. A number of factors such as friction, magnetic fields of the generators and others can build up a voltage across the shaft which then acts as voltage source (electro-motive force-emf). This inducted voltage of approx. 10 to 30 V is dependent on the load, the system and the machine.

If the oil film covering a bearing is too thin, breakdown can occur. Due to the low resistance (shaft, bearing and earthing), high currents may flow that destroy the bearing. Past experience has shown that currents greater than 1 A are critical for the bearings. As different bearings can be affected, the current entering the shaft is detected by means of a special transformer (folding transformer).

Interturn protection (ANSI 59N (IT))

The interturn fault protection detects faults between turns within a generator winding (phase). This situation may involve relatively high circulating currents that flow in the short-circuited turns and damage the winding and the stator. The protection function is characterized by a high sensitivity.

The displacement voltage is measured at the open delta winding by means of 3 two-phase isolated voltage transformers. So as to be insensitive towards earth faults, the isolated voltage transformer star point has to be connected to the generator star point by means of a high-voltage cable. The voltage transformer star point must not be earthed since this implies that the generator star point, too, would be earthed with the consequence that each fault would lead to a single-pole earth fault.

In the event of an interturn fault, the voltage in the affected phase will be reduced causing a displacement voltage that is detected at the broken delta winding. The sensitivity is limited rather by the winding asymmetries than by the protection unit.

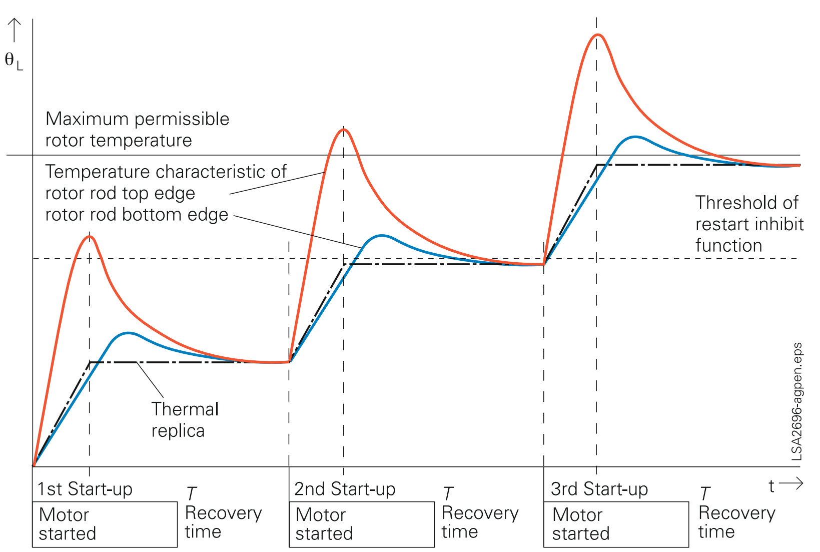


Fig. 11/43 Temperature characteristic at rotor and thermal replica of the rotor (multiple start-ups)

An FIR filter determines the fundamental component of the voltage based an the scanned displacement voltage. Selecting an appropriate window function has the effect that the sensitivity towards higher-frequency oscillations is improved and the disturbing influence of the third harmonic is eliminated while achieving the required measurement sensitivity.

External trip coupling

For recording and processing of external trip information, there are 4 binary inputs. They are provided for information from the Buchholz relay or generator-specific commands and act like a protection function. Each input initiates a fault event and can be individually delayed by a timer.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Phase rotation reversal

If the relay is used in a pumped-storage power plant, matching to the prevailing rotary field is possible via a binary input (generator/motor operation via phase rotation reversal).

2 pre-definable parameter groups

In the protection, the setting values can be stored in two data sets. In addition to the standard parameter group, the second group is provided for certain operating conditions (pumped-storage power stations). It can be activated via binary input, local control or DIGSI 4.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Fuse failure and other monitoring

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions.

The positive and negative-sequence system (voltage and current) are evaluated.

Filter time

All binary inputs can be subjected to a filter time (indication suppression).

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program during commissioning is particularly advantageous.

Rear-mounted interfaces

At the rear of the unit there is one fixed interface and two communication modules which incorporate optional equipment complements and permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces (electrical or optical) and protocols (IEC 60870, PROFIBUS, DIGSI).

The interfaces make provision for the following applications:

Service interface (fixed)

In the RS485 version, several protection units can be centrally operated with DIGSI 4. By using a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned substations.

System interface

This is used to communicate with a control or protection and control system and supports, depending on the module connected, a variety of communication protocols and interface designs. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is of the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for communication in the protected area.

IEC 60870-5-103 is supported by a number of protection unit manufacturers and is used worldwide.

The generator protection functions are stored in the manufacturer-specific, published part of the protocol.

PROFIBUS-DP

PROFIBUS is an internationally standardized communication system (EN 50170).

PROFIBUS is supported internationally by several hundred manufacturers.

With the PROFIBUS-DP, the protection can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and information from or to the logic (CFC).

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any faults.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

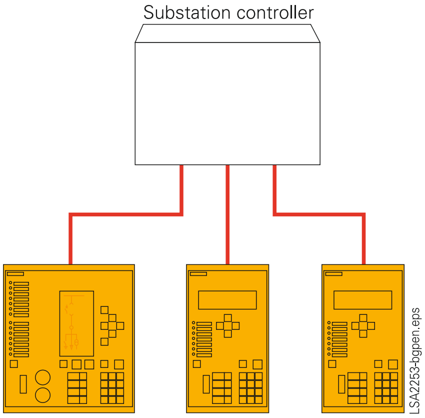


Fig. 11/44
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

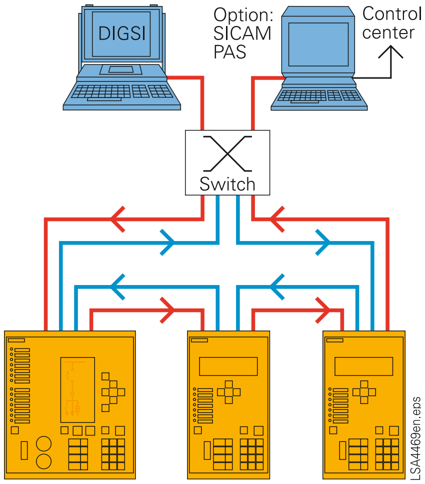


Fig. 11/45
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

Communication

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit.

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbit/s Ethernet bus, the unit are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 11/45).

Analog output 0 to 20 mA

Alternatively to the serial interfaces up to two analog output modules (4 channels) can be installed in the 7UM62.
Several operational measured values (I_1, I_2, V, P, Q, f, PF ($\cos\varphi$), Θ_{stator},Θ_{rotor}) can be selected and transmitted via the 0 to 20 mA interfaces.

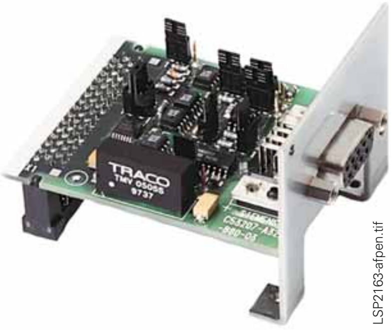


Fig. 11/46
RS232/RS485 electrical communication module

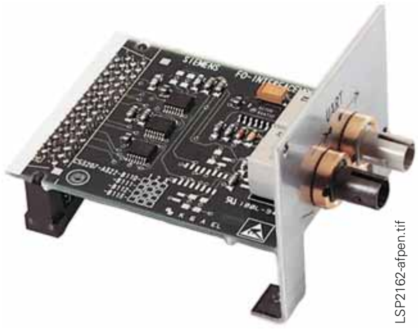


Fig. 11/47
820 nm fiber-optic communication module

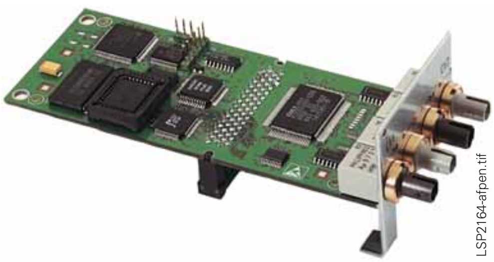


Fig. 11/48
PROFIBUS communication module, optical, double-ring

Fig. 11/49
Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

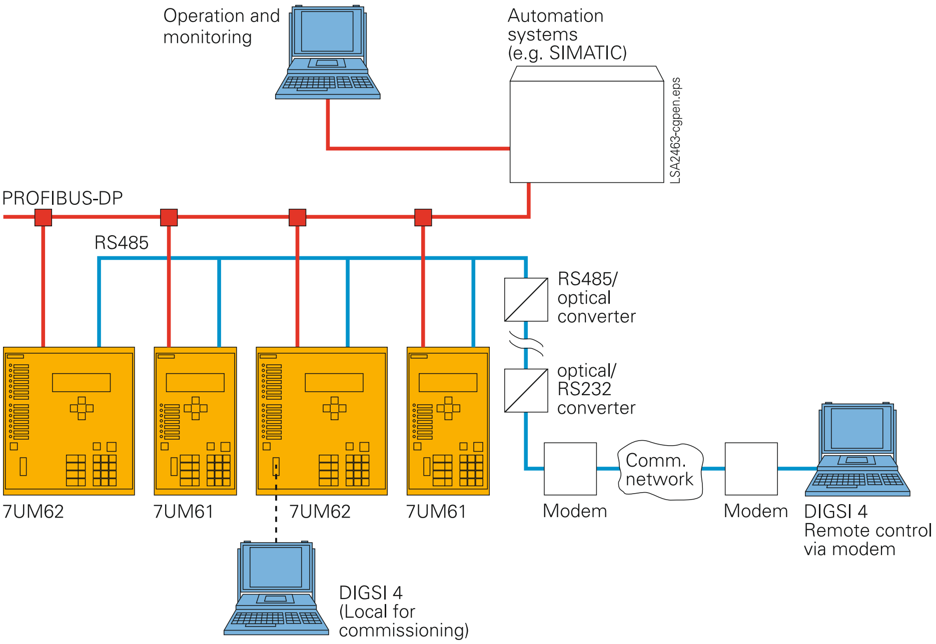


Fig. 11/50 System solution: Communications

Typical connections

Direct generator - busbar connection

Figure 11/51 illustrates the recommended standard connection when several generators supply one busbar. Phase-to-earth faults are disconnected by employing the directional earth-fault criterion. The earth-fault current is driven through the cables of the system.
If this is not sufficient, an earthing transformer connected to the busbar supplies the necessary current (maximum approximately 10 A) and permits a protection range of up to 90 %. The earth-fault current should be detected by means of core-balance current transformers in order to achieve the necessary sensitivity. The displacement voltage can be used as earth-fault criterion during starting operations until synchronization is achieved.

Differential protection embraces protection of the generator and of the outgoing cable. The permissible cable length and the current transformer design (permissible load) are mutually dependent. Recalculation is advisable for lengths of more than 100 m.

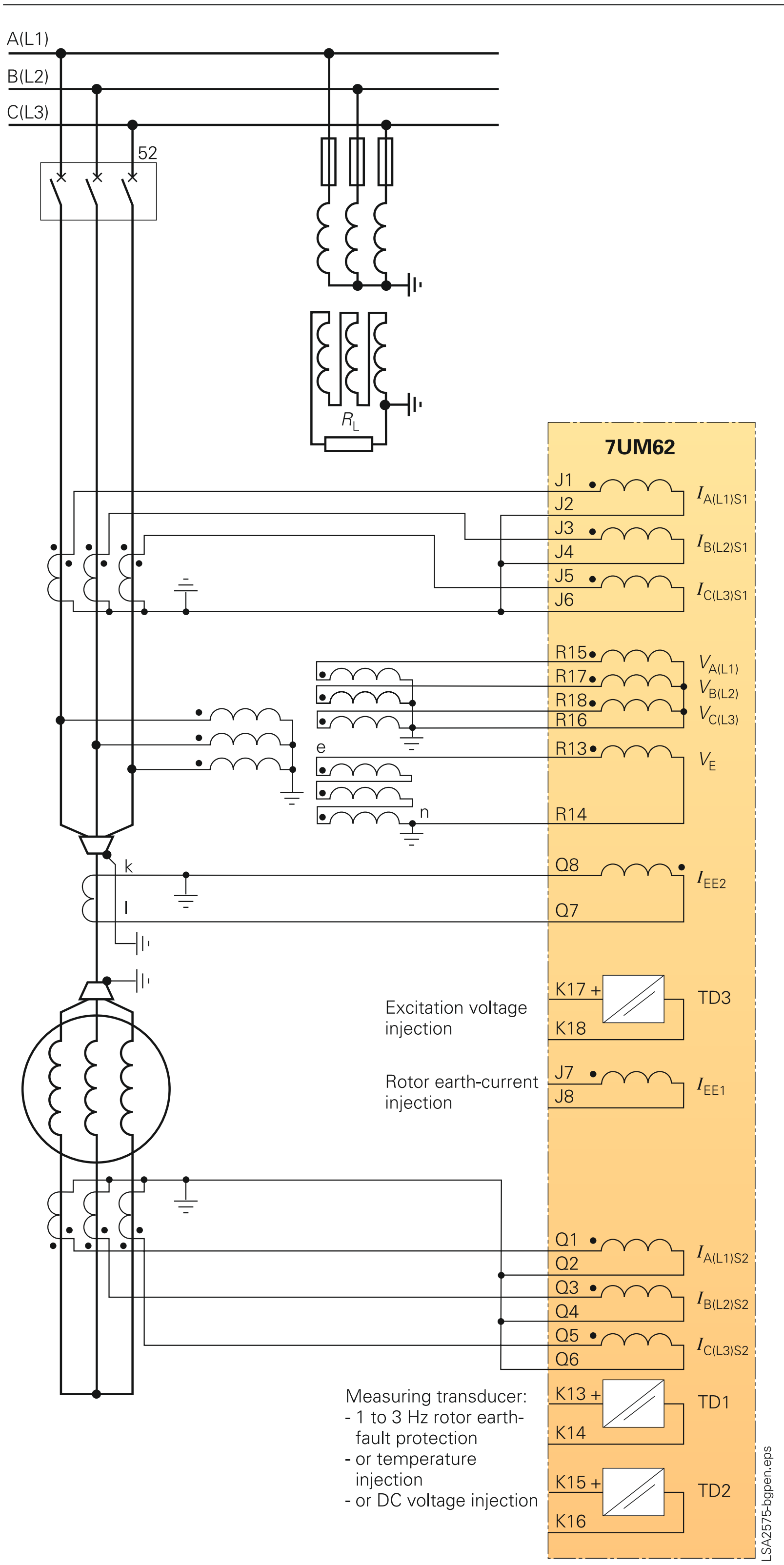


Fig. 11/51

Typical connections

Direct generator - busbar connection with low-resistance earthing

If the generator neutral point has low-resistance earthing, the connection illustrated in Fig. 11/52 is recommended. In the case of several generators, the resistance must be connected to only one generator, in order to prevent circulating currents (3rd harmonic).

For selective earth-fault detection, the earth-current input should be looped into the common return conductor of the two current transformer sets (differential connection). The current transformers must be earthed at only one point. The displacement voltage V_E is utilized as an additional enabling criterion.

Balanced current transformers (calibration of windings) are desirable with this form of connection. In the case of higher generator power (for example, I_N approximately 2000 A), current transformers with a secondary rated current of 5 A are recommended.

Earth-current differential protection can be used as an alternative (not illustrated).

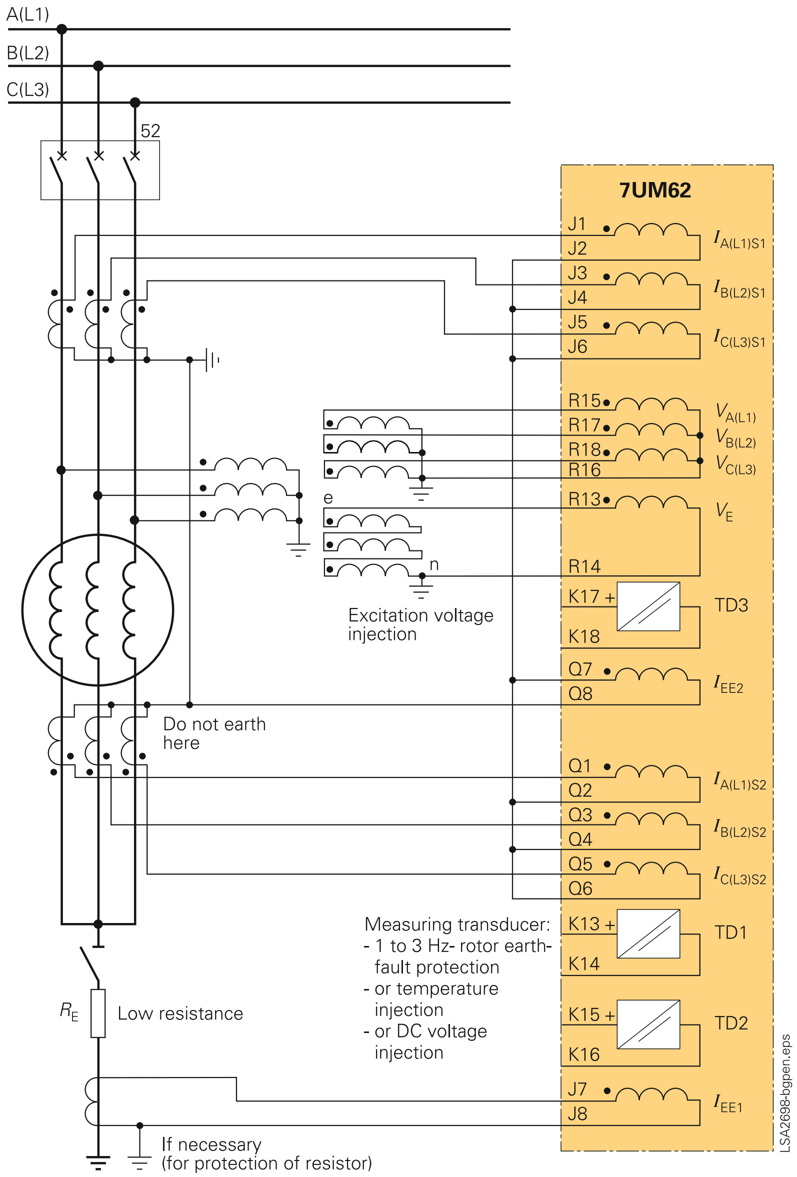


Fig. 11/52

Typical connections

Unit connection with isolated star point

This configuration of unit connection is a variant to be recommended (see Fig. 11/53). Earth-fault detection is effected by means of the displacement voltage. In order to prevent unwanted operation in the event of earth faults in the system, a load resistor must be provided at the broken delta winding. Depending on the plant (or substation), a voltage transformer with a high power (VA) may in fact be sufficient. If not, an earthing transformer should be employed. The available measuring winding can be used for the purpose of voltage measurement.

In the application example, differential protection is intended for the generator. The unit transformer is protected by its own differential relay (e.g. 7UT612).

As indicated in the figure, additional protection functions are available for the other inputs. They are used on larger generator/transformer units (see also Figures 11/56 and 11/58).

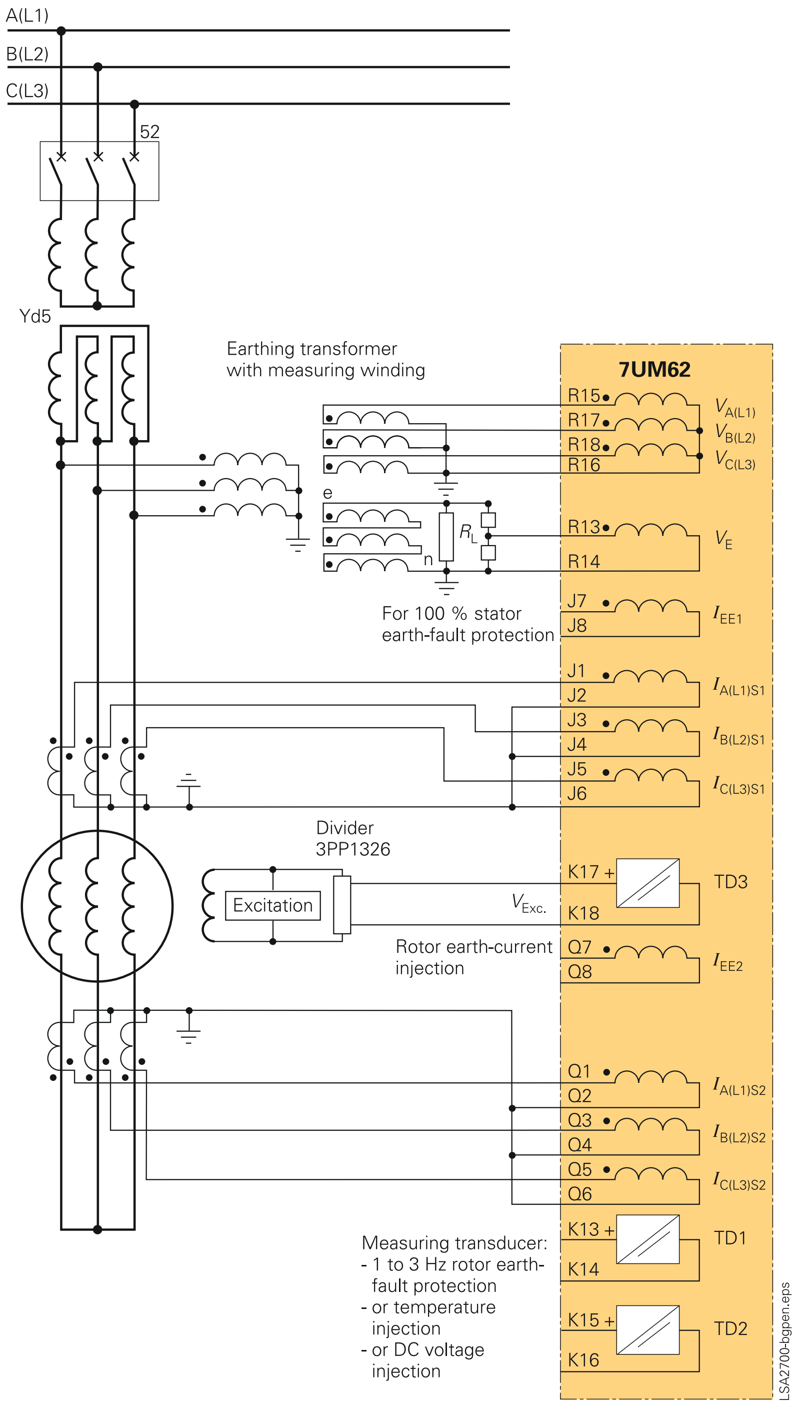


Fig. 11/53

Typical connections

Unit connection with neutral transformer

With this system configuration, disturbance voltage reduction and damping in the event of earth faults in the generator area are effected by a load resistor connected to the generator neutral point.

The maximum earth-fault current is limited to approximately 10 A. Configuration can take the form of a primary or secondary resistor with neutral transformer. In order to avoid low secondary resistance, the transformation ratio of the neutral transformer should be below

$$\left(\frac{V_{Gen}}{\sqrt{3}}\Big/500\,\text{V}\right)$$

The higher secondary voltage can be reduced by means of a voltage divider.

Electrically, the circuit is identical to the configuration in Fig. 11/53.

In the application opposite, the differential protection is designed as an overall function and embraces the generator and unit transformer. The protection function carries out vector group adaptation as well as other adaptations.

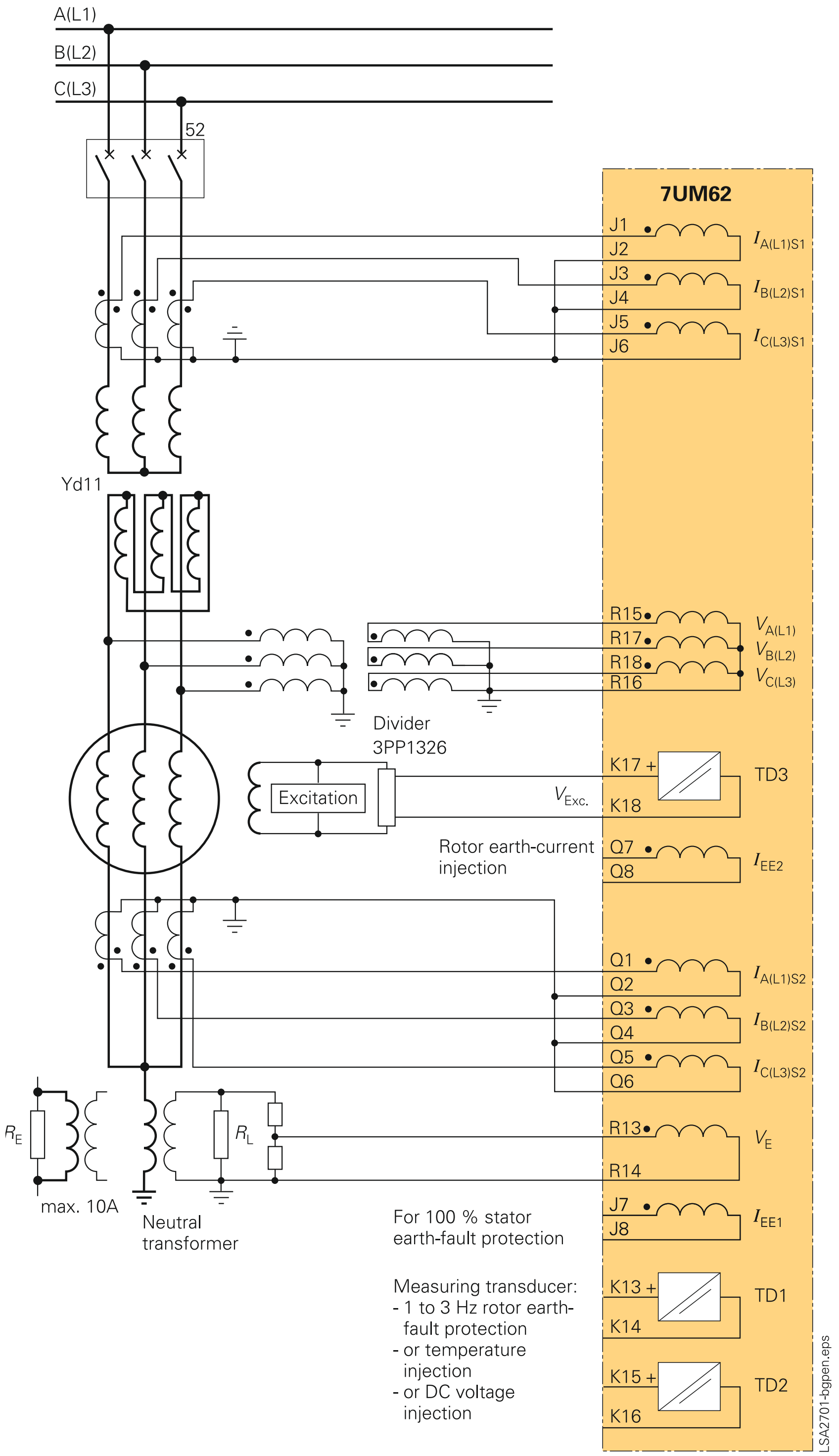


Fig. 11/54

Typical connections

Voltage transformer in open delta connection (V-connection)

Protection can also be implemented on voltage transformers in open delta connection (Fig. 11/55). If necessary, the operational measured values for the phase-to-earth voltages can be slightly asymmetrical. If this is disturbing, the neutral point (R16) can be connected to earth via a capacitor.

In the case of open delta connection, it is not possible to calculate the displacement voltage from the secondary voltages. It must be passed to the protection relay along a different path (for example, voltage transformer at the generator neutral point or from the earthing transformer).

100 % stator earth-fault protection, earth-fault protection during start-up

Fig. 11/56 illustrates the interfacing of 100 % stator earth-fault protection with voltage injection of 20 Hz, as meant for the example of the neutral transformer. The same interfacing connection also applies to the broken delta winding of the earthing transformer.

The 20 Hz generator can be connected both to the DC voltage and also to a powerful voltage transformer (>100 VA). The load of the current transformer 4NC1225 should not exceed 0.5 Ω.

The 7XT33, 7XT34 and load resistance connection must be established with a low resistance ($R_{\text{Connection}} < R_L$). If large distances are covered, the devices are accommodated in the earthing cubicle.

Connection of the DC voltage protection function (TD 1) is shown for systems with a starting converter. Depending on the device selection, the 7KG6 boosts the measured signal at the shunt to 10 V or 20 mA.

The TD 1 input can be jumpered to the relevant signal.

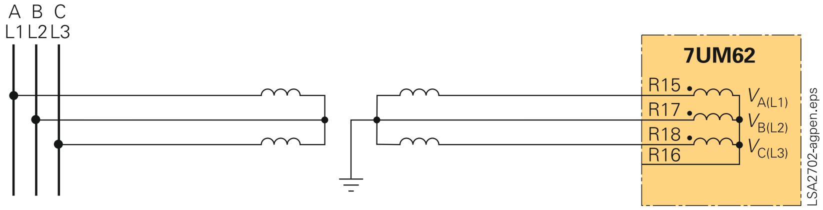


Fig. 11/55

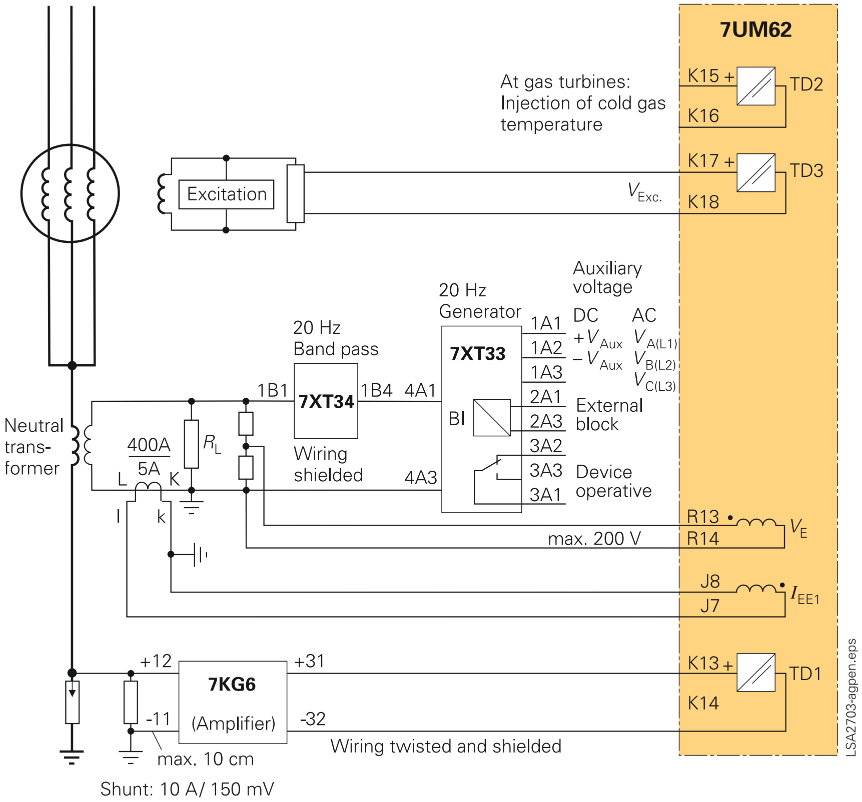


Fig. 11/56

Typical connections

Rotor earth-fault protection with voltage injection at rated frequency

Fig. 11/57 shows the connection of rotor earth-fault protection to a generator with static excitation. If only the rotor current is evaluated, there is no need for voltage connection to the relay.

Earth must be connected to the earthing brush. The external resistors 3PP1336 must be added to the coupling device 7XR61 if the circulating current can exceed 0.2 A as the result of excitation (sixth harmonic). This is the case as from a rated excitation voltage of >150 V, under worst-case conditions.

Rotor earth-fault protection with a square wave voltage of 1 to 3 Hz

The measuring transducers TD1 and TD2 are used for this application. The controlling unit 7XT71 generates a square wave voltage of about ± 50 V at the output. The frequency can be jumpered and depends on the rotor earth capacitance. Voltage polarity reversal is measured via the control input and the flowing circular current is measured via the measurement input. Earth must be connected to the earthing brush.

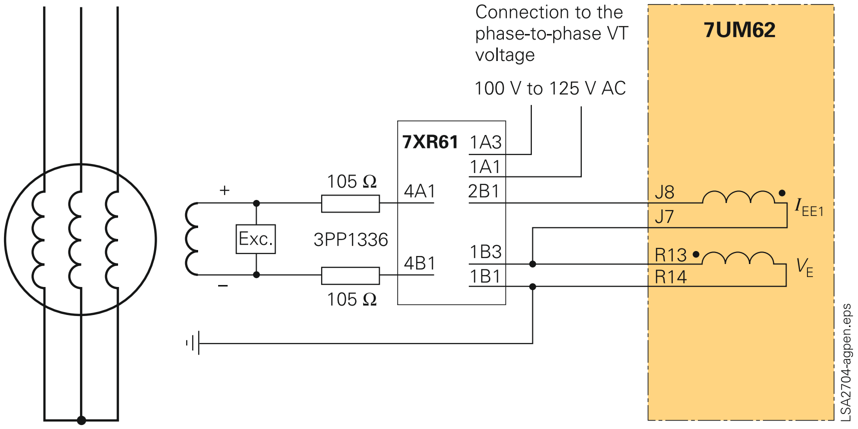


Fig. 11/57

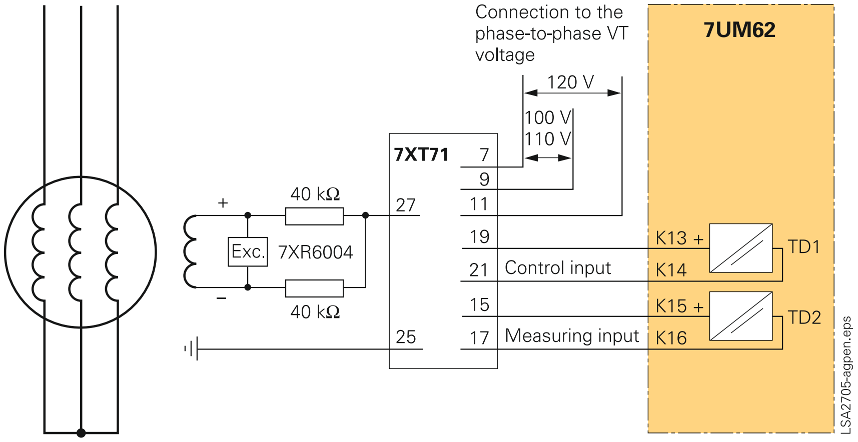


Fig. 11/58

Typical connections

Protection of an asynchronous motor

Fig. 11/59 shows a typical connection of the protection function to a large asynchronous motor. Differential protection embraces the motor including the cable. Recalculation of the permissible current transformer burden is advisable for lengths of more than 100 m.

The voltage for voltage and displacement voltage monitoring is generally tapped off the busbar. If several motors are connected to the busbar, earth faults can be detected with the directional earth-fault protection and selective tripping is possible. A core balance current transformer is used to detect the earth current. The chosen pickup value must be slightly higher if there are several cables in parallel.

The necessary shutdown of the motor in the event of idling can be realized with active power monitoring.

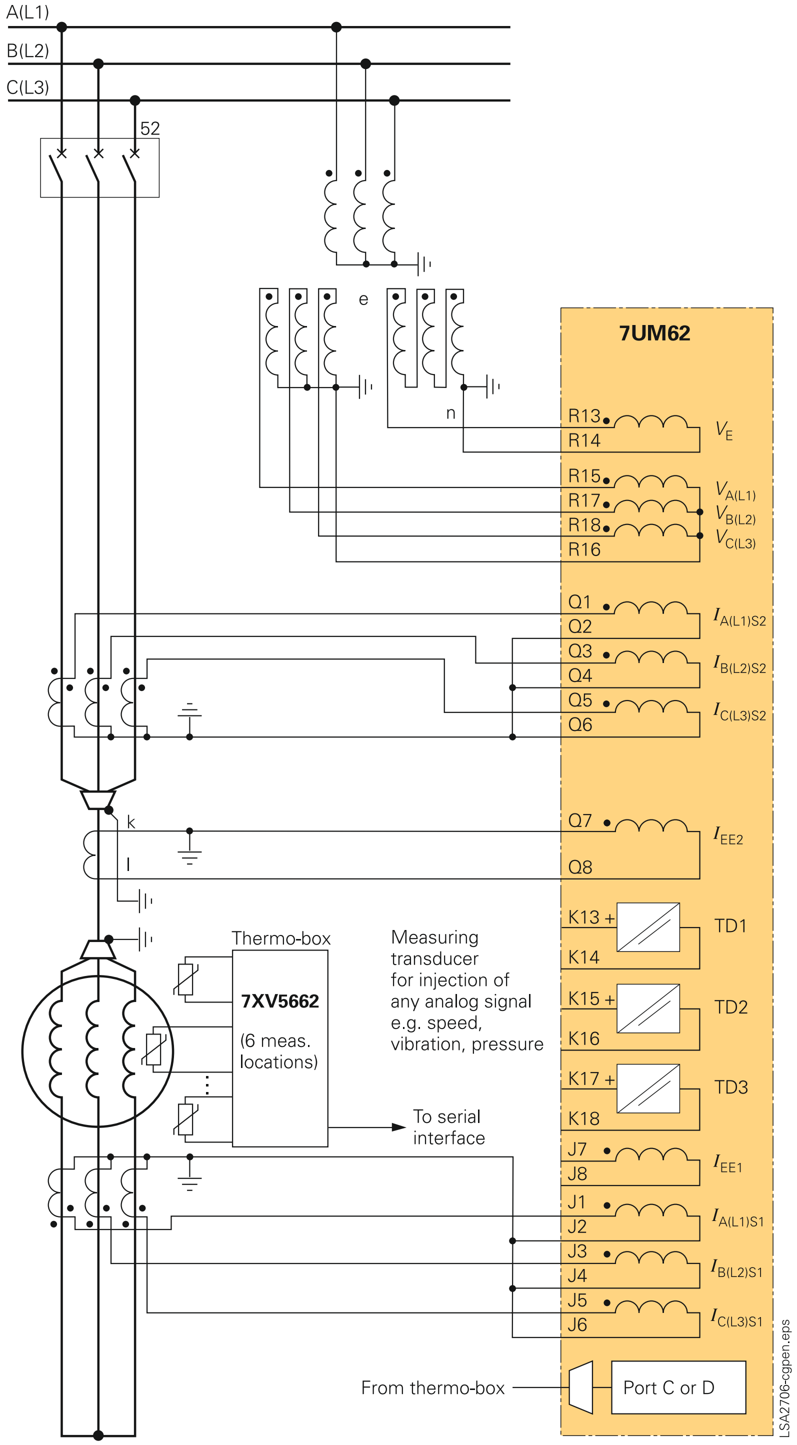


Fig. 11/59

Typical connections

Use of selected analog inputs

Several protection functions take recourse to the same analog inputs, thus ruling out certain functions depending on the application. One input may only be used by one protection function. A different combination can be used by the unit belonging to Protection Group 2, for example.

Multiple use refers to the sensitive earth-current inputs and the displacement voltage input (see Table 11/5).

The same applies to the measuring transducers (Table 11/6).

Current transformer requirements

The requirements imposed on the current transformer are determined by the differential protection function. The instantaneous trip stage (I_{Diff}>>) reliably masters (via the instantaneous algorithm) any high-current internal short-circuits.

The external short-circuit determines the requirements imposed on the current transformer as a result of the DC component. The non-saturated period of a flowing short-circuit current should be at least 5 ms. Table 11/7 shows the design recommendations.
IEC 60044-1 and 60044-6 were taken into account. The necessary equations are shown for converting the requirements into the knee-point voltages. The customary practice which presently applies should also be used to determine the rated primary current of the current transformer rated current. It should be greater than or equal to the rated current of the protected object.

	I_{EE1}	I_{EE2}	V_E
Sensitive earth-fault protection	X[1]	X[1]	
Directional stator earth-fault protection		X	X
Rotor earth-fault protection (f_n, R-measuring)	X		X
100 % stator earth-fault protection with 20 Hz voltage	X		X
Earth-current differential protection	X[1]	X[1]	

[1] optional (either I_{EE1} or I_{EE2})

Table 11/5: Multiple use of analog inputs

	TD1	TD2	TD3
Injection of excitation voltage			X
DC voltage time/DC current time protection	X		
Injection of a temperature		X	
Rotor earth-fault protection (1 to 3 Hz)	X	X	
Processing of analog values via CFC	X	X	X

Table 11/6: Multiple use of measuring transducers

Symmetrical short-circuit limiting factor

Required actual accuracy limiting factor	Resulting rated accuracy limiting factor
$K'_{ssc} = K_{td} \cdot \frac{I_{pssc}}{I_{pn}}$	$K_{ssc} = \frac{R'_b + R_{Ct}}{R_{BN} + R_{Ct}} \cdot K'_{ssc}$

Current transformer requirements

	Transformer	Generator
Transient dimensioning factor K_{td}	≥ 4 $\tau_N \leq 100$ ms	$>$ (4 to 5) $\tau_N > 100$ ms
Symmetrical short-circuit current I_{pssc}	$\approx \frac{1}{v_{sc}} \cdot I_{pn, Tr}$	$\approx \frac{1}{x''_d} \cdot I_{pn, G}$
Example	$v_{sc} = 0.1$ $K'_{ssc} > 40$	$x''_d = 0.12$ $K'_{ssc} >$ (34 to 42)
Note: Identical transformers have to be employed	Rated power ≥ 10 or 15 VA Example: Network transformer 10P10: (10 or 15) VA (I_{sn} = 1 or 5 A)	Note: Secondary winding resistance Example: $I_{N, G}$ approx. 1000 to 2000 A 5P15: 15 VA (I_{sn} = 1 or 5 A) $I_{N, G} >$ 5 000 A 5P20: 30 VA (I_{sn} = 1 or 5 A)

Knee-point voltage

IEC	British Standard	ANSI
$V = K_{ssc}(R_{ct} + R_b)I_{sn}$	$V = \frac{(R_{ct} + R_b)I_{sn}}{1.3} K_{ssc}$	$V = 20 \cdot I_{sn} \cdot (R_{ct} + R_b) \cdot \frac{K_{ssc}}{20}$ $I_{sn} = 5\text{A}$ (typical value)

K_{td}	Rated transient dimensioning factor	R_{ct}	Secondary winding resistance
I_{pssc}	Primary symmetrical short-circuit current	v_{sc}	Short-circuit voltage (impedance voltage)
I_{pn}	Rated primary current (transformer)	x''_d	Subtransient reactance
R'_b	Connected burden	I_{sn}	Rated secondary current (transformer)
R_b	Rated resistive burden	τ_N	Network time constant

Table 11/7: Recommendations for dimensioning

Technical data

Hardware

Analog input

Rated frequency	50 or 60 Hz
Rated current I_N	1 or 5 A
Earth current, sensitive I_{Emax}	1.6 A
Rated voltage V_N (at 100 V)	100 to 125 V
Measuring transducer	- 10 to + 10 V ($R_i = 1$ MΩ) or - 20 to + 20 mA ($R_i = 10$ Ω)
Power consumption	
With $I_N = 1$ A	Approx. 0.05 VA
With $I_N = 5$ A	Approx. 0.3 VA
For sensitive earth current	Approx. 0.05 VA
Voltage inputs (with 100 V)	Approx. 0.3 VA
Capability in CT circuits	
Thermal (r.m.s. values)	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak)	250 I_N (one half cycle)
Earth current, sensitive	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (peak)	750 A (one half cycle)
Capability in voltage paths	230 V continuous
Capability of measuring transducer	
As voltage input	60 V continuous
As current input	100 mA continuous

Auxiliary voltage

Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V/230 V AC with 50/60 Hz
Permitted tolerance	–20 to +20 %
Superimposed (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	
7UM621	Approx. 5.3 W
7UM622	Approx. 5.5 W
7UM623	Approx. 8.1 W
During pickup with all inputs and outputs activated	
7UM621	Approx. 12 W
7UM622	Approx. 15 W
7UM623	Approx. 14.5 W
Bridging time during auxiliary voltage failure	
at $V_{aux} = 48$ V and $V_{aux} \geq 110$ V	≥ 50 ms
at $V_{aux} = 24$ V and $V_{aux} = 60$ V	≥ 20 ms

Binary inputs

Number	
7UM621, 7UM623	7
7UM622	15
3 pickup thresholds Range is selectable with jumpers	10 to 19 V DC or 44 to 88 V DC 88 to 176 V DC
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

Output relays

Number	
7UM621	12 (1 NO; 4 optional as NC, via jumper)
7UM622	21 (1 NO; 5 optional as NC, via jumper)
Switching capacity	
Make	1000 W / VA
Break	30 VA
Break (for resistive load)	40 W
Break (for L/R ≤ 50 ms)	25 VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds

LED

Number	
RUN (green)	1
ERROR (red)	1
Assignable LED (red)	14

Unit design

7XP20 housing	For dimensions see dimension drawings, part 15
Degree of protection acc. to EN 60529	
For surface-mounting housing	IP 51
For flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 2x with terminal cover put on
Weight	
Flush-mounting housing	
7UM621/7UM623 (1/2 x 19″)	Approx. 7 kg
7UM622 (1/1 x 19″)	Approx. 9.5 kg
Surface-mounting housing	
7UM621/7UM623 (1/2 x 19″)	Approx. 12 kg
7UM622 (1/1 x 19″)	Approx. 15 kg

Serial interfaces

Operating interface for DIGSI 4

Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector
Baud rate	4800 to 115200 baud

Time synchronization IRIG B / DCF 77 signal (Format: IRIG-B000)

Connection	9-pin subminiature connector, terminal with surface-mounting case
Voltage levels	Selectable 5 V, 12 V or 24 V

Service/modem interface (Port C) for DIGSI 4 / modem / service

Isolated RS232/RS485	9-pin subminiature connector
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

Technical data

System interface (Port B) IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU

Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 115200 baud
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Test voltage	500 V / 50 Hz
Baud rate	Max. 12 MBaud
Distance	1000 m at 93.75 kBaud; 100 m at 12 MBaud
PROFIBUS fiber-optic	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[1)]
Baud rate	Max. 1.5 MBaud
Optical wavelength	$\lambda = 820$ nm
Permissible path attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	1.6 km (500 kB/s) 530 m (1500 kB/s)
Analog output module (electrical)	2 ports with 0 to 20 mA

System interface (Port B) IEC 61850

Ethernet, electrical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit/s acc. to IEEE802.3
for surface-mounting case	At bottom part of the housing
Test voltage	500 V; 50 Hz
Transmission speed	100 Mbits/s
Distance	20 m/66 ft
Ethernet, optical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", LC connector receiver/transmitter
for panel surface-mounting case	Not available
Optical wavelength	$\lambda = 1350$ nm
Transmission speed	100 Mbits/s
Laser class 1 acc. to EN 60825-1/-2	Glass fiber 50/125 µm or glass fiber 62/125µm
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125 µm
Distance	Max. 800 m/0.5 mile

Electrical tests

Specifications

Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below

Insulation tests

Standards	IEC 60255-5
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) only isolated communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for noise immunity; type test

Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; $\tau = 15$ ms 400 pulses per s; duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated, IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω, 9 µF Differential (transversal) mode: 1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	Common (longitudinal) mode: 2 kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; duration 2 s; $R_i = 150$ to $200\ \Omega$
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200\ \Omega$

---

1) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order code L0A (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Technical data

EMC tests for interference emission; type tests

Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests

Vibration, shock stress and seismic vibration

<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress test

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	–25 °C to +85 °C / –13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	–20 °C to +70 °C / –4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	–5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	–25 °C to +55 °C / –13 °F to +131 °F
– Limiting temperature during transport	–25 °C to +70 °C / –13 °F to +158 °F

Humidity

Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permitted

Functions

General

Frequency range	11 to 69 Hz

Definite-time overcurrent protection, directional (ANSI 50, 51, 67)

Setting ranges	
Overcurrent $I>$, $I>>$	0.05 to 20 A (steps 0.01 A); 5 times at $I_N = 5$ A
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1 V)
Seal-in time of $V<$	0.1 to 60 s (steps 0.01 s)
Angle of the directional element (at $I>>$)	- 90 ° to + 90 ° (steps 1 °)
Times	
Pickup time $I>$, $I>>$	
at 2 times of set value	Approx. 35 ms
at 10 times of set value	Approx. 25 ms
Drop-off time $I>$, $I>>$	Approx. 50 ms
Drop-off ratio	$I>$: 0.95; $I>>$: 0.9 to 0.99 (steps 0.01)
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Current pickup (starting) $I>$, $I>>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Angle of the directional element	1 °
Time delays	1 % or 10 ms

Inverse-time overcurrent protection (ANSI 51V)

Setting ranges	
Pickup overcurrent I_P	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$A
Time multiplier IEC-characteristics T	0.05 to 3.2 s (steps 0,01 s) or indefinite
Time multiplier ANSI-characteristics D	0.5 to 15 (steps 0.01) or indefinite
Undervoltage release $V<$	10 to 125 V (steps 0.1 V)
Trip characteristics	
IEC	Normal inverse; very inverse; extremely inverse
ANSI	Inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Pickup threshold	Approx. 1.1 I_P
Drop-off threshold	Approx. 1.05 I_P for $I_P/I_N \geq 0.3$
Tolerances	
Pickup threshold I_P	1 % of set value or 10/50 mA
Pickup threshold $V<$	1 % of set value or 0.5 V
Time for $2 \leq I/I_P \leq 20$	5 % of nominal value + 1 % current tolerance or 40 ms

Technical data

Stator overload protection, thermal (ANSI 49)

Setting ranges	
Factor k according to IEC 60255-8	0.5 to 2.5 (steps 0.01)
Time constant	30 to 32000 s (steps 1 s)
Time delay factor at stand still	1 to 10 (steps 0.01)
Alarm overtemperature $\Theta_{Alarm}/\Theta_{Trip}$	70 to 100 % related to the trip temperature (steps 1 %)
Overcurrent alarm stage I_{Alarm}	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$ A
Temperature at I_N	40 to 200 °C (steps 1 °C) or 104 to 392 °F (steps 1 °F)
Scaling temperature of cooling medium	40 to 300 °C (steps 1 °C) or 104 to 572 °F (steps 1 °F)
Limit current I_{Limit}	0.5 to 8 A (steps 0.01), 5 times at $I_N = 5$ A
Reset time at emergency start	20 to 150000 s (steps 1 s)
Drop-off ratio	
Θ / Θ_{Trip}	Drop-off with Θ_{Alarrn}
Θ / Θ_{Alarrm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.95
Tolerances	
Regarding k x I_N	2 % or 10/50 mA; class 2 % according to IEC 60255-8
Regarding trip time	3 % or 1 s: class 3 % according to IEC 60255-8 for $I/(k\ I_N)>1.25$

Negative-sequence protection (ANSI 46)

Setting ranges	
Permissible negative sequence $I_{2\ perm.}/I_N$	3 to 30 % (steps 1 %)
Definite time trip stage $I_2>>/I_N$	10 to 200 % (steps 1 %)
Time delays T_{Alarm}; $T_{I2>>}$	0 to 60 s (steps 0.01 s) or indefinite
Negative-sequence factor K	1 to 40 s (steps 0.1 s)
Cooling down time $T_{Cooling}$	0 to 50000 s (steps 1 s)
Times	
Pickup time (definite stage)	Approx. 50 ms
Drop-off time (definite stage)	Approx. 50 ms
Drop-off ratios $I_{2\ perm.}$; $I_2>>$	Approx. 0.95
Drop-off ratio thermal stage	Drop-off at fall below of $I_{2\ perm.}$
Tolerances	
Pickup values $I_{2\ perm.}$; $I_2>>$	3 % of set value or 0.3 % negative sequence
Time delays	1 % or 10 ms
Thermal characteristic	5 % of set point + 1 % current tolerance
Time for $2 \leq I_2/I_{2\ perm.} \leq 20$	or 600 ms

Underexcitation protection (ANSI 40)

Setting ranges	
Conductance thresholds 1/xd characteristic (3 characteristics)	0.20 to 3.0 (steps 0.01)
Inclination angle $\alpha_1, \alpha_2, \alpha_3$	50 to 120 ° (steps 1 °)
Time delay T	0 to 50 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Times	
Stator criterion 1/xd characteristic; α	Approx. 60 ms
Undervoltage blocking	Approx. 50 ms
Drop-off ratio	
Stator criterion 1/xd characteristic; α	Approx. 0.95
Undervoltage blocking	Approx. 1.1
Tolerances	
Stator criterion 1/xd characteristic	3 % of set value
Stator criterion α	1 ° electrical
Undervoltage blocking	1 % or 0.5 V
Time delays T	1 % or 10 ms

Reverse-power protection (ANSI 32R)

Setting ranges	
Reverse power $P_{Rev.}>/S_N$	- 0.5 to - 30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.}>$	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.}>$	0.25 % S_N ± 3 % set value
Time delays T	1 % or 10 ms

Forward-power protection (ANSI 32F)

Setting ranges	
Forward power $P_{Forw.}</S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{Forw.}>/S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{Forw.}<$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{Forw.}>$	Approx. 0.9 or – 0.5 % of S_N
Tolerances	
Active power $P_{Forw.}<$, $P_{Forw.}>$	0.25 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at accurate measuring 0.5 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at fast measuring
Time delays T	1 % or 10 ms

Technical data

***Impedance protection** (ANSI 21)*

Setting ranges	
Overcurrent pickup $I>$	0.1 to 20 A (steps 0.01 A); 5 times at $I_N = 5A$
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1V)
Impedance Z1 (related to I_N =1 A)	0.05 to 130 Ω (steps 0.01 Ω)
Impedance Z1B (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Impedance Z2 (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Shortest tripping time	Approx. 40 ms
Drop-off time	Approx. 50 ms
Drop-off ratio	
Overcurrent pickup $I>$	Approx. 0.95
Undervoltage seal-in $V<$	Approx. 1.05
Tolerances	
Overcurrent pickup $I>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Impedance measuring Z1, Z2	$\lvert\Delta Z/Z\rvert \leq 5$ % for 30 ° $\leq \varphi_K \leq$ 90 °
Time delays T	1 % or 10 ms

***Undervoltage protection (definite-time and inverse-time function)** (ANSI 27)*

Setting range	
Undervoltage pickup $V<$, $V<<$, $V_p<$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time multiplier T_M	0.1 to 5 s (steps 0.01 s)
Times	
Pickup time $V<$, $V<<$	Approx. 50 ms
Drop-off time $V<$, $V<<$	Approx. 50 ms
Drop-off ratio $V<$, $V<<$, $V_p<$	1.01 or 0.5 V
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Inverse-time characteristic	1 % of measured value of voltage

***Overvoltage protection** (ANSI 59)*

Setting ranges	
Overvoltage pickup $V>$, $V>>$ (maximum phase-to-phase voltage or phase-to-earth-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Drop-off times $V>$, $V>>$	Approx. 50 ms
Drop-off ratio $V>$, $V>>$	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms

***Frequency protection** (ANSI 81)*

Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	3 stages 0 to 100 s, 1 stage up to 600 s
Undervoltage blocking $V_1<$	(steps 0.01 s)
	10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms
Drop-off times $f>$, $f<$	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V_1<$	Approx. 1.05
Tolerances	
Frequency	10 mHz (at $V>$ 0.5 V_N)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

***Overexcitation protection (Volt/Hertz)** (ANSI 24)*

Setting ranges	
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Pickup threshold $V/f>>$-stage	1 to 1.4 (steps 0.01)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Characteristic values of V/f	1.05/1.1/1.15/1.2/1.25/1.3/1.35/1.4
and assigned times t(V/f)	0 to 20000 s (steps 1 s)
Cooling down time $T_{Cooling}$	0 to 20000 s (steps 1 s)
Times (Alarm and $V/f>>$-stage)	
Pickup times at 1.1 of set value	Approx. 60 ms
Drop-off times	Approx. 60 ms
Drop-off ratio (alarm, trip)	0.95
Tolerances	
V/f-pickup	3 % of set value
Time delays T	1 % or 10 ms
Thermal characteristic (time)	5 % rated to V/f or 600 ms

***90 % stator earth-fault protection, non-directional, directional** (ANSI 59N, 64G, 67G)*

Setting ranges	
Displacement voltage V_0 >	2 to 125 V (steps 0.1 V)
Earth current $3I_0>$	2 to 1000 mA (steps 1 mA)
Angle of direction element	0 to 360 ° (steps 1 °)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times $V_0>$, $3I_0>$	Approx. 50 ms
Drop-off times $V_0>$/ $3I_0>$	Approx. 50 ms
Drop-off ratio $V_0>$, $3I_0>$	0.95
Drop-off difference angle	10 ° directed to power system
Tolerances	
Displacement voltage	1 % of set value or 0.5 V
Earth current	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms

Technical data

Sensitive earth-fault protection (ANSI 50/51GN, 64R)

Setting ranges	
Earth current pickup $I_{EE}>$, $I_{EE}>>$	2 to 1000 mA (steps 1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Measuring circuit supervision $I_{EE}<$	1.5 to 50 mA (steps 0.1 mA)
Times	
Pickup times	Approx. 50 ms
Drop-off times	Approx. 50 ms
Measuring circuit supervision	Approx. 2 s
Drop-off ratio $I_{EE}>$, $I_{EE}>>$	0.95 or 1 mA
Drop-off ratio measuring circuit supervision $I_{EE}<$	Approx. 1.1 or 1 mA
Tolerances	
Earth current pickup	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms

100 % stator earth-fault protection with 3rd harmonic (ANSI 59TN, 27TN) (3rd H.)

Setting ranges	
Displacement voltage $V_{0\,(3\text{rd harm.})}>$, $V_{0\,(3\text{rd harm.})}<$	0.2 to 40 V (steps 0.1 V)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Active-power release	10 to 100 % (steps 1 %) or indefinite
Positive-sequence voltage release	50 to 125 V (steps 0.1 V) or indefinite
Times	
Pickup time	Approx. 80 ms
Drop-off time	Approx. 80 ms
Drop-off ratio	
Undervoltage stage $V_{0\,(3\text{rd harm.})}<$	Approx. 1.4
Overvoltage stage $V_{0\,(3\text{rd harm.})}>$	Approx. 0.6
Active-power release	Approx. 0.9
Positive-sequence voltage release	Approx. 0.95
Tolerances	
Displacement voltage	3 % of set value or 0.1 V
Time delay T	1 % or 10 ms

Breaker failure protection (ANSI 50BF)

Setting ranges	
Current thresholds I>BF	0.04 to 1 A (steps 0.01 A)
Time delay BF-T	0.06 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 50 ms
Drop-off time	Approx. 50 ms
Tolerances	
Current threshold I>BF/I_N	1 % of set value or 10/50 mA
Time delay T	1 % or 10 ms

Inadvertent energizing protection (ANSI 50, 27)

Setting ranges	
Current pickup $I>>>$	0.1 to 20 A (steps 0.1 A); 5 times at I_N= 5 A
Voltage release $V_1<$	10 to 125 V (steps 1 V)
Time delay	0 to 60 s (steps 0.01 s) or indefinite
Drop-off time	0 to 60 s (steps 0.01 s) or indefinite
Times	
Reaction time	Approx. 25 ms
Drop-off time	Approx. 35 ms
Drop-off ratio $I>>>$	Approx. 0.8
Drop-off ratio $V_1<$	Approx. 1.05
Tolerances	
Current pickup	5 % of set value or 20/100 mA
Undervoltage seal-in $V_1<$	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

Current differential protection (ANSI 87G, 87M, 87T)

Setting ranges	
Differential current $I_D>I_N$	0.05 to 2 (steps 0.01)
High-current stage $I_D>>I_N$	0.8 to 12 (steps 0.1)
Inrush stabilization ratio I_{2fN}/I_N	10 to 80 (steps 1 %)
Harmonic stabilization ratio I_{nfN}/I_N (n=3rd or 4th or 5th harmonics)	10 to 80 (steps 1 %)
Additional trip time delay T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time ($I_D \geq$ 1.5 setting value $I_D>$)	Approx. 35 ms
Pickup time ($I_D \geq$ 1.5 setting value $I_D>>$)	Approx. 20 ms
Drop-off time	Approx. 35 ms
Drop-off ratio	Approx. 0.7
Tolerances	
Pickup characteristic	3 % of set value or 0.01 I/I_N
Inrush stabilization	3 % of set value or 0.01 I/I_N
Additional time delays	1 % or 10 ms

Earth-current differential protection (ANSI 87GN, 87TN)

Setting ranges	
Differential current $I_{E\text{-}D}>/I_N$	0.01 to 1 (steps 0.01)
Additional trip time delay	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time ($I_{E\text{-}D} \geq$ 1.5 setting value $I_{E\text{-}D}>$)	Approx. 50 ms
Drop-off time	Approx. 50 ms
Drop-off ratio	Approx. 0.7
Tolerances	
Pickup characteristic	3 % of set value
Additional time delay	1 % or 10 ms

Technical data

Rotor earth-fault protection with f_N *(ANSI 64R) (f_N)*

Setting ranges	
Alarm stage $R_{E, Alarrn}$ <	3 to 30 kΩ (steps 1 kΩ)
Trip stage $R_{E, Trip}$ <	1.0 to 5 kΩ (steps 0.1 kΩ)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Correction angle	- 15 ° to + 15 ° (steps 1 °)
Times	
Pickup time	≤ 80 ms
Drop-off time	≤ 80 ms
Drop-off ratio	Approx. 1.25
Tolerances	
Trip stage $R_{E, Trip}$ <,	Approx. 5 % of set value
Alarm stage $R_{E, Alarm}$ <	Approx. 10 % of set value
Time delays T	1 % or 10 ms
Permissible rotor earth capacitance	0.15 to 3 µF

Sensitive rotor fault protection with 1 to 3 Hz *(ANSI 64R) (1 to 3 Hz)*

Setting ranges	
Alarm stage $R_{E,Alarm}$ <	5 to 80 kΩ (steps 1 kΩ)
Trip stage $R_{E, Trip}$ <	1 to 10 kΩ (steps 1 kΩ)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Pickup value of meas. circuit supervision Q_C<	0.01 to 1 mAs (steps 0.01 mAs)
Times	
Pickup time	Approx. 1 to 1.5 s (depends on frequency of 7XT71)
Drop-off time	Approx. 1 to 1.5 s
Drop-off ratio R_E	Approx 1.25
Drop-off ratio Q_C <	1.2 or 0.01 mAs
Tolerances	
Trip stage ($R_{E,Trip}$ <; Alarm stage $R_{E, Alarm}$<)	Approx. 5 % or 0.5 kΩ at 0.15 µF ≤ C_E < 1µF Approx. 10 % or 0.5 kΩ at 1 µF ≤ C_E < 3 µF
Time delays T	1 % or 10 ms
Permissible rotor earth-capacitance	0.15 to 3 µF

100 % stator earth-fault protection with 20 Hz *(ANSI 64G) (100 %)*

Setting ranges	
Alarm stage R_{SEF} <	20 to 500 Ω (steps 1 Ω)
Trip stage R_{SEF} <<	10 to 300 Ω (steps 1 Ω)
Earth current stage I_{SEF} >	0.02 to 1.5 A (steps 0.01 A)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Supervision of 20 Hz generator	
$V_{20 Hz}$	0.3 to 15 V (steps 0.1 V)
$I_{20 Hz}$	5 to 40 mA (steps 1 mA)
Correction angle	- 60 ° to + 60 ° (steps 1 °)
Times	
Pickup times R_{SEF}<, R_{SEF}<<	≤ 1.3 s
Pickup time I_{SEF}>	≤ 250 ms
Drop-off times R_{SEF}<, R_{SEF}<<	≤ 0.8 s
Drop-off time I_{SEF}>	≤ 120 ms
Drop-off ratio	Approx. 1.2 to 1.7
Tolerances	
Resistance (R_{SEF})	ca. 5 % or 2 Ω
Earth current stage (I_{SEF} >)	3 % or 3 mA
Time delays T	1 % or 10 ms

Out-of-step protection *(ANSI 78)*

Setting ranges	
Positive sequence current pickup I_1>	0.2 to 4 I_1/I_N (steps 0.1 I_1/I_N)
Negative-sequence current pickup I_2<	0.05 to 1 I_2/I_N (steps 0.01 I_2/I_N)
Impedances Z_a to Z_d (based on I_N =1 A)	0.05 to 130 Ω (steps 0.01 Ω)
Inclination angle of polygon φ_P	60 to 90 ° (steps 1 °)
Number of out-of-step periods characteristic 1	1 to 10
Number of out-of-step periods characteristic 2	1 to 20
Holding time of pickup t_H	0.2 to 60 s (steps 0.01 s)
Holding time for out-of-step annunciation	0.02 to 0.15 s (steps 0.01 s)
Times	
Typical trip time	Depending from the out-of-step frequency
Tolerances	
Impedance measurement	$\|\Delta Z/Z\|$ ≤ 5 % for 30 ° ≤ φ_{SC} ≤ 90 ° or 10 mΩ
Time delays T	1 % to 10 ms

DC voltage time / DC current time protection *(ANSI 59N (DC) ; 51N (DC))*

Setting ranges	
Voltage pickup V = >,<	0.1 to 8.5 V (steps 0.1 V)
Current pickup I = >, <	0.2 to 17 mA (steps 0.1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (operational condition 1)	Approx. 60 ms
Pickup time (operational condition 0)	Approx. 200 ms
Drop-off time	Approx. 60 ms or 200 ms
Drop-off ratio	0.9 or 1.1
Tolerances	
Voltage	1 % of set value, or 0.1 V
Current	1 % of set value, or 0.1 mA
Time delays T	1 % or 10 ms

Starting time supervision for motors *(ANSI 48)*

Setting ranges	
Motor starting current $I_{Start\ max}$ $/I_N$	1.0 to 16 (steps 0.01)
Starting current pickup $I_{Start, pickup.}$ $/I_N$	0.6 to 10 (steps 0.01)
Permissible starting time $T_{Start\ max}$	1.0 to 180 s (steps 0.1 s)
Permissible locked rotor time $T_{Blocking}$	0.5 to 120 s (steps 0.1 s) or indefinite
Times	Depending on the settings
Drop-off ratio	Approx. 0.95
Tolerances	
Current threshold	1 % of set value, or 1 % of I_N
Time delays T	5 % or 30 ms

Technical data

Restart inhibit for motors *(ANSI 66, 49 Rotor)*

Setting ranges	
Motor starting current $I_{\text{Start max}}$ /I_{N}	3.0 to 10.0 (steps 0.01)
Permissible starting time $T_{\text{Start max}}$	3.0 to 120.0 s (steps 0.1 s)
Rotor temperature equalization time $T_{\text{Equali.}}$	0 to 60.0 min (steps 0.1 min)
Minimum restart inhibit time $T_{\text{Restart, min}}$	0.2 to 120.0 min (steps 0.1 min)
Permissible number of warm starts n_{W}	1 to 4
Difference between warm and cold starts n_{K}-n_{W}	1 to 2
Extensions of time constants (running and stop)	1.0 to 100.0
Tolerances	
Time delays T	1 % or 0.1 ms

Rate-of-frequency-change protection *(ANSI 81R)*

Setting ranges	
Steps, selectable +d*f*/d*t* >; - d*f*/d*t*	4
Pickup value d*f*/d*t*	0.2 to 10 Hz/s (steps 0.1 Hz/s);
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Times	
Pickup times d*f*/d*t*	Approx. 200 ms
Drop-off times d*f*/d*t*	Approx. 200 ms
Drop-off ratio d*f*/d*t*	Approx. 0.95 or 0.1 Hz/s
Drop-off ratio V<	Approx. 1.05
Tolerances	
Rate-of-frequency change	Approx. 0.1 Hz/s at V> 0.5 V_{N}
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Vector jump supervision (voltage)

Setting ranges	
Stage $\Delta\varphi$	0.5 ° to 15 ° (steps 0.1 °)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Tolerances	
Vector jump	0.3 ° at V> 0.5 V_{N}
Undervoltage blocking	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

Sensitive earth-fault protection B *(ANSI 51GN)*

Setting ranges	
Earth current $I_{\text{EE-B}}$>,	0.3 to 1000 mA (steps 0.1 A)
Earth current $I_{\text{EE-B}}$<,	0.3 to 500 mA (steps 0.1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Measuring method	- Fundamental, - 3$^{\text{rd}}$ harmonica - 1$^{\text{rst}}$ and 3$^{\text{rd}}$ harmonics
Times	
Pick-up times	Approx. 50 ms
Drop-off times	Approx. 50 ms
Drop-off ratio $I_{\text{EE-B}}$>	0.90 or 0.15 mA
Drop-off ratio $I_{\text{EE-B}}$<	1.1 or 0.15 mA
Tolerances	
Earth current	1 % of set value or 0.1 mA
Time delays T	1 % of set value or 10 ms

Interturn protection *(ANSI 59N(IT))*

Setting ranges	
Displacement voltage $V_{\text{Interturn}}$>	0.3 to 130 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pick-up times $V_{\text{Interturn}}$>	Approx. 60 ms
Drop-off times $V_{\text{Interturn}}$>	Approx. 60 ms
Drop-off ratio $V_{\text{Interturn}}$>	0.5 to 0.95 adjustable
Tolerances	
Displacement voltage	1 % of set value or 0.5 V
Time delays T	1 % of set value or 10 ms

Incoupling of temperature via serial interface (thermo-box) *(ANSI 38)*

Number of measuring sensors	6 or 12
Temperature thresholds	40 to 250 °C or 100 to 480 °F (steps 1 °C or 1 °F)
Sensors types	Pt100; Ni 100, Ni 120

External trip coupling

Number of external trip couplings	4

Threshold supervision

Setting ranges	
Threshold of measured values MV$_1$ > to MV$_{10}$<	-200 % to +200 % (steps 1 %)
Assignable measured values	P, active power Q, reactive power change of active power ΔP Voltage V_{L1}, V_{L2}, V_{L3}, V_{E}, V_0, V_1, V_2, V_{E3h} Current 3I_0, I_1, I_2, I_{EE1}, I_{EE2} Power angle φ Power factor cos φ Value at TD1
Times	
Pick-up times	Approx. 20 - 40 ms
Drop-off times	Approx. 20 - 40 ms
Drop-off to pick-up ratio	
Threshold MV$_x$>	0.95
Threshold MV$_x$<	1.05

Trip circuit supervision *(ANSI 74TC)*

Number of supervised trip circuits	1

Technical data

Operational measured values

Description	Primary; secondary or per unit (%)
Currents	$I_{L1, S1}$; $I_{L2, S1}$; $I_{L3, S1}$; $I_{L1, S2}$; $I_{L2, S2}$; $I_{L3, S2}$; I_{EE1}; I_{EE2}; I_1; I_2; I_{20Hz}
Tolerance	0.2 % of measurement values or ± 10 mA ± 1 digit
Differential protection currents	I_{DiffL1}; I_{DiffL2}; I_{DiffL3}; I_{RestL1}; I_{RestL2}; I_{RestL3};
Tolerances	0.1 % of measured or ± 10 mA ± 1 digit
Phase angles of currents	$\varphi I_{L1,S1}$; $\varphi I_{L2,S1}$; $\varphi I_{L3,S1}$; $\varphi I_{L1,S2}$; $\varphi I_{L2,S2}$; $\varphi I_{L3,S2}$;
Tolerances	$< 0.5°$
Voltages	V_{L1}; V_{L2}; V_{L3}; V_E; V_{L12}; V_{L23}; V_{L31}; V_1; V_2; $V_{20\ Hz}$
Tolerance	0.2 % of measured values or ± 0.2 V ± 1 digit
Impedance	R, X
Tolerance	1 %
Power	S; P; Q
Tolerance	1 % of measured values or ± 0.25 % S_N
Phase angle	φ
Tolerance	<0.1 °
Power factor	cos φ (p.f.)
Tolerance	1 % ± 1 digit
Frequency	f
Tolerance	10 mHz (at $V > 0.5\ V_N$; 40 Hz $< f < 65$ Hz)
Overexcitation	V/f;
Tolerance	1 %
Thermal measurement	Θ_{L1}; Θ_{L2}, Θ_{L3}, Θ_{I2}, $\Theta_{V/f}$, sensors
Tolerance	5 %

Min./max. memory

Memory	Measured values with date and time
Reset manual	Via binary input Via key pad Via communication
Values	
Positive sequence voltage	V_1
Positive sequence current	I_1
Active power	P
Reactive power	Q
Frequency	f
Displacement voltage (3^{rd} harmonics)	$V_{E(3rd\ harm.)}$

Energy metering

Meter of 4 quadrants	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance	1 %

Analog outputs (optional)

Number	max. 4 (depending on variant)
Possible measured values	I_1, I_2, I_{EE1}, I_{EE2}, V_1, V_0, V_{03h}, $\|P\|$, $\|Q\|$, $\|S\|$, $\|\cos\varphi\|$ f, V/f, φ, $\Theta_S/\Theta_{S\ Trip}$, $\Theta_{Rotor}/\Theta_{Rotor\ Trip}$, $R_{E,\ REF}$; $R_{E,\ REF\ 1\text{-}3Hz}$; $R_{E\ SEF}$
Range	0 to 22.5 mA
Minimum threshold (limit of validity)	0 to 5 mA (steps 0.1 mA)
Maximum threshold	22 mA (fixed)
Configurable reference value 20 mA	10 to 1000 % (steps 0.1 %)

Fault records

Number of fault records	Max. 8 fault records
Instantaneous values	
Storage time	Max. 5 s
Sampling interval	Depending on the actual frequency (e. g. 1.25 ms at 50 Hz; 1.04 ms at 60 Hz)
Channels	v_{L1}, v_{L2}, v_{L3}, v_E; $i_{L1,S1}$; $i_{L2,S1}$; $i_{L3,S1}$; i_{EE1}; $i_{L1,S2}$; $i_{L2,S2}$; $i_{L3,S2}$; i_{EE2}; TD1; TD2; TD3
R.m.s. values	
Storage period	Max. 80 s
Sampling interval	Fixed (20 ms at 50 Hz; 16.67 ms at 60 Hz)
Channels	V_1, V_E, I_1, I_2, I_{EE1}, I_{EE2}, P, Q, φ, R, X, f-f_n

Additional functions

Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits (criterion: current threshold)
Switching statistics	Number of breaker operation Phase-summated tripping current

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

Description	Order No.	Order Code
7UM62 multifunction generator, motor and transformer protection relay	*7UM62□□-□□□□□-□□□0*	*□□□*
Housing, binary inputs and outputs		
Housing 1/2 19", 7 BI, 12 BO, 1 live status contact	1	
Housing 1/1 19", 15 BI, 20 BO, 1 live status contact	2	
Graphic display, 1/2 19'', 7BI, 12 BO, 1 live status contact	3	
Current transformer I		
1 A1), I_{EE} (sensitive)	1	
5 A1), I_{EE} (sensitive)	5	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V3)	2	
60 to 125 V DC2), threshold binary input 19 V3)	4	
110 to 220 V DC2), 115 V/230 V AC, threshold binary input 88 V3)	5	
220 to 250 V DC, 115 V/230 V AC, threshold binary input 176 V	6	
Unit version		
For panel surface mounting, 2-tier screw-type terminals top/bottom	B	
For panel flush mounting, plug-in terminals (2-/3- pin connector)	D	
Flush-mounting housing, screw-type terminal (direct connection, ring-type cable lugs)	E	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, IEC characteristics, language: German, (language can be selected)	A	
Region World, 50/60 Hz, IEC/ANSI characteristics, language: English (UK), (language can be selected)	B	
Region US, 60 Hz, ANSI characteristics, language: English (US), (language can be selected)	C	
Port B (System interface)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
Analog output 2 x 0 to 20 mA	7	
PROFIBUS-DP slave, electrical RS485	9	L 0 A
PROFIBUS-DP slave, optical 820 nm, double ring, ST connector*	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector*	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector*	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connectors	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector4)	9	L 0 S
Only Port C (Service Interface)		
DIGSI 4 / modem, electrical RS232	1	
DIGSI 4 / modem, temperature monitoring box, electrical RS485	2	
Port C (Service interface) and Port D (Additional Interface)	9	M □ □
Port C (Service Interface)		
DIGSI 4 / modem, electrical RS232		1
DIGSI 4 / modem, temperature monitoring box, electrical RS485		2
Port D (Additional Interface)		
Temperature monitoring box, optical 820 nm, ST connector		A
Temperature monitoring box, electrical RS485		F
Analog outputs 2 x 0 to 20 mA		K

Cont'd on next page

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected in stages by means of jumpers.

4) Not available with position 9 = "*B*"

* Not with position 9 = *B*; if 9 = "*B*", please order 7UM62 unit with RS485 port and separate fiber-optic converters.

Selection and ordering data

Description	Order No.
7UM62 multifunction generator, motor and transformer protection	*7UM62□□-□□□□□-□□□0*
Measuring functions	
Without extended measuring functions	*0*
Min./max. values, energy metering	*3*
Functions	
Generator Basic	*A*
Generator Standard	*B*
Generator Full	*C*
Asynchronous Motor	*F*
Transformer	*H*
Functions (additional functions)	
Without	*A*
Sensitive rotor earth-fault protection and 100 % stator earth-fault protection	*B*
Restricted earth-fault protection	*C*
Network decoupling (d*f*/d*t* and vector jump)	*E*
All additional functions	*G*

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850 Complete version DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 95/98/ME/NT/2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*

---

1) For more detailed information on the functions see Table 11/3.

Accessories

Description	Order No.
Connecting cable	
Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Cable between thermo-box and relay	
- length 5 m / 5.5 yd	*7XV5103-7AA05*
- length 25 m / 27.3 yd	*7XV5103-7AA25*
- length 50 m / 54.7 yd	*7XV5103-7AA50*
Coupling device for rotor earth-fault protection	*7XR6100-0CA00*
	Short code
Series resistor for rotor earth-fault protection (group: 013002)	*3PP1336-0DZ K2Y*
Resistor for underexcitation protection (voltage divider, 20:1) (group: 012009)	*3PP1326-0BZ K2Y*
Resistor for stator earth-fault protection (voltage divider, 5:1) (group 013001)	*3PP1336-1CZ K2Y*
20 Hz generator	*7XT3300-0CA00*
20 Hz band pass filter	*7XT3400-0CA00*
Current transformer (400 A /5 A, 5 VA)	*4NC5225-2CE20*
Controlling unit f. rotor earth-fault protection (0.5 to 4 Hz)	*7XT7100-0EA00*
Resistor for 1 to 3 Hz rotor earth-fault protection	*7XR6004-0CA00*
Temperature monitoring box (thermo-box)	
24 to 60 V AC/DC	*7XV5662-2AD10*
90 to 240 V AC/DC	*7XV5662-5AD10*

LSP2089-afpen.tif

Fig. 11/60 Mounting rail for 19" rack

LSP2090-afpen.eps

Fig. 11/61
2-pin connector

LSP2091-afpen.eps

Fig. 11/62
3-pin connector

LSP2093-afpen.eps

Fig. 11/63
Short-circuit link for current terminals

LSP2092-afpen.eps

Fig. 11/64
Short-circuit link for voltage terminals/ indications terminals

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	11/61
	3-pin	*C73334-A1-C36-1*	1	Siemens	11/62
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	*0-539635-1*	1	AMP 1)	
	and matching female	*0-539668-2*		AMP 1)	
	For CI2	*0-734372-1*	1	AMP 1)	
	and matching female	*1-734387-1*		AMP 1)	
Mounting rail		*C73165-A63-D200-1*	1	Siemens	11/60
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	11/63
	For other terminals	*C73334-A1-C34-1*	1	Siemens	11/64
Safety cover for terminals	Large	*C73334-A1-C31-1*	1	Siemens	11/35
	Small	*C73334-A1-C32-1*	1	Siemens	11/35

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram, IEC

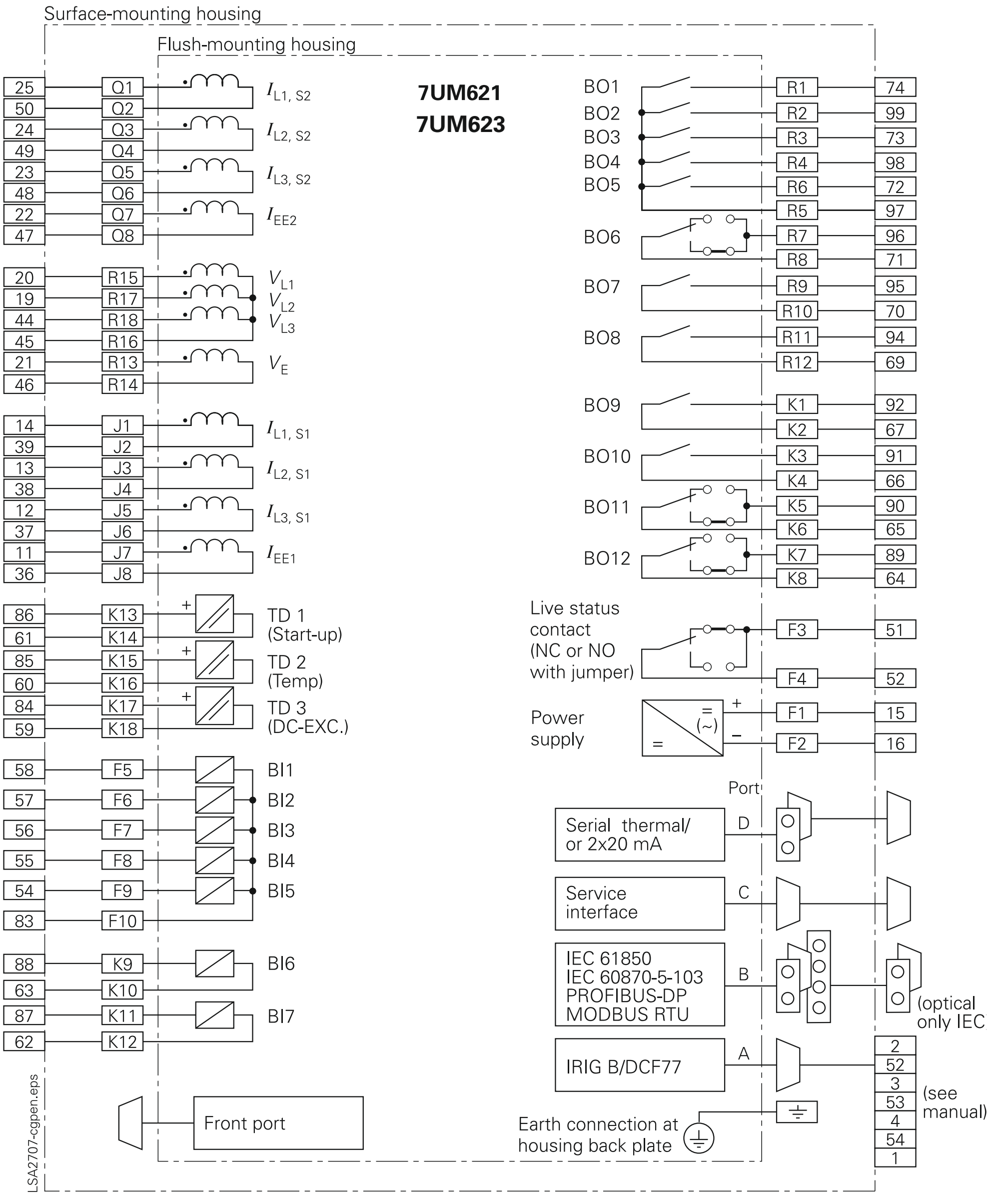


Fig. 11/65

7UM621 and 7UM623 connection diagram (IEC standard)

Connection diagram, IEC

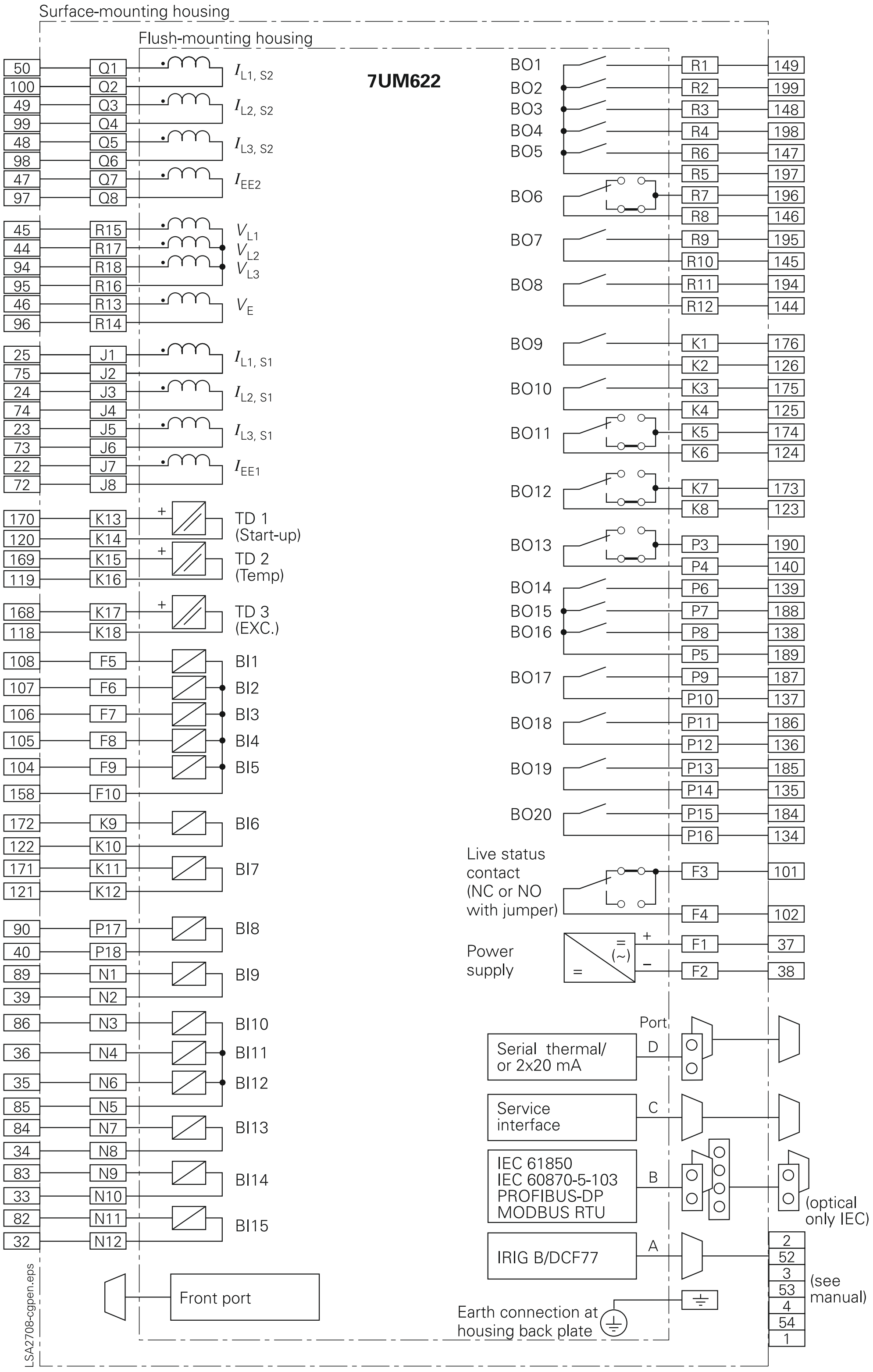


Fig. 11/66

7UM622 connection diagram (IEC standard)

Connection diagram, ANSI

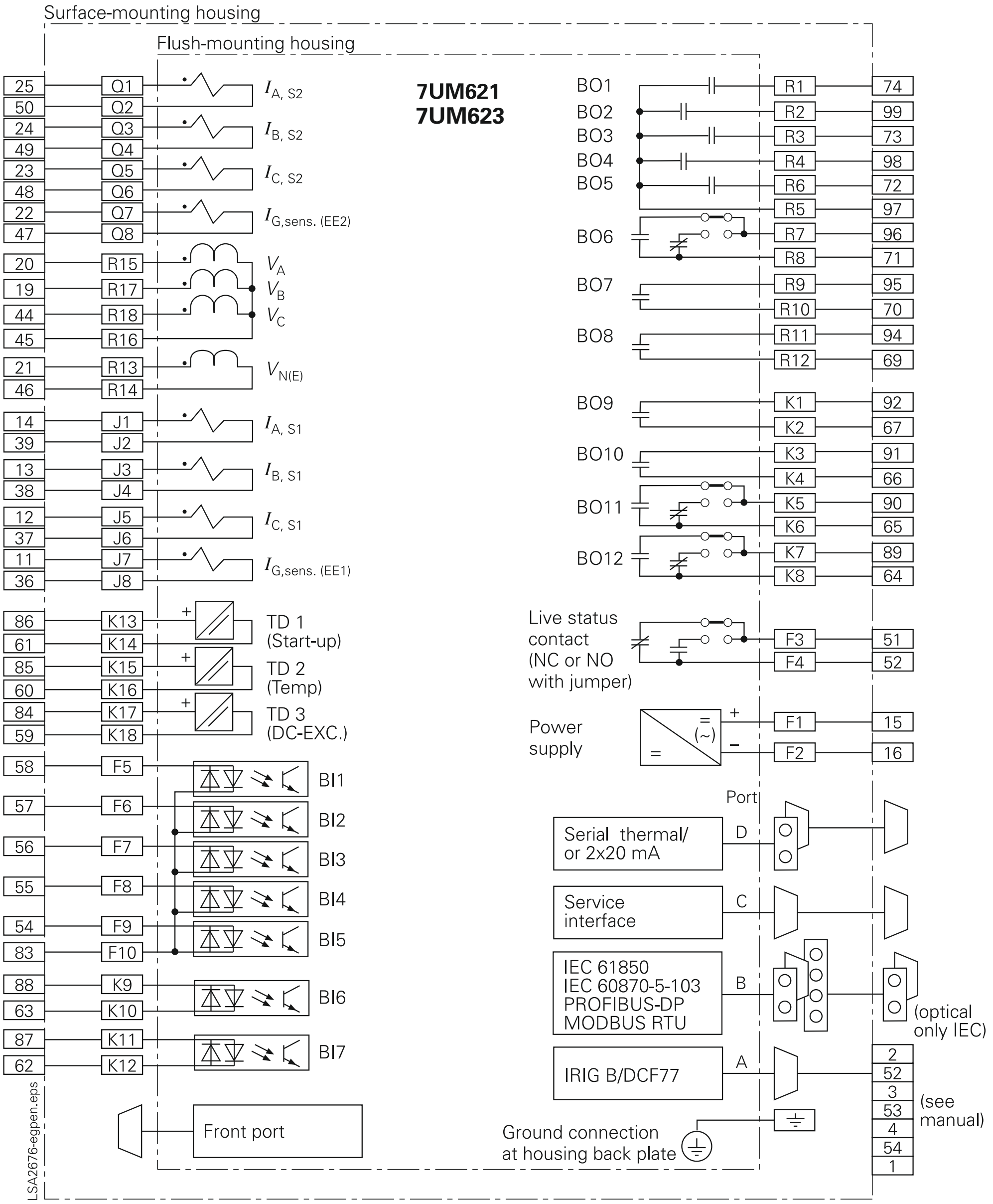


Fig. 11/67

7UM621 and 7UM623 connection diagram (ANSI standard)

Connection diagram, ANSI

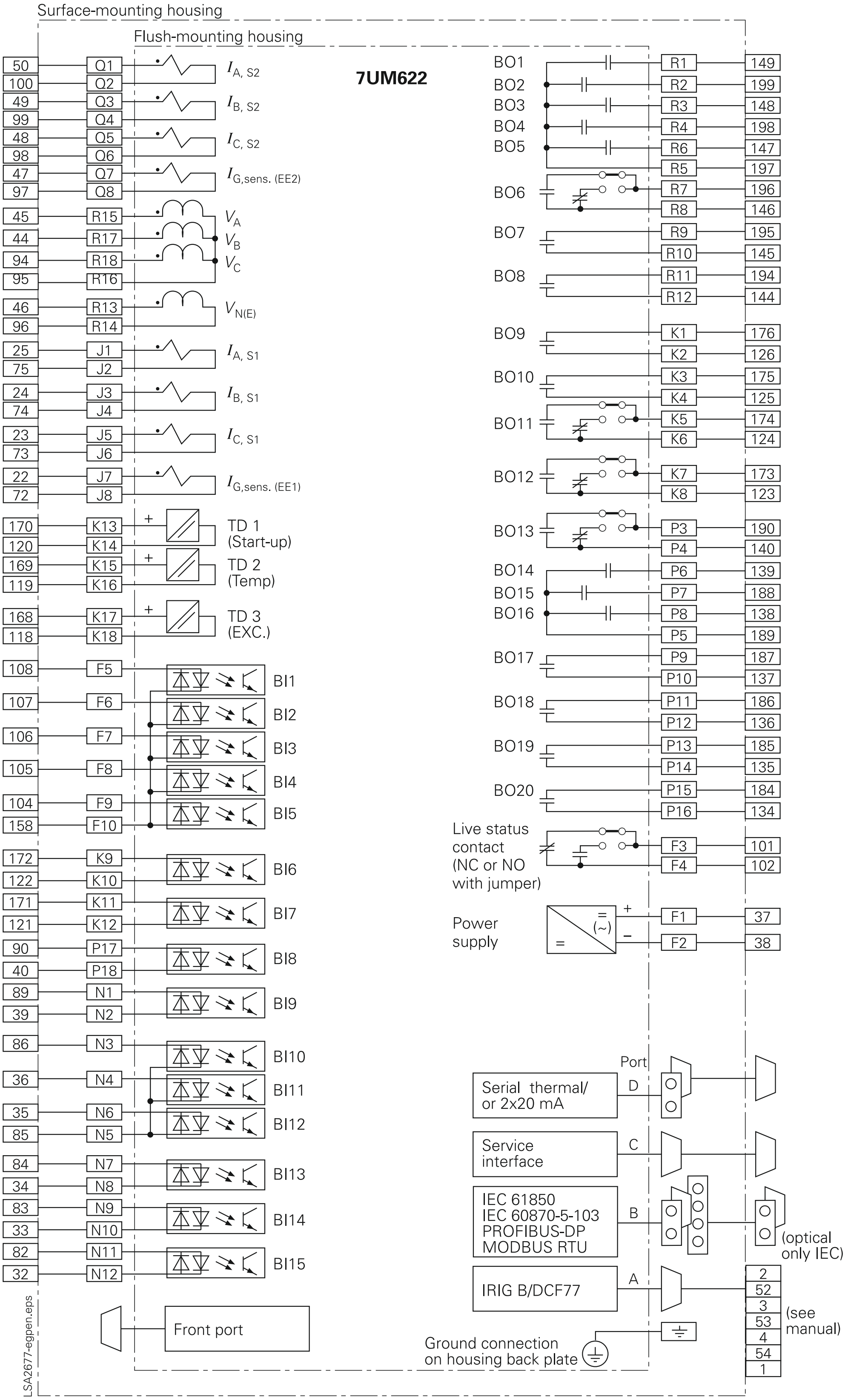


Fig. 11/68

7UM622 connection diagram (ANSI standard)

SIPROTEC 7UW50 Tripping Matrix

Fig. 11/69 SIPROTEC 7UW50 tripping matrix

Function overview

Functions

- Hardware tripping matrix
- 28 inputs
- 10 outputs
- One LED is assigned to each input and output

Features

- Easy marshalling of trip signals via diode plugs
- Plexiglass cover prevents unauthorized marshalling

Description

The tripping matrix 7UW50 is a component of the Siemens numerical generator protection system. The tripping matrix provides a transparent, easily programmable facility for combining output commands of the trip outputs of individual protection devices with plant items such as the circuit-breakers, de-excitation etc. The matrix was developed for marshalling tripping commands of large power stations.

With its help, the tripping schematic can be temporarily changed, e.g., on the basis of a generator circuit-breaker revision. If the software matrix incorporated in each generator protection unit is used for marshalling the tripping commands, the marshalling in the protection units must be changed for this purpose.

Selection and ordering data

Description	Order No.
7UW50 tripping matrix	*7UW5000-☐☐A00*
Rated auxiliary voltage	
60 V, 110 V, 125 V DC	*4*
220 V, 250 V DC	*5*
Unit design	
For panel surface mounting	*B*
For panel flush mounting or cubicle mounting	*C*

SIPROTEC 7RW600
Numerical Voltage, Frequency and Overexcitation Protection Relay

Fig. 11/70 SIPROTEC 7RW600 voltage, frequency and overexcitation protection relay

Description

The SIPROTEC 7RW600 is a numerical multifunction protection relay for connection to voltage transformers. It can be used in distribution systems, on transformers and for electrical machines. If the SIPROTEC 7RW600 detects any deviation from the permitted voltage, frequency or overexcitation values, it will respond according to the values set. The SIPROTEC 7RW600 can be used for the purposes of system decoupling and for load shedding if ever there is a risk of a system collapse as a result of inadmissibly large frequency drops. Voltage and frequency thresholds can also be monitored.

The SIPROTEC 7RW600 voltage, frequency and overexcitation relay can be used to protect generators and transformers in the event of defective voltage control, of defective frequency control, or of full load rejection, or furthermore islanding generation systems.

This device is intended as a supplement to Siemens substation systems and for use in individual applications. It has two voltage inputs (V; V_x) to which a variety of functions have been assigned. While input V serves all of the implemented functions, input V_x is exclusively dedicated to the voltage protection functions. The scope of functions can be selected from three ordering options.

Function overview

Line protection

- Voltage protection
- Frequency protection

Generator protection

- Voltage protection
- Frequency protection
- Overexcitation protection

Transformer protection

- Voltage protection
- Overexcitation protection

Power system decoupling

- Voltage protection
- Frequency protection

Load shedding

- Frequency protection
- Rate-of-frequency-change protection

Status measured values

Monitoring functions

- Hardware
- Software
- Event logging
- Fault recording
- Continuous self-monitoring

Hardware

- Auxiliary voltages:
  - 24, 48 V DC
  - 60, 110, 125 V DC
  - 220, 250 V DC, 115 V AC
- Local operation
- LCD for setting and analysis
- Housing for
  - Flush-mounting 1/6 19-inch 7XP20;
  - Surface-mounting 1/6 19-inch 7XP20

Communication ports

- Personal computer
- Via RS485 – RS232 converter
- Via modem
- SCADA
  - IEC 60870-5-103 protocol
- Bus-capable

Application

The SIPROTEC 7RW600 is a numerical multifunction protection relay for connection to voltage transformers. It can be used in distribution systems, on transformers and for electrical machines.
If the SIPROTEC 7RW600 detects any deviation from the permitted voltage, frequency or overexcitation values, it will respond according to the values set. The SIPROTEC 7RW600 can be used for the purposes of system decoupling and for load shedding if ever there is a risk of a system collapse as a result of inadmissibly large frequency drops. Voltage and frequency thresholds can also be monitored.

The SIPROTEC 7RW600 voltage, frequency and overexcitation relay can be used to protect generators and transformers in the event of defective voltage control, of defective frequency control, or of full load rejection, or furthermore islanding generation systems.

Applications

ANSI	IEC	Protection functions
㉗	$V<, t; t = f(V<)$	Undervoltage protection
(59) (59N)	$V>>, t; V>, t$	Overvoltage protection
(81) (81R)	$f>; f<; \left\lvert -\frac{\mathrm{d}f}{\mathrm{d}t} \right\rvert >; +\frac{\mathrm{d}f}{\mathrm{d}t}$	Frequency protection, rate-of-frequency-change protection
㉔	$\frac{V}{f} >, t; \frac{V}{f} = f(t)$	Overexcitation protection

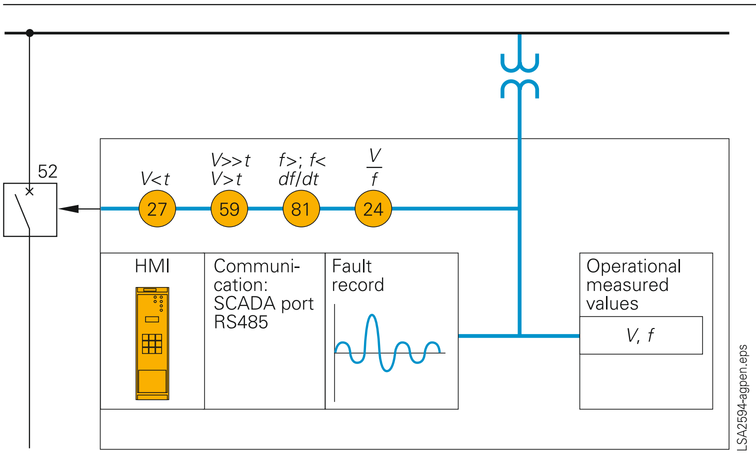


Fig. 11/71 Function diagram

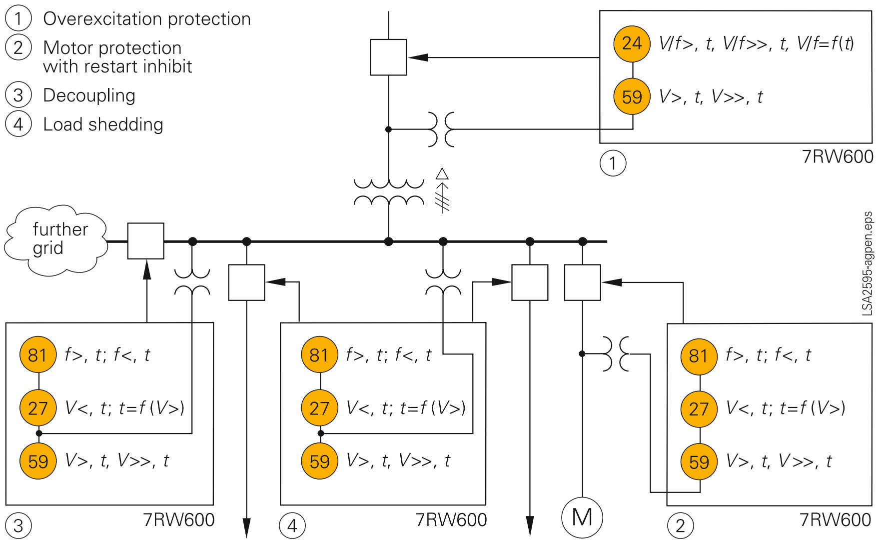


Fig. 11/72

Construction

The SIPROTEC 7RW600 relay contains, in a compact form, all the components needed for:

- Acquisition and evaluation of measured values
- Operation and display
- Output of messages, signals and commands
- Input and evaluation of binary signals
- Data transmission (RS485) and
- Auxiliary voltage supply.

The SIPROTEC 7RW600 receives AC voltages from the primary voltage transformer. The secondary rated voltage range, 100 to 125 V, is adapted internally on the device.

There are two device variants available:

- The first version, for panel flush mounting or cubicle mounting, has its terminals accessible from the rear.
- The second version for panel surface mounting, has its terminals accessible from the front.

Fig. 11/73
Rear view of surface-mounting case

Protection functions

Overvoltage protection

The overvoltage protection has the function of detecting inadmissible overvoltages in power systems and electrical machines and, in such event, it initiates system decoupling or shuts down the generators.

Two voltage measuring inputs (V, V_x) are provided on the unit. These must be connected to two phase-to-phase voltages. The input voltages are processed separately in two two-stage protective functions. From these, two principle connection variants are derived.

Fig. 11/76, Fig. 11/77, and Fig. 11/78, on page 11/75, show the following connection examples:

Fig. 11/76:
Separated connection, used for overvoltage protection and earth-fault detection

Fig. 11/77:
Two-phase connection to a voltage transformer

Fig. 11/78:
Alternative *V* connection

Undervoltage protection

The main function of the undervoltage protection is protecting electrical machines (e.g. pumped-storage power generators and motors) against the consequences of dangerous voltage drops. It separates the machines from the power system and thus avoids inadmissible operating states and the possible risk of stability loss. This is a necessary criterion in system decoupling.

To ensure that the protection functions in a physically correct manner, when used in conjunction with electrical machines, the positive-sequence system must be evaluated.

The protection function can be blocked, via a binary input, causing a drop in energizing power. The auxiliary contact of the circuit-breaker can be used for this purpose with the circuit-breaker open. Alternatively, undervoltage acquisition can be activated on a conductor-separated basis ($V<, V_x<$).

Additionally, it is possible to use an inverse-time undervoltage protection function for motor protection. The tripping time depends in the undervoltage drop. A time grading is possible.

Frequency protection

The frequency protection can be used to protect against overfrequency or against underfrequency. It protects electrical machines and plants/substations against adverse effects in the event of deviations in the rated speed (e.g. vibration, heating, etc.), detects and records frequency fluctuations in the power system, and disconnects certain loads according to the thresholds set. It can also be used for the purposes of system decoupling, and thus improves the availability of in-plant power generation.

The frequency protection function is implemented via voltage input *V*. From the sampled voltage, the frequency is measured by means of various filter functions. The system thus remains unaffected by harmonics, ripple control frequencies and other disturbances.

The frequency protection function operates over a wide frequency range (25-70 Hz).

It is implemented (optionally for overfrequency or for underfrequency) on a four-stage basis; each stage can be individually delayed. The frequency stages can be blocked either via the binary input or by an undervoltage stage.

Rate-of-frequency-change protection

The rate-of-frequency-change protection calculates, from the measured frequency, the gradient of frequency change df/dt. It is thus possible to detect and record any major active power overloading in the power system, to disconnect certain consumers accordingly, and to restore the system to stability. Unlike frequency protection, rate-of-frequency-change protection already reacts before the frequency threshold is undershot. To ensure effective protection settings, power system studies are recommended. The rate-of-frequency-change protection function can also be used for the purposes of system decoupling.

The rate-of-frequency-change protection function is implemented on a four-stage basis; each stage can be individually delayed. It detects and records any negative or positive frequency gradient. The measured result is generally released as soon as the rated frequency is undershot or overshot.

Rate-of-frequency-change protection can also be enabled by an underfrequency or overfrequency stage.

Protection functions

Overexcitation protection

The overexcitation protection detects and records any inadmissibly high induction

$$(B \sim \frac{V}{f})$$

in electrical equipment, e.g. generators or transformers, that may occur as a result of a voltage increase and/or frequency drop. Increased induction of this nature may lead to saturation of the iron core, excessive eddy current losses, and thus to inadmissible heating.

It is recommended to use the overexcitation protection function in power systems subject to large frequency fluctuations (e.g. systems in island configuration or with weak infeed) and for electrical block units that are separated from the system.

The overexcitation protection function calculates, from the maximum voltage (V, V_x) and the frequency, the ratio V/f. This function incorporates an independent warning and tripping stage and a curve which is dependent on and adaptable to the object to be protected and which takes due account of the object's thermal behavior. Incorrect adaptation of the voltage transformer is also corrected. The overexcitation protection function is effective over a broad frequency range (25 to 70 Hz) and voltage range (10 to 170 V).

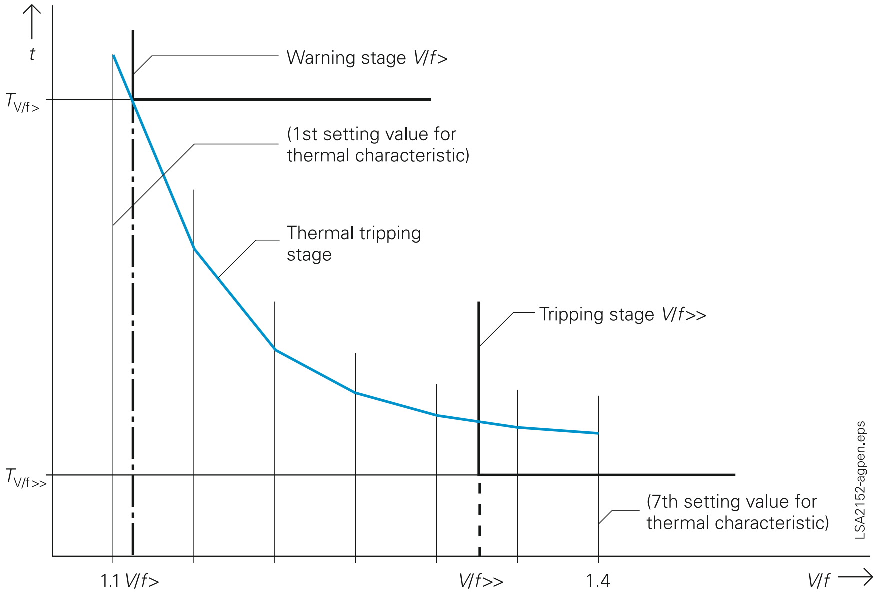


Fig. 11/74 Tripping range of overexcitation protection

Features

Serial data transmission

The SIPROTEC 7RW600 relay is fitted with an RS485 port, via which a PC can be connected, thus providing, in conjunction with the DIGSI operating and analysis program, a convenient tool for configuring and parameter setting. The DIGSI program (which runs under MS-Windows) also performs fault recording and fault evaluation. The SIPROTEC 7RW600 relay can also be linked, via the appropriate converters, either directly or over an optoelectronic connection (optical fiber) to the interface of the PC or substation control system (IEC 60870-5-103 protocol).

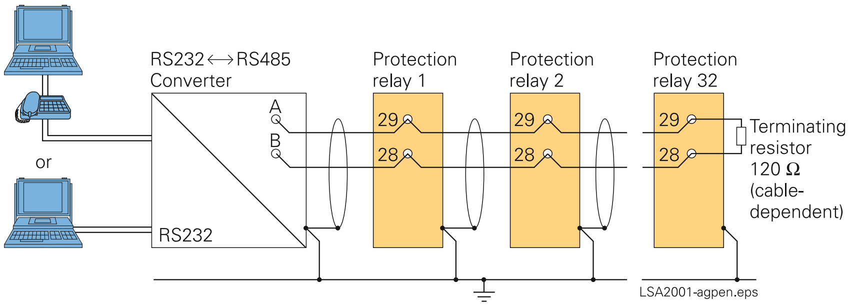


Fig. 11/75 Wiring communication
For convenient wiring of the RS485 bus, use bus cable system 7XV5103 (see part 13 of this catalog)

Connection diagrams

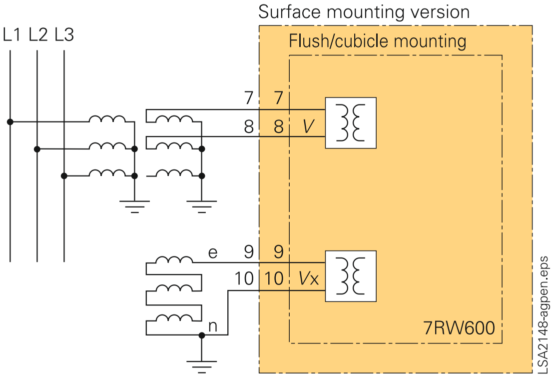


Fig. 11/76
Connection of a phase-to-phase voltage *V* and a displacement voltage *V*

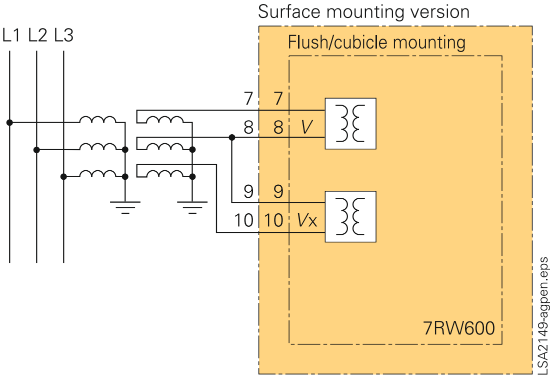


Fig. 11/77
Connection of two phase-to-phase voltages *V* to one voltage transformer set

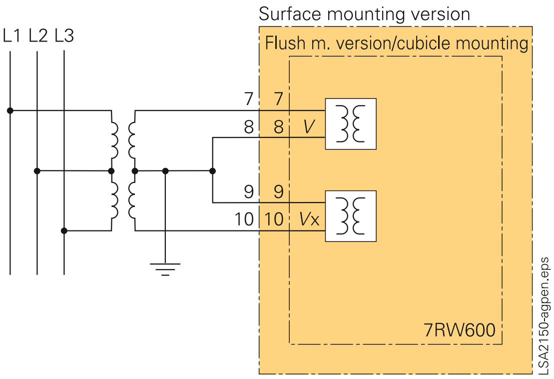


Fig. 11/78
Connection to voltage transformers in *V*-configuration

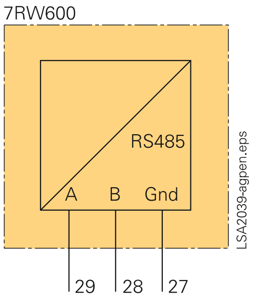


Fig. 11/79
Communication port

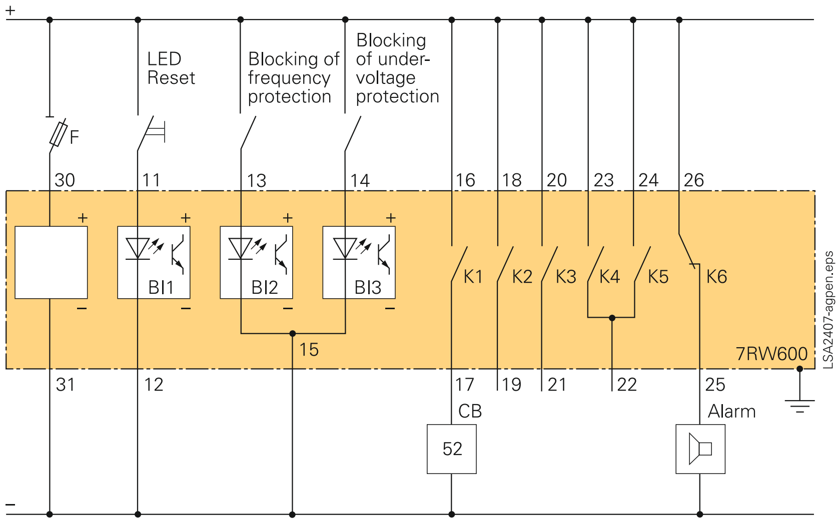


Fig. 11/80
Typical auxiliary voltage wiring

Technical data

Hardware

Measuring circuits (v.t. circuits)

Rated voltage V_N	100 to 125 V
Rated frequency f_N	50 or 60 Hz
Dynamic range	170 V
Power consumption	≤ 0.2 VA
Thermal overload capacity,	
continuous	200 V
for ≤ 10 s	230 V

Power supply via integrated DC/DC converter

Rated auxiliary voltage V_{aux}	24/48 V DC 60/110/125 V DC 220/250 V DC, 115 V AC
Maximum ripple at rated voltage	≤ 12 %
Power consumption	
Quiescent	Approx. 2 W
Energized	Approx. 4 W
Maximum bridging time following failure of auxiliary voltage	≥ 20 ms at V_{AUX} (24 V DC) ≥ 50 ms at V_{AUX} (110 V DC)

Binary inputs

Number	3
Voltage range	24 to 250 V DC
Current consumption, independent of operating voltage	Approx. 2.5 mA
2 switching thresholds (adjustable)	17 V, 75 V

Command contacts

Number of relays, total	6
Number of relays with 2-channel energization	2
Contacts per relay (K1 to K5)	1 NO contact
Contact for relay (K6)	1 NC contact or 1 NO contact (set via jumper)
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V (AC/DC)
Permissible current,	
continuous	5 A
0.5 s	30 A

LEDs

Ready-to-operate (green)	1
Marshallable displays (red)	4
Fault indication (red)	1

Serial port (isolated)

Type	RS485
Test voltage	2 kV AC for 1 min
Connections	Data cable at housing, two data wires, one frame reference for connection of a PC or similar
Transmission speed	At least 1200 baud, max. 19 200 baud

Unit design

Case 7XP20	For dimensions, see dimension drawings, part 15
Weight	
Flush mounting/cubicle mounting	Approx. 4 kg
Surface mounting	Approx. 4.5 kg
Degree of protection to IEC 60529/EN 60529	IP 51

Electrical test

Specifications

Standards	IEC 60255-5, ANSI / IEEE C37.90.0

Insulation tests

Voltage test (routine test)	
All circuits except auxiliary voltage and RS485	2.0 kV (rms), 50 Hz
Auxiliary voltage and RS485 only	2.8 kV DC
Voltage test (type test)	
Over open command contacts	1.5 kV (rms), 50 Hz
Impulse withstand capability (SWC) test (type test)	5 kV (peak); 1.2 / 50 μs; 0.5 J
All circuits, class III	3 positive and 3 negative impulses at intervals of 5 s
Test crosswise:	
Measurement circuits, pilot-wire connections, power supply, binary inputs, class III, (no tests crosswise over open contacts, RS485 interface terminals)	

EMC tests, immunity; type tests

Standards	IEC 60255-22 (product standard) EN 50082-2 (generic standard) DIN VDE 0435, Part 303
High-frequency test IEC 60255-22-1, class III and DIN VDE 0435 Part 303, class III	2.5 kV (peak), 1 MHz, $\tau = 15$ μs, 400 shots/s duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge, 8 kV air discharge, both polarities, 150 pF, $R_i = 330\ \Omega$
Irradiation with RF field	
Non-modulated, IEC 60255-22-3 (report), class III	10 V/m, 27 to 500 MHz
Amplitude-modulated, IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, 80 % AM, 1 kHz
Pulse-modulated, IEC 6100-4-3, class III	10 V/m, 900 MHz, repetition frequency 200 Hz, duty cycle 50 %

Technical data

EMC tests, immunity; type tests

Fast transients IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV, 5/50 ns, 5 kHz, burst length 15 ms, repetition rate 300 ms, both polarities, $R_i = 50\ \Omega$, duration 1 min
Conducted disturbances induced by radio-frequency fields, amplitude-modulated, IEC 61000-4-6, class III	10 V, 150 kHz to 80 MHz, 80 % AM, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV	30 A/m continuous, 50 Hz 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 kV to 3 kV (peak), 1 MHz to 1.5 MHz, decaying oscillation, 50 shots per s, duration 2 s, $R_i = 150$ to $200\ \Omega$
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV, 10/150 ns, 50 shots per s, both polarities, duration 2 s, $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m, 25 to 1000 MHz, amplitude- and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity), 100, 1, 10 and 50 MHz, decaying oscillation, $R_i = 50\ \Omega$

EMC tests, emission; type tests

Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage only CISPR 11, EN 55022, DIN VDE 0878 Part 22, limit value, class B	150 kHz to 30 MHz
Interference field strength CISPR 11, EN 55011, DIN VDE 0875 Part 11, limit value, class A	30 to 1000 MHz

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude 60 to 150 Hz: 0.5 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 *g*, duration 11 ms 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class 1	Sinusoidal 1 to 8 Hz: ± 4 mm amplitude (horizontal axis)
IEC 60068-2-59	1 to 8 Hz: ± 2 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 15 *g*, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal acceleration 10 *g*, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests

Temperatures

Recommended temperature during service	–5 to +55 °C (legibility may be impaired > +55 °C)
Temperature tolerances:	
During service	–20 to +70 °C
During storage	–25 to +55 °C
During transport (storage and transport in standard works packaging)	–25 to +70 °C

Humidity

Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity, on 30 days during the year 95 % relative humidity, condensation not permitted!

Functions

Undervoltage protection

Setting range $V<$, $V_x<V_p<$	20 to 120 V (in steps of 1 V)
Delay times	0 to 60 s (in steps of 0.01 s) or ∞ (i.e. non-effective)
Time multiplier for inverse characteristic	0.1 to 5 s
Pickup time	≤ 50 ms
Reset time	≤ 50 ms
Reset ratio	1.05
Tolerances	
Voltage pickup	3 % of setting value or 1 V
Delay times	1 % of setting value or 10 ms

Overvoltage protection

Setting range	
$V>$, $V>>$	20 to 170 V (in steps of 1 V)
$V_x>$, $V_x>>$	10 to 170 V (in steps of 1 V)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Pickup time	≤ 50 ms
Reset time	≤ 50 ms
Reset ratio	0.95
Tolerances	
Voltage pickup	3 % of setting value or 1 V < 1 % of setting value for $V > V_n$
Delay times	1 % of setting value or 10 ms

Technical data

Frequency protection

Number of frequency stages $f>$ or $f<$	4
Setting range $f>$ or $f<$	40 to 68 Hz (in steps of 0.01 Hz)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Undervoltage blocking	20 to 100 V or ∞ (in steps of 1 V)
Pickup time $f>$, $f<$	Approx. 100 ms
Reset times $f>$, $f<$	Approx. 100 ms
Reset difference	Approx. 20 mHz
Reset ratio (undervoltage blocking)	1.05
Tolerances	
Frequencies $f>$, $f<$	5 mHz at $f = f_N$ and $V = V_N$ 10 mHz at $f = f_N$
Undervoltage blocking	3 % of setting value or 1 V
Delay times	1 % of setting value or 10 ms

Rate-of-frequency-change protection

Number of rates-of-frequency-changing stages	4
Setting range $\frac{df}{dt}$	0.4 to 10 Hz/s or ∞ (in steps of 0.1 Hz/s)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Undervoltage blocking	20 to 100 V or ∞ (in steps of 1 V)
Pickup time $\frac{df}{dt}$	Approx. 200 ms
Reset ratio pickup $\frac{df}{dt}$	Approx. 0.6
Reset ratio (undervoltage blocking)	1.05
Tolerances	
Changes of frequencies $\frac{df}{dt}$	
In the 45 to 50 Hz range	100 mHz/s at $f_N = 50$ Hz and $V = V_N$
In the 54 to 60 Hz range	150 mHz/s at $f_N = 60$ Hz and $V = V_N$
Undervoltage blocking $V<$	3 % of setting value or 1 V
Delay times	1 % of setting value or 10 ms

Overexcitation protection

Warning stage $\frac{V / V_N}{f / f_N}$	1 to 1.2 (in steps of 0.01)
Tripping stage $\frac{V / V_N}{f / f_N}$	1 to 1.4 (in steps of 0.01)
Delay times, warning and tripping stages	0 to 60 s, or ∞ (in steps of 0.01 s)
Curve values V/f	1.1 / 1.15 / 1.2 / 1.25 / 1.3 / 1.35 / 1.4
Associated delay times	0 to 20000 s (in steps of 1 s)
Cooling-down time	0 to 20000 s (in steps of 1 s)
Voltage transformer adaption factor	0.5 to 2 (in steps 0.01)
Pickup response time (stage curve)	≤ 50 ms
Reset time (stage curve)	≤ 60 ms
Reset ratio	0.95
Tolerances	
Overexcitation V/f	3 % of setting value
Delay times (stage curve)	1 % of setting value or 10 ms
Delay times (dependent curve)	5 % with respect to V/f value ± 0.5 s

Fault recording

Instantaneous value fault record	
Measured values	V, V_x
Pattern	1.00 ms (50 Hz) 0.83 ms (60 Hz)
Fault record duration	Max. 5 s
Start signal	Tripping, energization, binary input, PC
R.m.s. fault record	
Measured values	V, V_x, f-f_N
Pattern	10 ms (50 Hz) 8.3 ms (60 Hz)
Fault record duration	Max. 50 s
Starting signal	Tripping, energization, binary input, PC

Operational measured values

Measured values	V, V_x, V_1, V/f, f
Measuring range voltage	0 to 170 V
Tolerance	≤ 2 V or 5 %
Measuring range overexcitation	0 to 2.4
Tolerance	≤ 5 %
Measuring range frequency	25 to 70 Hz
Tolerance	≤ 0.05 Hz or 5 MHz at $f = f_N$

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.
7RW600 numerical voltage, frequency and overexcitation protection relay	*7RW6000-☐☐A☐0-☐DA0*
Rated auxiliary voltage	
24, 48 V DC	*2*
60, 110, 125 V DC	*4*
220, 250 V DC, 115 V AC	*5*
Unit design	
For panel surface mounting, terminals on the side	*B*
For panel surface mounting, terminals on the top and bottom	*D*
For panel flush mounting/cubicle mounting, terminals on the rear	*E*
Languages	
English	*0*
German	*1*
Spanish	*2*
French	*3*
Scope of functions	
Voltage and frequency protection	*0*
Voltage, frequency and rate-of-frequency-change protection	*1*
Voltage and overexcitation protection	*2*

Accessories

DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
*Converter RS232 - RS485** With communication cable for the SIPROTEC 7RW600 numerical voltage, frequency and overexcitation relay; length 1 m With plug-in power supply unit 230 V AC	*7XV5700-0☐☐00* 1)
With plug-in power supply unit 110 V AC	*7XV5700-1☐☐00* 1)
Converter, full-duplex FO cable, RS485, with built-in power supply unit Auxiliary voltage 24 - 250 V DC and 110 / 230 V AC	*7XV5650-0BA00*
Manual for 7RW600 English	*C53000-G1176-C117-4*

---

1) Possible versions see part 13, 7XV57 RS232-RS485 Converter

* RS485 bus system up to 115 kbaud RS485 cable and adaptor 7XV5103-☐AA☐☐see part 13

Connection diagrams

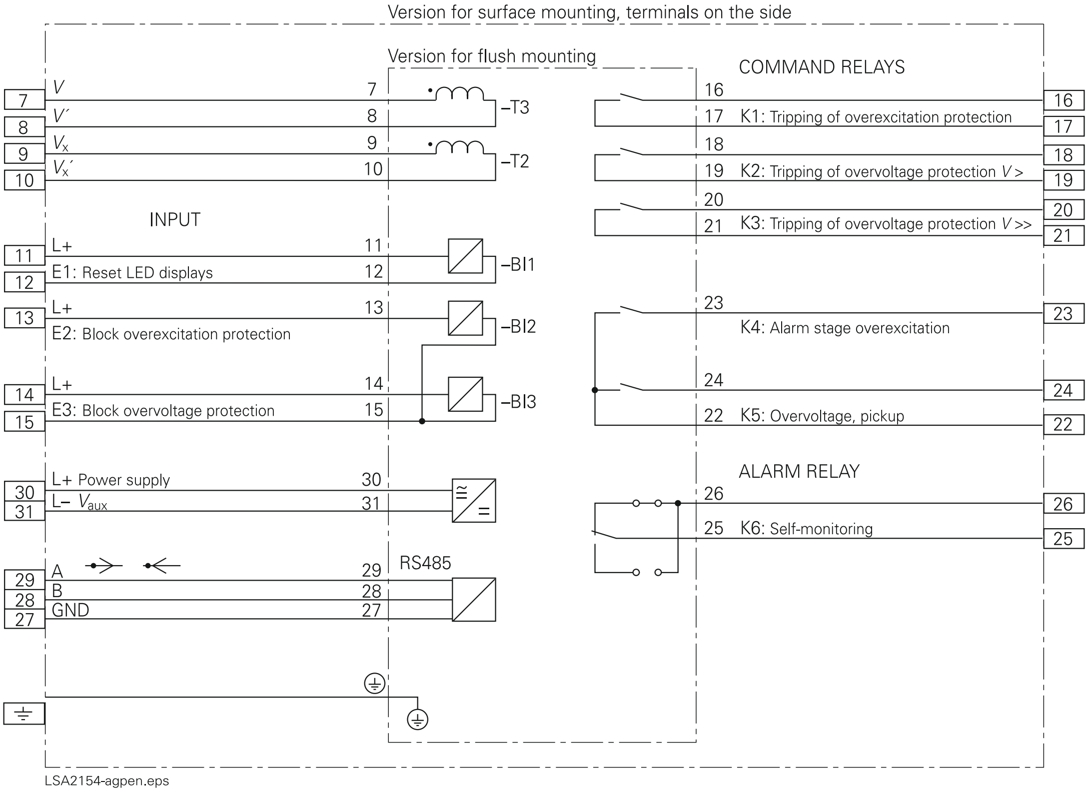


Fig. 11/81
Connection circuit diagram of 7RW600 voltage and frequency protection with presetting of marshallable binary inputs and command contacts. (Ordering Code: 7RW600x-xBxxx-; 7RW600x-xExxx-).

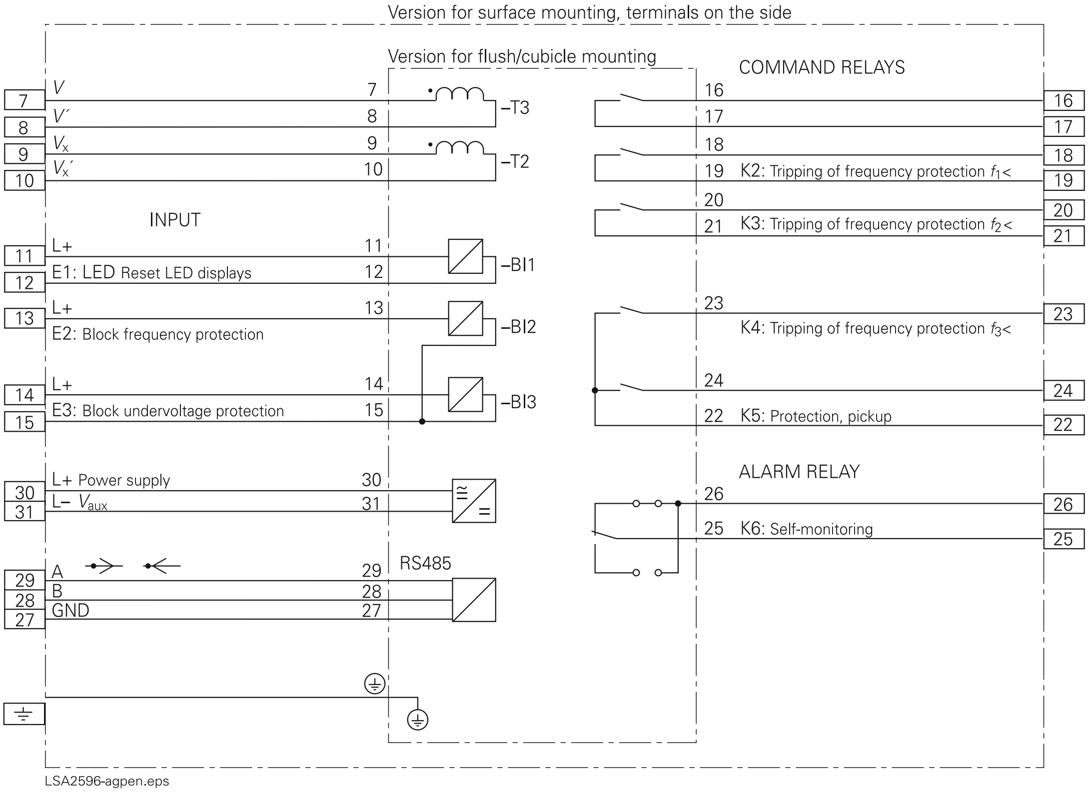


Fig. 11/82
Connection circuit diagram of 7RW600 voltage and overexcitation protection with presetting of marshallable binary inputs and command contacts. (Ordering Code: 7RW600x-xBxxx-; 7RW600x-xExxx-).

SIPROTEC 7VE6
Multifunction Paralleling Device

LSP2483-afpen.tif

Fig. 11/83
SIPROTEC 7VE6
multifunction paralleling device

Description

The 7VE61 and 7VE63 paralleling devices of the SIPROTEC 4 family are multifunctional compact units used for paralleling power systems and generators.

Their technical design ensures highly reliable paralleling due to their 1½-channel or 2-channel measurement method and their hardware design. This is supported by numerous monitoring functions.
The units automatically detect the operating conditions. The response to these conditions depends on settings.
In "synchronous network switching" mode, the frequency difference is measured with great accuracy. If the frequency difference is almost zero for a long enough time, the networks are already synchronous and a larger making angle is permissible.

If the conditions are asynchronous, as is the case when synchronizing generators, the generator speed is automatically matched to the system frequency and the generator voltage to the system voltage. The connection is then made at the synchronous point, allowing for circuit-breaker make-time.

The 7VE61 paralleling device is a 1½-channel unit (paralleling function + synchro-check) for use with small to medium-size generators and power systems. It is more reliable than 1-channel paralleling devices. It can also be used for synchro-check, with parallel operation of three synchronization points.

For larger generators and power systems with high reliability requirements, the 2-channel 7VE63 is recommended. Two independent methods decide on the connection conditions. The unit also has the full control functions of the SIPROTEC 4 family.

Voltage and frequency functions ($V>$, $V<$, $f>$, $f<$ df/dt) including voltage vector jump ($\Delta\varphi$) are optionally available for protection or network decoupling applications.

The integrated programmable logic functions (continuous function chart CFC) offer the user a high flexibility so that adjustments can easily be made to the varying requirements on the basis of special system conditions.

The flexible communication interfaces are open to modern communication architectures with control systems.

Function overview

Basic functions

- High reliability with a two-out-of-two design (1 ½ channels in 7VE61 and 2 channels in 7VE63)
- Paralleling of asynchronous voltage sources
- Balancing commands for voltage and speed (frequency)
- Paralleling of synchronous voltage sources
- Synchro-check function for manual synchronization
- Parameter blocks for use on several synchronizing points (7VE61 max. 4 and 7VE63 max. 8)

Additional functions

- Consideration of transformer vector group and tap changer
- Synchronization record (instantaneous or r.m.s. record)
- Commissioning support (CB-time measurement, test synchronization)
- Browser operation
- Full control functionality of SIPROTEC 4
- Analog outputs of operational measured values
- Functions for protection or network decoupling tasks

Protection functions (option)

- Undervoltage protection(27)
- Overvoltage protection (59)
- Frequency protection (81)
- Rate-of-frequency-change protection (81R)
- Jump of voltage vector monitoring

Monitoring functions

- Self-supervision of paralleling function
- Operational measured values
- 8 oscillographic fault records

Communication interfaces

- System interface
  - – IEC 60870-5-103
  - – IEC 61850 protocol
  - – PROFIBUS-DP
  - – MODBUS RTU and DNP 3.0
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/ DCF77

Application

The 7VE61 and 7VE63 paralleling devices of the SIPROTEC 4 family are multifunctional compact units used for paralleling power systems and generators.

Their technical design ensures highly reliable paralleling due to their 1½-channel or 2-channel measurement method and their hardware design. This is supported by numerous monitoring functions.

The units automatically detect the operating conditions. The response to these conditions depends on settings.

In "synchronous network switching" mode, the frequency difference is measured with great accuracy. If the frequency difference is almost zero for a long enough time, the networks are already synchronous and a larger making angle is permissible.

If the conditions are asynchronous, as is the case when synchronizing generators, the generator speed is automatically matched to the system frequency and the generator voltage to the system voltage. The connection is then made at the synchronous point, allowing for circuit-breaker make-time.

The 7VE61 paralleling device is a 1½-channel unit (paralleling function + synchro-check) for use with small to medium-size generators and power systems.
It is more reliable than 1-channel paralleling devices. It can also be used for synchro-check, with parallel operation of three synchronization points.

For larger generators and power systems with high reliability requirements, the 2-channel 7VE63 is recommended. Two independent methods decide on the connection conditions. The unit also has the full control functions of the SIPROTEC 4 family.

Voltage and frequency functions ($V>$, $V<$, $f>$, $f<$ $\mathrm{d}f/\mathrm{d}t$) including voltage vector jump ($\Delta\varphi$) are optionally available for protection or network decoupling applications.

Uniform design

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control and automation.
Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays (graphic display for 7VE63) were a major design aim. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

Highly reliable

The 7VE6 hardware is based on 20 years of Siemens experience with numerical protection equipment. State-of-the-art technology and a high-efficiency, 32-bit microprocessor are employed. Production is subject to exacting quality standards.

Special attention has been paid to electromagnetic compatibility, and the number of electronic modules has been drastically reduced by the use of highly integrated circuits.

The software design incorporates accumulated experience and the latest technical knowledge. Object orientation and high-level language programming, combined with the continuous quality assurance system, ensure maximized software reliability.

Programmable logic

The integrated programmable logic function allows the user to implement his own functions for automation of switchgear (interlocking) via a graphic user interface. The user can also generate user-defined messages.

Adjustments can easily be made to the varying power station requirements.

Measurement method

Powerful and successful algorithms based on years of experience have been incorporated. They ensure both a high level of measurement accuracy and effective noise signal suppression. That makes for reliable paralleling even in networks with harmonics. Complementary measurement methods avoid unwanted operation.

Design

The units are available in two designs: the ½ 19" wide 7VE61 and the ½ 19" wide 7VE63. The 7VE61 features a four-line display. The 7VE63 is equipped with a graphic display for visualization of switching states. It also has a larger number of binary inputs and outputs than the 7VE61.

Communication

Flexible and powerful communication is paramount. That is why the paralleling devices have up to five serial interfaces (for details see chapter 4 "Communication"):

- Front interface for connecting a PC
- Service interface for connecting a PC (e.g. via a modem)
- System interface for connecting to a control system via IEC 60870-5-103, IEC 61850, PROFIBUS-DP, MODBUS RTU or DNP 3.0
- Interface for an analog output module (2 – 20 mA) and an input
- For time synchronization via DCF77 or IRIG B.

Operational measured values

In order to assist system management and for commissioning purposes, relevant measured values are displayed as primary and secondary values with unit and values relating to the object to be protected.

The measured values can also be transferred via the serial interfaces.

In addition, the programmable logic permits limit value scans and status indications derived therefrom.

Metered values are available in the form of energy metered values for the active and reactive energy supplied and are also provided by an elapsed-hour meter.

Application

Indications

The SIPROTEC 4 units provide detailed data for analysis of synchronization (fault events from activated protection functions) and for checking states during operation. All indications are protected against power supply failure.

- **Synchronization indications**
  (Fault indications)
  The last eight synchronizations (faults) are stored in the unit at all times. A fresh synchronization (fault) will erase the oldest one. The fault indications have a time resolution of 1 ms. They provide detailed information on history. The buffer memory is designed for a total of 600 indications.
- **Operational indications**
  All indications that are not directly associated with the synchronization (fault) (e.g. operating or switching actions) are stored in the status indication buffer. The time resolution is 1 ms, buffer size: 200 indications.

Fault recording at up to 10 or 100 seconds

An instantaneous value or r.m.s. value recorder is provided. The firmware permits storage of 8 fault recordings. Triggering can be effected by the synchronization function (starting or closing command), protection function (pickup or tripping), binary input, the DIGSI 4 operating program or by the control system.

The instantaneous value recording stores the voltage input values (v_a,v_b,v_c,v_d,v_e,v_f), voltage differences (v_a-v_d,v_b-v_e, v_c-v_f), and calculated r.m.s. values ΔV, Δf, $\Delta\alpha$ at 1-ms intervals (or 0.83-ms intervals for 60 Hz). The r.m.s. values are calculated every half cycle. The total duration of the fault recording is 10 seconds. If the time is exceeded, the oldest recording is overwritten.

If you want to record for a longer period for commissioning purposes (for example, to show the effect of balancing commands), r.m.s. value recording is advisable. The relevant calculated values (V_1,V_2, f_1, f_2, ΔV, Δf, $\Delta\alpha$) are recorded at half-cycle intervals. The total duration is 100 seconds.

Time synchronization

A battery-backed clock is a standard component and can be synchronized via a synchronization signal (DCF77; IRIG B via satellite receiver), binary input, system interface or SCADA (e.g. SICAM). A date and time are assigned to every indication.

Freely assignable binary inputs and outputs

Binary inputs, output relays, and LEDs can each be given separate user-specific assignments. Assignment is effected using a software matrix, which greatly simplifies the allocation of individual signals.

To ensure dual-channel redundancy, control of the CLOSE relay (relay R1 and R2) is prioritized and should not be altered. These two relays have a special, highly reliable control and monitoring logic (see Fig. 11/89).

Continuous self-monitoring

The hardware and software are continuously monitored. If abnormal conditions are detected, the unit signals immediately. In this way, a great degree of safety, reliability and availability is achieved.

Reliable battery monitoring

The battery buffers the indications and fault recordings in the event of power supply voltage failure. Its function is checked at regular intervals by the processor. If the capacity of the battery is found to be declining, an alarm indication is generated.

All setting parameters are stored in the Flash-EPROM which are not lost if the power supply or battery fails. The SIPROTEC 4 unit remains fully functional.

Functions

Functional scope of the paralleling function

The units contain numerous individually settable functions for different applications. They cover the following operating modes:

Synchro-check

In this mode, the variables ΔV, Δf, $\Delta\alpha$ are checked. If they reach set values, a release command is issued for as long as all three conditions are met, but at least for a settable time.

Switching synchronous networks

The characteristic of synchronous networks is their identical frequency ($\Delta f \approx 0$). This state is detected, and fulfillment of the ΔV and $\Delta\alpha$ conditions is checked. If the conditions remain met for a set time, the CLOSE command is issued.

Switching asynchronous networks

This state occurs in the power system and generator (open generator circuit-breaker). A check is made for fulfillment of ΔV and Δf conditions and the connection time is calculated, taking account of $\Delta\alpha$, and the circuit-breaker making time. By means of balancing commands (for voltage and frequency), the generator can automatically be put into a synchronous condition.

Switching onto dead busbars

The voltage inputs are checked here. The CLOSE command is issued depending on the set program and the result of measurement. A three-phase connection increases reliability because several voltages must fulfill the conditions (see Fig. 11/84).

The following operating states are possible:
- $V1 < V2 >$
  (connection to dead busbar (side 1))
- $V1 > V2 <$
  (connection to dead line (side 2))
- $V1 < V2 <$
  (forced closing)

Functions

Voltage and frequency band query

Synchronization is not activated until the set limits are reached. Then the remaining parameters (see above) are checked.

Vector group adaptation

If synchronization is effected using a transformer, the unit will take account of the phase-angle rotation of the voltage phasor in accordance with the vector group entry for the transformer. On transformers with a tap changer, the tap setting can be communicated to the unit, for example, as BCD code (implemented in the 7VE63). When using the IEC 61850 communication standard, it is possible to detect tap position indications with a bay control unit (e.g. 6MD66) and to transmit these indications via GOOSE to the 7VE6 paralleling device. Deviations from the rated transformation ratio result in the appropriate voltage amplitude adaptation.

Voltage and frequency balancing

If the synchronization conditions are not fulfilled, the unit will automatically issue balancing signals. These are the appropriate up or down commands to the voltage or speed controller (frequency controller). The balancing signals are proportional to the voltage or frequency difference, which means that if the voltage or frequency difference is substantial, longer balancing commands will be output. A set pause is allowed to elapse between balancing commands to allow the state change to settle. This method ensures rapid balancing of the generator voltage or frequency to the target conditions.

If identical frequency is detected during generator-network synchronization (“motionless synchronization phasor”), a kick pulse will put the generator out of this state.

For example, if the voltage is to be adjusted using the transformer tap changer, a defined control pulse will be issued.

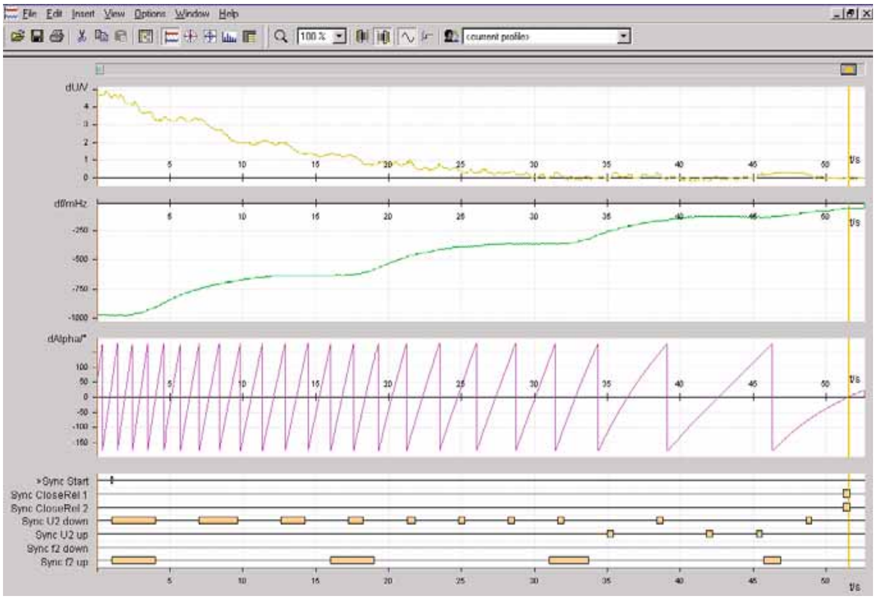
Several synchronizing points

Depending on the ordered scope, several synchronization points can be operated. The data for synchronization of each circuit-breaker (synchronization function group) are stored individually. In the maximum version, the 7VE63 operates up to 8 synchronization points. Selection is made either via the binary input or the serial interface. With the CFC, it is also possible to control the connection of the measured variables or commands via a master relay.

Commissioning aids

The paralleling device is designed to be commissioned without an external tester/recorder (see Fig. 11/84). For that purpose, it contains a codeword-protected commissioning section. This can be used to measure the make time automatically with the unit (internal command issue until the CB poles are closed). This process is logged by the fault recording function.

The operational measured values also include all measured values required for commissioning. The behavior of the paralleling function or the unit is also documented in detail in the operational annunciation and synchronization annunciation buffer. The connection conditions are documented in the synchronization record. Test synchronization is also permitted. All actions inside the synchronizer are taken but the two CLOSE relays are not operated (R1 and R2). This state can also be initiated via a binary input.



LSP2480fen.tif

Fig. 11/84
SIGRA 4, synchronization record with balancing commands

Functions

Great safety and reliability due to multi-channel redundancy

Generator synchronization especially requires units in which unwanted operation can be ruled out. The paralleling device achieves this multi-channel redundancy with a two-out-of-two decision. That means that two conditions for the CLOSE command must be fulfilled. Fig. 11/85 shows the structure of the two designs.

In the 1½-channel version (7VE61), the paralleling function is the function that gives the CLOSE command. The synchro-check function acts as a release criterion with rougher monitoring limit settings. Other monitoring functions are also active at the same time (see below).

In the two-channel version (7VE63), two independent methods work in parallel. The CLOSE command is given when the two methods simultaneously decide on CLOSE. Fig. 11/86 shows the consistent implementation of dual-channel redundancy.

The measured quantities are fed to two ADCs. The second ADC processes the values rotated through 180° (e.g. $V1$). The monitoring methods test all the transformer circuits including internal data acquisition for plausibility and they block measurement if deviations are found. The phase-sequence test detects connection errors. The measuring methods 1 and 2 include the measurement algorithms and logic functions.

In keeping with the two-channel redundancy principle, differing measurement methods are used to prevent unwanted operation due to systematic errors.

In addition, numerous methods are also active, such as closure monitoring (synchronism monitoring of both methods). Unwanted relay operation is avoided by two-channel operation of both CLOSE relays. The two measurement methods operate the transistors crossed over.

Moreover, coil operation is monitored in the background. For this purpose, transistors are activated individually and the response is fed back. Both interruptions and transistor breakdown are detected. When faults are found, the unit is blocked immediately.

The plausibility monitoring of set values (valid limits) and selection of the synchronization function groups (only one can be selected) are also supported. In the event of any deviations, messages are output and the paralleling function is blocked.

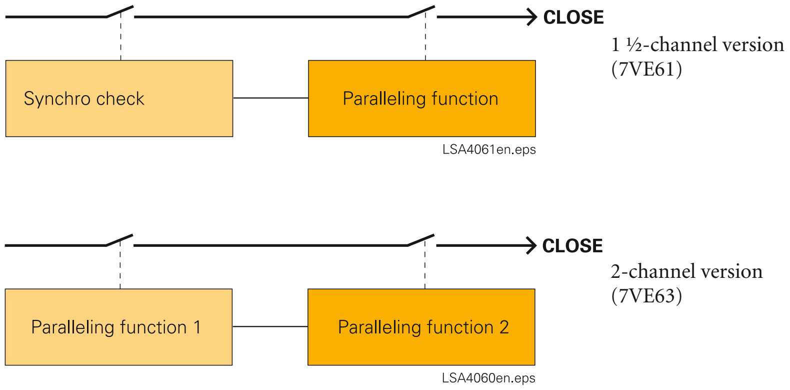


Fig. 11/86
Design of multi-channel redundancy

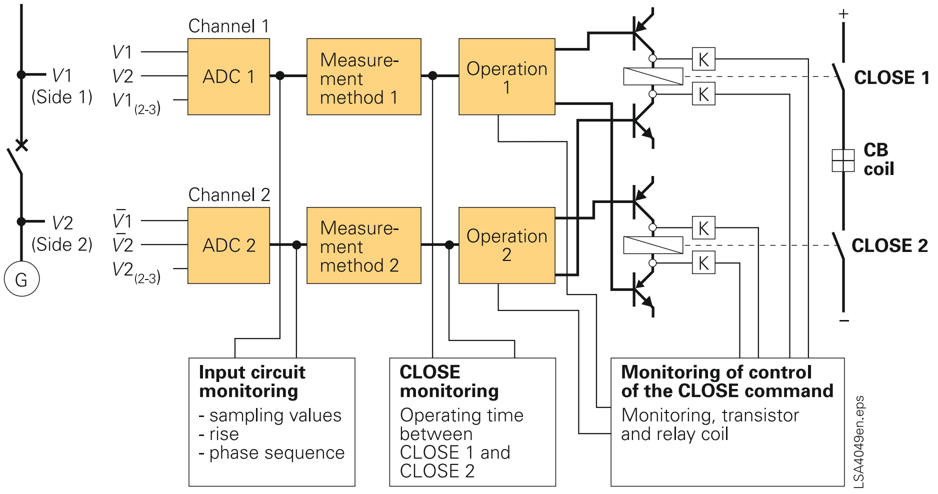
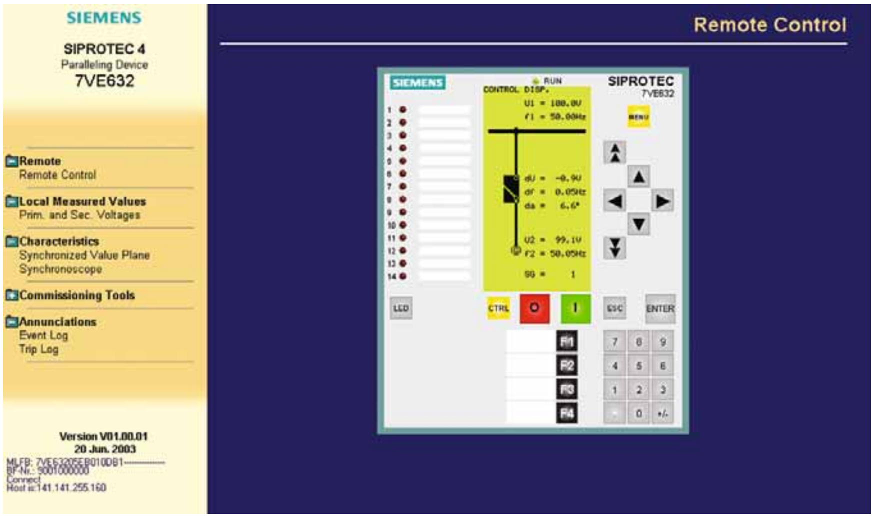


Fig. 11/85
Two-channel redundancy

Functions

Internet technology simplifies commissioning

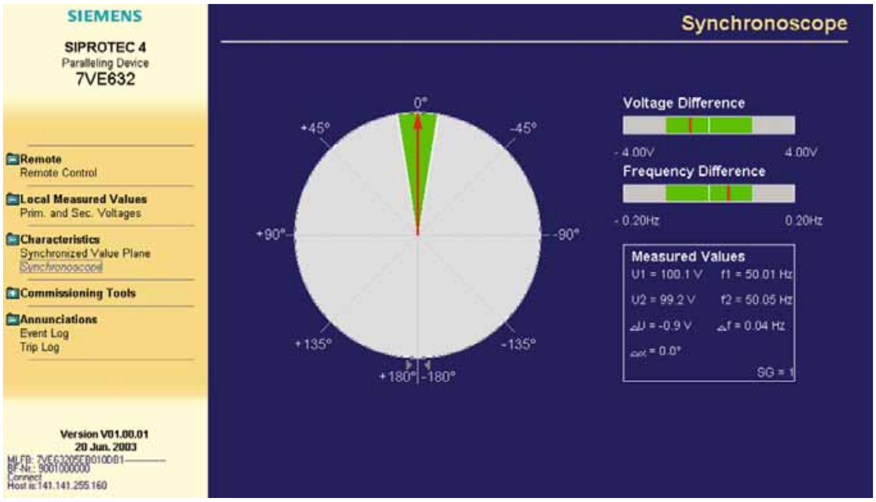
In addition to the universal DIGSI 4 operating program, the synchronizer contains a Web server that can be accessed via a telecommunications link using a browser (e.g. Internet Explorer). The advantage of this solution is that it is both possible to operate the unit with standard software tools and to make use of the Intranet/ Internet infrastructure. Moreover, information can be stored in the unit without any problems. In addition to numeric values, visualizations facilitate work with the unit. In particular, graphical displays provide clear information and a high degree of operating reliability. Fig. 11/88 shows an example of an overview that is familiar from conventional synchronizers. The current status of synchronization conditions is clearly visible. Of course, it is possible to call up further measured value displays and annunciation buffers. By emulation of integrated unit operation, it is also possible to adjust selected settings for commissioning purposes, (see Fig. 11/87).



CONTROL DISP.
U1 = 100.0V
f1 = 50.00Hz
dU = -0.9V
df = 0.05Hz
da = 6.6°
U2 = 99.1V
f2 = 50.05Hz
SG = 1

LSP2481fen.tif

Fig. 11/87
Browser-based operation



Measured Values
U1 = 100.1 V f1 = 50.01 Hz
U2 = 99.2 V f2 = 50.05 Hz
ΔU = -0.9 V Δf = 0.04 Hz
Δα = 0.0°
SG = 1

LSP2482fen.tif

Fig. 11/88
Overview display of the synchronization function

Functions

Protection and automation functions

Basic concept

The paralleling function is not performed constantly. Therefore the measured quantities provided at the analog inputs are available for other functions. Voltage and frequency protection or limit value monitoring of these quantities are typical applications. Another possible application is network decoupling. After network disconnection, automatic resynchronization using the CFC is possible on request.
To allow for great flexibility, these functions can be assigned to the analog inputs. This is defined for the specific application.

Undervoltage protection (ANSI 27)

The protection function is implemented on two stages and evaluates the voltage at an input assigned to it. Analysis of a phase-to-phase voltage is beneficial as it avoids starting in the event of earth faults. The protection function can be used for monitoring and decoupling purposes or to prevent voltage-induced instability of generators by disconnection.

Overvoltage protection (ANSI 59)

The protection function is implemented on two stages and evaluates the voltage at an input assigned to it.
The overvoltage protection prevents impermissible stress on equipment due to excessive voltages.

Frequency protection (ANSI 81)

The protection function is implemented on four stages and evaluates the frequency of an input assigned to it. Depending on the frequency threshold setting, the function can provide overfrequency protection (setting $> f_n$) or underfrequency protection (setting $< f_n$. Each stage can be delayed separately. Stage 4 can be configured either as an overfrequency or underfrequency stage.

The application consists of frequency monitoring usually causing network disconnection in the event of any deviations. The function is suitable as a load shedding criterion.

Rate-of-frequency-change protection (ANSI 81R)

This function can also be assigned to an input. The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed to react to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

This function is used for fast load shedding or for network decoupling.

Jump of voltage vector monitoring

Smaller generating plants frequently require the vector jump function. With this criterion it is possible to detect a disconnected supply (e.g. due to the dead time during an automatic reclosure) and initiate generator disconnection. This avoids impermissible loads on the generating plant, especially the drive gearing, if reconnection to the network is asynchronous.

The vector jump function monitors the phase angle change in the voltage.

If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

Vector jump monitoring is performed again for the assigned voltage input. This function is blocked during synchronization.

Threshold monitoring

The threshold function is provided for fast monitoring and further processing in the CFC. Optional monitoring of the calculated voltage (for violation of an upper or lower threshold) at the six voltage inputs is possible. A total of three greater-than and three less-than thresholds are available. The check is made once per cycle, resulting in a minimum operating time of about 30 ms for the voltage. The times can be extended by the internal check time, if necessary (about 1 cycle).

Typical applications

Connection to three-phase voltage transformer

If three-phase voltage transformers are available, connection as shown in Fig. 11/89 is recommended. This is the standard circuit because it provides a high level of reliability for the paralleling function. The phase-sequence test is additionally active, and several voltages are checked on connection to a dead busbar. Interruption in the voltage connection does not lead to unwanted operation. Please note that side 1 (that is, V_1) is always the feed side. That is important for the direction of balancing commands.

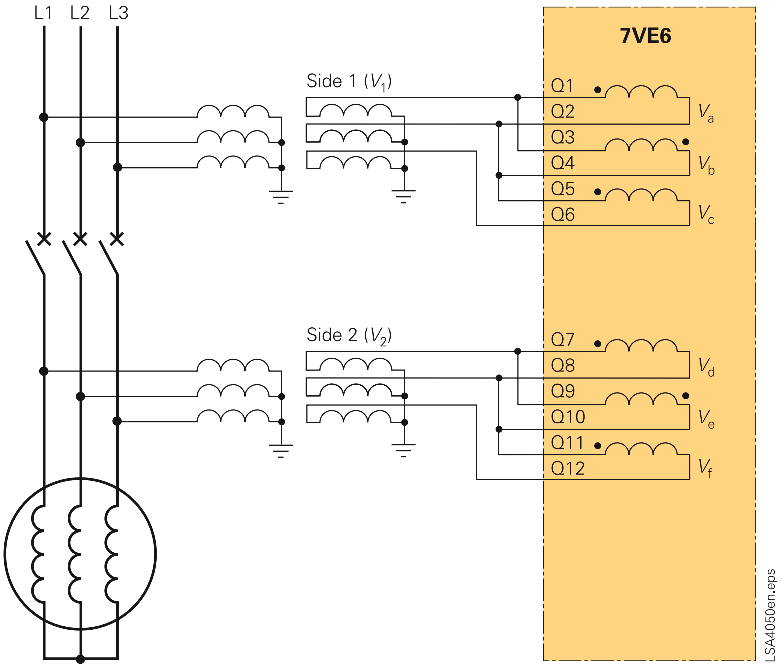


Fig. 11/89

Connection to open delta connection (V-connection) voltage transformer

Fig. 11/90 shows an alternative to Fig. 11/89 for substations in which the voltage transformers have to be V-connected. For the paralleling device, this connection is the electrical equivalent of the connection described above. It is also possible to combine the two: three one-pole isolated voltage transformers on one side and the V-connection on the other. If, additionally, a synchroscope is connected, it must be electrically isolated by means of an interposing transformer.

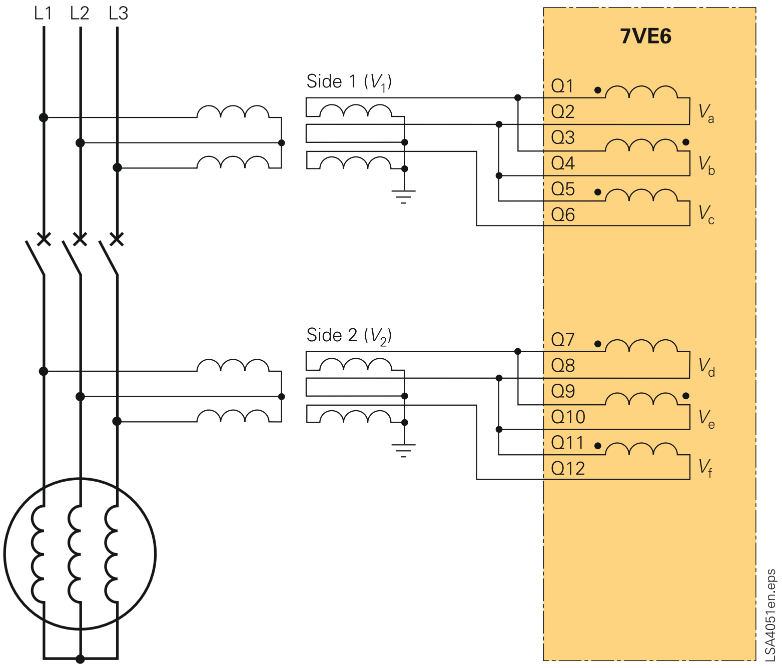


Fig. 11/90

Typical applications

Connection to unearthed voltage transformer

To save costs for the voltage transformer, two-phase isolated voltage transformers are used that are connected to the phase-to-phase voltage (see Fig. 11/91). In that case, the phase-rotation supervision is inactive and reliability restrictions when connecting to the dead busbar must be accepted.

Full two-channel redundancy is ensured.

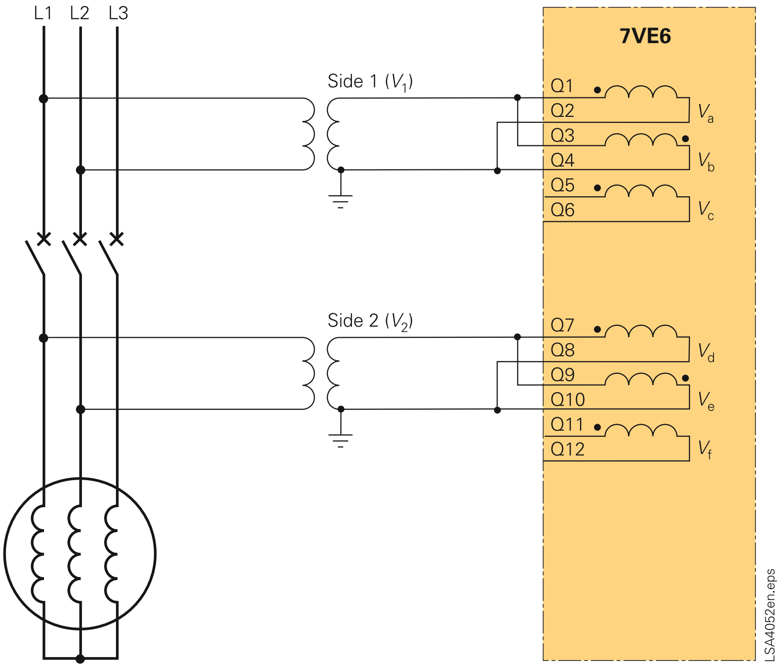


Fig. 11/91

Connection to single-phase isolated voltage transformer

As an alternative to Fig. 11/91, some substations use single-phase isolated voltage transformers (see Fig. 11/92). In this case, only a phase-to-earth voltage is available. This connection should be avoided if possible. Especially in isolated or resonant-(star point) neutral-earthed networks, an earth fault would lead to a voltage value of zero. That does not permit synchronization and the busbar is detected as dead.
If $V_1 <$ and $V_2 >$ connection is permitted, there is a high risk of incorrect synchronization. Furthermore, an earth fault in phase L2 leads to an angle rotation of – for instance – 30° in phase L1. This means that the device switches at a large fault angle.

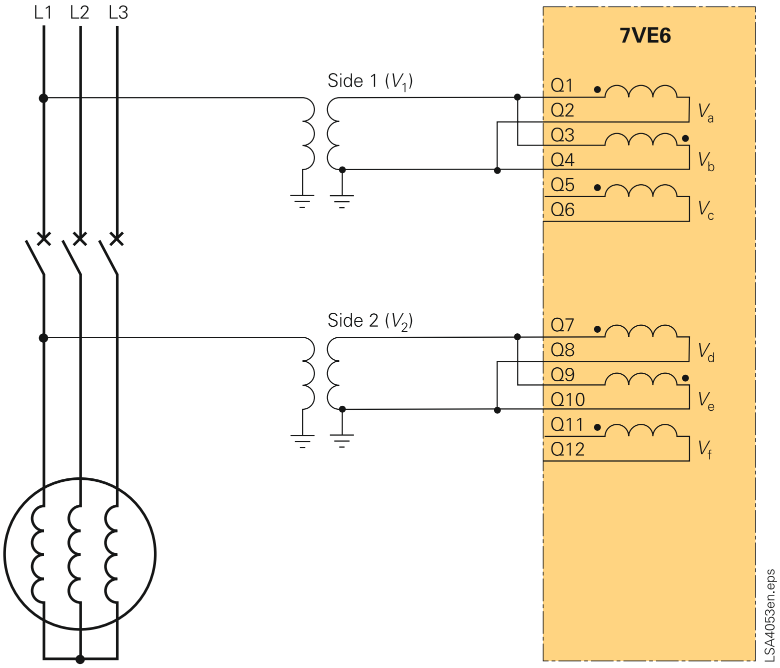


Fig. 11/92

Typical applications

Switching in 16.7 Hz networks for application in traction systems

The unit can also be used for synchronizing railway networks or generators. The connection has to be executed according to Fig. 11/93. No phase sequence test is available here. Two-channel redundancy is ensured.

The voltage inputs permit the application of the 16.7 Hz frequency without any difficulties.

On connection to a dead busbar, a broken wire in the external voltage transformer circuit is not detected. It is recommended to make another interrogation of a second voltage transformer.

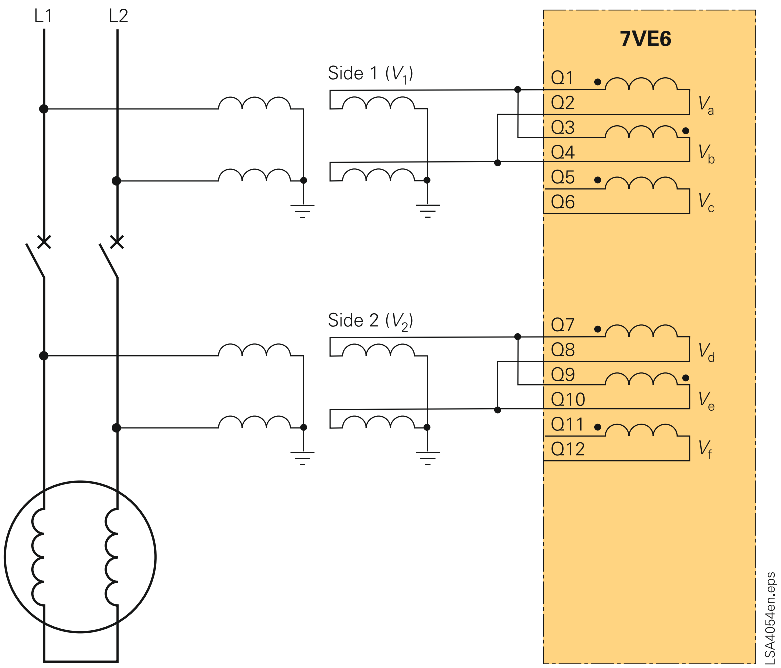


Fig. 11/93

Typical applications

Synchro-check for several synchronizing points

To avoid unwanted operation during manual synchronization or during connection of circuit-breakers in the network, the synchro-check function is used as an enabling criterion. It is fully compatible with all of the connections described above (see Figs. 11/89 to 11/93). With the “synchro-check” ordering option, the paralleling device also allows up to three circuit-breakers to be monitored in parallel. That saves wiring, switching and testing. In particular, that is an application for the 1½ circuit-breaker method. Moreover, on smaller generating plants one unit can be used for up to three generators, which helps reduce costs.

The connection shown in Fig. 11/94 is a single-pole version, which is acceptable for the synchro-check function.

An alternative is the connection for two switching devices (see Fig. 11/95).

The two free voltage inputs can be used for monitoring purposes.

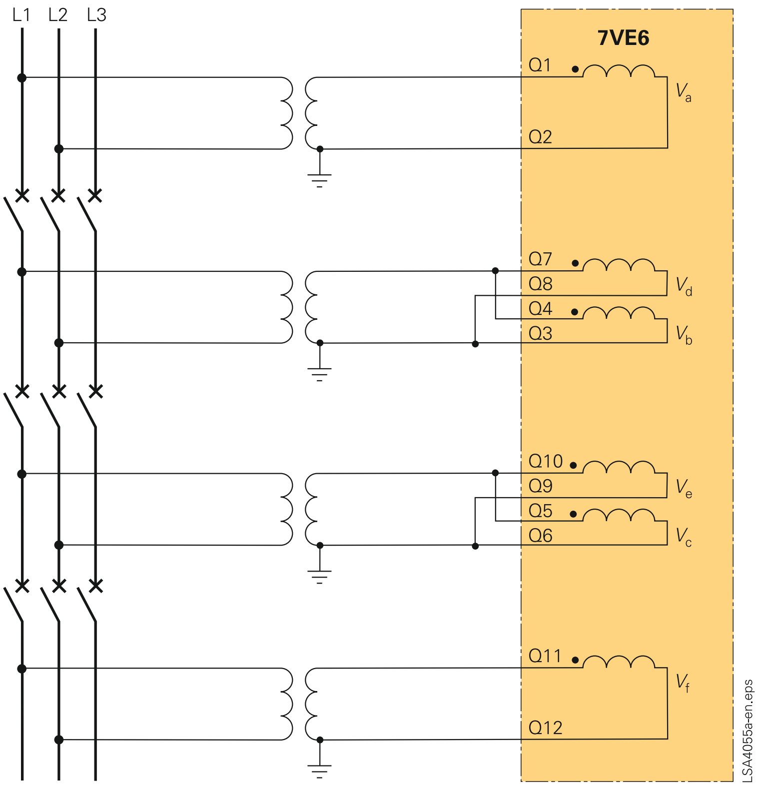


Fig. 11/94

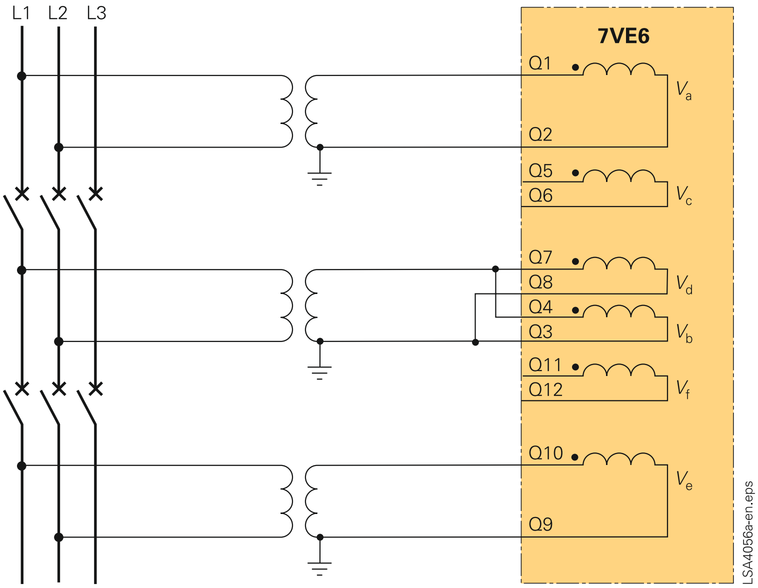


Fig. 11/95

Typical applications

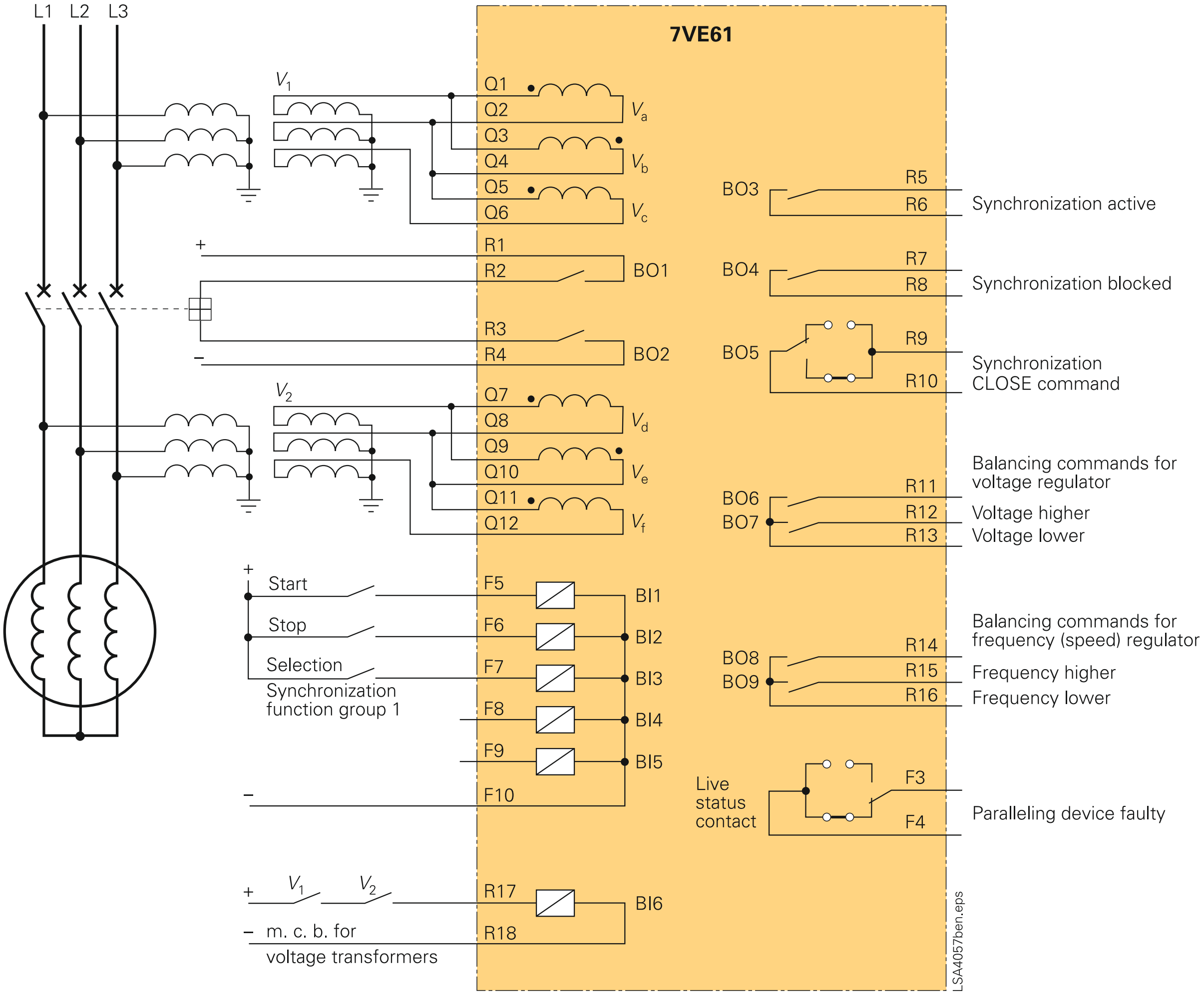


Fig. 11/96

Synchronization of a generator

Fig. 11/96 shows an example of the 7VE61 paralleling device connected to a medium-power generator. Where three-phase voltage transformers are available, direct connection is recommended. The synchronization point and start of synchronization is selected via the binary inputs. If cancellation is necessary, the stop input must be used.

If synchronization onto a dead busbar is permitted, the alarm contact of the voltage transformer miniature circuit-breakers (m.c.b.) must be connected to the unit.

Relays R1 and R2 are used for a CLOSE command. The other relays are used for selected indications and for the balancing commands.

The live status contact operated by the unit self-supervision function must also be wired.

Technical data

Hardware

Analog inputs

Rated frequency	50, 60 or 16.7 Hz
Rated voltage V_N	100 to 125 V
Power consumption	
Voltage inputs (at 100 V)	Approx. 0.3 VA
Capability in voltage paths	230 V continuous

Auxiliary voltage

Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC 220 to 250 V DC 115 and 230 V AC (50/60 Hz)
Permitted tolerance	-20 to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Quiescent	
7VE61	Approx. 4 W
7VE63	Approx. 5.5 W
Energized	
7VE61	Approx. 9.5 W
7VE63	Approx. 12 W
Bridging time during auxiliary voltage failure	
at V_{aux} = 48 V and $V_{aux} \geq$ 110 V	≥ 50 ms
at V_{aux} = 24 V and V_{aux} = 60 V	≥ 20 ms

Binary inputs

Quantity	
7VE61	6
7VE63	14
3 pickup thresholds	14 to 19 V DC, 66 to 88 V DC;
Range is settable with jumpers	117 to 176 V DC
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

Output relays

Quantity	
7VE61	9 (each with 1 NO; 1 optional as NC, via jumper)
7VE62	17 (each with 1 NO; 2 optional as NC, via jumper)
7VE61+7VE63	1 live status contact (NC, NO via jumper)
Switching capacity	
Make	1000 W / VA
Break	30 VA
Break (for resistive load)	40 W
Break (for L/R ≤ 50 ms)	25 W
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds

LEDs

Quantity	
RUN (green)	1
ERROR (red)	1
Assignable LED (red)	
7VE61	7
7VE63	14

Unit design

7XP20 housing	For dimensions see dimension drawings part 15
Degree of protection acc. to EN 60529	
For surface-mounting housing	IP 51
For flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 2x with terminal cover put on
Weight	
Flush-mounting housing	
7VE61 (½ x 19“)	Approx. 5.2 kg
7VE63 (½ x 19“)	Approx. 7 kg
Surface-mounting housing	
7VE61 (½ x 19”)	Approx. 9.2 kg
7VE63 (½ x 19”)	Approx. 12 kg

Serial interfaces

Operating interface for DIGSI 4

Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115,200 baud

Time synchronization IRIG-B / DCF77 signal (Format: IRIG B000)

Connection	9-pin subminiature connector, (SUB-D), terminal with surface-mounting case
Voltage levels	Selectable 5, 12 or 24 V

Service / modem interface (Port C) for DIGSI 4 / modem / service

Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

System interface (Port B) IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU, DNP 3.0) and interface (Port D)

Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 Baud
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
RS485: PROFIBUS-DP, MODBUS RTU, DNP 3.0	9-pin subminiature connector (SUB-D)
Test voltage	500 V / 50 Hz
Baud rate	
PROFIBUS-DP	Max. 12 MBaud
MODBUS RTU, DNP 3.0	Max. 19200 Baud
Distance	
PROFIBUS-DP	Max. 1000 m with 93.75 kBaud; Max. 100 m with 12 MBaud
MODBUS RTU, DNP 3.0	1000 m
Fiber optic: IEC, PROFIBUS-DP, MODBUS RTU, DNP 3.0	ST connector
PROFIBUS-DP	Double ring
IEC, MODBUS RTU, DNP 3.0	Point-to-point
Baud rate	
PROFIBUS-DP	Max. 1.5 MBaud
MODBUS RTU, DNP 3.0	Max. 19200 Baud
Optical wavelength	λ = 820 nm
Permissible path attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	Max. 1.5 km
Analog output module (electrical)	2 ports with 0 to +20 mA

Technical data

System interface (Port B) IEC 61850	
Ethernet, electrical (EN 100) for IEC 61850 and DIGSI	
Connection for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit/s acc. to IEEE802.3
for surface-mounting case	At bottom part of the housing
Test voltage	500 V; 50 Hz
Transmission speed	100 Mbits/s
Distance	20 m/66 ft
Ethernet, optical (EN 100) for IEC 61850 and DIGSI	
Connection for flush-mounting case	Rear panel, mounting location "B", LC connector receiver/transmitter
for panel surface-mounting case	Not available
Optical wavelength	λ = 1350 nm
Transmission speed	100 Mbits/s
Laser class 1 acc. to EN 60825-1/-2	Glass fiber 50/125 µm or glass fiber 62/125 µm
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125µm
Distance	Max. 800 m/0.5 mile

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below
Insulating tests	
Standards	IEC 60255-5
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) only isolated communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for noise immunity (type test)	
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; τ = 15 ms 400 pulses per s; duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated, IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω, 9 µF Differential (transversal) mode: 1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	Common (longitudinal) mode: 2 kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; Duration 2 s; $R_i = 150$ to $200\ \Omega$
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s ; $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200\ \Omega$
EMC tests for interference emission (type test)	
Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes

Technical data

Seismic vibration IEC 60255-21-2, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress test

Temperatures

Standards	IEC 60068-2-1, IEC 60068-2-2
Recommended operating limiting temperature	–5 °C to +55 °C / +25 °F to +131 °F
Temporarily permissible operating temperature	-20 to +70 °C (Legibility of display may be impaired above +55 °C / +131 °F)
Limiting temperature during permanent storage (with supplied packing)	–25 °C to +55 °C / –13 °F to +131 °F
Limiting temperature during transport (with supplied packing)	–25 °C to +70 °C / –13 °F to +158 °F

Humidity

Standards	IEC 60068-2-3
Permissible humidity stress	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permitted
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	

Functions

General

Frequency range	25 to 75 Hz ($f_N = 50$ Hz) 30 to 90 Hz ($f_N = 60$ Hz) 8.35 to 25 Hz ($f_N = 16.7$ Hz)

Paralleling function (ANSI 25)

Setting ranges	
Upper voltage limit V_{max}	20 to 140 V (steps 1 V)
Lower voltage limit V_{min}	20 to 125 V (steps 1 V)
$V <$ for de-eergized status	1 to 60 V (steps 1 V)
$V >$ for energized status	20 to 140 V (steps 1 V)
Voltage difference ΔV	0 to 40 V (steps 1 V)
Frequency difference Δf	0 to 2 Hz (steps 0.01 Hz)
Angle difference $\Delta\alpha$	2 to 80° (steps 1°)
Changeover threshold asynchronous – synchronous	0.01 to 0.04 Hz (steps 0.01 Hz)
Angle correction of vector group	0 to 359° (steps 1°)
Matching voltage transformer V_1/V_2	0.5 to 2 (steps 0.01)
Circuit-breaker making time	10 to 1000 ms (steps 1 ms)
Operating time of circuit-breaker	0.01 to 10 s (steps 0.01 s)
Max. operating time after start	0.01 to 1200 s (steps 0.01 s)
Monitoring time of voltage	0 to 60 s (steps 0.1 s)
Release delay	0 to 60 s (steps 0.01 s)
Synchronous switching	0 to 60 s (steps 0.01 s)
Times	
Minimum measuring time	Approx. 80 ms (50/60 Hz) Approx. 240 ms (16.7 Hz)
Drop-off	
Drop-off ratio voltage	Approx. 0.9 ($V >$) or 1 ($V <$)
Drop-off difference frequency	20 mHz
Drop-off difference phase angle	1 °
Tolerance	
Voltage measurement	1 % of pickup value or 0.5 V
Voltage difference ΔV	1 % of pickup value or max. 0.5 V (typical < 0.2 V)
Frequency difference Δf	< 10 mHz (synchronous network) < 15 mHz (asynchronous network)
Angle difference $\Delta\alpha$	0.5° with minor slip and approx. rated frequency 3° for $\Delta f < 1$ Hz, 5° for $\Delta f > 1$ Hz
Delay times	1 % or 10 ms

Readjustment commands for synchronization

Frequency balancing	
Minimum control pulse	10 to 1000 ms (steps 1 ms)
Maximum control pulse	1 to 32 s (steps 0.01 s)
Frequency change of controller	0.05 to 5 Hz/s (steps 0.01 Hz/s)
Setting time of controller	0 to 32 s (steps 0.01 s)
Target value for frequency balancing	-1 to 1 Hz (steps 0.01 Hz)
Kick pulse	Available
Voltage balancing	
Minimum control pulse	10 to 1000 ms (steps 1 ms)
Maximum control pulse	1 to 32 s (steps 0.01 s)
Voltage change of controller	0.1 to 50 V/s (steps 0.1 V/s)
Setting time of controller	0 to 32 s (steps 0.01 s)
Permissible overexcitation $(V/V_N)/(f/f_N)$	1 to 1.4 (steps 0.01)
Tolerances	
Minimum control pulse	1 %
Control times	Approx. 5 % or ± 20 ms

Undervoltage protection (ANSI 27)

Setting range	
Undervoltage pickup $V <, V <<$	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times $V <, V <<$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times $V <, V <<$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio $V <, V <<$	1.01 to 1.10 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Technical data

Overvoltage protection (ANSI 59)

Setting ranges	
Overvoltage pickup $V>$, $V>>$	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup times $V>$, $V>>$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times $V>$, $V>>$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio $V>$, $V>>$	0.90 to 0.99 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Frequency protection (ANSI 81)

Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms (300 ms at 16.7 Hz)
Drop-off times $f>$, $f<$	Approx. 100 ms (300 ms at 16.7 Hz)
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Frequencies	10 mHz at $f = f_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Rate-of-frequency-change protection (ANSI 81R)

Setting ranges	
Steps, selectable $+df/dt >$; $- df/dt$	4
Pickup value df/dt	0.1 to 10 Hz/s (steps 0.1 Hz/s);
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times df/dt at 16.7 Hz: times x 3	Approx. 200 to 700 ms (depending on measuring duration)
Drop-off times df/dt at 16.7 Hz: times x 3	Approx. 200 to 700 ms (depending on measuring duration)
Drop-off ratio df/dt	0.02 at 0.99 Hz/s (settable)
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Rate-of-frequency change	Approx. 0.1 Hz/s at $V > 0.5\ V_N$
Measuring duration < 5	Approx. 5 % or 0.15 Hz/s at $V > 0.5\ V_N$
Measuring duration > 5	Approx. 3 % or 0.15 Hz/s at $V > 0.5\ V_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Jump of voltage vector monitoring

Setting ranges	
Stage $\Delta\varphi$	2° to 30° (steps 0.1°)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Maximum voltage	10 to 170 V (steps 0.1 V)
Times	
Pickup times $\Delta\varphi$	Approx. 75 ms (225 ms at 16.7 Hz)
Drop-off times $\Delta\varphi$	Approx. 75 ms (225 ms at 16.7 Hz)
Tolerances	
Vector jump	0.5° at $V > 0.5\ V_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

External trip coupling

Number of external trip couplings	4

Threshold value supervision

Number of steps	6 (3 larger and 3 smaller)
Measured quantity	V_a, V_b, V_c, V_d, V_e, V_f
Setting ranges	2 to + 200 % (steps 1 %)
Times	
Pickup times	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio	0.95
Voltage tolerance	1 % of set value or 0.5 V

Typical operational measured values

Description	Secondary
Voltages	V_a; V_b; V_c; V_d; V_e; V_f; V_1, V_2, ΔV
Tolerance	0.2 % of measured value or ± 0.2 V ± 1 digit
Phase angle	$\Delta\alpha$
Tolerance	< 0.5°
Frequency	f_1, f_2, Δf
Tolerance	10 mHz at $f = f_N$ 15 mHz at $f = f_N \pm 10\ \%$

Fault records

Number of fault records	Max. 8 fault records
Instantaneous values	
Storage time	Max. 10 s
Sampling interval	Depending on the actual frequency (e. g. 1 ms at 50 Hz; 0.83 ms at 60 Hz)
Channels	V_a, V_b, V_c, V_d, V_e, V_f, V_d-V_a, V_e-V_b, V_f-V_c, ΔV, Δf, $\Delta\alpha$
R.m.s. values	
Storage period	Max. 100 s
Sampling interval	Fixed (10 ms at 50 Hz, 8.33 ms at 60 Hz)
Channels	V_1, V_2, f_1, f_2, ΔV, Δf, $\Delta\alpha$

Additional functions

Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits
Switching statistics	Number of break operations Number of make operations

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Order code
7VE61 multifunction paralleling unit Housing 1/3 19", 6 BI, 9 BO, 1 live status contact	*7VE6110-□□□□□-0□□□*	*□□□*
Auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC , threshold binary input 19 V	*2*	
60 to 125 V DC, threshold binary input 19 V	*4*	
110 to 250 V DC, 115 to 230 V AC, threshold binary input 88 V DC	*5*	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V DC	*6*	
Unit design		
Surface-mounting housing, 2-tier screw-type terminals at top/bottom	*B*	
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	*E*	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, language German (language selectable)	*A*	
Region World, 50/60 Hz, language English (GB) (language selectable)	*B*	
Region US, 60 Hz, language English (US) (language selectable)	*C*	
Region World, 50/60 Hz, language Spanish (language selectable)	*E*	
Port B (system interface)		
No system interface	*0*	
IEC 60870-5-103-protocol, electrical RS232	*1*	
IEC 60870-5-103-protocol, electrical RS485	*2*	
IEC 60870-5-103-protocol, optical 820 nm, ST connector	*3*	
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA	*7*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector 1)	*9*	*L 0 B*
MODBUS RTU, electrical RS485	*9*	*L 0 D*
MODBUS RTU, optical 820 nm, ST connector 1)	*9*	*L 0 E*
DNP 3.0, electrical RS485	*9*	*L 0 G*
DNP 3.0, optical 820 nm, ST connector 1)	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connectors	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector2)	*9*	*L 0 S*
Port C (service interface)		
DIGSI 4/modem, electrical RS232	*1*	
DIGSI 4/modem, electrical RS485	*2*	
Port C (service interface) and Port D (additional interface)		
Port C (service interface)		
DIGSI 4/modem, electrical RS232	*9*	*M 1 □*
DIGSI 4/modem, electrical RS485	*9*	*M 2 □*
Port D (additional interface)		
Analog outputs 2 x 0 to 20 mA or 4 to20 mA		*K*
Scope of functions of the unit		
Synchro-check for up to 3 synchronizing points (with dead bus/line monitoring)	*A*	
Paralleling function for 2 synchronizing points without balancing commands, 1½-channel, synchro-check in 2nd channel	*B*	
Paralleling function for 2 synchronizing points with balancing commands, 1½-channel, synchro-check in 2nd channel	*C*	
Paralleling function for 4 synchronizing points with balancing commands, 1½-channel, synchro-check in 2nd channel	*D*	
Additional functions		
Without	*A*	
Protection and network decoupling function (voltage, frequency and rate-of-frequency-change protection, vector jump)	*B*	
Additional applications		
Without	*0*	
Application for traction systems (f_n = 16.7 Hz)	*1*	

1) With position 9 = *B* (surface-mounting housing) the unit must be ordered with RS485 interface and a separate FO converter.

2) Not available with position 9 = "*B*"

Selection and ordering data

Description	Order No.	Order code
7VE63 multifunction paralleling unit *Housing 1/2 19", 14 BI, 17 BO,1 live status contact*	*7VE6320-☐☐☐☐☐-0☐☐☐*	*☐☐☐*
Auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC , threshold binary input 19 V DC	*2*	
60 to 125 V DC, threshold binary input 19 V DC	*4*	
110 to 250 V DC, 115 to 230 V AC, threshold binary input 88 V DC	*5*	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V DC	*6*	
Unit design		
Surface-mounting housing, 2-tier screw-type terminals at top/bottom	*B*	
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	*E*	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, language German (language selectable)	*A*	
Region World, 50/60 Hz, language English (GB) (language selectable)	*B*	
Region US, 60 Hz, language English (US) (language selectable)	*C*	
Region World, 50/60 Hz, language Spanish (language selectable)	*E*	
Port B (system interface)		
No system interface	*0*	
IEC 60870-5-103-protocol, electrical RS232	*1*	
IEC 60870-5-103-protocol, electrical RS485	*2*	
IEC 60870-5-103-protocol, optical 820 nm, ST connector	*3*	
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA	*7*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector [1]	*9*	*L 0 B*
MODBUS RTU, electrical RS485	*9*	*L 0 D*
MODBUS RTU, optical 820 nm, ST connector [1]	*9*	*L 0 E*
DNP 3.0, electrical RS485	*9*	*L 0 G*
DNP 3.0, optical 820 nm, ST connector [1]	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connectors	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector[2]	*9*	*L 0 S*
Port C (service interface)		
DIGSI 4/modem, electrical RS232	*1*	
DIGSI 4/modem, electrical RS485	*2*	
Port C (service interface) and Port D (additional interface)		
Port C (service interface)		
DIGSI 4/modem, electrical RS232	*9*	*M 1 ☐*
DIGSI 4/modem, electrical RS485	*9*	*M 2 ☐*
Port D (additional interface)		
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA		*K*
Scope of functions of the unit		
Synchro-check for up to 3 synchronizing points (with dead bus/line monitoring)	*A*	
Paralleling function for 2 synchronizing points without balancing commands, 2-channel, independent measuring procedures	*B*	
Paralleling function for 2 synchronizing points with balancing commands, 2-channel , independent measuring procedures	*C*	
Paralleling function for 8 synchronizing points with balancing commands, 2-channel, independent measuring procedures	*D*	
Additional functions		
Without	*A*	
Protection and network decoupling function (voltage, frequency and rate-of-frequency-change protection, vector jump)	*B*	
Additional applications		
Without	*0*	
Application for traction systems (f_n = 16.7 Hz)	*1*	

1) With position 9 = *B* (surface-mounting housing) the unit must be ordered with RS485 interface and a separate FO converter.

2) Not available with position 9 = "*B*"

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition, device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional Basis and all optional packages on CD-ROM, DIGSI 4 and DIGSI 3	*7XS5402-0AA00*
Copper connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Manual 7VE61 and 7VE63 Multifunction Paralleling Device	*C53000-G1176-C163-1*


LSP2092-afp.eps

Fig. 11/97
Short-circuit links
for voltage contacts


LSP2289-afp.eps

Fig. 11/98
Mounting rail for 19" rack

Description		Order No.	Size of package	Supplier
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP 1)
		0-827396-1	1	AMP 1)
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP 1)
		0-827397-1	1	AMP 1)
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP 1)
		0-163084-2	1	AMP 1)
Crimping tool	for type III+	*0-539635-1*	1	AMP 1)
	and matching female	*0-539668-2*		AMP 1)
	for CI2	*0-734372-1*	1	AMP 1)
	and matching female	*1-734387-1*		AMP 1)
19"-mounting rail		*C73165-A63-D200-1*	1	Siemens
Short-circuit links	For voltage terminals	*C73334-A1-C34-1*	1	Siemens
Safety cover for terminals	large	*C73334-A1-C31-1*	1	Siemens
	small	*C73334-A1-C32-1*	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

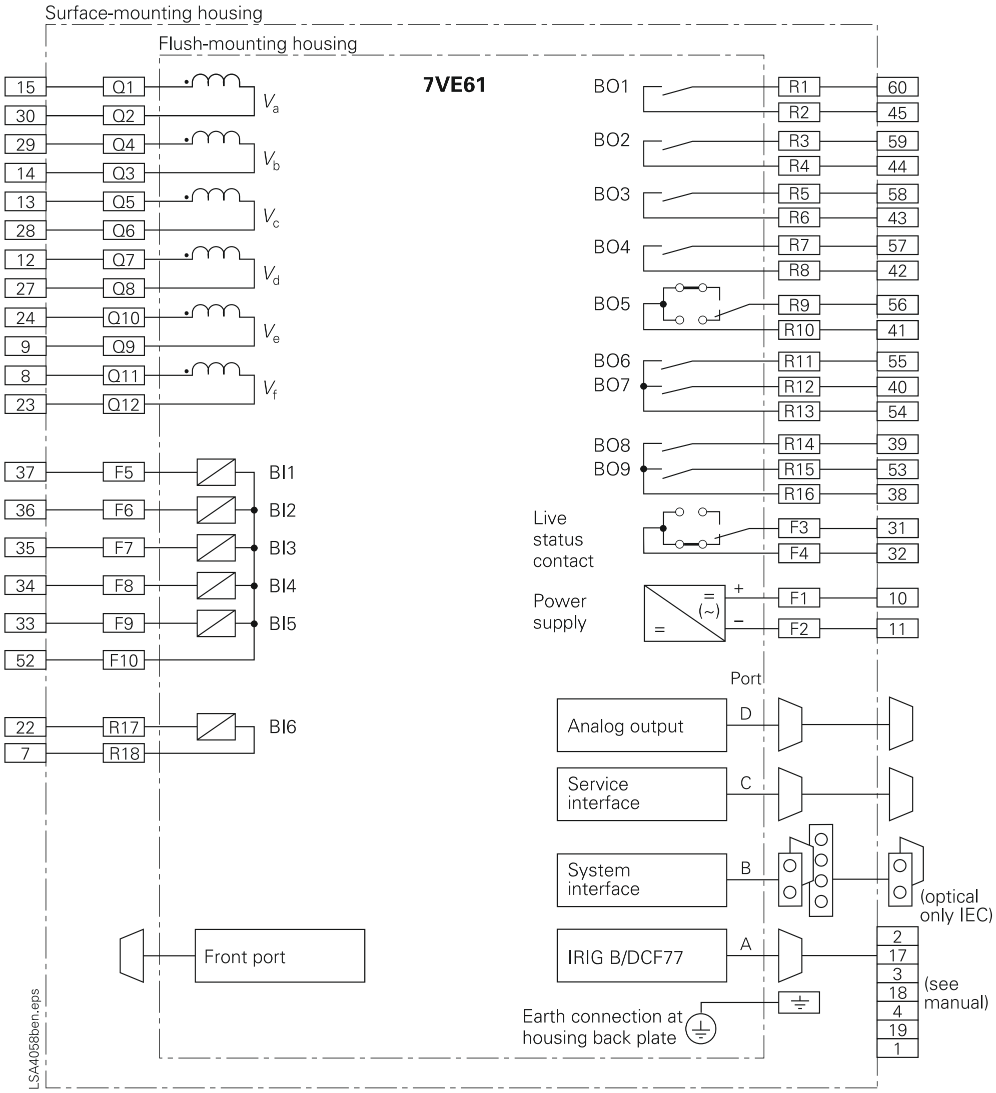


Fig. 11/99
Connection diagram

Connection diagram

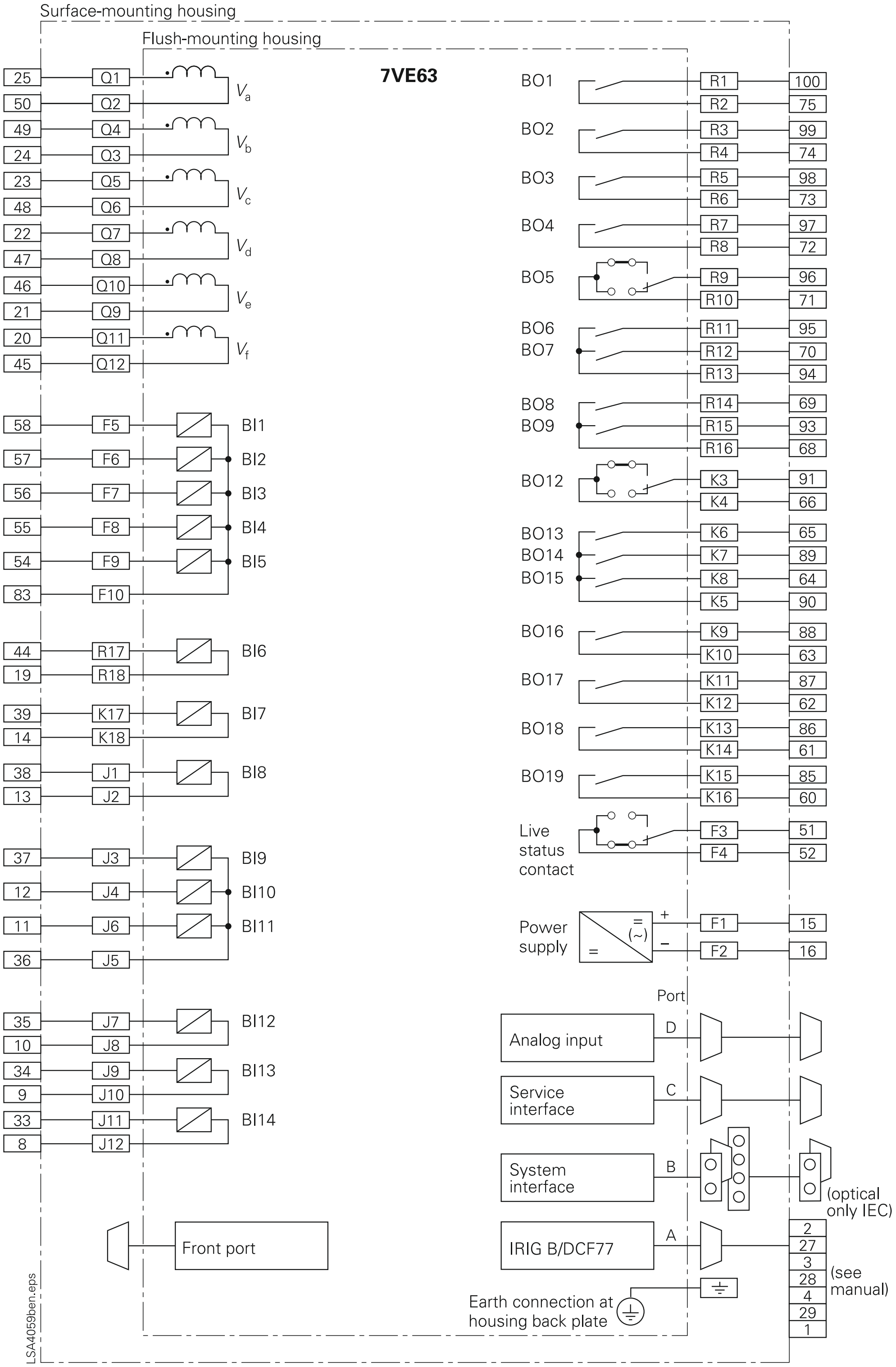
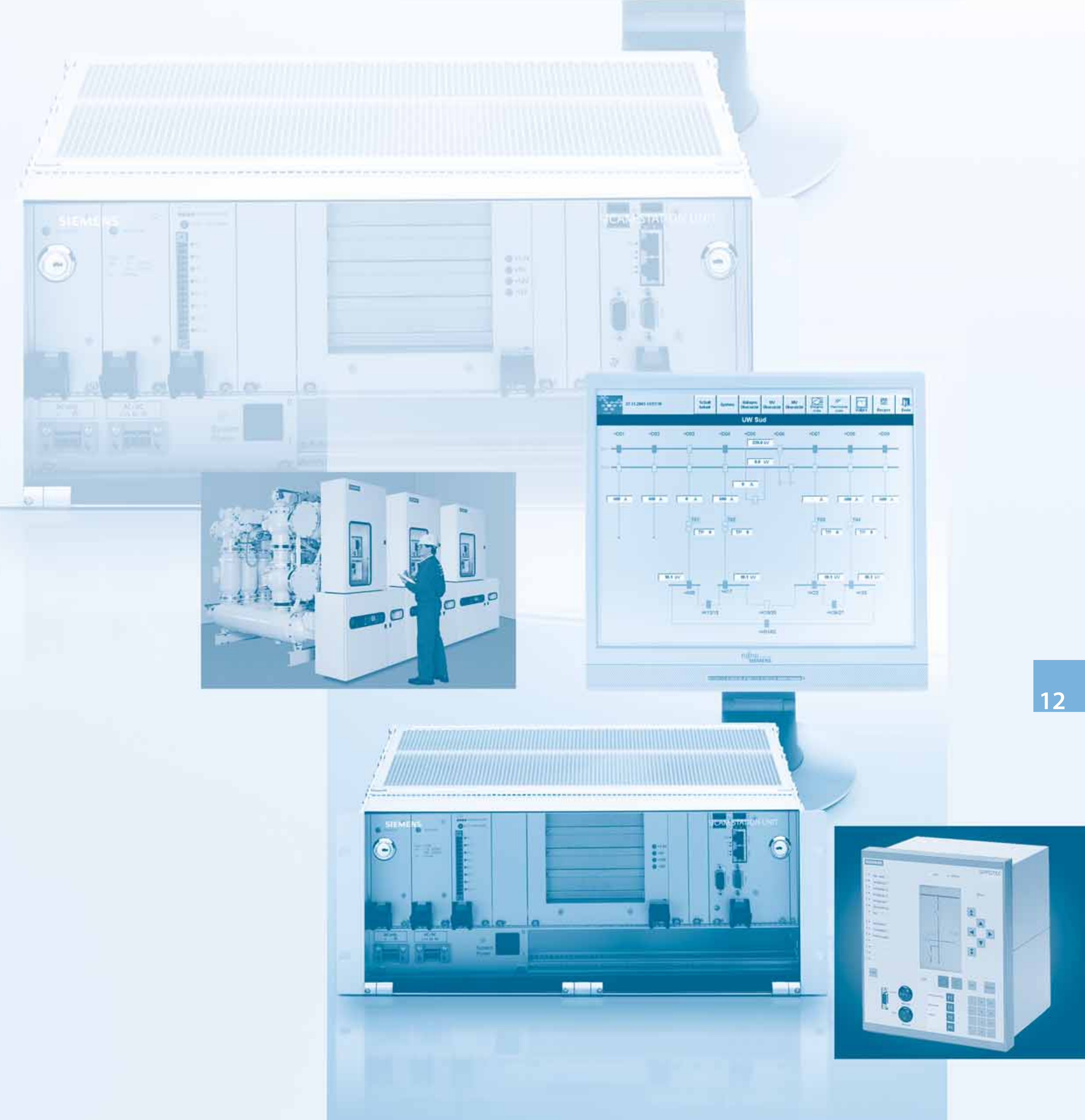


Fig. 11/100
Connection diagram

Substation Automation



SIPROTEC 4 6MD61
IO-Box

Fig. 12/1 SIPROTEC 4 6MD61 IO-Box

Description

The SIPROTEC 4 IO-Box 6MD61 enables in a simple, easy way to enhance the number of binary inputs and outputs in the switchgear. It can be used directly in the bay together with other SIPROTEC4 units and also together with SICAM PAS to serve as a central process connection.

The IO-Box is based on the SIPROTEC 6MD63 and 6MD66 series, so it can be easily integrated in systems with other SIPROTEC 4 units.

The IO-Box supports a wide range of demand for additional binary inputs (BI) and binary outputs (BO), starting from 20 BI+10 BO and going up to 80 BI+53 BO. All important standard communication protocols are supported. With IEC 61850-GOOSE communication, a direct information interchange with other SIPROTEC units is possible. For simplification and cost reduction, the IO-Box is available only without automation (CFC), without keypad and without display.

Function overview

Application

- Extension of number of inputs and outputs of bay controller
- Extension of number of inputs and outputs of protection unit
- Central process connection for SICAM PAS

Features

- Standard SIPROTEC hardware for easy configuration with DIGSI
- Full EMC compliance like all other SIPROTEC devices
- Housing can be used for surface mounting or flush mounting (units are always delivered with two mounting rails for surface mounting. These rails can be dismounted for flush mounting)
- Three types with different amount of inputs and outputs available

Monitoring functions

- Operational measured values (only 6MD612)
- Energy metering values (only 6MD612)
- Time metering of operating hours
- Self supervision of relay

Communication interfaces

- IEC 61850 Ethernet
- IEC 60870-5-103 protocol
- PROFIBUS-FMS
- PROFIBUS-DP
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI4
- Time synchronization via IRIG B / DCF77

Application

The following figures show the most important applications of the SIPROTEC IO-Box 6MD61.

The configuration shown in Fig. 12/2 allows direct GOOSE communication between the SIPROTEC 4 units (6MD66, 7SJ63) and the IO-Boxes, independent of the substation controller. Of course, this configuration is also possible without substation controller. The IO-Box is used as additional digital inputs and measurements (measurements only with 6MD612), and serves as an additional command output.
The communication between IO-Box and the substation controller is established by using the IEC 61850 standard protocol.

Fig. 12/3 shows a configuration in which the IO-Box is used as a central process connection in the cubicle of the substation controller. For example, cubicle signaling lamps or a signaling horn are controlled by the command relays of the IO-Box.

Fig. 12/4 shows the communication for substations with no Ethernet protocol used. In this case, all communication lines go directly to the substation controller. If information from the IO-Box is used for switchgear interlocking, the interlocking logic must be part of the substation controller.

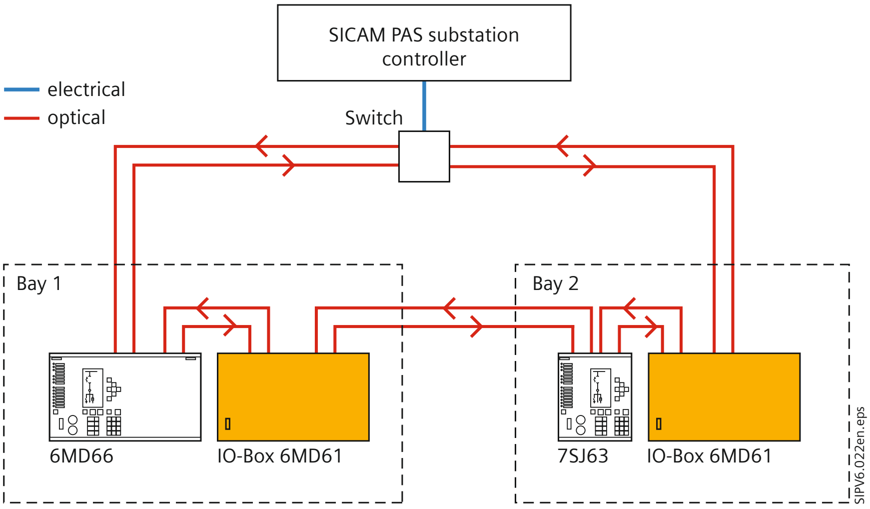


Fig. 12/2 Configuration with IO-Box in IEC 61850 substation

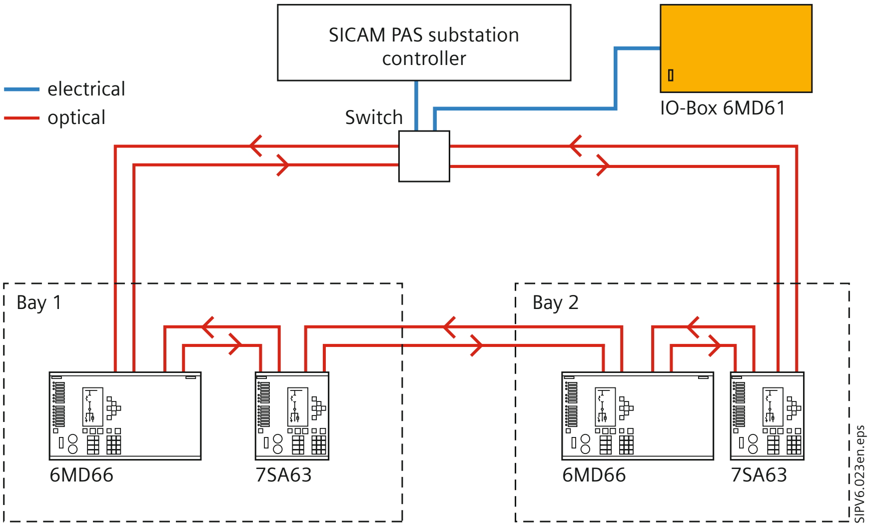


Fig. 12/3 IO-Box as central input/output for SICAM PAS substation controller

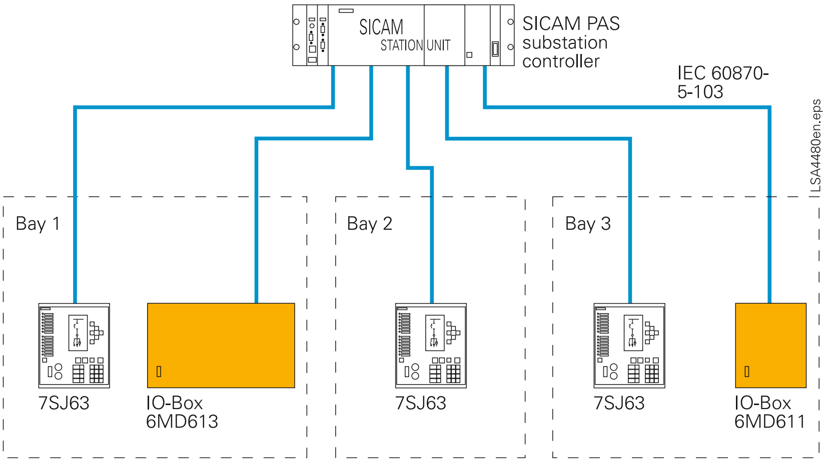


Fig. 12/4 Direct connection of IO-Boxes and protection relays to substation controller via standard protocol

Selection and ordering data

Description	Order No.	Order code
6MD61 IO-Box	*6MD61□□ – □□□□□ – 0AA0*	*□□□*
20 binary inputs, 6 command relays, 4 (2) power relays, 1 live status contact (similar to 6MD634) in 1/2 19" housing	*1*	
33 binary inputs, 14 command relays, 8 (4) power relays, 1 live status contact, 2 x 20mA, 3 x *V*, 4 x *I*, (similar to 6MD636) in 1/1 19" housing	**2**	
80 binary inputs, 53 command relays, 1 live status contact in 1/1 19" housing	*3*	
Current transformer: rated current I_n		
no analog measuring	*0*	
1 A 1)	*1*	
5 A 1)	*5*	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V	*2*	
60 V DC, threshold binary input 19 V 2)	*3*	
110 V DC, threshold binary input 88 V 2)	*4*	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V for input No. 8-80 for 6MD613 (C-I/O 4), otherwise threshold 88 V 2)	*5*	
Unit design		
Surface mounting case, without HMI, mounting in low voltage compartment, screw-type terminals (direct wiring / ring lugs), also usable as flush mounting case	*F*	
Region-specific default settings/function and language presettings		
Region DE, 50 Hz, language German (changeable)	*A*	
Region World, 50/60Hz, language English (GB) (changeable)	*B*	
Region USA (ANSI), 60 Hz, language English (US) (changeable)	*C*	
Region FR, language French (changeable)	*D*	
Region World, 50/60Hz, language Spanish (changeable)	*E*	
System interface (on rear of unit, port B)		
no system port	*0*	
IEC 60870-5-103 protocol, electrical RS232	*1*	
IEC 60870-5-103 protocol, electrical RS485	*2*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
PROFIBUS-FMS Slave, electrical RS485	*4*	
PROFIBUS-FMS Slave, fiber, double ring, ST connector	*6*	
PROFIBUS DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm fiber, double ring, ST connectors	*9*	*L 0 B*
IEC 61850, 100 BaseT (100 Mbit Ethernet electric, double, RJ45 connector)	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, fiber optic, double, LC connectors	*9*	*L 0 S*
Function interface (on rear of unit, port C)		
no function port	*0*	
DIGSI 4, RS232	*1*	
DIGSI 4, RS485	*2*	
DIGSI 4, 820nm fiber, ST connector	*3*	

1) Only for position 6 = *2*

2) Thresholds can be changed (jumper) for each binary input between 19 V and 88 V, for 6MD613 BI No. 8-80 also to 176 V.

Connection diagram

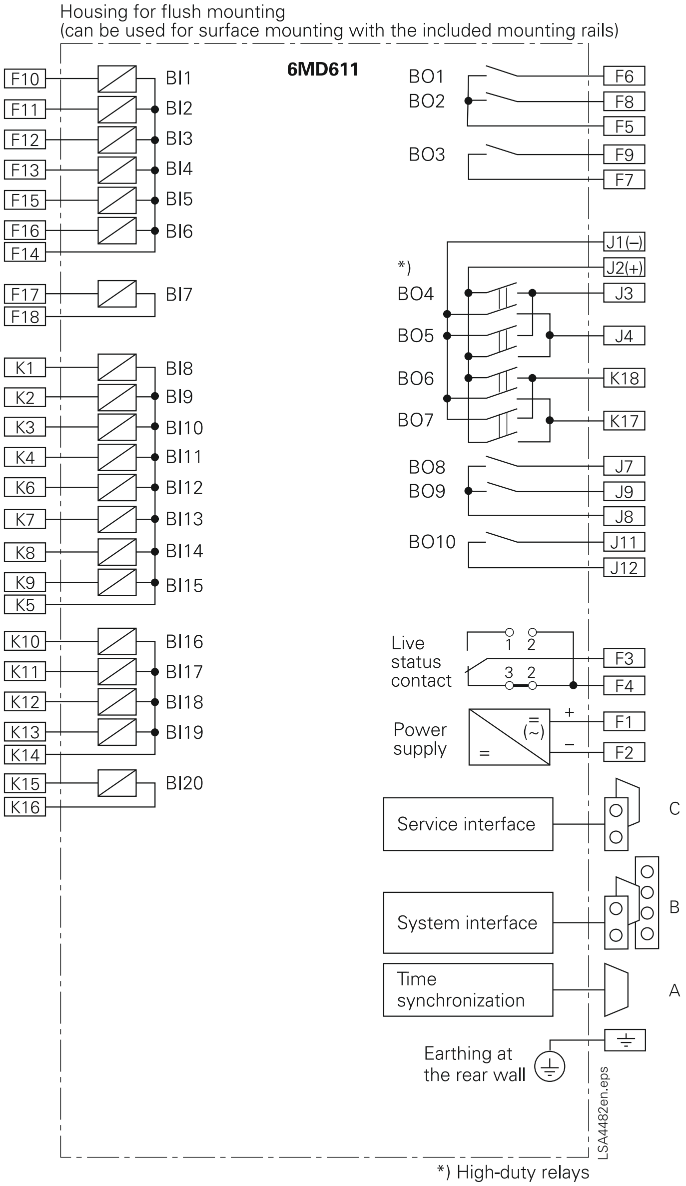
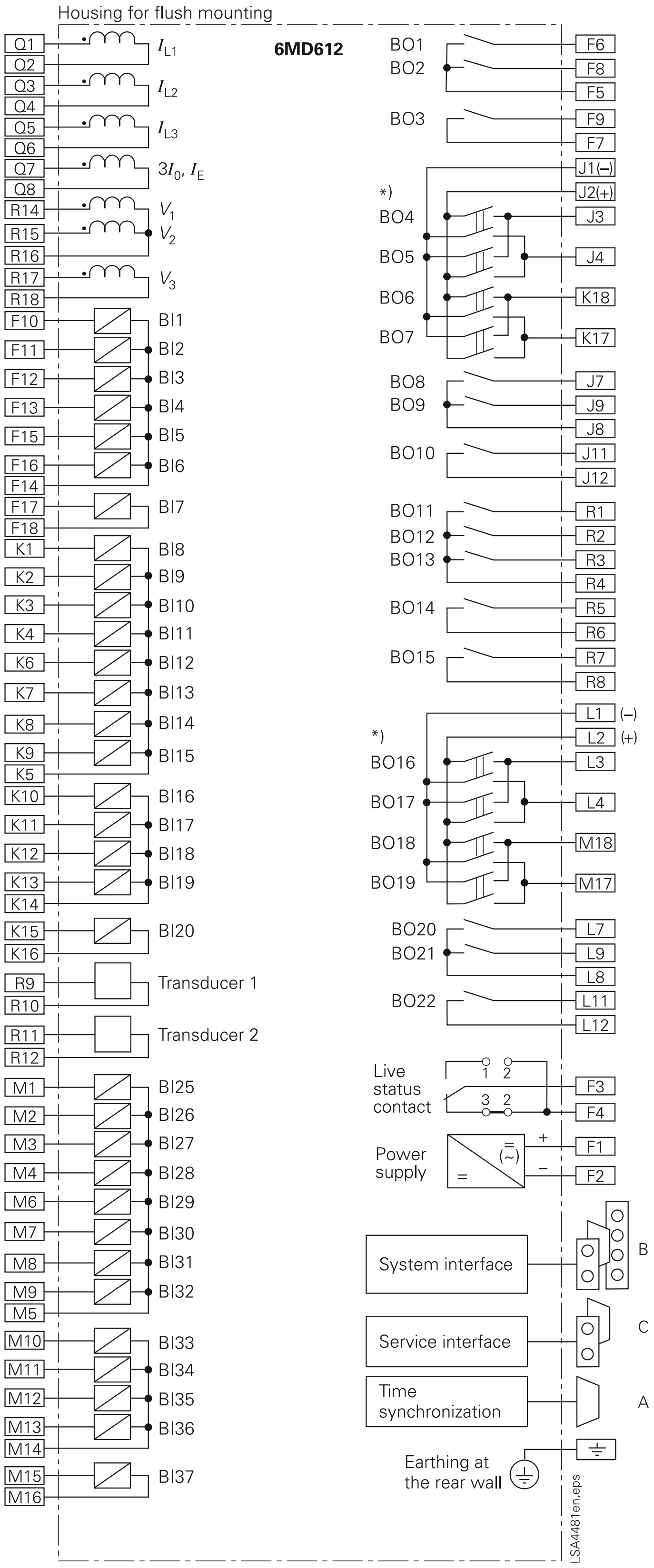


Fig. 12/5 Connection diagram

Connection diagram



*) High-duty relays

Fig. 12/6 Connection diagram

Connection diagram

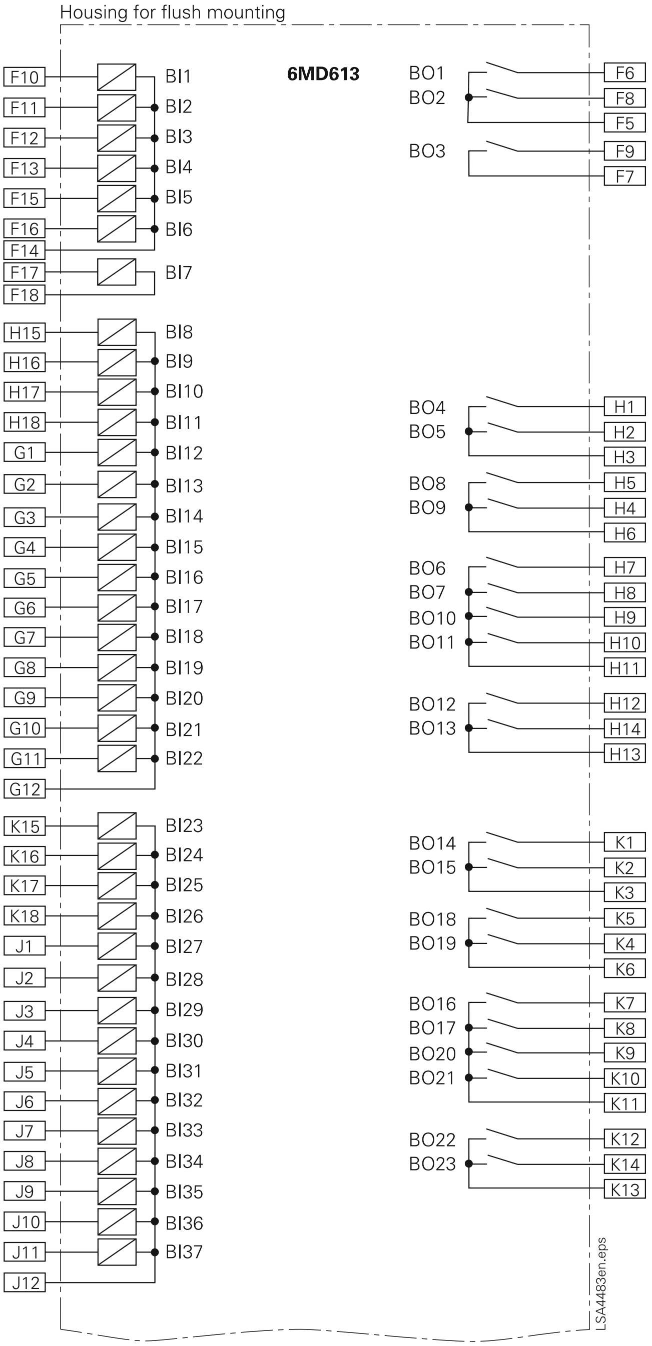


Fig. 12/7 Connection diagram, part 1; continued on the following page

Connection diagram

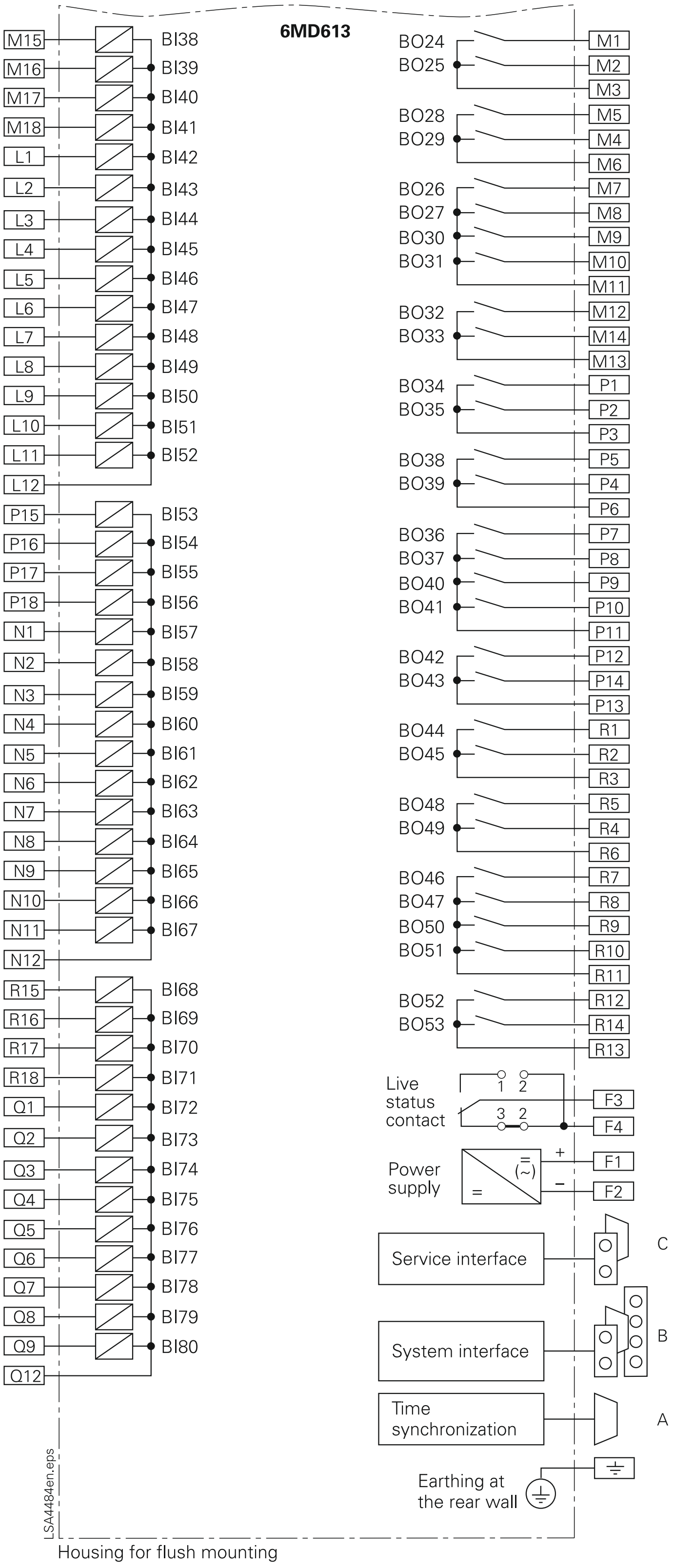


Fig. 12/8 Connection diagram part 2

SIPROTEC 4 6MD63 Bay Control Unit

LSP2314-afp.tif

Fig. 12/9
SIPROTEC 4
6MD63 bay control unit

Description

The 6MD63 bay control unit is a flexible, easy-to-use control unit. It is optimally tailored for medium-voltage applications but can also be used in high-voltage substations.

The 6MD63 bay control unit has the same design (look and feel) as the other protection and combined units of the SIPROTEC 4 relay series. Configuration is also performed in a standardized way with the easy-to-use DIGSI 4 configuration tool .

For operation, a large graphic display with a keyboard is available. The important operating actions are performed in a simple and intuitive way, e.g. alarm list display or switchgear control. The operator panel can be mounted separately from the relay, if required. Thus, flexibility with regard to the mounting position of the unit is ensured.

Integrated key-operated switches control the switching authority and authorization for switching without interlocking.

Function overview

Application

- Optimized for connection to three-position disconnectors
- Switchgear interlocking interface
- Suitable for redundant master station
- Automation can be configured easily by graphic means with CFC

Control functions

- Number of switching devices only limited by number of available inputs and outputs
- Position of switching elements is shown on the graphic display
- Local/remote switching via key switch
- Command derivation from an indication
- 4 freely assignable function keys to speed up frequently recurring operator actions
- Switchgear interlocking isolator/c.-b.
- Key-operated switching authority
- Feeder control diagram
- Measured-value acquisition
- Signal and command indications
- P, Q, cos φ (power factor) and meter-reading calculation
- Event logging
- Switching statistics

Monitoring functions

- Operational measured values
- Energy metering values
- Time metering of operating hours
- Slave pointer
- Self-supervision of relay

Communication interfaces

- System interface
  - IEC 61850 Ethernet
  - IEC 60870-5-103 protocol
  - PROFIBUS-FMS
  - DNP 3.0
  - PROFIBUS-DP
  - MODBUS
  - Service interface for DIGSI 4 (modem)/temperature detection (thermo-box)
  - Front interface for DIGSI 4
  - Time synchronization via IRIG-B/DCF 77

Selection and ordering data

Description	Order No.		Order code
6MD63 bay control unit with local control	*6MD63☐☐ – ☐☐☐☐☐ – ☐AA0*		*☐☐☐*
Housing, binary inputs (BI) and outputs (BO), measuring transducer			
Housing ½ 19”, 11 BI, 8 BO, 1 live status contact	1		
Housing ½ 19”, 24 BI, 11 BO, 4 power relays, 1 live status contact	2		
Housing ½ 19”, 20 BI, 11 BO, 2 measuring transducer inputs, 4 power relays, 1 live status contact	3		
Housing ½ 19”, 20 BI, 6 BO, 4 power relays, 1 live status contact	4	1)	
Housing ¹/₁ 19”, 37 BI, 14 BO, 8 power relays, 1 live status contact	5		
Housing ¹/₁ 19”, 33 BI, 14 BO, 2 measuring transducer inputs, 8 power relays, 1 live status contact	6		
Housing ½ 19”, 33 BI, 9 BO, 8 power relays, 1 live status contact	7	1)	
Current transformer I_n			
No analog measured variables	0		
1 A[2]	1		
5 A[2]	5		
Rated auxiliary voltage (power supply, indication voltage)			
24 to 48 V DC, threshold binary input 19 V[3]	2		
60 to 125 V DC[4], threshold binary input 19 V[3]	4		
110 to 250 V DC[4], 115 to 230 V AC, threshold binary input 88 V[3]	5		
Unit design			
For panel surface mounting, plug-in terminal, detached operator panel	A		
For panel surface mounting, 2-tier terminal, top/bottom	B		
For panel surface mounting, screw-type terminal, detached operator panel	C		
For panel flush mounting, plug-in terminal (2/3 pin AMP connector)	D		
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	E		
For panel surface mounting, screw-type terminal (direct connection / ring-type cable lugs), without HMI	F		
For panel surface mounting, plug-in terminal without HMI	G		
Region-specific default settings/function versions and language settings			
Region DE, 50 Hz, IEC, language: German, changeable	A		
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), changeable	B		
Region US, 60 Hz, ANSI, language: English (US), changeable	C		
Region FR, IEC/ANSI, language: French, changeable	D		
Region World, IEC/ANSI, language: Spanish, changeable	E		
System interface (on rear of unit/Port B)			
No system port	0		
IEC 60870-5-103 protocol, electrical RS232	1		
IEC 60870-5-103 protocol, electrical RS485	2		
IEC 60870-5-103 protocol, 820 nm fiber optic, ST connector	3		
PROFIBUS-FMS Slave, electrical RS485	4		
PROFIBUS-FMS Slave, fiber optic, single ring, ST connector[5]	5		
PROFIBUS-FMS Slave, fiber optic, double ring, ST connector[5]	6		
PROFIBUS-DP Slave, RS485	9		L 0 A
PROFIBUS-DP Slave, 820 nm fiber optic, double ring, ST connector[5]	9		L 0 B
MODBUS, RS485	9		L 0 D
MODBUS, 820 nm fiber optic, ST connector[5]	9		L 0 E
DNP 3.0, RS485	9		L 0 G
DNP 3.0, 820 nm fiber optic, ST connector[5]	9		L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9		L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector[5]	9		L 0 S
DIGSI 4/modem interface (on rear of unit/Port C)			
No port on rear side	0		
DIGSI 4, electrical RS232	1		
DIGSI 4, electrical RS485	2		
DIGSI 4, optical 820 nm, ST connector	3		
Measuring			
Basic metering (current, voltage)	0		
Slave pointer, mean values, min/max values only for position 7= 1 and 5	2		

1) Only for position 7 = 0

2) Rated current can be selected by means of jumpers.

3) The binary input thresholds can be selected in two stages by means of jumpers.

4) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

5) Not with position 9 = “B”; if 9 = “B”; please order 6MD6 unit with RS485 port and separate fiber-optic converter.

SIPROTEC 4 6MD66
High-Voltage Bay Control Unit

Fig. 12/10 SIPROTEC 4 6MD66 high-voltage bay control unit

Description

The 6MD66 high-voltage bay control unit is the control unit for high voltage bays from the SIPROTEC 4 relay series. Because of its integrated functions, it is an optimum, low-cost solution for high-voltage switchbays.

The 6MD66 high-voltage bay control unit also has the same design (look and feel) as the other protection and combined units of the SIPROTEC 4 relay series. Configuration is performed in a standardized way with the easy-to-use DIGSI 4 configuration tool.

For operation, a large graphic display with a keyboard is available. The important operating actions are performed in a simple and intuitive way, e.g. alarm list display or switchgear control. The operator panel can be mounted separately from the unit, if required. Thus, flexibility with regard to the mounting position of the unit is ensured. Integrated key-operated switches control the switching authority and authorization for switching without interlocking. High-accuracy measurement (± 0.5 %) for voltage, current and calculated values *P* and *Q* are another feature of the unit.

Function overview

Application

- Integrated synchro-check for synchronized closing of the circuit-breaker
- Breaker-related protection functions (Breaker Failure 50BF, Autoreclosure 79)
- Automation can be configured easily by graphic means with CFC
- Flexible, powerful measured-value processing
- Connection for 4 voltage transformers, 3 current transformers, two 20 mA transducers
- Volume of signals for high voltage
- Up to 14 1 ½-pole circuit-breakers can be operated
- Up to 11 2-pole switching devices can be operated
- Up to 65 indication inputs, up to 45 command relays
- Can be supplied with 3 volumes of signals as 6MD662 (35 indications, 25 commands), 6MD663 (50 indications, 35 commands) or 6MD664 (65 indications, 45 commands); number of measured values is the same
- Switchgear interlocking
- Inter-relay communication with other devices of the 6MD66 series, even without a master station interface with higher level control and protection
- Suitable for redundant master station
- Display of operational measured values V, I, P, Q, S, f, $\cos\varphi$ (power factor) (single and three-phase measurement)
- Limit values for measured values
- Can be supplied in a standard housing for cubicle mounting or with a separate display for free location of the operator elements
- 4 freely assignable function keys to speed up frequently recurring operator actions

Communication interfaces

- System interface
  - – IEC 61850 Ethernet
  - – IEC 60870-5-103 protocol
  - – PROFIBUS-FMS/-DP
  - – Service interface for DIGSI 4 (modem)
  - – Front interface for DIGSI 4
  - – Time synchronization via IRIG B/DCF 77

Functions

Communication

With regard to communication between components, particular emphasis is placed on the SIPROTEC 4 functions required for energy automation.

- Every data item is time-stamped at its source, i.e. where it originates.
- Information is marked according to where it originates from (e.g. if a command originates "local" or "remote")
- The feedback to switching processes is allocated to the commands.
- Communication processes the transfer of large data blocks, e.g. file transfers, independently.
- For the reliable execution of a command, the relevant signal is first acknowledged in the unit executing the command. A check-back indication is issued after the command has been enabled (i.e. interlocking check, target = actual check) and executed.

In addition to the communication interfaces on the rear of the unit, which are equipped to suit the customer's requirements, the front includes an RS232 interface for connection of DIGSI. This is used for quick diagnostics as well as for the loading of parameters. DIGSI 4 can read out and represent the entire status of the unit online, thus making diagnostics and documentation more convenient.

Control

The bay control units of the 6MD66 series have command outputs and indication inputs that are particularly suited to the requirements of high-voltage technology. As an example, the 2-pole control of a switching device is illustrated (see Fig. 12/11). In this example, two poles of the circuit-breaker are closed and 1 pole is open. All other switching devices (disconnectors, earthing switches) are closed and open in 1½-pole control. A maximum of 14 switching devices can be controlled in this manner.

A complete 2-pole control of all switching devices (see Fig. 12/12) is likewise possible. However more contacts are required for this. A maximum of 11 switching devices can be controlled in this manner.

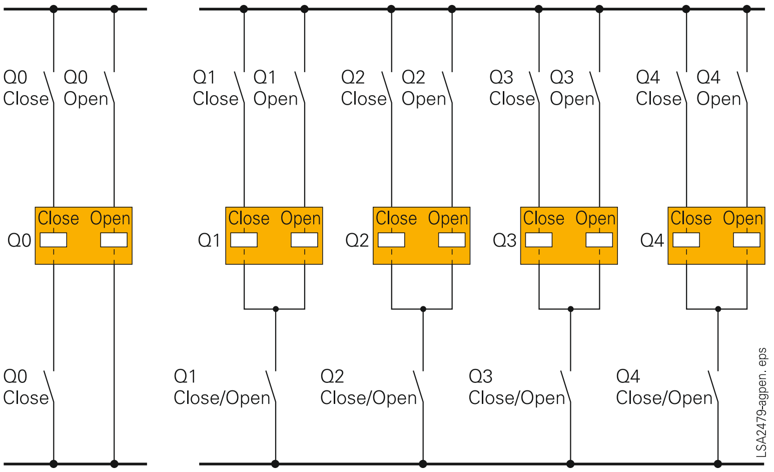


Fig. 12/11 Connection diagram of the switching devices (circuit-breaker 2 poles closed, 1 pole open; disconnector/earthing switch 1½ pole)

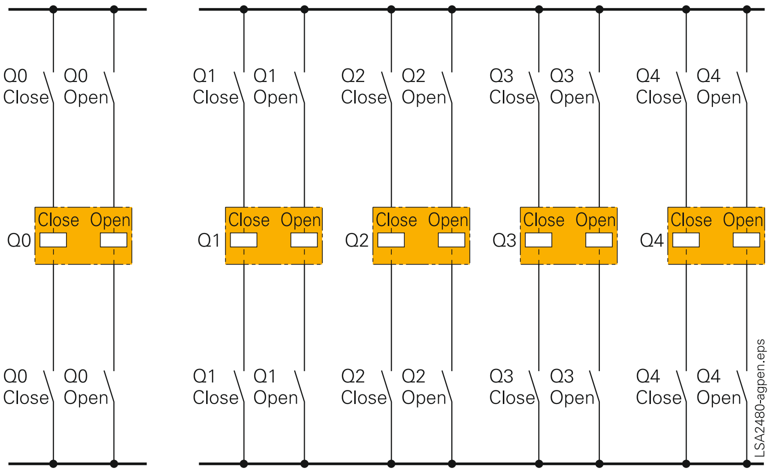


Fig. 12/12 2-pole connection diagram of circuit-breakers and disconnectors

A possible method to connect the switching devices to the bay control unit 6MD66 is shown in Fig. 12/13. There it is shown how three switching devices Q0, Q1, and Q2 are connected using 1½ pole control.

Functions

Switchgear interlockings

Using the CFC (Continuous Function Chart) available in all SIPROTEC 4 units, the bay interlock conditions can, among other things, be conveniently configured graphically in the 6MD66 bay control unit. The inter-bay interlock conditions can be checked via the "inter-relay communication" (see next section) to other 6MD66 devices. With the introduction of IEC 61850 communication, the exchange of information for interlocking purposes is also possible via Ethernet. This is handled via the GOOSE message method. Possible partners are all other bay devices or protection devices which support IEC 61850-GOOSE message.

In the tests prior to command output, the positions of both key-operated switches are also taken into consideration. The upper key-operated switch corresponds to the S5 function (local/remote switch), which is already familiar from the 8TK switchgear interlock system. The lower key-operated switch effects the changeover to non-interlocked command output (S1 function). In the position "Interlocking Off" the key cannot be withdrawn, with the result that non-operation of the configured interlocks is immediately evident.

The precise action of the key-operated switch can be set using the parameter "switching authority".

With the integrated function "switchgear interlocking" there is no need for an external switchgear interlock device.

Furthermore, the following tests are implemented (parameterizable) before the output of a command:

- Target = Actual, i.e. is the switching device already in the desired position?
- Double command lockout, i.e. is another command already running?
- Individual commands, e.g. earthing control can additionally be secured using a code.

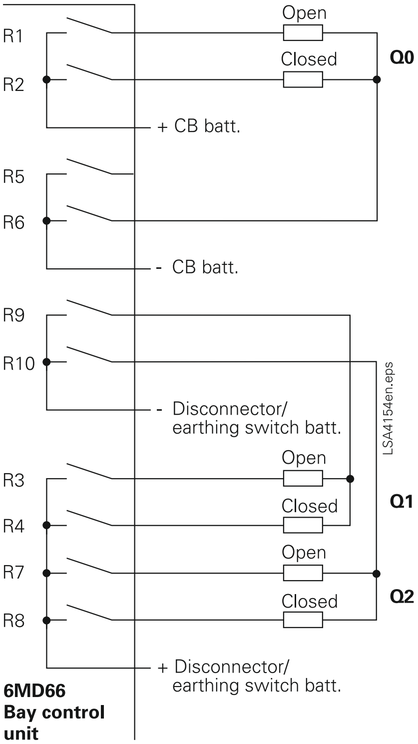


Fig. 12/13
Typical connection for 1½-pole control

Functions

Synchronization

The bay control unit can, upon closing of the circuit-breaker, check whether the synchronization conditions of both partial networks are met (synchro-check). Thus an additional, external synchronization device is not required. The synchronization conditions can be easily specified using the configuration system DIGSI 4. The unit differentiates between synchronous and asynchronous networks and reacts differently upon connection:

In synchronous networks there are minor differences with regard to phase angle and voltage moduli and so the circuit-breaker response time does not need to be taken into consideration. For asynchronous networks however, the differences are larger and the range of the connection window is traversed at a faster rate. Therefore it is wise here to take the circuit-breaker response time into consideration. The command is automatically dated in advance of this time so that the circuit-breaker contacts close at precisely the right time.
Fig. 12/14 illustrates the connection of the voltages.

As is evident from Fig. 12/14, the synchronization conditions are tested for one phase. The important parameters for synchronization are:

$|U_{\text{min}}| < |U| < |U_{\text{max}}|$
(Voltage modulus)

$\Delta\varphi < \Delta\varphi_{\text{max}}$
(Angle difference)

$\Delta f < \Delta f_{\text{max}}$
(Frequency difference)

Using the automation functions available in the bay control unit, it is possible to connect various reference voltages depending on the setting of a disconnector. Thus in the case of a double busbar system, the reference voltage of the active busbar can be automatically used for synchronization (see Fig. 12/15).

Alternatively the selection of the reference voltage can also take place via relay switching, if the measurement inputs are already being used for other purposes.

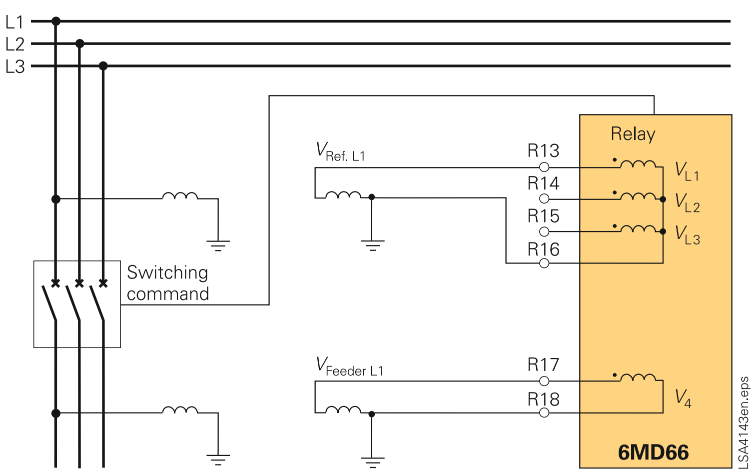


Fig. 12/14
Connection of the measured values for synchronization

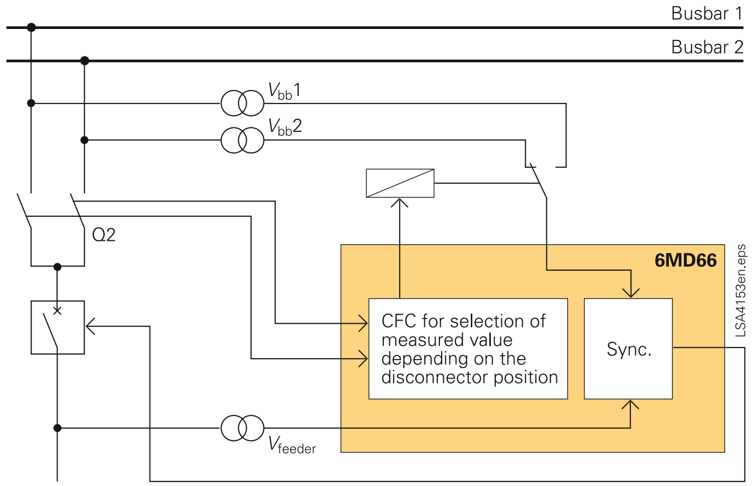


Fig. 12/15
Voltage selection for synchronization with duplicate busbar system

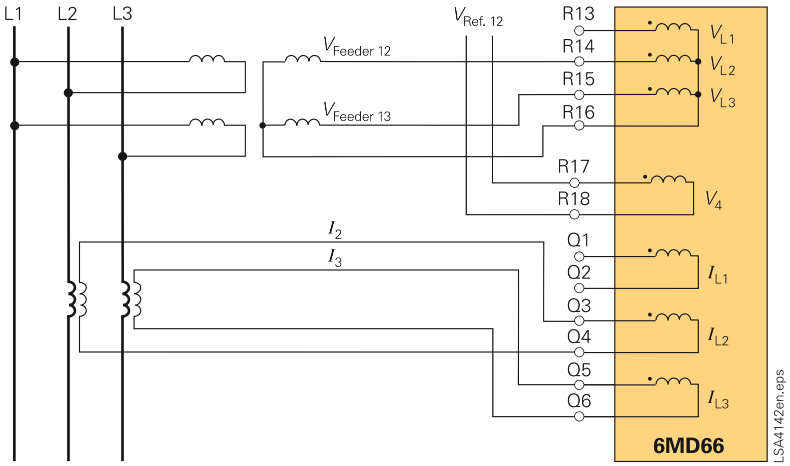


Fig. 12/16
Simultaneous connection of measured values according to a two-wattmeter circuit and synchronization

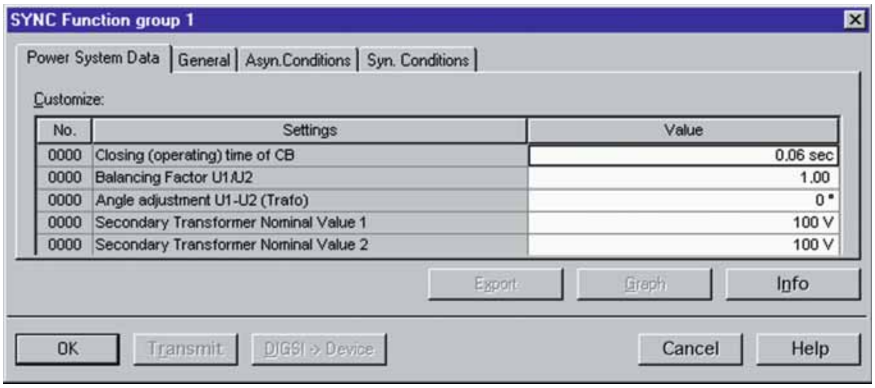
Functions

Synchronization

The bay control unit offers the option of storing various parameter sets (up to eight) for the synchronization function and of selecting one of these for operation. Thus the different properties of several circuit-breakers can be taken into consideration. These are then used at the appropriate time. This is relevant if several circuit-breakers with e.g. different response times are to be served by one bay control unit.

The measured values can be connected to the bay control unit in accordance with Fig. 12/14 (single-phase system) or Fig. 12/16 (two-wattmeter circuit).

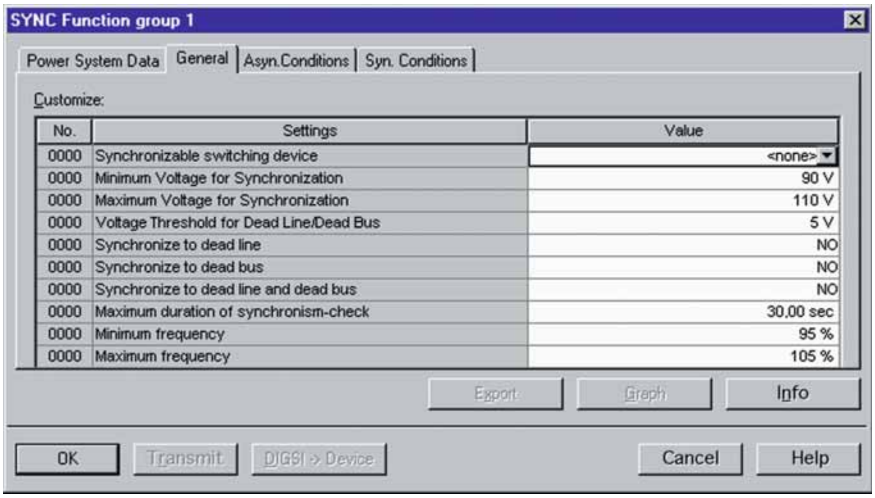
The synchronization function can be parameterized via four tabs in DIGSI.



No.	Settings	Value
0000	Closing (operating) time of CB	0.06 sec
0000	Balancing Factor U1/U2	1.00
0000	Angle adjustment U1-U2 (Trafo)	0 °
0000	Secondary Transformer Nominal Value 1	100 V
0000	Secondary Transformer Nominal Value 2	100 V

LSP2493en.tif

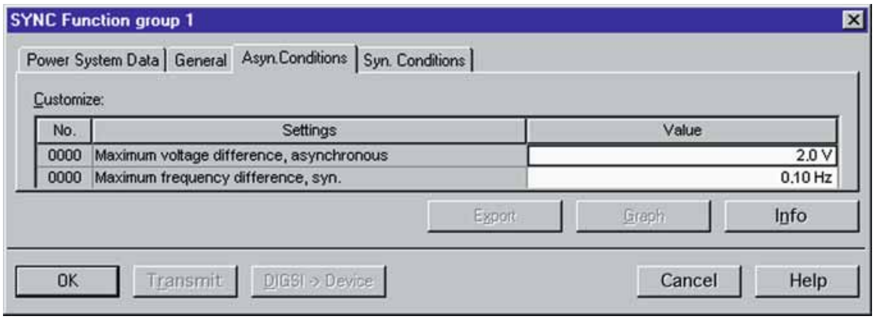
Fig. 12/17
"Power System Data", sheet for parameters of the synchronization function



No.	Settings	Value
0000	Synchronizable switching device	<none>
0000	Minimum Voltage for Synchronization	90 V
0000	Maximum Voltage for Synchronization	110 V
0000	Voltage Threshold for Dead Line/Dead Bus	5 V
0000	Synchronize to dead line	NO
0000	Synchronize to dead bus	NO
0000	Synchronize to dead line and dead bus	NO
0000	Maximum duration of synchronism-check	30.00 sec
0000	Minimum frequency	95 %
0000	Maximum frequency	105 %

LSP2496en.tif

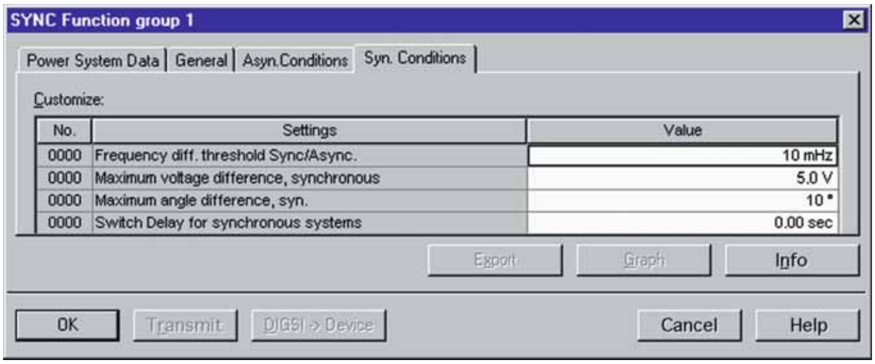
Fig. 12/18
General parameters of the synchronization function



No.	Settings	Value
0000	Maximum voltage difference, asynchronous	2.0 V
0000	Maximum frequency difference, syn.	0.10 Hz

LSP2494en.tif

Fig. 12/19
Parameter page for asynchronous networks



No.	Settings	Value
0000	Frequency diff. threshold Sync/Async.	10 mHz
0000	Maximum voltage difference, synchronous	5.0 V
0000	Maximum angle difference, syn.	10 °
0000	Switch Delay for synchronous systems	0.00 sec

LSP2495en.tif

Fig. 12/20
Parameter page for asynchronous networks

Communication

Communication

The device is not only able to communicate to the substation control level via standard protocol like IEC 61850, IEC 60870-5-103 or others. It is also possible to communicate with other bay devices or protection devices. Two possibilities are available.

Inter-relay-communication

The function "inter-relay-communication" enables the exchange of information directly between 6MD66 bay controller devices. The communication is realized via Port "C" of the devices, so it is independent from the substation communication port "B". Port "C" is equipped with a RS485 interface. For communication over longer distances, an external converter to fiber-optic cable can be used.

An application example for inter-relay-communication is shown in Fig. 12/22. Three 6MD66 devices are used for control of a 1½ circuit-breaker bay. One device is assigned to each of the three circuit-breakers. By this means, the redundancy of the primary equipment is also available on the secondary side. Even if one circuit-breaker fails, both feeders can be supplied. Control over the entire bay is retained, even if one bay control unit fails. The three bay control units use the inter-relay-communication for interchange of switchgear interlocking conditions. So the interlocking is working completely independent from the substation control level.

IEC 61850-GOOSE

With the communication standard IEC 61850, a similar function like inter-relay-communication is provided with the "GOOSE" communication to other IEC 61850-devices. Since the standard IEC 61850 is used by nearly all SIPROTEC devices and many devices from other suppliers, the number of possible communication partners is large.

The applications for IEC 61850-GOOSE are quite the same as for inter-relay-communication. The most used application is the interchange of switchgear interlocking information between bay devices. GOOSE uses the IEC 61850 substation Ethernet, so no separate communication port is needed. The configuration is shown in Fig. 12/23. The SIPROTEC devices are connected via optical Ethernet and grouped by voltage levels (110 kV and 20 kV). The devices in the same voltage level can interchange the substation-wide interlocking information. GOOSE uses the substation Ethernet.

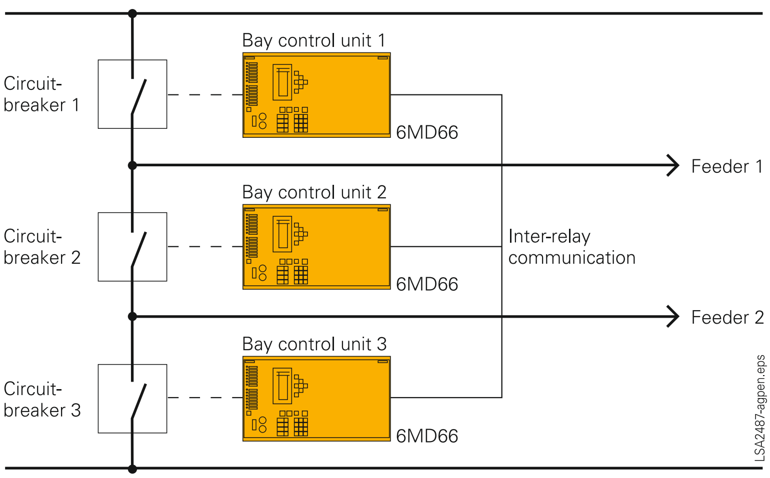
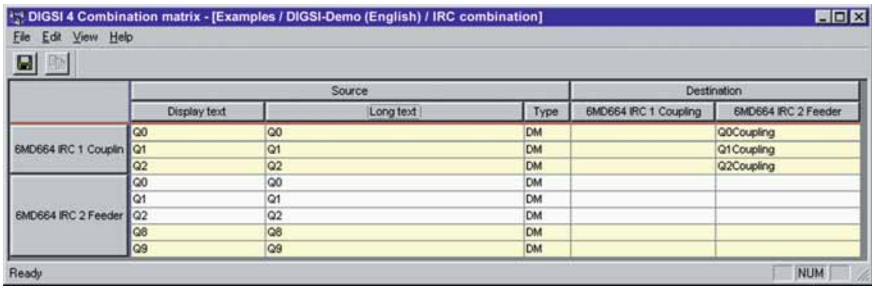


Fig. 12/21 Typical application: 1½ circuit-breaker method (disconnector and earthing switch not shown)



DIGSI 4 Combination matrix - [Examples / DIGSI-Demo (English) / IRC combination]

File Edit View Help

	Source			Destination	
	Display text	Long text	Type	6MD664 IRC 1 Coupling	6MD664 IRC 2 Feeder
6MD664 IRC 1 Couplin	Q0	Q0	DM		Q0Coupling
	Q1	Q1	DM		Q1Coupling
	Q2	Q2	DM		Q2Coupling
6MD664 IRC 2 Feeder	Q0	Q0	DM		
	Q1	Q1	DM		
	Q2	Q2	DM		
	Q8	Q8	DM		
	Q9	Q9	DM		

Ready NUM

LSP2227f.tif

Fig. 12/22 Connection matrix of inter-relay communication in DIGSI 4

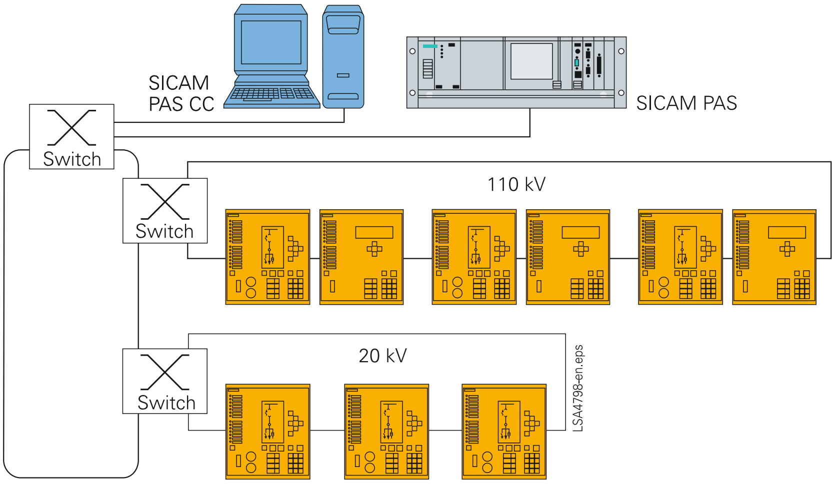


Fig. 12/23 Connection for IEC 61850-GOOSE communication

Like inter-relay-communication, GOOSE also supplies a status information for supervision of the communication. In case of interruption, the respective information is marked as "invalid".

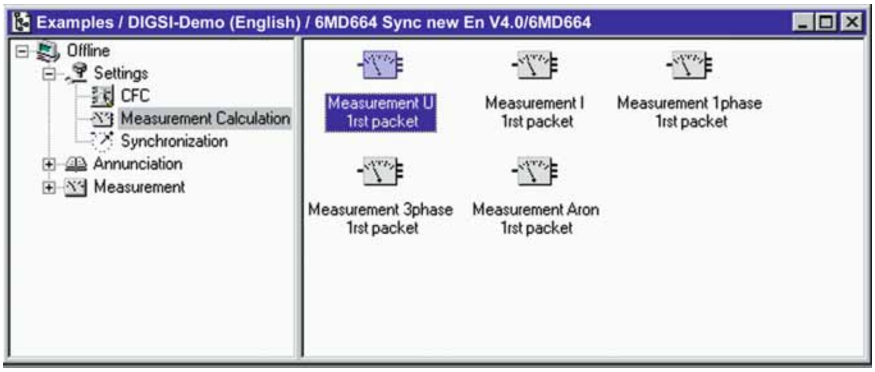
Therefore, non-affected information still can be used for interlocking, and a maximum functional availability is guaranteed.

Functions

Measured-value processing

Measured-value processing is implemented by predefined function modules, which are likewise configured using DIGSI 4.

The transducer modules are assigned in the DIGSI 4 assignment matrix to current and voltage channels of the bay control unit. From these input variables, they form various computation variables (see Table 12/1).



LSP2228f.tif

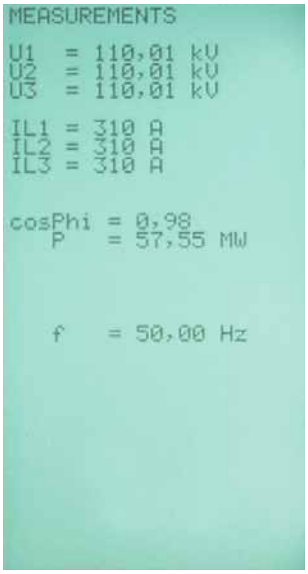
Fig. 12/24
DIGSI 4 Parameter view – transducer packets

The individual transducer modules can be activated in the functional scope of the unit and will then appear in the DIGSI 4 assignment matrix with the input channels and output variables from Table 1. The output variables can then be assigned to the system interface or represented in the measured value window in the display.

Name of the transducer module	Max. availability of transducers on the unit (can be set via the functional scope)	Required input channels	Calculated variables (= output variables)
Transducer V	x 1	V	V, f
Transducer I	x 1	I	I, f
Transducer packet 1 phase	x 3	V, I	$V, I, P, Q, S, \varphi, \cos\varphi$ (PF), $\sin\varphi, f$
Transducer packet 3 phase	x 1	$V1, V2, V3, I1, I2, I3$	$V0, V1, V2, V3, V12, V23, V31, I0, I1, I2, I3, P, Q, S, \varphi, \cos\varphi$ (PF), $\sin\varphi, f$
Transducer packet two-wattmeter circuit	x 1	$V1, V2, I1, I2$	$V12, V13, I2, I3, P, Q, S, \varphi, \cos\varphi$ (PF), $\sin\varphi, f$

Table 12/1
Properties of measured-value processing

Sample presentation of the measured value display.



```
MEASUREMENTS

U1   = 110,01 kV
U2   = 110,01 kV
U3   = 110,01 kV

IL1  = 310 A
IL2  = 310 A
IL3  = 310 A

cosPhi  = 0,98
   P    = 57,55 MW


   f    = 50,00 Hz
```

LSP2189f.tif

Fig. 12/25

Functions

The connection of the input channels can be chosen without restriction. For the two-wattmeter circuit, the interface connection should be selected in accordance with Fig. 12/26. The two-wattmeter circuit enables the complete calculation of a three-phase system with only two voltage and two current transformers.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the bay control unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a master unit. A distinction is made between forward, reverse, active and reactive power (± kWh, ± kvarh).

Automation

With integrated logic, the user can set, via a graphic interface (CFC, Continuous Function Chart), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface. Processing of internal indications or measured values is also possible.

Switching authorization/ Key-operated switch

The switching authorization (control authorization) (interlocked/non-interlocked, corresponds to key-operated S1 in the 8TK interlock system) and the switching authority (local/remote, corresponds to key-operated S5 for 8TK) can be preset for the SIPROTEC 4 bay control unit using key-operated switches. The position of both keys is automatically evaluated by command processing. The key for operation without interlocks cannot be removed when in the position “non-interlocked”, such that this mode of operation is immediately recognizable (see also page 12/15, Section “Switchgear interlockings”).

Every change in the key-operated switch positions is logged.

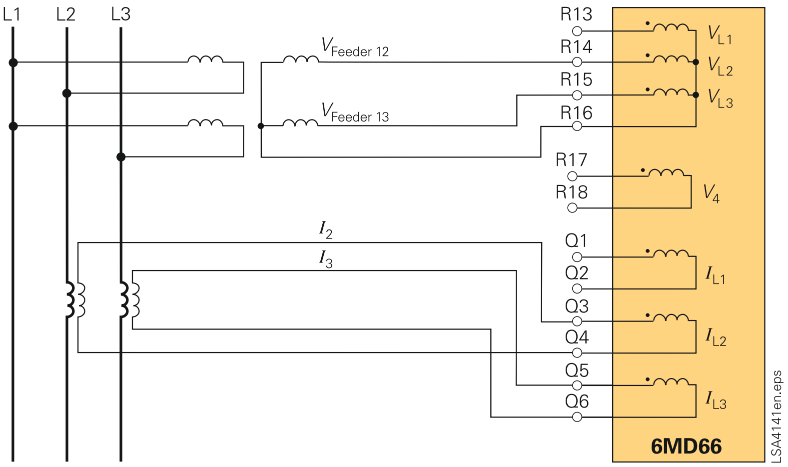


Fig. 12/26
Two-wattmeter circuit (connection to bay control unit)

Chatter blocking

Chatter blocking feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the communication line to the master unit will not be overloaded by disturbed inputs.

For every binary input, it is possible to set separately whether the chatter blocking should be active or not. The parameters (number of status changes, test time, etc.) can be set once per unit.

Indication / measured value blocking

To avoid the transmission of information to the master unit during works on the bay, a transmission blocking can be activated.

Indication filtering

Indications can be filtered and delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time.
The filter time can be set from 0 to 24 hours in 1 ms steps. It is also possible to set the filter time so that it can, if desired, be retriggered.

Furthermore, the hardware filter time can be taken into consideration in the time stamp; i.e. the time stamp of a message that is detected as arriving will be predated by the known, constant hardware filter time. This can be set individually for every binary input in a 6MD66 bay control unit.

Functions

Auto-Reclosure (ANSI 79)

The 6MD66 is equipped with an auto-reclosure function (AR). The function includes several operating modes:

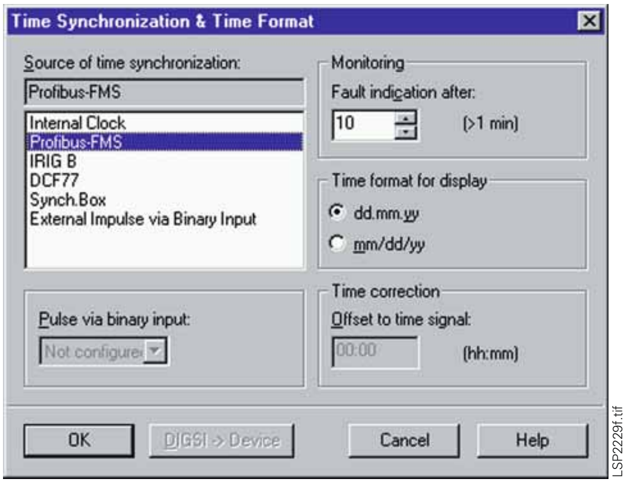
- Interaction with an external device for auto-reclosure via binary inputs and binary outputs; also possible with interaction via IEC 61850-GOOSE
- Control of the internal AR function by external protection
- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of the fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults, no reclosing for multi-phase faults.
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosure for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults and 3-phase auto-reclosure for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with the internal synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC). Integration of auto-reclosure in the feeder protection allows the line-side voltages to be evaluated. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line-check (DLC), reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure)
- ADT
  The adaptive dead time (ADT) is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- RDT
  Reduced dead time (RDT) is employed in conjunction with auto-reclosure where no teleprotection method is employed: When faults within the zone extension but external to the protected line of a distance protection are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Breaker failure protection (ANSI 50BF)

The 6MD66 incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example, due to a defective circuit breaker. The current detection logic is phase-selective and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command will be generated. The breaker failure protection can be initiated by external devices via binary input signals or IEC 61850 GOOSE messages.



Time Synchronization & Time Format

Source of time synchronization: Profibus-FMS

Internal Clock
Profibus-FMS
IRIG B
DCF77
Synch.Box
External Impulse via Binary Input

Monitoring
Fault indication after: 10 (>1 min)

Time format for display
● dd.mm.yy
○ mm/dd/yy

Pulse via binary input: Not configure

Time correction
Offset to time signal: 00:00 (hh:mm)

Fig. 12/27
Parameterization of time management

Time management

The 6MD66 bay control units can, like the other units in the SIPROTEC 4 range, be provided with the current time by a number of different methods:

- Via the interface to the higher-level system control (PROFIBUS FMS or IEC 61850)
- Via the external time synchronization interface on the rear of the unit (various protocols such as IRIG B and DCF77 are possible)
- Via external minute impulse, assigned to a binary input
- From another bay control unit by means of inter-relay communication
- Via the internal unit clock.

Fig. 12/27 illustrates the settings that are possible on the DIGSI interface.

DIGSI 4 Configuration tool

The PC program DIGSI 4 is used for the convenient configuration of all SIPROTEC 4 units. Data exchange with the configuration tool SICAM PAS of the energy automation system is possible, such that the bay level information needs only be entered once. Thus errors that could arise as a result of duplicated entries are excluded.

DIGSI 4 offers the user a modern and intuitive Windows interface, with which the units can be set and also read out.

DIGSI 4 configuration matrix

The DIGSI 4 configuration matrix allows the user to see the overall view of the unit configuration at a glance (see Part 3, Fig. 3/2). For example, all allocations of the binary inputs, the output relays and the LEDs are shown at a glance. And with one click of the button, connections can be switched. Also the measuring and metering values are contained in this matrix.

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be read and set directly. This can simplify the wire checking process significantly for the user.

CFC: Reduced time and planning for programming logic

With the help of the CFC (Continuous Function Chart), you can configure interlocks and switching sequences simply by drawing the logic sequences; no special knowledge of software is required. Logical elements, such as AND, OR and time elements, measured limit values, etc. are available.

Display editor

A convenient display editor is available to design the display on SIPROTEC 4 units. The predefined symbol sets can be expanded to suit the user. Drawing a single-line diagram is extremely simple. Operational measured values (analog values) in the unit can be placed where required.

In order to also display the comprehensive plant of the high-voltage switchgear and controlgear, the feeder control display of the 6MD66 bay control unit can have a number of pages.

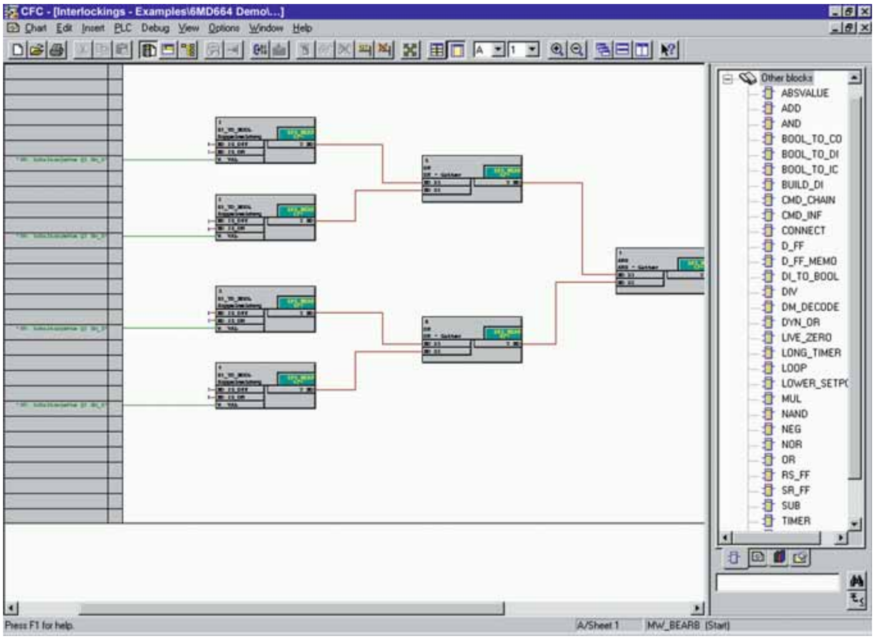


Fig. 12/28
CFC plan for interlocking logic (example)

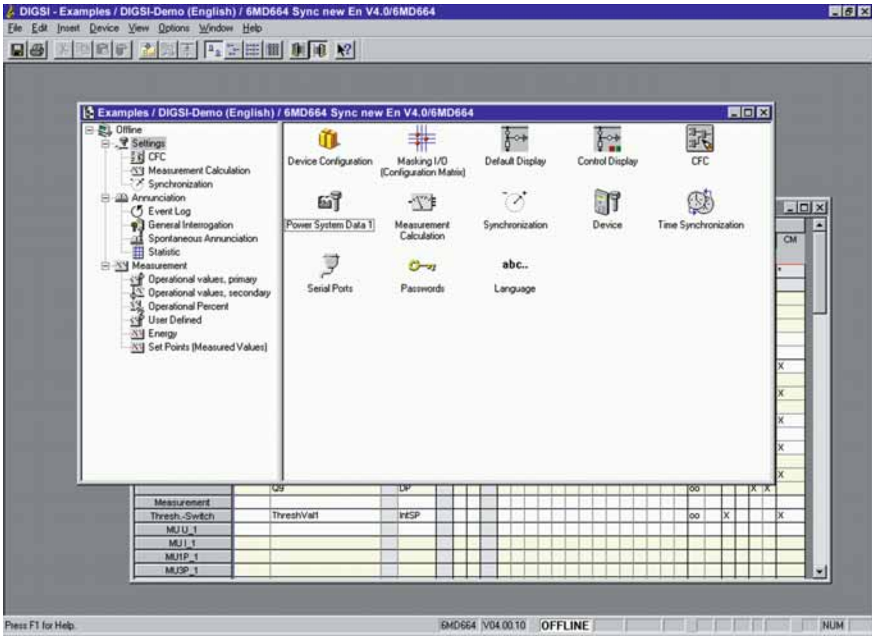


Fig. 12/29
General configuration view of the bay control unit

In this process, several pages of a control display can be configured under one another, and the user can switch between them using the cursor. The number of pages, including the basic display and the feeder control display, should not exceed 10, as otherwise the memory in the unit will be completely occupied.

Fig. 12/29 illustrates the general view of the 6MD66 bay control unit on the DIGSI 4 configuration interface.

As is the case with the SIPROTEC 4 protection units, there is an icon called “Functional Scope”. It enables the configuration of measured-value processing and the synchronization function and the protection functions (auto-reclosure and breaker failure protection).

Technical data

General unit data

Analog inputs

Rated frequency	50 or 60 Hz (adjustable, depending on the order number)
Rated current I_N	1 or 5 A (can be changed via plug-in jumper)
Rated voltage V_N	100 V, 110 V, 125 V, 100 $V/\sqrt{3}$, 110 $V/\sqrt{3}$ can be adjusted using parameters
Power consumption	
at $I_N = 1A$	< 0.1 VA
at $I_N = 5A$	< 0.5 VA
Voltage inputs	< 0.3 VA with 100 V
Measurement range current I	Up to 1.2 times the rated current
Thermal loading capacity	12 A continuous, 15 A for 10 s, 200 A for 1 s
Measurement range voltage V	Up to 170 V (rms value)
Max. permitted voltage	170 V (rms value) continuous
Transducer inputs	
Measurement range	± 24 mA DC
Max. permitted continuous current	± 250 mA DC
Input resistance,	10 Ω ± 1 %
recorded power loss at 24 mA	5.76 mW

Power supply

Rated auxiliary voltages	24 to 48 V DC, 60 to 125 V DC, 110 to 250 V DC
Permitted tolerance	-20 % to +20 %
Permitted ripple of the rated auxiliary voltage	15 %
Power consumption	
Max. at 60 to 250 V DC	20 W
Max. at 24 to 48 V DC	21.5 W
Typical at 60 to 250 V DC	17.5 W
Typical at 24 to 48 V DC	18.5 W
(typical = 5 relays picked up + live contact active + LCD display illuminated + 2 interface cards plugged in)	
Bridging time	
at 24 and 60 V DC	≥ 20 ms
at 48 and ≥ 110 V DC	≥ 50 ms

Binary inputs

Number	
6MD662	35
6MD663	50
6MD664	65
Rated voltage range	24 to 250 V DC (selectable)
Pick-up value (range can be set using jumpers for every binary input)	17, 73 or 154 V DC
Function (allocation)	Can be assigned freely
Minimum voltage threshold (presetting)	
for rated voltage 24, 48, 60 V	17 V DC
for rated voltage 110 V	73 V DC
for rated voltage 220, 250 V	154 V DC
Maximum permitted voltage	300 V DC

Binary inputs (cont'd)

Current consumption, excited	approx. 1.5 mA
for 3 ms	approx. 50 mA to increase pickup time
Permitted capacitive coupling of the indication inputs	220 nF
Minimum impulse duration for message	4.3 ms

Output relay

Live contact	1 NC/NO (can be set via jumper: Factory setting is "Break contact", i.e. the contact is normally open but then closes in the event of an error)
Number of command relays, single pole	
6MD662	25, grouping in 2 groups of 4, 1 group of 3, 6 groups of 2 and two ungrouped relays
6MD663	35, grouping in 3 groups of 4, 1 group of 3, 9 groups of 2 and two ungrouped relays
6MD664	45, grouping 4 groups of 4, 1 group of 3, 12 groups of 2 plus two ungrouped relays
Switching capacity, command relay	
Make	max. 1000 W/ VA
Break	max. 30 VA
Break (at L/R ≤ 50 ms)	25 VA
Max. switching voltage	250 V
Max. contact continuous current	5 A
Max. (short-duration) current for 4 s	15 A
Switching capacity,	
live contact ON and OFF	20 W/VA
Max. switching voltage	250 V
Max. contact continuous current	1 A
Max. make-time	8 ms
Max. chatter time	2.5 ms
Max. break time	2 ms

LED

Number	
RUN (green)	1
ERROR (red)	1
Display (red), function can be allocated	14

Unit design

Housing 7XP20	For dimensions drawings, see part 15
Type of protection acc. to EN60529	
in the surface-mounting housing	IP20
in the flush-mounting housing	
front	IP51
rear	IP20
Weight	
Flush-mounting housing, integrated local control	
6MD663	approx. 10.5 kg
6MD664	approx. 11 kg
Surface-mounting housing, without local control, with assembly angle	
6MD663	approx. 12.5 kg
6MD664	approx. 13 kg
Detached local control	approx. 2.5 kg

Technical data

Serial interfaces

System interfaces

PROFIBUS FMS, Hardware version depending on Order No.:	
PROFIBUS fiber optic cable	ST connector
Baud rate	max 1.5 Mbaud
Optical wave length	820 nm
Permissible path attenuation	max. 8 dB for glassfiber 62.5/125 µm
Distance, bridgeable	max. 1.5 km
PROFIBUS RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 Mbaud
PROFIBUS RS232	9-pin SUB-D connector
Baud rate	4800 to 115200 baud
Distance, bridgeable	max. 15 m

Time synchronization DCF77/IRIG B signal

Connection	9-pin SUB-D connector
Input voltage level	either 5 V, 12 V or 24 V
Connection allocation Pin 1	24 V input for minute impulse
Pin 2	5 V input for minute impulse
Pin 3	Return conductor for minute impulse
Pin 4	Return conductor for time message
Pin 7	5 V input for minute impulse
Pin 8	24 V input for time message
Pin 5, 9	Screen
Pin 6	Not allocated
Message type (IRIG B, DCF, etc.)	Can be adjusted using parameters

Control interface for RS232 DIGSI 4

Connection	Front side, non-isolated, 9-pin SUB-D connector

DIGSI 4 interface (rear of unit)

Fiber optic	ST connector
Baud rate	max. 1.5 Mbaud
Optical wave length	820 nm
Permissible path attenuation	max. 8 dB for glass fiber of 62.5/ 125 µm
Distance, bridgeable	max. 1.5 km
RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 MBaud
RS232	9-pin SUB-D connector
Baud rate	4800 to 115200 Baud
Distance, bridgeable	max. 15m

Interface for inter-unit communication

RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 Mbaud

Ethernet interface

IEC 61850 protocol

Isolated interface for data transfer: to a control center with DIGSI between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE 802.3
Transmission rate	1000 MBit
Ethernet, electrical	
Connection	
for flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors, mounting location “B”
Distance	Max. 20 m/65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	
for flush-mounting housing/ surface-mounting housing with detached operator panel	Integrated LC connector for FO connection, mounting location “B”
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles

Electrical tests

Specifications

Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 DIN 57435 Part 303 For further standards see specific tests

Insulation tests

Standards	IEC 60255-5 and IEC 60870-2-1
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (rms), 50 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) only isolated communication and time synchronization interfaces	500 V (rms value), 50 Hz
Surge voltage test (type test) All circuits except for communication and time synchronization interfaces, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative surges at intervals of 5 s

EMC tests for noise immunity; type test

Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57 435 Part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; $\tau = 15$ ms 400 pulses per s; duration 2 s
Discharge of static electricity IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Exposure to RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Exposure to RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Exposure to RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition frequency 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min

Technical data

EMC tests for noise immunity; type test (cont'd)

High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	common mode: 2 kV; 12 Ω, 9 µF differential mode:1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	common mode: 2 kV; 42 Ω, 0.5 µF differential mode: 1 kV; 42 Ω, 0.5 µF
Conducted RF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 impulses per second; both polarities; duration 2 s ; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), 100 kHz polarity alternating, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

EMC tests for interference emission; type tests

Standard	EN 50081-1 (Basic specification)
Radio interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz class B

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ±0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Vibration during earthquake IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4 mm amplitude (horizontal axis) 1 to 8 Hz: ± 2 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0,5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress tests

Temperatures

Standards	IEC 60255-6	
Recommended temperature during operation	–5 to +55 °C	25 to 131 °F
Temporary permissible temperature limit during operation (The legibility of the display may be impaired above 55 °C/131 °F)	–20 to +70 °C	-4 to 158 °F
Limit temperature during storage	–25 to +55 °C	-13 to 131 °F
Limit temperature during transport Storage and transport with standard factory packaging	–25 to +70 °C	-13 to 158 °F

Humidity

Permissible humidity stress We recommend arranging the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation during operation is not permitted

CE conformity

The product meets the stipulations of the guideline of the council of the European Communities for harmonization of the legal requirements of the member states on electro-magnetic compatibility (EMC directive 89/336/EEC) and product use within certain voltage limits (low-voltage directive 73/23/EEC).
The product conforms with the international standard of the IEC 60255 series and the German national standard DIN VDE 57 435,Part 303. The unit has been developed and manufactured for use in industrial areas in accordance with the EMC standard.

Further applicable standards:
ANSI/IEEE C37.90.0 and C37.90.1

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the directive in conformance with generic standards EN 50081-2 and EN 50082-2 for the EMC directive and EN 60255-6 for the low-voltage directive.

Selection and ordering data

Description	Order No.	Order code
6MD66 high-voltage bay control unit	*6MD662☐ – ☐☐☐☐☐ – 0☐☐☐*	*☐☐☐*
Processor module with power supply, input/output modules with a total of:		
Number of inputs and outputs		
35 single-point indications, 22 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current 4 x voltage via direct CT inputs, 2 measuring transducer inputs	see next page	
Current transformer I_N		
1 A	*1*	
1 A / 150 % I_N	*2*	
1 A / 200 % I_N	*3*	
5 A	*5*	
5 A / 150 % I_N	*6*	
5 A / 200 % I_N	*7*	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V2)	*2*	
60 V DC, threshold binary input 19 V2)	*3*	
110 V DC, threshold binary input 88 V2)	*4*	
220 to 250 V DC, threshold binary input 176 V2)	*5*	
Unit design		
For panel flush mounting, with integr. local operation, HMI, plug-in terminal (2/3-pole AMP socket)	*D*	
For panel flush mounting, with integr. local operation, graphic display, keyboard, screw-type terminals (direct connec./ring-type cable lugs)	*E*	
Region-specific default settings/function and language presettings		
Region DE, 50 Hz, language: German, changeable	*A*	
Region World, 50/60 Hz, language: English (GB), changeable	*B*	
Region US, ANSI, language: English (US), changeable	*C*	
Region World, 50/60 Hz, language: French, changeable	*D*	
Region World, 50/60 Hz, language: Spanish, changeable	*E*	
System interface (on rear of unit, port B)		
No system interface	*0*	
IEC 60870-5-103 protocol, electrical RS485	*2*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
PROFIBUS-FMS Slave, electrical RS485	*4*	
PROFIBUS-FMS Slave, optical, single ring, ST connector	*5*	
PROFIBUS-FMS Slave, optical, double ring, ST connector	*6*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm fiber, double ring, ST plugs	*9*	*L 0 B*
PROFIBUS-DP Slave, double electrical RS485 (second module on port D)	*9*	*L 1 A*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector	*9*	*L 0 S*
Function interface (on rear of unit, port C and D)		
No function interface	*0*	
DIGSI 4, electrical RS232, port C	*1*	
DIGSI 4, electrical RS485, port C	*2*	
DIGSI 4, optical 820 nm, ST connector, port D	*3*	
With RS485 interface for inter-relay communication, port C and DIGSI 4	*4*	
With RS485 interface for inter-relay communication, port C and DIGSI 4, with optical 820 nm, ST connector, port D	*5*	

---

2) The binary input thresholds can be selected in two stages by means of jumpers.

Selection and ordering data

Description	Order No.	Order code
6MD66 high-voltage bay control unit	*6MD662☐ – ☐☐☐☐☐ – 0☐☐☐ ☐☐☐*	
Measured-value processing		
Full measured-value processing and display	*A*	
No measured-value processing and no display	*F*	
Synchronization		
With synchronization	*A*	
Without synchronization	*F*	
Protection function		
Without protection functions	*0*	
With auto-reclosure (AR)	*1*	
With circuit-breaker failure protection	*2*	
With auto-reclosure and circuit-breaker failure protection	*3*	
With fault recording	*4*	

Selection and ordering data

Description	Order No.	Order code
6MD66 high-voltage bay control unit	*6MD66□□ – □□□□□ – 0□□□ □□□*	
Processor module with power supply, input/output modules with a total of:		
Number of inputs and outputs		
50 single-point indications, 32 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current, 4 x voltage via direct CT inputs 2 measuring transducer inputs	*3*	
65 single-point indications, 42 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current, 4 x voltage via direct CT inputs 2 measuring transducer inputs	*4*	
Current transformer I_N		
1 A	*1*	
1 A / 150 % I_N	*2*	
1 A / 200 % I_N	*3*	
5 A	*5*	
5 A / 150 % I_N	*6*	
5 A / 200 % I_N (for 6MD664)	*7*	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V1)	*2*	
60 V DC, threshold binary input 19 V1)	*3*	
110 V DC, threshold binary input 88 V1)	*4*	
220 to 250 V DC, threshold binary input 176 V1)	*5*	
Unit design		
For panel surface mounting, detached operator panel, f. mount. in l.-v. case, screw-type terminals (direct connec./ring-type cable lugs)	*C*	
For panel flush mounting, with integr. local operation, graphic display, keyboard, screw-type terminals (direct connec./ring-type cable lugs)	*E*	
For panel surface mounting, w /o operator unit, f. mount. in l.-v. case, screw-type terminals (direct connec./ring-type cable lugs)	*F*	
Region-specific default settings/function and language presettings		
Region DE, 50 Hz, language: German, changeable	*A*	
Region World, 50/60 Hz, language: English (GB), changeable	*B*	
Region US, ANSI, language: English (US), changeable	*C*	
Region World, 50/60 Hz, language: French, changeable	*D*	
Region World, 50/60 Hz, language: Spanish, changeable	*E*	
System interface (on rear of unit, port B)		
No system interface	*0*	
IEC 60870-5-103 protocol, electrical RS485	*2*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
PROFIBUS-FMS Slave, electrical RS485	*4*	
PROFIBUS-FMS Slave, optical, single ring, ST connector	*5*	
PROFIBUS-FMS Slave, optical, double ring, ST connector	*6*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector	*9*	*L 0 B*
PROFIBUS-DP Slave, double electrical RS485 (second module on port D)	*9*	*L 1 A*
PROFIBUS-DP Slave, double optical double ring ST (second module on port D)	*9*	*L 1 B*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector	*9*	*L 0 S*

see next page

---

1) The binary input thresholds can be selected by means of jumpers.

Selection and ordering data

Description	Order No.
6MD66 high-voltage bay control unit	*6MD66□□ – □□□□□ – 0□□□*
Function interface (on rear of unit, port C and D)	
No function interface	*0*
DIGSI 4, electrical RS232, port C	*1*
DIGSI 4, electrical RS485, port C	*2*
DIGSI 4, optical 820 nm, ST connector, port D 1)	*3*
With RS485 interface for inter-relay communication, port C and DIGSI 4	*4*
With RS485 interface for inter-relay communication, port C and DIGSI 4, with optical 820 nm, ST connector, port D 1)	*5*
Measured-value processing	
Full measured-value processing and display	*A*
No measured-value processing and no display 2)	*F*
Synchronization	
With synchronization	*A*
Without synchronization	*F*
Protection function	
Without protection functions	*0*
With auto-reclosure (AR) incl. fault recording	*1*
With circuit-breaker failure protection (BF) incl. fault recording	*2*
With auto-reclosure (AR) and circuit-breaker failure protection (BF) incl. fault recording	*3*
Fault recording	*4*

---

1) Not for double PROFIBUS-DP (position 11 = *9-L1A* or *9-L1B*).

2) Only for position 16 = *0* (without protection functions).

Connection diagrams

Bay unit 6MD662

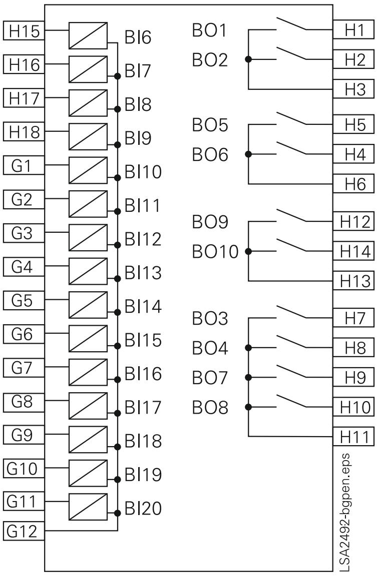


Fig. 12/30
Module 1, indications, commands

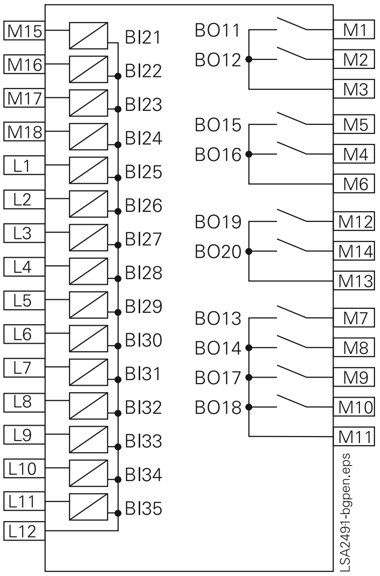


Fig. 12/31
Module 2, indications, commands

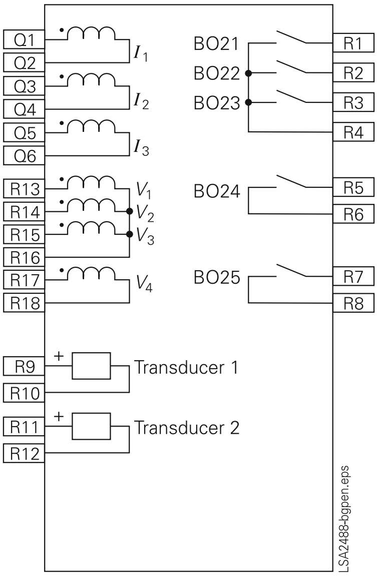


Fig. 12/32
Module 4, measuring values commands

Connection diagrams

Bay unit 6MD662

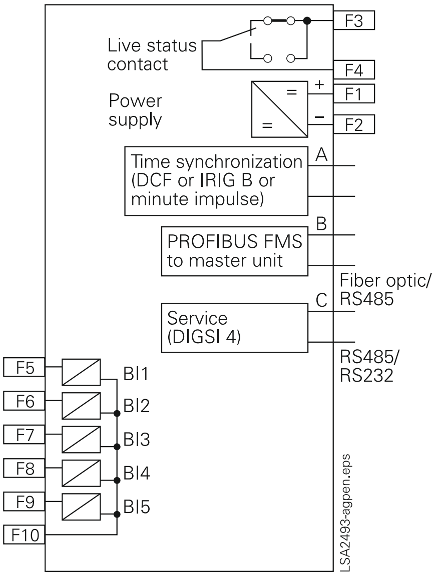


Fig. 12/33
CPU, C-CPU 2
For unit 6MD662*-****1-0AA0
and 6MD662*-****2-0AA0
(DIGSI interface, electrical, system interface
optical or electrical)

or

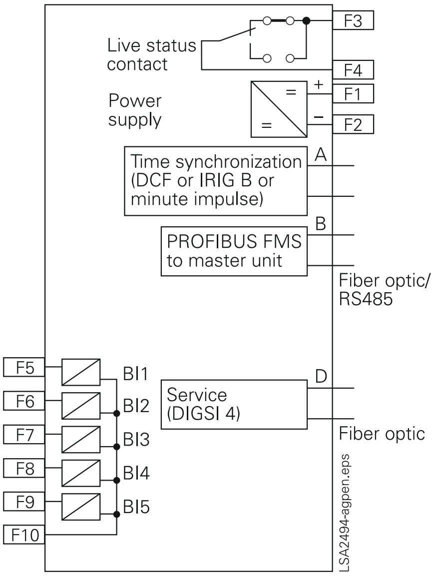


Fig. 12/34
CPU, C-CPU 2
For unit 6MD662*-****3-0AA0
(DIGSI interface, optical, system interface
optical or electrical)

or

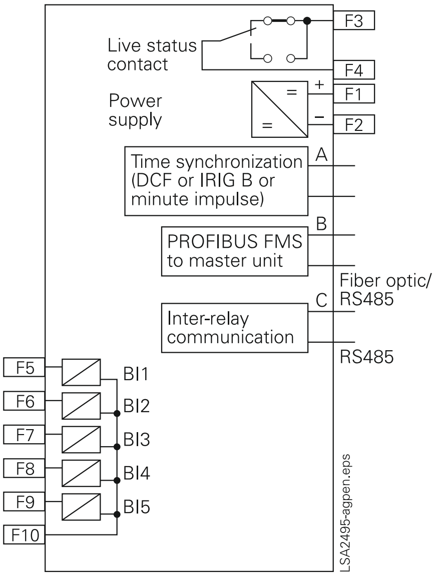


Fig. 12/35
CPU, C-CPU 2
For unit 6MD662*-****4-0AA0
(Inter-relay communication
interface electrical, system interface
optical or electrical)

or

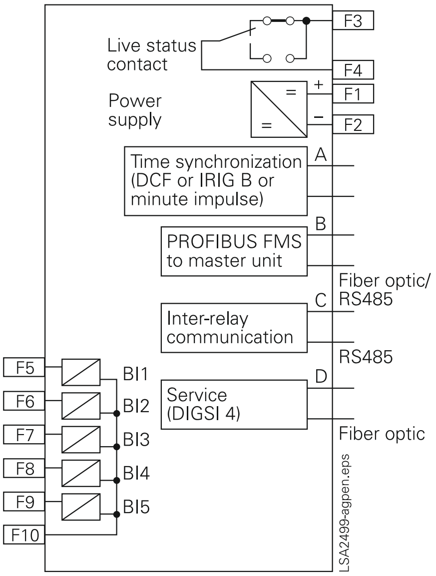


Fig. 12/36
CPU, C-CPU 2
For unit 6MD662*-****5-0AA0
(DIGSI interface, optical,
Inter-relay communication
interface electrical, system interface
optical or electrical)

Connection diagrams

Bay unit 6MD664

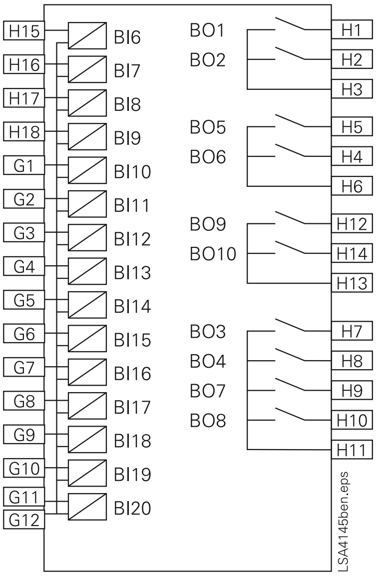


Fig. 12/37
Module 1, indications commands

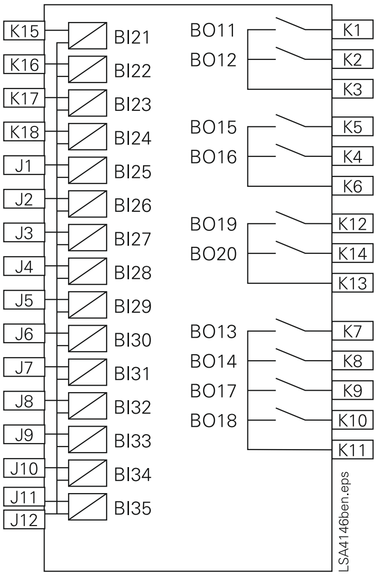


Fig. 12/38
Module 2, indications commands

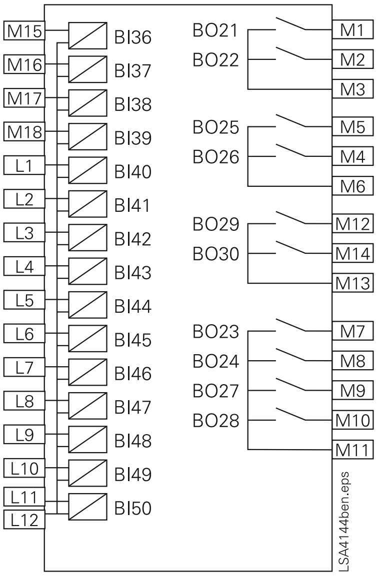


Fig. 12/39
Module 3, indications, commands

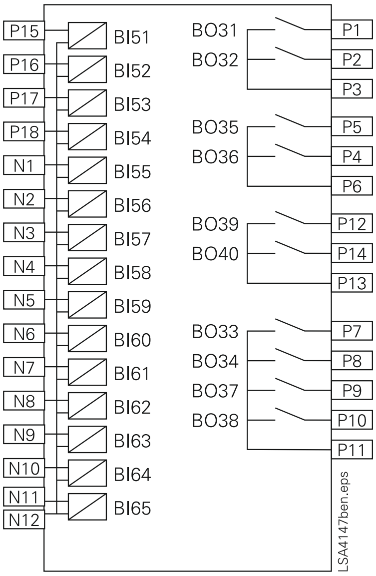


Fig. 12/40
Module 4, indications, commands

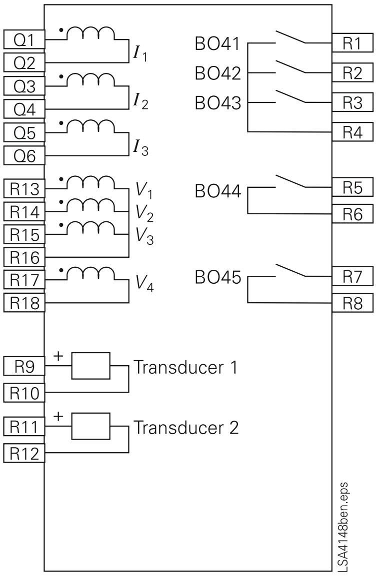


Fig. 12/41
Module 5, measuring values, commands

Connection diagrams

Bay unit 6MD664

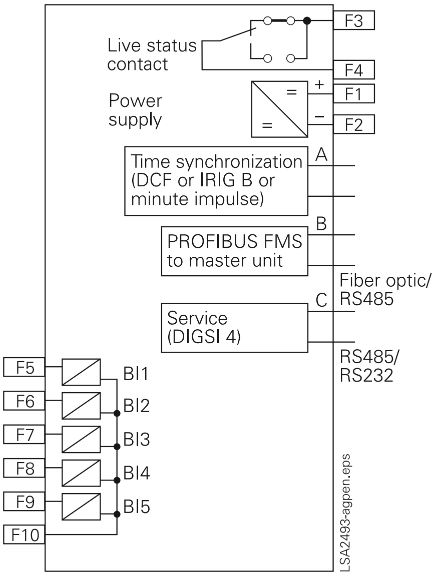


Fig. 12/42
CPU, C-CPU 2
For unit 6MD664*-****1-0AA0
and 6MD664*-****2-0AA0
(DIGSI interface electric, system interface optical optical or electric)

or

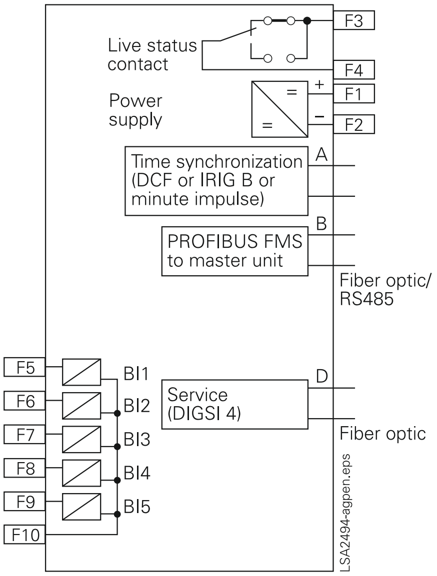


Fig. 12/43
CPU, C-CPU 2
For unit 6MD664*-****3-0AA0
(DIGSI interface optical,
system interface optical
optical or electric)

or

or

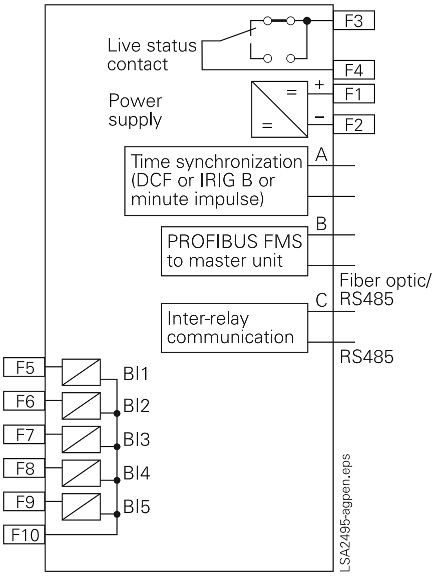


Fig. 12/44
CPU, C-CPU 2
For unit 6MD664*-****4-0AA0
(Inter-relay communication
interface electric, system
interface optical or electric)

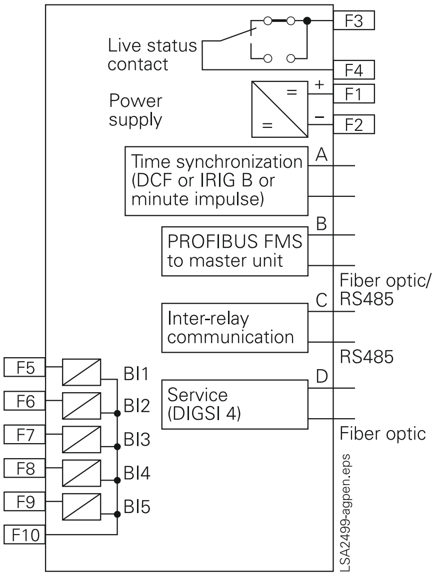
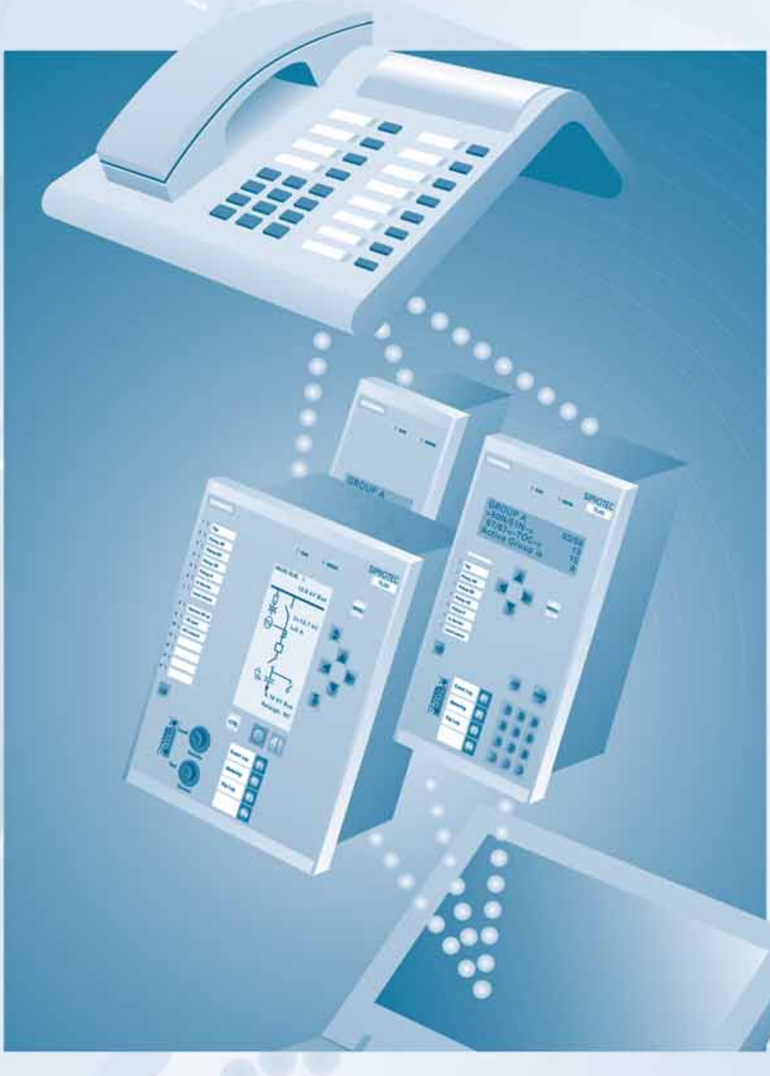


Fig. 12/45
CPU, C-CPU 2
For unit 6MD664*-****5-0AA0
(DIGSI interface optical,
(Inter-relay communication
electric, system
interface optical or electric)

Relay Communication Equipment

Table of contents see next page



Contents *Page*

7XV5101
RS232-FO Connector Module

Fig. 13/1
Connector modules/adapters 7XV5101-3C

Description

Connector modules 7XV5101

Optical connection of protection relays with an electrical (non-isolated) RS232 interface, e.g. to a star coupler, for centralized control is made possible with the fiber-optic RS232 connector modules.

Thus, further devices such as PCs or notebooks, modems or serial data switches can be effectively protected against electromagnetic interference. An appropriate connector module is available for each of the above-mentioned applications. These fiber-optic RS232 connector modules are housed in a SUB-D plug casing and can be directly plugged into the respective interfaces of the pertaining devices. No further settings are required. In its normal position, the optical interface is set to steady light OFF. Data transmission is fully duplex and transparent. The optical interface with FSMA connectors has an operational wavelength of 820 nm and can reach distances of up to 1500 m with 62.5/125 µm multi-mode FO cables.

Technical data

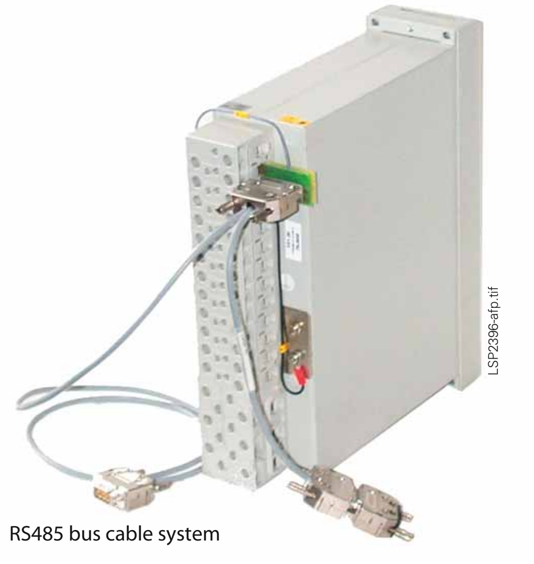
			7XV5101- 3C
Housing	Plastics, metal-plated		X
	Dimensions 72 x 32 x 17 mm		X
	Via external keyboard connector located at the notebook		X
Electrical interfaces	Bridge contact 7 - 8, 1 - 4 - 6	9-pin	X
Optical interfaces	FSMA connector (screw-type)	T = transmit, R = receive	X
	Optical power	27 µW (- 15.7 dBm) 1)	X
	Sensitivity	1 µW (- 30 dBm) 1)	X
	Optical budget	7 dB (+ 3 dB backup) 1)	X
	Wavelength 850 nm		X
	Transmission range	1500 m (with 62.5 µm multi-mode FO cable) 800 m (with 50 µm multi-mode FO cable)	X

1) Valid for 62.5 µm FO cable.

Selection and ordering data

Description	Order No.
7XV5101 fiber-optic connector module 820 nm - RS232	*7XV5101-3C*
9-pin female connector for notebook	

7XV5103
RS485 Bus Systems up to 115 kbit/s (not suitable for PROFIBUS)



RS485 bus cable system

Fig. 13/2

7XV5103 cable and connector modules/adapters

Description

The RS485 bus is a low-cost half-duplex communication bus, which, due to its relatively high interference immunity, is not only used for monitoring and control in industrial systems, but is now increasingly used for SCADA and protection applications by utilities in substations. Protocols, such as DIGSI, IEC 60870-5-103, DNP 3 and MODBUS up to 115 kbit/s, are used between a station master and up to 31 slave devices on shielded twisted-pair (STP) cable. In ideal conditions, the length of the bus may be up to 1000 m. This requires correct configuration of the bus, use of suitable cables, and connector connectors, as well as correct termination of the bus. Devices with different termination methods require special adaptors to achieve the highest possible interference immunity. The RS485 bus systems 7XV5103 are optimized in this respect for our control and protection product range.

With the ordering code 7XV5103, two different RS485 bus systems are available.

When combining the required components for a RS485 bus, the corresponding application examples contained in this document can be of assistance.

The bus system with 9-pin SUB-D connectors has long been applied in systems with SIPROTEC protection devices, 7XV5 converters, and master units. Connection to the individual devices is achieved directly with a special Y-cable or with a corresponding adapter cable to devices with different termination methods. The bus terminates in a 9-pin SUB-D bus terminating connector with an integrated 220-Ω resistor.

On some SIPROTEC devices, the serial signals are routed to RJ45 female connectors on the communication module, as is the case, for example, with the redundant IEC 60870-5-103 module. There the bus is based on double-shielded CAT 5 patch cables. Connection of the individual devices to the two redundant buses is achieved via two special Y-adapter cables each. The buses each terminate with a RJ45 bus terminating connector with a 120-Ω resistor.

A combination of the two bus systems and the different device interfaces or a combination of the two systems is also possible using the Y-adapter cable 7XV5103-2BA00.

Function overview

- For data transfer up to 115 kbit/s (e.g. DIGSI, IEC 60870-5-103, DNP 3)
- Variable bus structure with shielded cables of various lengths.
- Metal-plated, shielded connector housings with reduced mounting depth and strain relief.
- Bus termination with terminating connectors and integrated resistor.
- Connection of the SIPROTEC 4 protection devices with redundant IEC 60870-5-103 interface via the Y-adapter cable and RJ45 connector.
- Connection of the SIPROTEC 4 protection devices with RS485 interface and SUB-D connector directly, or via a Y-adapter cable.
- Adapter/cable for compact protection devices with RS485 interface on screw-type terminals, e.g. 7SJ600, 7SD600, 7RW600 etc.
- Connection to various RS485 converters, e.g. 7XV5650/51.
- Combination of both bus systems is possible.
- Max. length of the bus within a common grounding system may be up to 1000 m.

Please note that this system must not be used for PROFIBUS-FMS or PROFIBUS-DP. These have their own bus system with components suitable for use with PROFIBUS.

Application

Notes on configuring the RS485 bus system

The housings of all devices connected to the bus must be solidly grounded to a common ground to avoid dangerous ground currents flowing via the cable shields.

Larger distances, especially into other buildings with separate grounding system should preferably be covered via converters (e.g. 7XV5650/51) using FO links.

The RS485 bus must be linear, i.e. tee-offs from the bus (e.g. a terminal strip) to the connected bus devices must not be used. This would form a star configuration, which has negative influence on the functionality.

The bus must be terminated at the first device (usually the master) and at the last device with a bus terminating resistor to avoid interference due to reflection. No further terminating resistors must be connected between these terminals.

As all of the devices, maximum 32 (including the master) are listening in on the RS485 bus, all the devices on the bus must be set to the same baud rate and the same data format.

The slaves must all have different device addresses.

Within the system, only one master may be active at any one time and only one slave may respond.

The bus system with 9-pin SUB-D connectors

The bus system with 9-pin SUB-D bus terminating connectors has long been used with SIPROTEC protection devices, the converters 7XV5 and Siemens master units. Connection of individual devices to devices with various connection modes is achieved directly via specialized Y cables, or via suitable adapter cables. The bus terminates at a 9-pin SUB-D bus terminating connector with an integrated 220-Ω resistor.


LSP2396.tif

Fig. 13/3 Protection unit connected to the RS485 bus

Specifications

- Direct connection to SIPROTEC 4 protection devices with RS485 interface via a FO-RS485 converter 7XV5650/51
- Adapter/cable for compact protection devices with RS485 interface on screw-type terminals, e.g. 7SJ600, 7SD600, 7RW600 etc.
- 4 cable lengths from 1 to 10 meters
- Shielded twisted-pair (STP) cable with 9-pin SUB-D connector connectors
- Metal-plated, shielded connector housings with reduced mounting depth and strain relief
- Data transfer up to 115 kbit/s (e.g. DIGSI, IEC 60870-5/VDEW)
- Maximum length of the bus up to 1000 m within a common grounding system
- Bus termination with terminating connectors and integrated 220-Ω resistor

Application

Application example 1:

The 9-pin male connector of the Y bus cable S1 always comes from the master side and provides the connection to the slaves via the 1, 3, 5 or 10-m cable and 9-pin male connector S2. At the connector S2 a 20-cm long cable with a 9-pin female connection B3 is provided to extend the bus. The compact protection devices, e.g. 7SJ600 are directly connected via the adapter cable 7XV5103-2AA00 with female connector B2 or an RS485 adapter 7XV5103-3AA00. After the final device, a bus terminating connector 7XV5103-5AA00 is connected to connector B3 to terminate the bus.

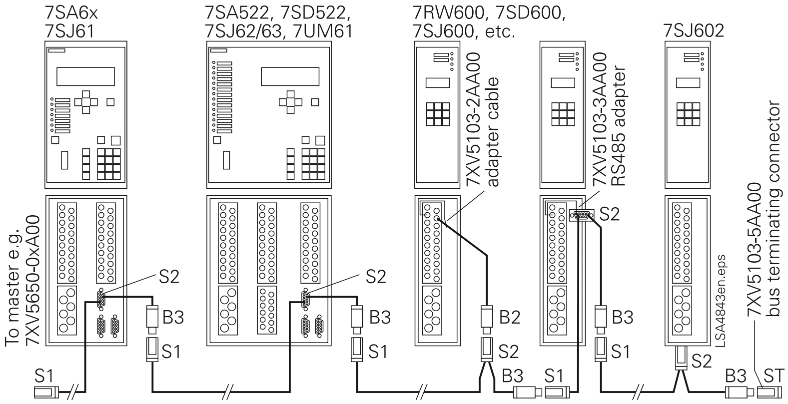


Fig. 13/4 SIPROTEC protection devices on the RS485 bus

Selection and ordering data

Description	Order No.
RS485 Y-bus cable shielded twisted pair with 9-pin SUB-D connectors *7XV5103 RS485 bus with SUB-D connectors*	*7XV5103-0AA☐☐*
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
RS485 bus extension cable STP with 9-pin SUB-D connector	*7XV5103-1AA☐☐*
Length 10 m	1 0
Length 20 m	2 0
Length 30 m	3 0
Length 40 m	4 0
Length 50 m	5 0
RS485 adapter	*7XV5103-☐AA00*
Adapter cable with STP with ferrule/9-pin SUB-D connector for units with screw-type terminals or compact protection units, e.g. 7SJ600, 7SD600 etc.	2
RS485 adapter with 9-pin SUB-D connector for mounting on screw-type terminals on compact protection units, e.g. 7SJ600, 7SD600 etc.	3
Bus terminating connector 220-Ω, 9-pin SUB-D connector	5
RS485 cable to thermo-box (RTD)	*7XV5103-7AA☐☐*
For connection between the 7XV5662-☐AD10 thermo-box and SIPROTEC 4 units (port C or port D with RS485 interface)	
Length 5 m	0 5
Length 25 m	2 5
Length 50 m	5 0

Application

Bus system with RJ45 patch cables

The bus system with RJ45 connectors was specially developed for SIPROTEC devices for communication modules with serial RJ45 connectors and is built with low cost double-shielded CAT 5 patch cables.

Connection of the individual devices to the two redundant buses is achieved via two special Y-adapter cables each. The buses each terminate with a RJ45 bus terminating connector with an integrated 120-Ω resistor.

Specifications

- Low-cost bus structure with shielded patch cables (CAT 5) with RJ45 connectors
- Cable lengths from 0.5 to 20 meters (7KE6000-8G)
- Connection of SIPROTEC 4 protection devices with redundant IEC 60870-5-103 interfaces via Y-adapter with RJ45 connector
- Connection of SIPROTEC 4 protection devices with RS485 interface via Y-cable to SUB-D connector
- Adapter/cable for compact protection devices, e.g. 7SJ600, 7SD600, 7RW600 etc.
- Metal-plated connector housings with strain relief of the cable connections
- Compact connectors
- Data transfer up to 115 kbit/s (e.g. DIGSI, IEC 60870-5/VDEW)
- Maximum extension of the bus of up to 800 m within a common grounding system
- Bus termination with terminating connectors and integrated 120-Ω resistor
- Connection to the FO-RS485 converter 7XV5650 or the bus system with SUB-D connector via Y-adapter

Notes on configuring the RS485 bus system (application examples 2 and 3, see page 13/9)

The housings of all devices connected to the bus must be solidly grounded to a common ground to avoid dangerous ground currents flowing via the cable shields.

Larger distances, especially into other buildings with separate grounding system should preferably be covered via converters (e.g. 7XV5650/51) using FO cables.

The RS485 bus must be linear, i.e. tee-offs from the bus (e.g. a terminal strip) to the connected bus devices must not be used. This would form a star configuration, which has negative influence on the functionality.

Fig. 13/5 Bus system with RJ45 patch cable

Only CAT 5 double-shielded patch cables (e.g. 7KE6000) must be used as the bus cables. The maximum bus length must not exceed 800 m.

The bus must be terminated at the first device (usually the master) and at the last device with a bus terminating resistor to avoid interference due to reflection. No further terminating resistors must be connected between these terminals.

As all of the devices, maximum 32 (including the master) are listening in on the RS485 bus, all the devices on the bus must be set to the same baud rate and the same data format. The slaves must all have different device addresses.

Within the system on each bus, only one master may be active at any one time and only one slave may respond.

Application

Application example 2: Connection of SIPROTEC 4 to a (redundant) control system

The RS485 bus cable system with patch cables (CAT 5) was developed as a low-cost alternative to the previous systems 7XV5103 with SUB-D connectors. The advantages are the widespread use of patch cables throughout the world and the compact dimensions of the RJ45 connector. This allows a redundant IEC 60870-5-103 interface with a single interface module within a SIPROTEC 4 device.

Two different Y-adapters permit implementation of a RS485 bus with patch cables and connection of devices having RS485 interfaces and different designs of interface connector. Both Y-adapters have two RJ45 female connectors in parallel to facilitate the implementation of the buses. The approx. 20 cm long connection cable to the device either has a RJ45 or SUB-D connector.

Devices with SUB-D connector (e.g. Master RTU, 7XV5650/51, SIPROTEC 4 devices with SUB-D) are connected using the Y-adapter 7XV5103-2BA00.

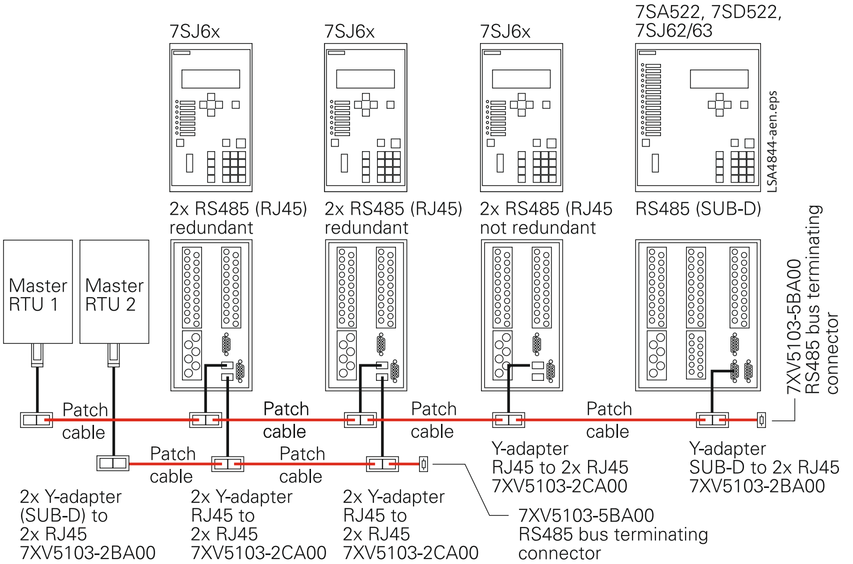
Devices with RJ45 connector such as SIPROTEC 4 with redundant IEC 60870-5-103 interface are connected with the Y-adapter 7XV5103-2CA00. For the redundant bus system 2 Y-adapters are required per SIPROTEC 4 device.

After the final device the bus is terminated with a bus terminating connector 7XV5103-5BA00. For the redundant bus system, a bus terminating resistor is required for each bus.

Application example 3: Central operation of SIPROTEC 4 units with DIGSI 4

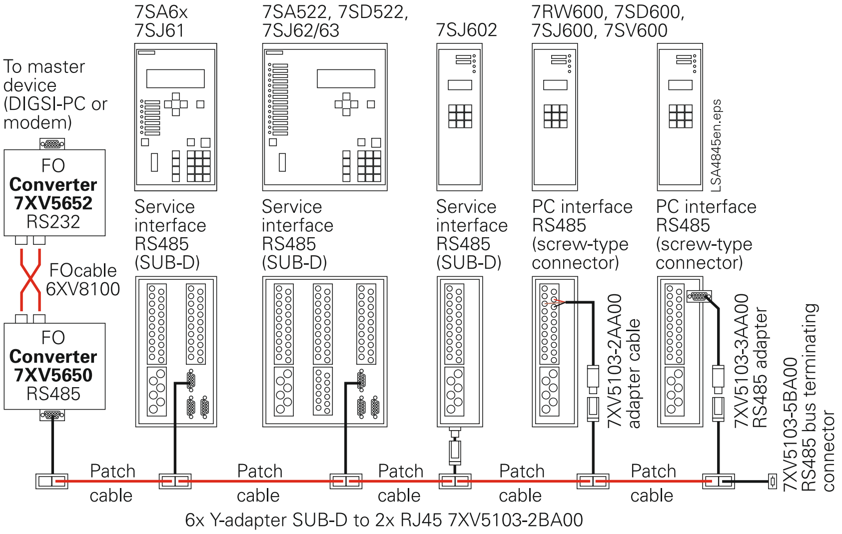
The RS485-bus cable system with patch cables (CAT 5) was developed as a low-cost alternative to the previous systems 7XV5103 with SUB-D connectors. The advantages are the widespread use of patch cables throughout the world and the compact dimensions of the RJ45 connector.

The Y-adapter 7XV5103-2BA00 allows for the implementation of a RS485 bus with patch cables and the connection of various SIPROTEC devices having RS485 interfaces. The Y-adapters have two RJ45 female connectors in parallel to facilitate the implementation of the buses. The approx. 20 cm long connection cable to the device has a RJ45 with suitable pin allocation.



Patch cable: 7KE6000-8GD0x-xAAx

Fig. 13/6 Connection of SIPROTEC 4 to a (redundant) control system



Patch cable: 7KE6000-8GD0x-xAAx

Fig. 13/7 Central operation of SIPROTEC 4 units with DIGSI 4

Devices with an RS485 interface and SUB-D connector (7XV5650/51, SIPROTEC 4 devices) with SUB-D are connected using the Y-adapter 7XV5103-2BA00.

Devices with an RS485 interface on screw-type connectors require an additional adapter for 9-pin SUB-D to single core, e.g. 7XV5103-2AA00 or 7XV5103-3AA00.

After the last device, the bus is terminated with a bus terminating connector 7XV5103-5BA00.

Selection and ordering data

Description	Order No.
RS485 adapter/accessories	*7XV5103-☐☐☐00*
Adapter cable STP with ferrule/9-pin SUB-D connection for devices with screw-type terminals or compact protection devices, e.g. 7SJ600	2 A A
Y-adapter cable for connection of SIPROTEC 4 or other devices with a 9-pin SUB-D connection to a RS485 bus with patch cables (RJ45)	2 B A
Y-adapter cable for connection of SIPROTEC 4 with a redundant T103 interface module to a RS485 bus with patch cables (RJ45)	2 C A
RS485 adapter with 9-pin SUB-D connection for mounting on screw-type terminals with compact protection devices, e.g. 7SJ600, 7SD600 etc.	3 A A
Bus terminating connector 220-Ω in a 9-pin SUB-D connector	5 A A
Bus terminating connector 120-Ω in a RJ45 connector	5 B A

Patch cable CAT 5 shielded with RJ45 connectors	*7KE6000-8GD0☐-☐AA0/BB*

See Accessories for Communication 7KE6000-8Gx

Application

Application example 4: Connecting the two bus systems 7XV5103

The Y-adapter 7XV5103-2BA00 enables configuration of the RS485 bus with RJ45 patch cables and connection of SIPROTEC devices with an RS485 interface with a SUB-D connector.

Use of an additional gender changer (female-female) enables connection of a RS485 bus with Y-bus cables 7XV5103-0AAxx instead of a SIPROTEC device.

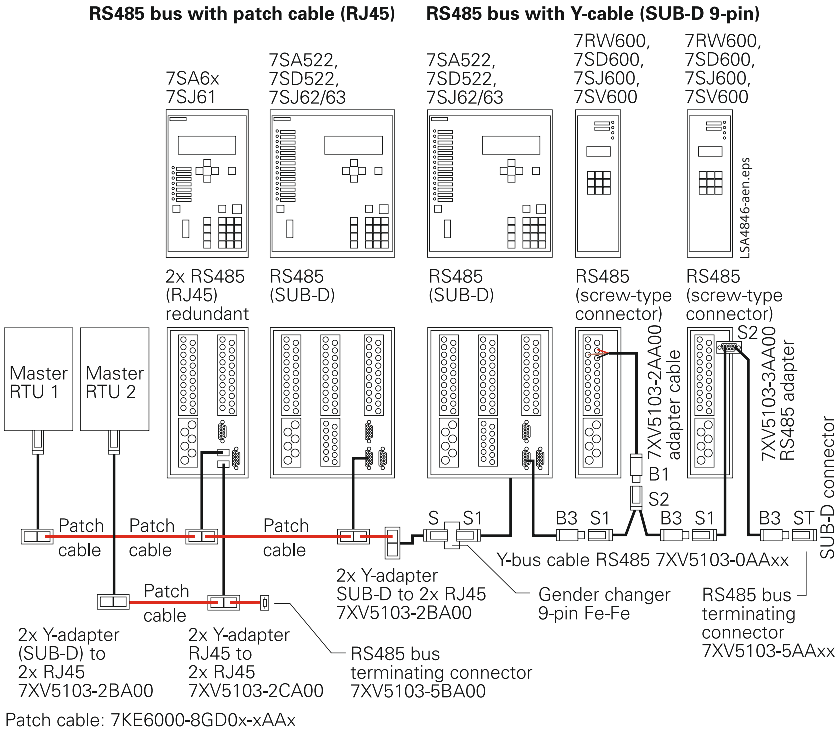


Fig. 13/8 Connecting the two 7XV5103 bus systems

Selection and ordering data

Description	Order No.
RS485 Y-bus cable shielded twisted-pair with 9-pin SUB-D connector	*7XV5103-0AA☐☐*
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
RS485 bus cable extension STP with 9-pin SUB-D connector	*7XV5103-1AA☐☐*
Length 10 m	1 0
Length 20 m	2 0
Length 30 m	3 0
Length 40 m	4 0
Length 50 m	5 0
RS485 adapter/accessories	*7XV5103-☐☐☐00*
Adapter cable STP with ferrule/9-pin SUB-D connector for devices with screw-type terminals or compact protection devices, e.g. 7SJ600	2 A A
Y-adapter cable for connection of SIPROTEC 4 or other devices with 9-pin SUB-D connection to a RS485 bus with patch cables (RJ45)	2 B A
Y-adapter cable for connection of SIPROTEC 4 with a redundant T103 interface module to a RS485 bus with patch cables (RJ45)	2 C A
RS485 adapter with 9-pin SUB-D connector for mounting to screw-type terminals for compact protection devices, e.g. 7SJ600, 7SD600 etc.	3 A A
Bus terminating connector 220-Ω in a 9-pin SUB-D connector	5 A A
Bus terminating connector 120-Ω in a RJ45 connector	5 B A
RS485 cable to thermo-box (RTD)	*7XV5103-7AA☐☐*
Connection cable for thermo-box 7XV5662-xAD to SIPROTEC 4 Open cable ends, each 5 / 20 cm with ferrules to 9-pin SUB-D connector with an integrated 220-Ω terminating resistor	
Length 5 m	0 5
Length 25 m	2 5
Length 50 m	5 0
Patch cable CAT 5 shielded with RJ45 connector	*7KE6000-8GD0☐-☐AA0/BB*
See Accessories for Communication 7KE6000-8G	

7XV5104
Bus Cable for Time Synchronization

Fig. 13/9 RS485 bus system

Function overview

- Opto-electrical solution for SIPROTEC 4 devices with IRIG-B interface (Port A)
- Direct connection of SIPROTEC 4 devices with IRIG-B interface to sync.-transceiver 7XV5654
- Adapter/cable for cascading and matching to other converters
- 4 orderable cable lengths from 1 m to 10 m
- 2-core, twisted and shielded cable with 9-pin SUB-D connectors
- Metal plug connector casings with fixing screws and strain relief for cable connections
- Compact dimensions of the plugs
- Max. extent of electrical bus 20 m within building

Description

The evaluation of fault records, operational alarms and fault signals calls for millisecond-accurate determination of the absolute time. The SIPROTEC 4 units have an internal clock on a quartz basis, which deviates from the normal time after a while. Radio clocks are therefore used for precise synchronization; they set the clocks in the devices via time signals or protocols such as DCF77 or IRIG-B. All the devices are connected in parallel with an electrical bus, so that all of them receive the time information at the same time at Port A. By means of the prefabricated bus cables and adapters 7XV5104 the SIPROTEC 4 units can be connected via their IRIG-B interface directly to the sync.-transceiver 7XV5654. The maximum length of the electrical bus when prefabricated cables are used is 20 m. Relevant applications are described in the manual for the sync.-transceiver 7XV5654.

Application

Notes on the IRIG-B bus

In this system solution only the 24 V DC time synchronization inputs of the SIPROTEC 4 units are used (see below). 7XV5105 cables are available for synchronizing the differential protection relays with an additional seconds pulse.

The housings of all bus users must be properly mutually earthed, as otherwise dangerous earth potential currents can flow via the bus cable shield.

Typical applications

The 9-pin male connector of the Y-bus cable S1 always comes from the direction of the radio clock or sync.-transceiver and provides via the 1, 3, 5 or 10 m cable and the 9-pin male connector the connection to the first and subsequent bus devices. At connector S2 a 9-pin female connector B3 is provided (on a 20 m long cable) to extend the bus. If more than six SIPROTEC 4 units are to be connected to the sync.-transceiver 7XV5654, the adapter 7XV5104-3AA00 splits the connection X1 of the sync.-transceiver into two buses for a maximum of 6 units each. (For typical applications see 7XV5654 manual).

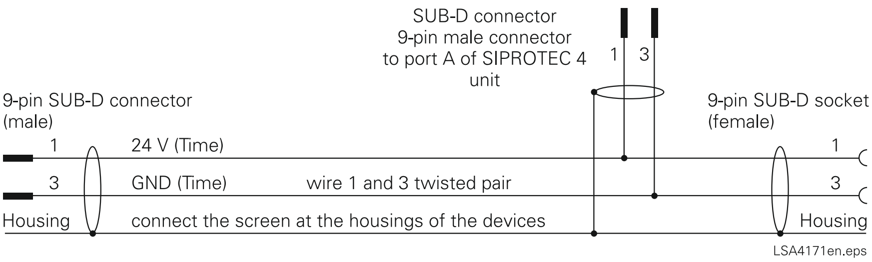


Fig. 13/10

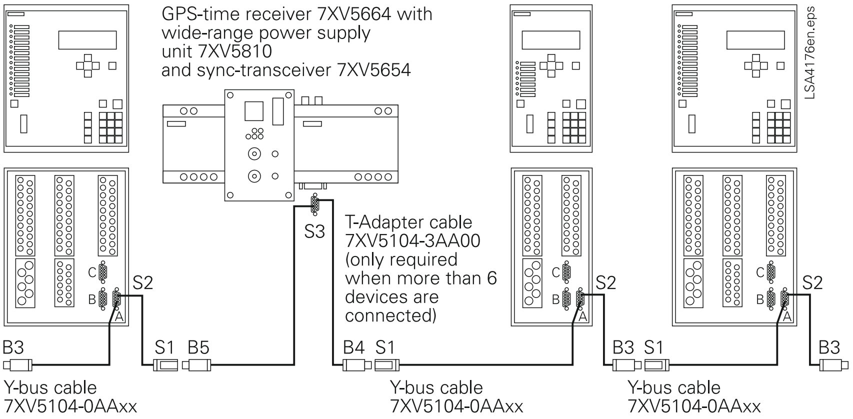


Fig. 13/11
Connection of max. twelve SIPROTEC 4 units to the IRIG-B bus via prefabricated Y-bus cable

Selection and ordering data

Description	Order No.
Y-connection cable IRIG-B / DCF77	*7XV5104-0AA☐☐*
Y-connection cable for SIPROTEC 4 unit with IRIG-B / DCF77 connection and bus extension. Copper cable 2-wire, shielded, with 9-pin SUB-D connectors	
Length 1 m	*0 1*
Length 3 m	*0 3*
Length 5 m	*0 5*
Length 10 m	*1 0*
Extension cable (copper)	
Cable for the bus length extension. Copper cable 2-wire, shielded, with 9-pin SUB-D connector Length 10 m	*7XV5104-1AA10*
Adapter / accessories	*7XV5104-☐AA00*
Adapter cable to sync.-transceiver 7KE6000-8Ax, length 0.3 m, shielded, 2 wires with end sleeves to 9-pin SUB-D connector (female)	*2*
T-adapter cable to sync.-transceiver 7XV5654-0BA00 Splits connector X1 into 2 buses for max. six SIPROTEC 4 units per bus 9-pin SUB-D connector (male) to 2 x 9-pin SUB-D connector (female) Copper cable 2-wire, shielded (length 0.3 m)	*3*

7XV5105
Bus Cable for Time Synchronization (for 7SD5 Relays)

Fig. 13/12 Y-cable 7XV5105

Function overview

- Opto-electrical solution for SIPROTEC 4 7SD5 differential protection relays with IRIG-B interface (Port A)
- Direct connection of 7SD5 protection relays via IRIG-B interface to sync.-transceiver 7XV5654
- Transmission of time telegram and seconds pulse at the same time
- 4 orderable cable lengths from 1 m to 10 m
- 4-wire, twisted and shielded cable with 9-pin SUB-D connectors
- Metal plug connector casing of compact dimensions, with fixing screw and strain relief for cable connections
- Max. extent of electrical bus 20 m within building

Description

The evaluation of fault records, operational alarms and fault signals calls for a millisecond-accurate absolute time stamp. The differential protection relays have an internal clock on a quartz basis, by means of which the protection is normally synchronized. In special applications, GPS radio clocks are used to synchronize the 7SD5 differential protection relays with the absolute time. These clocks send a time telegram together with a microsecond-accurate seconds pulse, so that the transmission time in both the sending and the receiving direction can be precisely measured. All the devices in each system are connected in parallel via an electrical bus, so that all devices receive the time information and the seconds pulse at the same time. By means of the prefabricated bus cables 7XV5105, the 7SD5 relays can be connected via their IRIG-B interface (Port A) directly to the sync.-transceiver 7XV5654. The maximum length of the electrical bus when the prefabricated cables are used is 20 m. Relevant applications are described in the manual for the sync.-transceiver 7XV5654.

Application

Notes on the IRIG-B bus

In this system solution only the 24 V DC time synchronization inputs (Port A) of the SIPROTEC 4 protection relays are used. 2-core 7XV5104 cables are available for time synchronization of the SIPROTEC 4 protection relays without additional seconds pulse.

The housings of all bus users must be properly mutually earthed, as otherwise dangerous earth potential currents can flow via the bus cable shield.

Typical applications

The 9-pin male connector of the Y-bus cable S1 always comes from the direction of the radio clock or sync.-transceiver and provides via the 1, 3, 5 or 10 m cable and the 9-pin male connector the connection to the first and subsequent bus devices. At connector S2 a 9-pin female connector B3 is provided (on a 20 m long cable) to extend the bus. If more than six SIPROTEC 4 units are to be connected to the radio clock, up to 4 sync.-transceivers 7XV5654 can be connected, each with 6 protection relays. (For typical applications see the 7XV5654 manual).

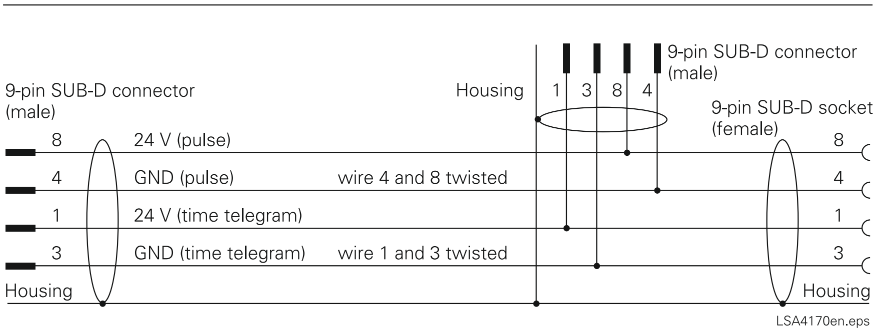


Fig. 13/13

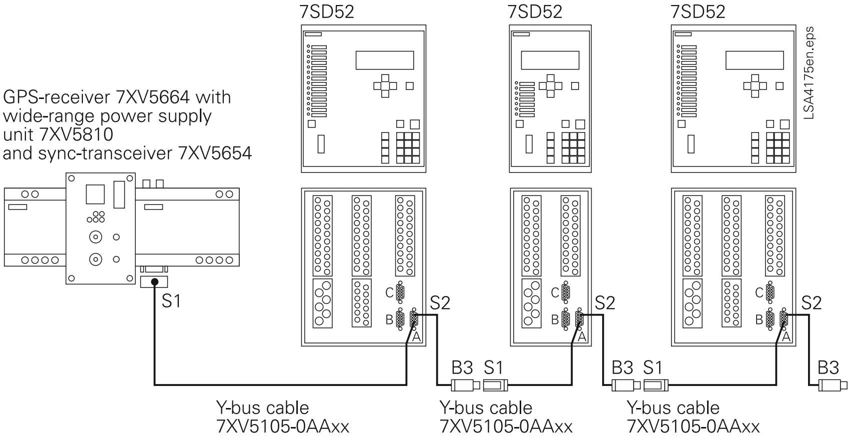


Fig. 13/14
Connection of max. six SIPROTEC 4 protection relays 7SD5 to the IRIG-B bus via prefabricated Y-bus cable

Selection and ordering data

Description	Order No.
Y-connection cable IRIG-B / DCF77	*7XV5105-0AA□□*
Y-connection cable for direct connection of a SIPROTEC 4 differential protection relay with IRIG-B / DCF77 connection to sync.-transceiver 7XV5654 and bus extension. Copper cable 4-wire, shielded, with 9-pin SUB-D connectors	
Length 1 m	*0 1*
Length 3 m	*0 3*
Length 5 m	*0 5*
Length 10 m	*1 0*
Extension cable (copper)	
Cable for bus length extension. Copper cable with 4 wires, shielded with 9-pin SUB-D connectors Length 10 m	*7XV5105-1AA10*
Adapter / accessories	
Adapter cable to two sync.-transceivers 7KE6000-8Ax, length 0.3 m shielded, 2 wires with end sleeves to 9-pin SUB-D connector (female)	*7XV5105-2AA00*

7XV5450
Mini Star-Coupler

Fig. 13/15
Mini star-coupler

Function overview

One optical input and up to 4 optical outputs

- Distance spanned: 1.5 km
  with 62.5/125 µm multi-mode fiber
- Multiple mini star-couplers cascadable
- RS232 interface for local access
- Baud rate via FO: up to 1.5 Mbaud;
  Baud rate with RS232:
  Up to 115 kbaud
- Protocol transparency
- Light idle state:
  Light ON/light OFF selectable
- Wide-range power supply
  with self-monitoring function
  and alarm contact
- Optical ST connectors

Description

The mini star-coupler multiplies an optical signal received at an input for up to four outputs. A signal received at one of the outputs is transmitted via the input interface to a central unit or to an upstream mini star-coupler or converter.
As the mini star-coupler does not transmit selectively to individual outputs, the protocols used for data transmission must operate with unique DTE addresses, so all units “hear” the central interrogation, but only the addressed unit answers to the request (e.g. IEC 60870-5-103 or DIGSI).

Data are transmitted in transparent full-duplex mode. An RS232 interface is provided for direct serial communication with DTEs at each mini star-coupler. As long as this interface is in use, the optical input interface to the central unit is blocked.

Cascading mini star-couplers replace the 7XV5300 star coupler.

Application

The mini star-coupler allows SIPROTEC relays to be centrally accessed or remotely interrogated with DIGSI via optical interfaces. The component is cascadable, so that star topologies or ring topologies can be configured. A ring structure ensures that all four outputs are used. The mini star-coupler has a local RS232 interface socket. By connecting a PC to this interface and using the 7XV5100-4 cable, the optical input is disconnected to avoid data collision due to local and remote access concurring at the same time.

Construction

The 7XV5450 mini star-coupler is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

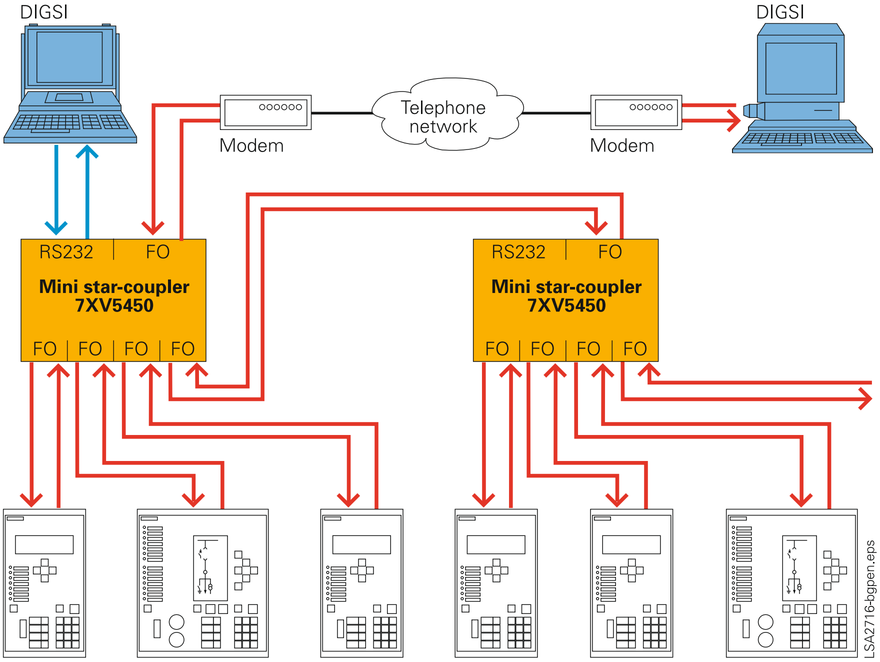


Fig. 13/16 Star topology with mini star-couplers

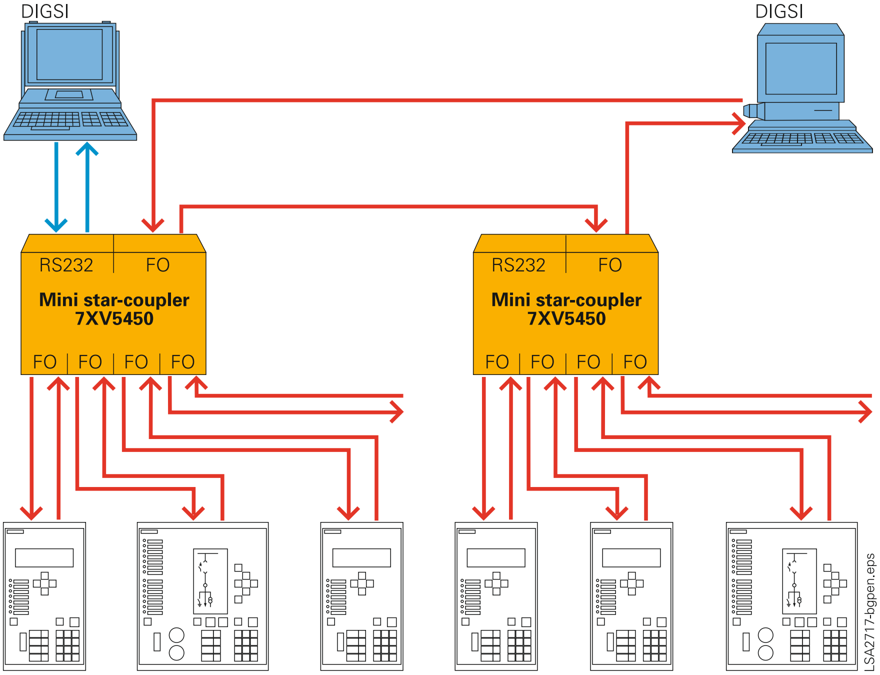


Fig. 13/17 Ring structure with mini star-couplers

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.25 to 0.4 A	
LEDs	
3 LEDs	
Green	Operating voltage o.k.
Yellow	Receiving data
Yellow	Sending data
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO cables	Multi-mode fiber with ST connectors
RS232	9-pin SUB-D socket
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	By jumpers
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting on 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5450 mini star-coupler	*7XV5450-0BA00*

Optical mini star-coupler with plastic housing for snap-on mounting onto 35 mm rail.

Rated auxiliary voltage 24 - 250 V DC and 110 - 220 V AC with alarm relay.

Connection of up to 4 protection units to a star coupler via FO cable for 62.5 / 125 µm and 850 nm wavelength, max. distance 1.5 km.

Connection of PC or modem to a star coupler via FO cable for 62.5 / 125 µm and 850 nm wavelength, max. distance 1.5 km.

Connection also by 9-pin RS232 connector.

Cascadable

Fiber-optic connectors with ST connector

7XV5461
Two-Channel Serial Optical Repeater (for duplex-mono-mode FO cables)

Fig. 13/18
Optical repeater with
wide-range power supply

Description

The optical repeater transmits serial optical signals over long distances via duplex-mono-mode FO cables. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range of 300 bit/s to 4.096 Mbit/s. Both synchronous and asynchronous signals can be connected. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. Two devices with an optical 820 nm interface, for example the 7SD5 / 7SD6 line differential protection relay or the RS232/ 820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via duplex-multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the LC-Duplex connector at wavelengths of 1300 nm/1550 nm for connection of a duplex-mono-mode FO cable. For Port 3 there are three options for max. 25 km (1300 nm) / 60 km (1300 nm) and 100 km / 170 km (1550 nm) optical fiber lengths. The device can be connected to all battery voltages and AC supply sources. Loops can be activated for Ports 1 / 2 for commissioning purposes, so that the input signals can be mirrored at the port in question.

Function overview

- Two independent multiplexed 820 nm ports with ST connectors for max. 1.5 km via 50/125 µm and 62.5/125 µm duplex-multi-mode FO cable.
- Data rate of serial ports 1 / 2 from 300 bit/s - 4.096 Mbit/s. Automatic baud rate adjustment to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm / 1550 nm port with LC-Duplex connector for distances up to 24 km / 60 km / 100 km / 170 km via 9/125 µm duplex-mono-mode FO cable
- 24 to 250 V DC and 115/230 V AC wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support

Typical applications

The protection relays (for example 7SD5 / 7SD6 differential protection or 7SA52 / 7SA6 distance protection) exchange information via Port 1. Interference-free data exchange is performed via duplex-mono-mode FO cable up to a distance of 170 km. Protection remote control with DIGSI is connected to Port 2 of the repeater via the 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC where DIGSI is installed. The protection relays on the remote substation can be scanned remotely via Port 2. The baud rate is optimally set to 57.6 kbit/s so that there is no difference from local operation. During commissioning and operation, data of the device on the other substation can be changed and read out. Alternatively, it is possible to connect power system control or additional protection data transmission to Port 2. This makes for optimum use of the long-distance optical fiber for two separate serial connections for transmitting data between 300 bit/s and 4.096 Mbit/s.

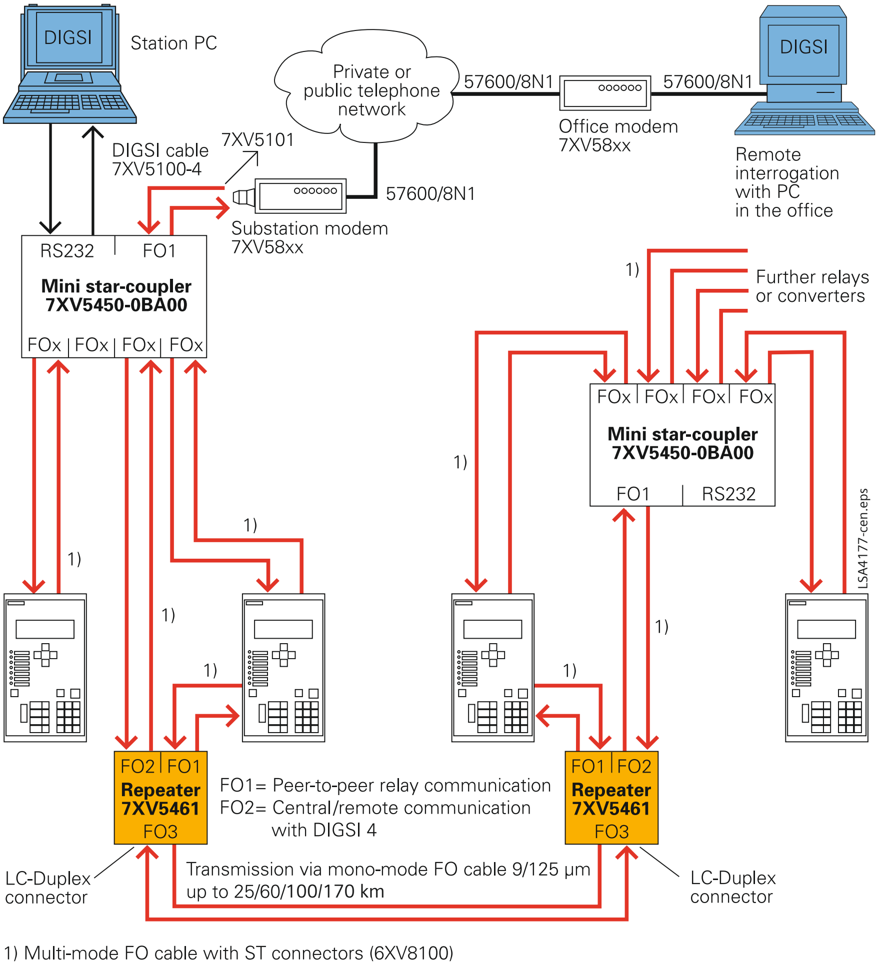


Fig. 13/19
Transfer of protection data and remote control of a substation via an optical long-distance connection

Technical data

Connections	
Ports 1 / 2	ST connector for 820 nm for 50/125 µm and 62.5/125 µm multi-mode FO cable
Port 3	LC-Duplex connector for 1300 nm/1550 nm for 9/125 µm mono-mode FO cable
Screw-type terminals	2-pole screw-type terminals for auxiliary voltage supply 3-pole make/break contact for alarm relay
Housing	
188 x 56 x 100 mm aluminum housing for mounting on 35 mm DIN rail to EN 50032. Weight 0.8 kg. Degree of protection acc. to EN 60529: IP41	
Power supply	
Wide range 24 to 250 V DC without connector jumpers, 115 / 230 V AC	
Displays	
4 LEDs	
Green	Power supply
Red	Alarm relays
2 yellow	Data exchange

Selection and ordering data

Description	Order No.
7XV5461 two-channel serial optical repeater (for duplex-mono-mode FO cables)	*7XV5461 - 0B☐00*
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s to 4.096 Mbit/s 24 to 250 V DC, 115/230 V AC wide-range power supply Fault relay and LED for operational and fault display	
Optical 1300 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 24 km (permissible path attenuation 13 dB)	*G*
Optical 1300 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 60 km (permissible path attenuation 29 dB)	*H* 1)
Optical 1550 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 100 km (permissible path attenuation 29 dB)	*J* 1)
Optical 1550 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 170 km (permissible path attenuation 43 dB)	*M* 1)

---

1) When ordering options H/J an additional attenuator is required if the devices are used for distances < 20 km

7XV5461
Two-Channel Serial Optical Repeater (for 1 mono-mode FO cable)

Fig. 13/20
Optical repeater with integrated 1300 nm/1550 nm wave length multiplexer for one single mono-mode FO-cable

Description

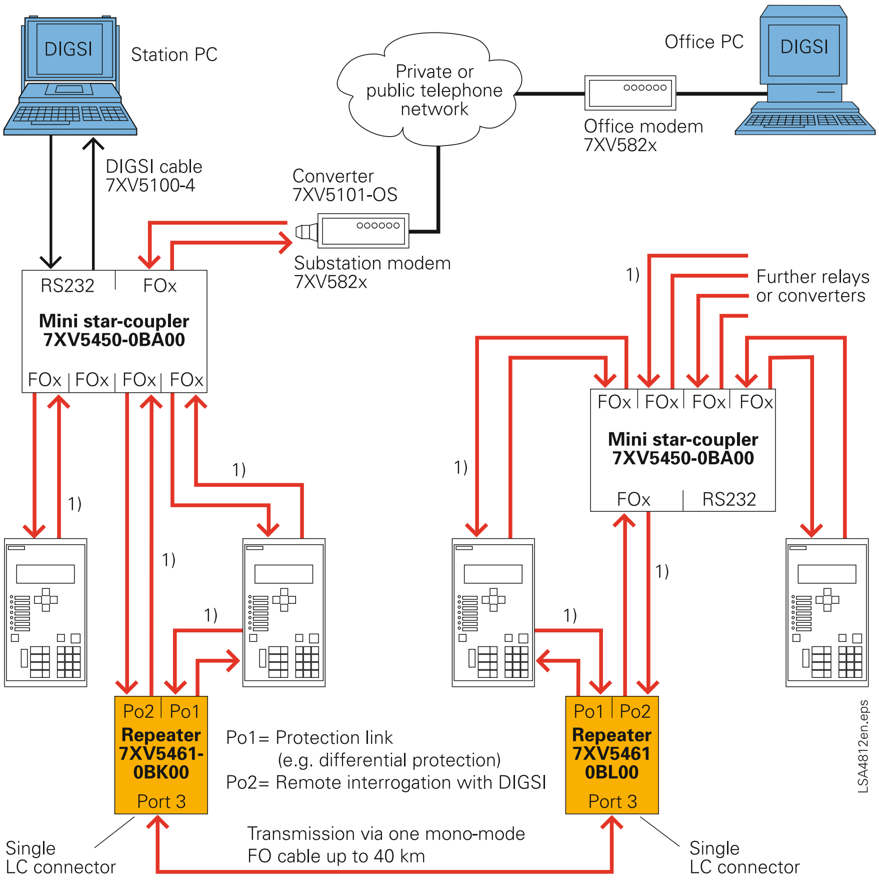
The optical repeater exchanges serial optical signals over long distances via only one single mono-mode FO cable. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range 300 bit/s – 4.096 Mbit/s to 1300/1550 nm for one mono-mode FO cable. Both synchronous and asynchronous signals can be connected at Port 1/2. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. Two devices with an optical 820 nm interface, for example the 7SD5/7SD610 line differential protection relay or the RS232/820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the single LC connector at wavelengths of 1300 nm/1550 nm for connection of mono-mode FO cable up to 40 km. The device can be connected to DC battery voltages and AC supply sources. Loops can be activated for Port 1/2 for commissioning purposes, so that the input signals can be mirrored at each port to support commissioning of the fiber optical links.

Function overview

- Two independent multiplexed 820 nm Ports 1/2 with ST connectors for max. 1.5 km via 50/125 µm and 62.5/125 µm multi-mode FO cable.
- Data rate of serial Ports 1/2 from 300 bit/s – 4.096 Mbit/s. Automatic baud rate adjustments to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm/1550 nm port with LC-single connector for distances up to 40 km via one 9/125 µm mono-mode FO cable
- 24 to 250 V DC and 115/230 V AC wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support

Application

Until now, two FO cables are required for the bidirectional transmission of protection signals. With the repeater with integrated wavelength multiplexer one FO cable is sufficient: Two protection relays e.g. 7SD52/7SD610 differential protection or 7SA52/7SA6 distance protection, exchange information via Port 1 (po1). Interference-free data exchange is performed via one optical mono-mode FO cable up to a max. distance of 40 km. Protection remote control with DIGSI is connected to Port 2 of the repeater via a 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC on which DIGSI is installed. In this way, the remote protection devices can be remotely interrogated via Port 2. The baud rate is optimally set to 57.6 kbit/s so that there is no difference from local operation. The data of the devices on the other substation can be changed or read out during commissioning and operation. Alternatively, it is possible to connect substation control devices, RTU or additional protection data transmission to Port 2. This makes for optimum use of the long-distance optical cable for two separate serial connections for transmitting serial data between 300 bit/s and 4.096 Mbit/s.



1) Multi-mode FO cable with ST connectors (6XV8100)

Fig. 13/21
Transfer of protection data signals and remote control/integration via one mono-mode FO cable (Note: Devices 7XV5461-0BK00 and 7XV5461-0BL00 must be used in pairs)

Technical data

Connections	
Ports 1 / 2	ST connector for 820 nm for 50/125 µm and 62.5/125 µm multi-mode FO cable
Port 3	LC-single connector for 1300 nm/1550 nm for 9/125 µm mono-mode FO cable
Screw-type terminals	2-pole screw-type terminals for auxiliary voltage supply 3-pole make/break contact for alarm relay
Housing	
Interference-free 188 x 56 x 120 mm metal housing for mounting on 35 mm DIN rail to EN 50032. Weight 0.8 kg. Degree of protection acc. to EN 60529: IP41	
Power supply	
Wide range 24 to 250 V DC or 115 / 230 V AC	
Displays	
4 LEDs	
Green	Power supply
Red	Alarm relays
2 yellow	Data exchange indication

Selection and ordering data

Description	Order No.
Two-channel serial optical repeater with integrated wavelength multiplexer	*7XV5461 - 0B☐00*
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s – 4.096 Mbit/s 24 – 250 V DC, 115/230 V AC wide-range power supply Alarm relay and LED for operational and fault display	
Optical 1550 nm output with LC-single connector for 9/125 µm mono-mode FO cable for distances up to 40 km (permissible path attenuation 25 dB)	*K*
Optical 1300 nm output with LC-single connector for 9/125 µm mono-mode FO cable for distances up to 40 km (permissible path attenuation 25 dB)	*L*

7XV5461
Two-Channel Serial Optical Repeater (for duplex-multi-mode FO cables)

Fig. 13/22
Optical repeater with
wide-range power supply

Description

The optical repeater transmits serial optical signals over long distances via duplex-multi-mode FO cables. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range 300 bit/s - 1.5 Mbit/s to 1300 nm for duplex-multi-mode fiber cables. Both synchronous and asynchronous signals can be connected. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. One transmit (Tx) and one receive (Rx) signal is supported (no RTS/CTS handshake signals). Two devices with an optical 820 nm interface, for example the 7SD52 / 7SD610 line differential protection relay or the RS232/820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via duplex-multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the LC-Duplex connector at wavelengths of 1300 nm for connection of a duplex-multi-mode FO cable. For Port 3 there are two options for a max. of 4 km (1300 nm) and 8 km (1300 nm) optical fiber lengths. The device can be connected to all battery voltages and AC supply sources. Loops can be activated for Ports 1 / 2 for commissioning purposes, so that the input signals can be mirrored at the port in question.

Function overview

- Two independent multiplexed 820 nm ports with ST connectors for a max. of 1.5 km via 50/125 µm and 62.5/125 µm duplex-multi-mode FO cable.
- Data rate of serial Ports 1 / 2 from 300 bit/s - 1.5 Mbit/s. Automatic baud rate adjustment to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm port with LC-Duplex connector for distances up to 4 km /8 km via 50/125 µm / 62.5/125 µm duplex-multi-mode FO cable
- 24 to 250 V DC and 115/230 V AC wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support with test loop feature

Typical applications

Two protection relays (for example 7SD52/7SD610 differential protection or 7SA52/7SA6 distance protection) exchange information via Port 1. Interference-free data exchange is performed via optical duplex-multi-mode FO cable up to a distance of 4/8 km. Protection remote control with DIGSI is connected to Port 2 of the repeater via 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC where DIGSI is installed. The protection relays on the remote substation can be interrogated remotely via Port 2. The baud rate is optimally set to 57.6 kbit/s so that there is no difference from local operation. During commissioning and operation, the data of the device in the other substation can be changed and read out. Alternatively, it is possible to connect a substation control system or additional protection data transmission to Port 2. This makes for optimum use of the long-distance optical fiber for two separate serial connections for transmitting data between 300 bit/s and 4.096 Mbit/s.

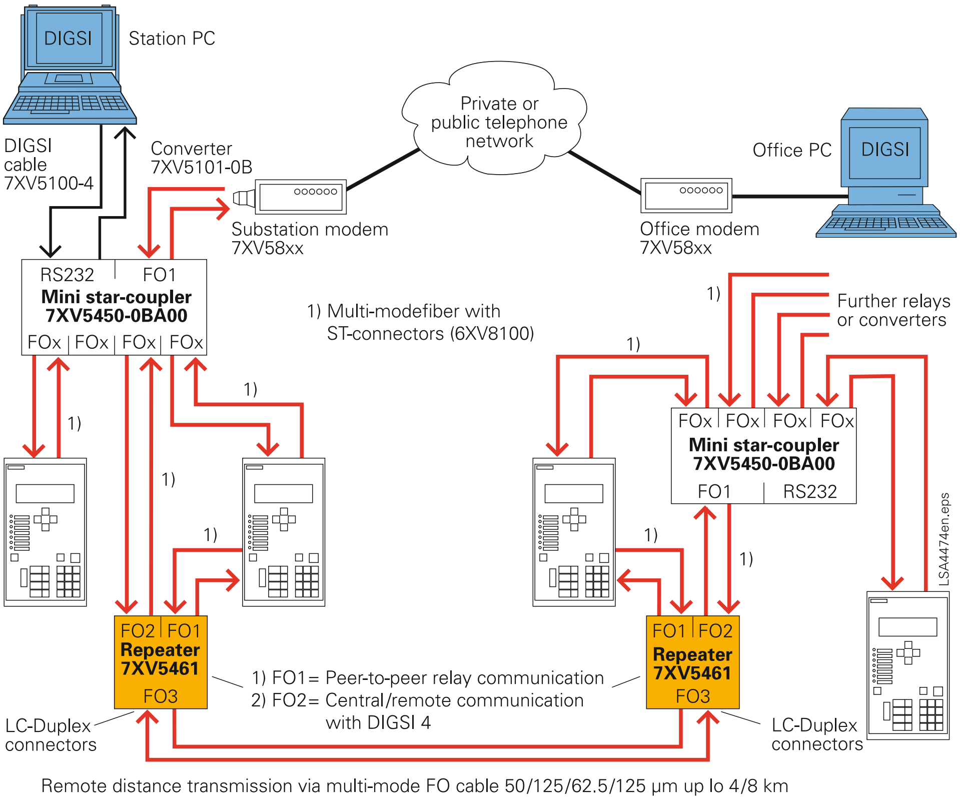


Fig. 13/23
Transfer of protection data and remote control of a substation via an optical long-distance connection

Technical data

Connections	
Ports 1 / 2	ST connector for 820 nm for 50/125 µm and 62.5/125 µm multi-mode FO cable
Port 3	LC-Duplex connector for 1300 nm for 50/125 µm / 62.5/125 µm multi-mode FO cable
Screw-type terminals	2-pole screw-type terminals for auxiliary voltage supply 3-pole make/break contact for alarm relay
Housing	
188 x 56 x 100 mm aluminum housing for mounting on 35 mm DIN rail to EN 50032. Weight 0.8 kg. Degree of protection to EN 60529: IP41	
Power supply	
Wide range 24 to 250 V DC without switchover 115 / 230 V AC	
Displays	
4 LEDs	
Green	Power supply
Red	Alarm relays
2 yellow	Data exchange

Selection and ordering data

Description	Order No.
Two-channel serial optical repeater (for duplex multi-mode FO cables)	*7XV5461 - 0B☐00*
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s to 1.5 Mbit/s 24 to 250 V DC, 115/230 V AC wide-range power supply Fault relay and LED for operational and fault display	
Optical 1300 nm output with LC-Duplex connector for 50/125 µm / 62.5/125 µm multi-mode FO cable for distances up to 4 km (permissible path attenuation 13 dB)	*F*
Optical 1300 nm output with LC-Duplex connector for 50/125 µm / 62.5/125 µm multi-mode FO cable for distances up to 8 km (permissible path attenuation 29 dB)	*E*

7XV5550
Active Mini Star-Coupler

Fig. 13/24
Active mini star-coupler

Function overview

One optical input and 4 optical outputs or one RS485 input and 5 optical outputs

- RS232 interface for local access
- RS485 interface for bus structure
- Baud rate and data format can be set independently for each port
- Baud rate 1200 baud – 115 kbaud
- Data format 8N1, 8N2, 8E1
- Max. distance: 1.5 km with 62.5/125 µm multi-mode FO cable
- Light idle state: Light ON/light OFF selectable
- Wide-range power supply with self-supervision function and alarm contact
- Optical ST connectors

Description

Five optical ports allow the active mini star-coupler to centrally or remotely communicate with devices with serial interfaces using different baud rates and data formats. Using a simple ASCII sequence, only one of the available output channels is switched to a transparent full duplex operation. The active mini star-coupler can be used with any terminal program or for SIPROTEC protection relays with the DIGSI operating program. Each of the input and output channels can be parameterized independently to the device attached by adjustable baud rates and data formats or as input or output ports. For communication with more than 5 devices, the active mini star-coupler can be cascaded together with an RS485 bus in half-duplex mode with further devices.

Please note:

The 7XV5450 passive mini Star-coupler is recommended for controlling several SIPROTEC 3 or SIPROTEC 4 devices with DIGSI or for communication by a remote control system.

Application

Using the integrated optical interfaces of the active mini star-coupler, data transmission for the protection relays V1/2, SIPROTEC 3 or 4 can be performed centrally or remotely with DIGSI. When using the RS485 bus structure each active mini star-coupler provides five optical outputs. An RS232 interface is available for local operation with a notebook. The control PC (directly or via modem) always operates with the same data format, while the interfaces to the different protection relays using other formats are adapted accordingly. For V1/2 protection relays, a 7XV5101-0A plug-in connector module is required for each relay and each relay must be connected to a separate port.

Construction

The active mini star-coupler is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

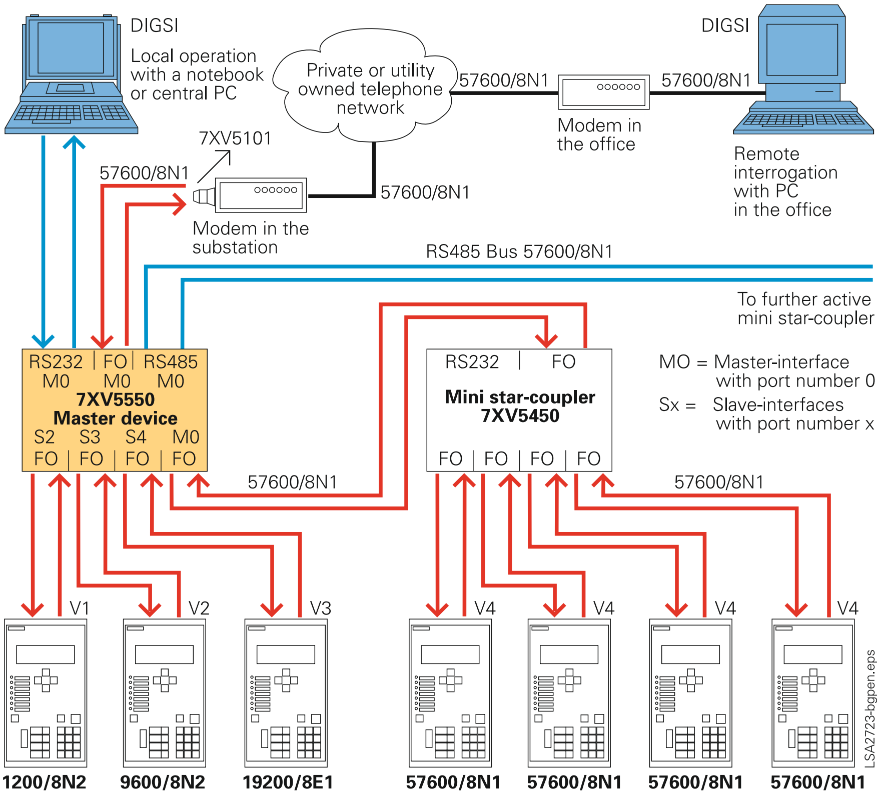


Fig. 13/25

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
LEDs	
3 LEDs Green Yellow Yellow	 Operating voltage o.k. Receiving data Sending data
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO connections	820 nm ST connectors
RS232	9-pin SUB-D socket
RS485	2-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	By jumpers
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5550 active mini star-coupler	*7XV5550-0BA00*

Optical active mini star-coupler with plastic housing for snap-on mounting onto 35 mm rail.

Rated auxiliary voltage 24 - 250 V DC and 110 - 230 V AC with alarm relay.

Connection of up to 4 protection units to an active mini star-coupler via FO cable for 62.5 / 125 μm and 850 nm wavelength, max. distance 1.5 km.

Connection of PC or modem to an active mini star-coupler via FO cable for 62.5 / 125 μm and 850 nm wavelength, max. distance 1.5 km.

Connection also by 9-pin RS232 connector.

Cascadable

Fiber-optic connectors with ST connector

7XV5650/5651
RS485 – FO Converter

Fig. 13/26
RS485 – FO converter

Function overview

- Baud rates 9.6 – 115 kbaud
- Topologies:
  7XV5650: Optical star
  7XV5651: Optical line, RS485 bus
- Protocol transparency
- Light idle state:
  Light ON/light OFF selectable
- Distance: 1.5 km with 62.5/125 µm FO cable
- 120 Ω terminator for RS485 bus, activated/deactivated by DIP switch
- Wide-range power supply with self-supervision function and fault output relay

Description

The RS485 – FO converter allows up to 31 devices to be connected with a bus-capable electrical RS485 interface. It provides an optical link-up to a central unit or a star coupler. The converter has been designed for use in substations for interference-free transmission of serial data with rates between 9.6 and 115.2 kbaud by multi-mode FO cable.

The 7XV5651 converter is designed to act as a T-coupler, data can be distributed in a line structure system, forming a basis for building up cost-effective optical bus systems.

The version 7XV5650 is designed for star topology via fiber-optic connection.

Application

The converters can be used in an optical line structure or in an optical star structure. Application in optical line structure allows relays to be connected interference-free via fiber-optic cables; for indoor installation, a cost-effective RS485 bus can be used.

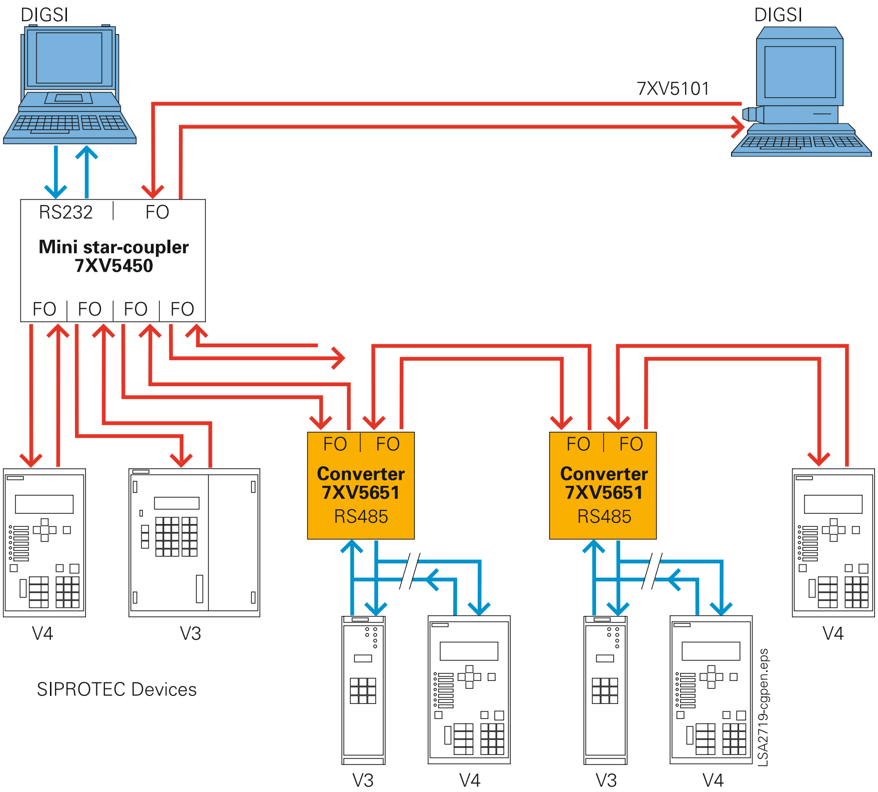


Fig. 13/27 Optical line structure with connected RS485 interfaces

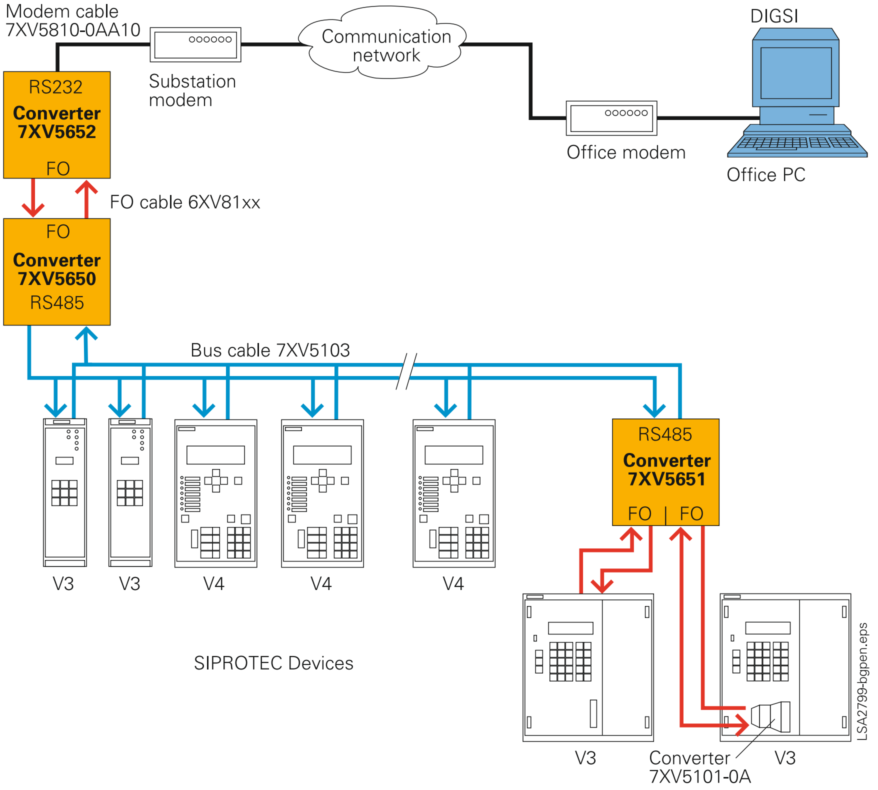


Fig. 13/28 Connection of optical interfaces to an RS485 bus

Application

Several units equipped with FO interface and DIGSI or IEC 60870-5-103 protocol can be connected to an existing RS485 bus structure.

Within one system, the data format and the baud rate have to be set to the same values.

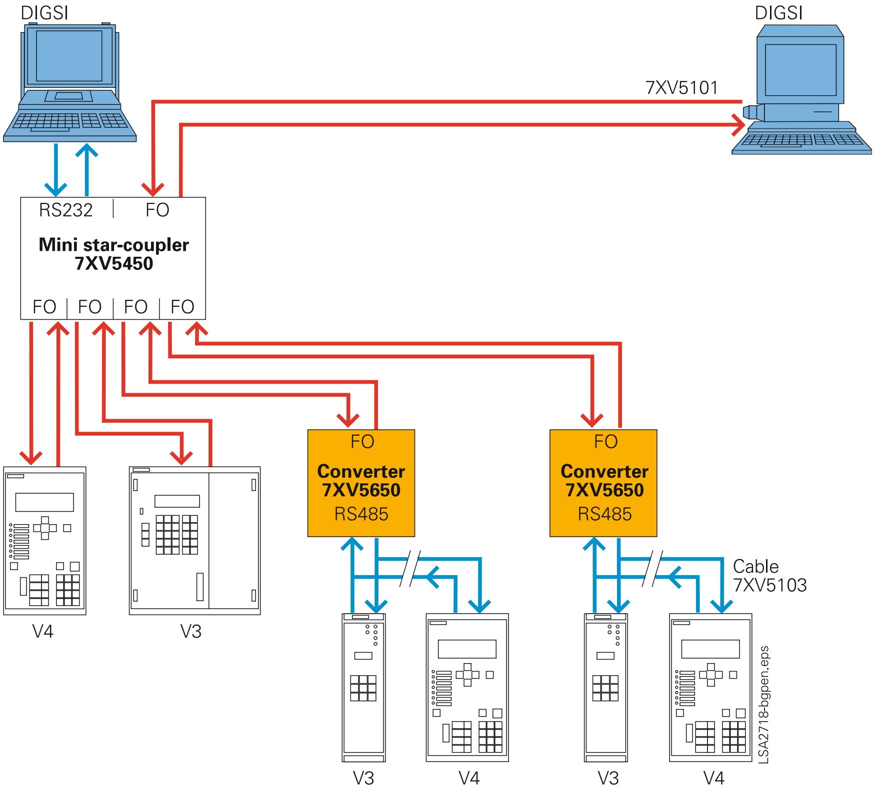


Fig. 13/29 Optical star structure with connected RS485 interfaces

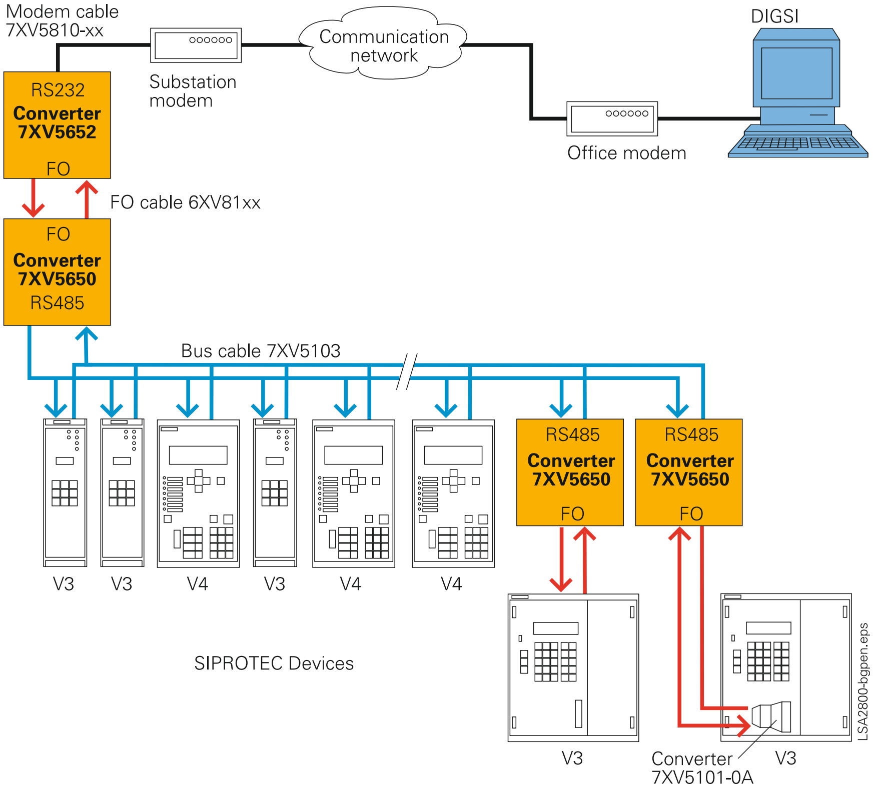


Fig. 13/30 Connection of optical interfaces to an RS485 bus

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals.

The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.2 to 0.3 A	
LEDs	
2/3 LEDs	
Green	Operating voltage o.k.
Yellow	Receiving data on FO channel 1
Yellow	Receiving data on FO channel 2 (7XV5651 only)
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO	820 nm ST connector
RS485	9-pin SUB-D socket 2-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV565 RS485 – FO converter	*7XV565□-0BA00*
Converter with 1 RS485 interface and 2 FO cables for transmission rates from 9.6 kbaud to 115 kbaud	
With plastic housing for snap-on mounting on 35 mm rail.	
Rated auxiliary voltage 24 - 250 V DC and 110 - 230 V AC with alarm contact.	
Connection of units with RS485 interface by 9-pin SUB-D connector or screw-type terminals.	
Connection of PC or modem to a star coupler via FO cable for 62.5/125 µm or 50/125 µm and 850 nm wavelength.	
Fiber-optic connectors: FO 820 nm with ST connector	
1 channel	*0*
2 channels	*1*

7XV5652
RS232 – FO Converter

Fig. 13/31
RS232 – FO converter

Function overview

- Serial baud rates up to 115 kbaud
- No setting of baud rate necessary
- Protocol transparency
- Light idle state: Light ON / light OFF selectable
- Distance: 3 km with 62.5/125 µm FO cable
- Wide-range power supply with self-supervision function and alarm contact
- Supports the serial TxD and RxD lines of the RS232 interface.
  No handshake lines supported

Description

The RS232 – FO converter is used to convert serial RS232 signals to FO transmission signals in full duplex mode. It has one FO channel for transmission and one for receiving, as well as a protected RS232 interface rated to withstand 2 kV discharges, thus allowing direct connection to the serial system interface of SIPROTEC relays. It is designed to be used in substations for isolated, interference-free transmission of serial signals to a central unit, a star coupler or a PC.

The converter supports the conversion of serial TxD (transmit) and RxD (receive) signals to an optical output. No handshake signals are supported.

Application

With the serial RS232 – FO converter, an existing RS232 interface at a SIPROTEC relay can be upgraded to an optical 820 nm interface to connect the relay with further optical components for central and remote interrogation with DIGSI. Another application is the interfacing between a line differential relay and a communication network, which provides electrical RS232 inputs. The connection between the communication room, where the converter is located, and the relay is executed without interference via multi- mode FO cables (Fig. 13/32).

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

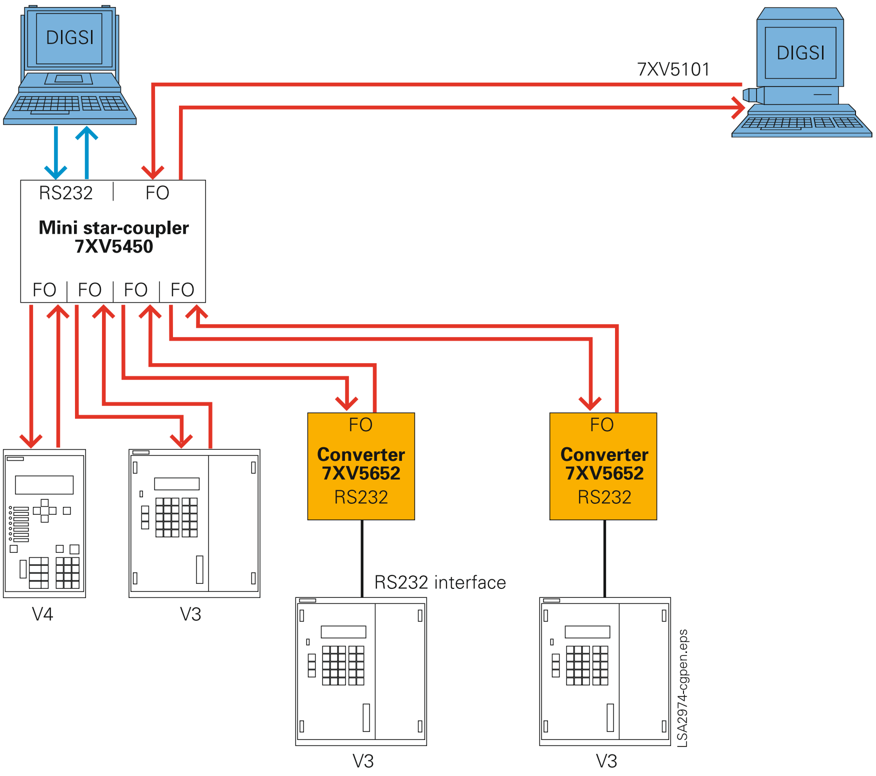


Fig. 13/32 Remote interrogation with the RS232 interface

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.1 to 0.2 A	
LEDs	
1 LED Green	Operating voltage o.k.
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO cables	820 nm ST connectors
RS232	9-pin SUB-D socket
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5652 RS232 – FO converter	*7XV5652-0BA00*

For conversion of FO to RS232 (V.24) signals up to 115 kbaud

With plastic housing for snap-on mounting on 35 mm rail

Rated auxiliary voltage 24 - 250 V DC and 110 - 230 V AC with alarm contact.

Connection of units with RS232 interface by 9-pin SUB-D connector

Connection of PC, star coupler, modem via FO cable for 62.5/125 µm and 850 nm wavelength

Fiber-optic connectors: FO 820 nm with ST connector

7XV5653
Two-Channel Binary Transducer

Fig. 13/33
Binary transducer

Description

The transducer registers binary information from contacts via two binary inputs and forwards it interference-free to the second transducer via fiber-optic cable. The indications/signals received by this second transducer are put out via its contacts. The two contacts can be used as trip contacts. The transducer is equipped with independent and bidirectional binary inputs (2) and contact outputs (2).

The transducer has been designed for application in substations. Highly reliable, telegram-backed serial data transmission is used between the transducers. Transmission errors and failure of the data link are indicated via an alarm contact, i.e. a permanent supervision of power supply and the datalink is integrated in the transducer.

Function overview

- 2 isolated binary inputs (24 to 250 V DC)
- 2 isolated trip contacts
- Fast remote trip via a serial point-to-point link of up to 115 kbaud/12 ms.
- Telegram-backed interference-free transmission via FO cable
- Permanent data link supervision and indication
- Distance of approx. 3 km via multi-mode FO cable 62.5/125 µm
- Transmission of up to 170 km via mono-mode FO cable with 7XV5461 repeater
- Transmission via communication networks and leased lines and pilot wires with 7XV5662-0AC01 communication converters
- Wide-range power supply with self-supervision function and alarm relay

Application

The bidirectional transducer registers binary information at two binary inputs and forwards it via fiber-optic cable to a second transducer, which outputs the signals via contacts. Distances of about 3 km can be covered directly via multi-mode fiber-optic cables. The 7XV5461 repeater is available for distances up to 170 km via mono-mode fiber-optic cable. (Fig. 13/34) With two transducers connected to 7XV5461, up to four binary signals can be transferred. One application is phase-selective intertripping.

With a communication converter, the transducer can be interfaced to different kinds of communication links. Modern N x 64 kbit/s digital networks can be used. Existing pilot wires can also be used for data exchange between the relays. The data to be exchanged includes directional signals, intertrip signals and other information.

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be effected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

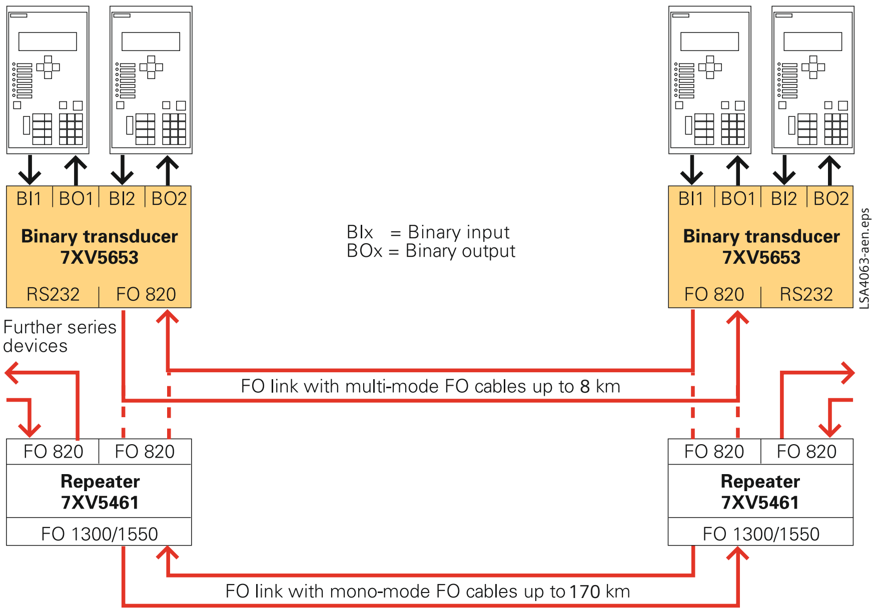
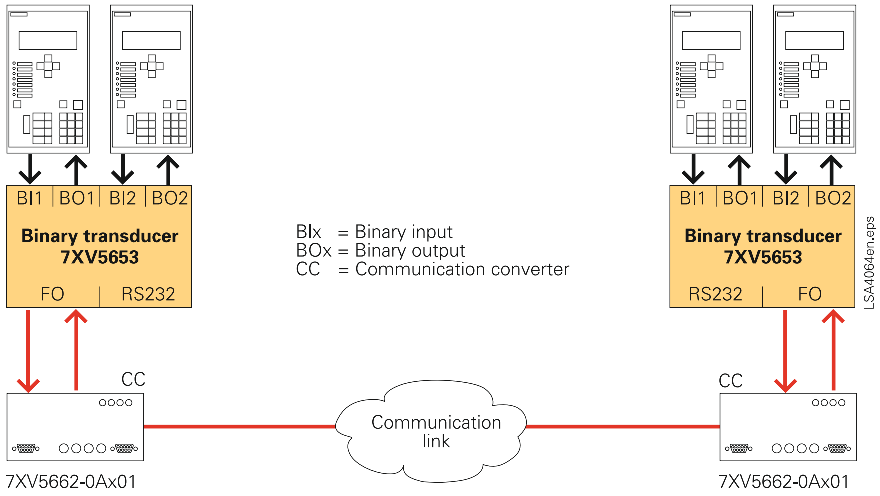


Fig. 13/34



X = A: Options for the communication link:
G.703.1, X.21 interface to a communication network
X = C: pilot-wire cable up to 10 km
X = D: G.703.6 (E1/T1) interface to a communication network

Fig. 13/35

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.15 to 0.25 A	
LEDs	
6 LEDs	
1 x green	Operating voltage o.k.
2 x yellow	Contact unit ½ active
2 x yellow	Command relay ½ active
1 x red	Alarm
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO connection	820 nm FSMA screw-type connector
FO connection	820 nm ST connector
Binary inputs	4-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5653 two-channel binary transducer	*7XV5653-0BA00*

Binary signal transducer

Plastic housing, for snap-on mounting onto 35 mm EN 50022 rail

Rated auxiliary voltage 24 to 250 V DC
and 110 to 230 V AC with alarm relay, 2 binary inputs, 2 trip contacts,
1 alarm relay with potential-free contact for pilot-wire supervision

Connection to a second transducer via FO cable for 62.5 / 125 µm
and 820 nm wavelength (ST connectors). Max. distance 3 km.

Connection to a second transducer via a communication system
with a RS232 interface, 9-pin SUB-D connector, baud rate settable by DIP-switches

Fiber-optic connectors with ST connector

7XV5655-0BB00
Ethernet Modem for Substations

Fig. 13/36
Front view of the Ethernet modem

Function overview

- RS232 interface for data transfer and configuration of the modems
- Serial data rate and data format (RS232/RS485) for the terminal devices is selectable from 2.4 kbit/s up to 57.6 kbit/s with data format 8N1, 8E1
- FO interface for serial data transfer
- 10 Mbit Ethernet interface (LAN) to the 10/100 Mbit Ethernet network
- Increased security with password protection and IP address selection is possible
- Exchange of serial data via Ethernet network between two Ethernet modems (e.g. DIGSI protocol, IEC 60870-5-103 protocol)
- Exchange of serial protocols via Ethenet without gaps in the telegram structure

Description

A control PC and protection relays can exchange serial data via an Ethernet network using two Ethernet modems 7XV5655. Connection to the Ethernet modem is in each case made via the asynchronous serial interface of the terminal devices. In the modem the serial data is packed into the secure IP protocol as information data, and is transferred between the modems using the Ethernet connection. Conformity with the standard and gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams (frames) via the network is ensured by the modem which receives the serial telegram communication and packs the serial IEC telegrams into blocks for communication via the Ethernet. Data is transmitted in full duplex mode, the serial handshake is not supported. Connection is set up between the IP address of the dialing modem in the office and the IP address of the answering modem in the substation and is configured prior to dial up with DIGSI by means of AT commands via the RS232 interface.

The substation modem may be configured to have password protection, and provides the additional security feature, permitting access only from defined IP addresses, e.g. only that of the office modem. The modem is accessed with DIGSI Remote like a normal telephone modem with the exception that instead of telephone numbers, IP addresses are assigned by the network administrator for each modem.

Application

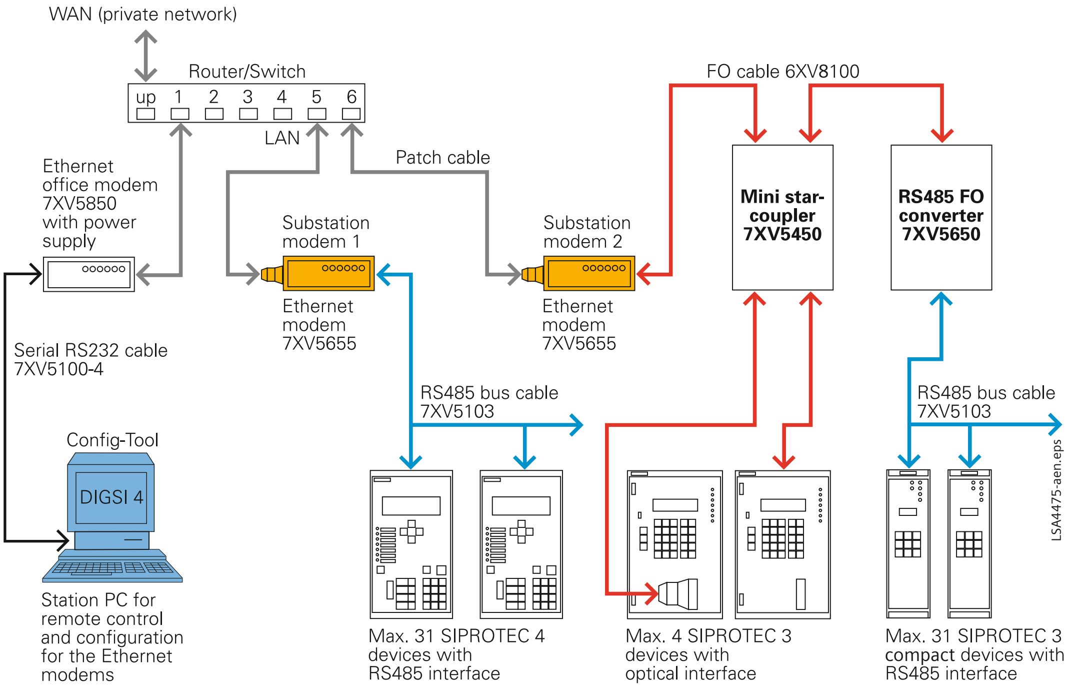


Fig. 13/37
Operation of various SIPROTEC protection unit generations via Ethernet modems

Using the office computer and DIGSI 4, both substations 1 and 2 may be dialed up via the Ethernet modems. An IP point-to-point data connection is established between the office and corresponding substation modem when dialed up via the network. This is maintained until the office modem terminates the connection. The serial data exchange takes place via this data connection whereby the modem converts the data from serial to Ethernet with full duplex mode. Between the office modem and the office PC the highest data rate e.g. 57.6 kbit/s for SIPROTEC 4 devices is always used. The serial data rate of the substation modem is adapted to the data rate required by the protection relays e.g. substation modem 1 with 57.6 kbit/s for SIPROTEC 4 and substation modem 2 with 9.6 kbit/s for SIPROTEC 3 devices. These settings are only pre-set once in the modem.

The Ethernet modems are integrated similarly to telephone modems in DIGSI 4. Instead of the telephone number, the pre-set IP address assigned to the modem is selected. If later an Ethernet connection is available in the substation, the existing modem can be replaced by an Ethernet modem. The entire serial bus structure and cabling may remain unchanged.

Technical data

Connections

RS232 interface 9-pin SUB-D or
RS485 interface 9-pin SUB-D settable by switches
FO interface 820 nm with ST connectors for the connection to 62.5/125 µm multi-mode FO cables.
Ethernet 10BaseT, 10/100 Mbit, RJ45 connector
Power supply / Fail safe relay with screw-type terminals

Housing

Rail mounting, plastic, charcoal grey, 90 x 90 x 107 (W x H x D) in mm

Wide-range power supply / fail safe relay

Auxiliary voltage 24 to 250 V DC and 115/230 V AC connected with screw-type terminals
Fail safe relay for power supervision connected with screw-type terminals

Indication (8 x LED)

Power	Operating voltage o.k.	System	RS232 connection established
RS232 T x D	Transmitting data to RS232	RS232 R x D	Receiving data from RS232
LAN T x	Transmitting data to LAN	LAN R x	Receiving data from LAN
Error	Error on RS232	Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
Ethernet modem	*7XV5655 - 0BB00*

Ethernet modem for serial, asynchronous transmission of data up to
57.6 kbit/s via the 10/100 Mbit Ethernet and configuration software
DIN-rail device mounting device suitable for substation.
Connection to Ethernet via RJ45 connector. Serial connection SUB-D 9-pin socket
RS232/RS485 interface settable by switches.
FO interface 820 nm for 62.5/125 µm multi-mode - FO cables.
Auxiliary supply 24 - 250 V DC and 115/230 V AC.
Fail safe contact for device supervision.
With gender-changer (pin-pin) for adaptation to
DIGSI - cable 7XV5100-4 (cable not included in the scope of supply).

7XV5655-0BA00
Ethernet Serial Hub for Substations

LSP2807.tif

Fig. 13/38
Front view of Ethernet serial hub for substation

Description

By means of the serial hub and the associated configuration software it is possible to establish serial communication via an Ethernet network between a PC or notebook running DIGSI 4 and SIPROTEC protection relays. The configuration software installs virtual serial interfaces (Com ports) on the PC. Each COM port is allocated to a serial hub within the network by means of its IP address. This must be set in the serial hub. The PC is connected to the network via Ethernet interface. The protection relays are connected via an RS232/RS485 or FO interface to the serial hub. Connection with DIGSI is achieved via the virtual COM port on the PC and the IP address of the serial hub in the substation. The serial data is packed as user data into a secure IP protocol in the PC and transferred via the Ethernet connection to the serial hub. The requirements regarding standard compliant gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams (frames) via the network is complied with by the communication driver on the PC and the serial hub which monitor the serial telegram communication. The serial IEC telegrams are transferred in blocks across the Ethernet. Data communication is full duplex. Control signals of the serial interfaces are not used.

Function overview

- Configuration software for Windows NT/2000/XP to configure virtual COM ports on the PC and for configuration of the serial hub.
- RS232/RS485 - interfaces for data transfer and configuration of the serial hub
- FO interface for serial data transfer
- Serial data rate and data format (RS232) for the terminal devices is selectable from 2.4 kbit/s up to 57.6 kbit/s with data format 8N1, 8E1.
- 10 Mbit Ethernet interface (LAN) to the 10/100 Mbit Ethernet network.
- Better security with password protection for the access to the protection relays via the serial hup
- Exchange of serial data via Ethernet network (e.g. DIGSI protocol, IEC 60870-5-103 protocol)
- Exchange of serial protocols via Ethernet without gaps in the telegram structure

Application

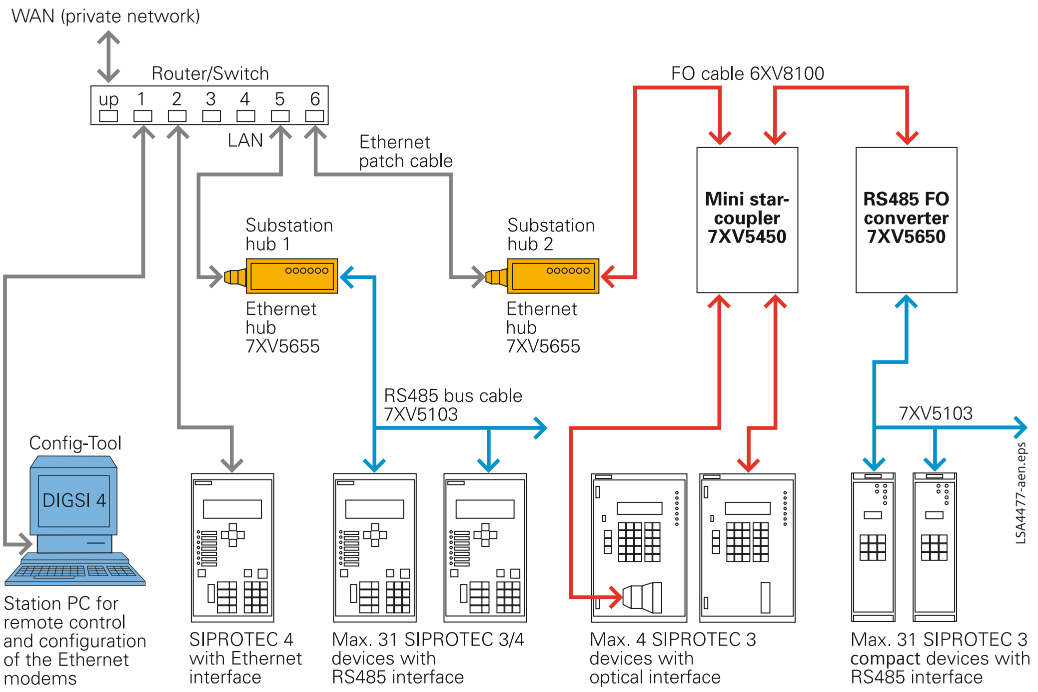


Fig. 13/39
Operation of various SIPROTEC protection unit generations via serial hub

From the office PC running DIGSI 4 it is possible to select one of the serial hubs 1 and 2 via one of the virtual COM ports. In DIGSI 4, when the COM port is selected, a IP point-to-point data connection via the network is established and maintained between the office and the relevant substation modem until the interface is released. The serial data exchange takes place via this data link, whereby the data conversion from serial to Ethernet is full duplex. The office PC towards the network is always operating with high data rate, as the data is fed to the network via the network driver on the PC. The serial data rate of the serial hub in the substation is adapted to the baud rate set in the protection relay, e.g. serial hub 1 with 57.6 kbit/s for SIPROTEC 4 and serial hub 2 with 9.6 kbit/s for SIPROTEC 3 devices. These parameters must be pre-set on the serial hub. With DIGSI 4 the serial hubs are integrated by means of further serial COM ports (max. 254). The connection to the IP address of the serial hub in the network is achieved by opening the corresponding COM port. If an Ethernet network to the substation or in the substation is available, serial data can then be transferred via this network.

The existing serial star or bus structure with cabling in the substation can still be used.

SIPROTEC 4 devices from version 4.6 and newer with integrated Ethernet interface may be connected directly to the router or switch by means of a patch cable.

Technical data

Connections

RS232 interface 9-pin SUB-D socket or
RS485 interface 9-pin SUB-D socket selectable via DIL switch.
FO interface 820 nm with ST connectors for connection to multi-mode FO cables.
Ethernet 10BaseT, 10/100 Mbit, RJ45 connector to Ethernet
Auxiliary voltage/alarm relay (5 terminals)

Housing

Rail mounting, plastic, charcoal grey, 90 x 90 x 107 (W x H x D) in mm

Wide-range power supply

Auxiliary voltage 24 to 250 V DC and 115/230 V AC connected with screw-type terminals
Alarm relay for monitoring of the device

Indication (8 x LED)

Power	Operating voltage o.k.	System	RS232 connection established
RS232 T x D	Transmitting data to RS232	RS232 R x D	Receiving data from RS232
LAN T x	Transmitting data to LAN	LAN R x	Receiving data from LAN
Error	Error on RS232	Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
Ethernet hub for substations	*7XV5655 - 0BA00*

Serial hub for serial, asynchronous transfer of data up to 57.6 kbit/s via 10/100 Mbit Ethernet including configuration software.
Connection to the Ethernet via RJ45 connector. Serial connection with RS232/RS485 interface via SUB-D 9-pin socket or optical with 820 nm ST connector and multi-mode FO cable.
Wide-range auxiliary supply for 24 - 250 V DC and 115/230 V AC.
With gender-changer (pin-pin) for adaptation to DIGSI cable 7XV5100-4 (cable not included in the scope of supply).

7XV5662-0AA00 / 7XV5662-0AA01 Communication Converter for X.21/RS422 and G.703.1

Fig. 13/40
Communication converter for X.21/RS422 and G.703.1

Description

The communication converter for coupling to a communication network is a peripheral device linked to the protection device via fiber-optic cables, which enables serial data exchange between two protection relays. A digital communication network is used. The electrical interfaces in the CC-XG for the access to the communication device are selectable as X.21 (64 kbit/s, 128 kbit/s, 256 kbit/s or 512 kbit/s) or G.703.1 (64 kbit/s). At the opposite side, the data are converted by second communication converter so that they can be read by the second device. The communication converters thus allow two protection devices to communicate synchronously and to exchange large data volumes over large distances. Typical applications are the serial protection interfaces of differential protection and distance protection of the devices 7SD5, 7SD6, 7SA52 and 7SA6, where 7XV5662-0AA00 must be used.

Should asynchronous serial data of differential protection 7SD51 or of the binary signal transducer 7XV5653 be transmitted, the device 7XV5662-0AA01 must be used (asynchronous from 300 bit/s to 115.2 kbit/s dependent on the baudrate set for X.21 or G.703.1 interface). Interference-free connection to the protection device is achieved by means of a multi-mode fiber-optic cable, with ST connectors at the CC-XG. The maximum optical transmission distance is 1.5 km (0.93 mile).

The data transfer between the protection devices is realized as a point-to-point connection that is bit-transparent. Data must be exchanged via dedicated communication channels, not via switching points.

Function overview

- Optical interface with ST connector for connection to the protection unit
- Distance: 1.5 km with 62.5/125 µm multi-mode FO cable between CC-XG and the protection unit / serial device
- Electrical interface to the communication device via SUB-D connector (X.21, 15 pins, settable to 64, 128, 256 or 512 kbit/s) or with 5-pin screw-type terminals (G.703.1, 64 kbit/s).
- Synchronous data exchange for 7SD52, 7SD6, 7SA6 and 7SA52 protection relays (communications converter version – 0AA00)
- Asynchronous data exchange for 7SD51 protection relay, 7XV5653 or other devices with asynchronous interface (communication converter version – 0AA01)
- Max. cable length between communication device and communication converter: 100 m for X.21 /RS422
- Max. cable length between communication device and communication converter: 300 m for G.703.1
- Monitoring of:
  - auxiliary supply voltage,
  - clock signal of communication network
  - and internal logic
- Loop test function selectable by jumpers in the CC-XG
- Wide-range power supply unit (PSU) for 24 to 250 V DC and 115 to 250 V AC

Application

The CC-XG can be used for two applications.
One application is the synchronous serial data exchange (converter version – 0AA00) between SIPROTEC 4 differential relays (7SD52, 7SD6) and/or the serial teleprotection between distance relays (7SA6 and 7SA52). The relays have to be equipped with an optical 820 nm plug-in module “FO5”.

Another application is the transmission of asynchronous serial data to the line differential protection relay 7SD51 or the binary signal transmitter 7XV5653.

Functions

The protection unit is optically linked to the CC-XG, which makes interference-free data transfer between the CC-XG and the protection unit possible. The communication converter is located close to the communication device. It adapts the FO active interface of the protection relay to the electrical specifications of the communication network interface. The interface types – optionally X.21/RS422 or G.703.1 – and the required transmission rate can be set by means of jumpers.

Data transfer between the protection units is effected on the basis of a point-to-point connection, furthermore it is a synchronous, bit-transparent transmission via the communication network.

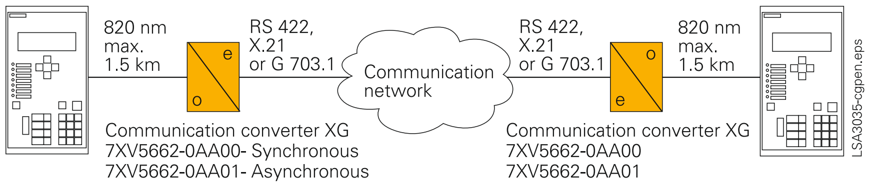


Fig. 13/41 Connection of two protection devices via a communication network linked with 7XV5662-0AA0x

Technical data

Rated auxiliary voltage	
24 to 250 V DC	± 20 %
115/230 V AC	± 20 % without switchover
Power consumption	Approx. 3.5 W
LEDs	
4 LEDs	
LED 1	Red: Error
LED 2	Yellow: Receiving from X.21/RS422/G.703 interface
LED 3	Yellow: Transmitting to X.21/RS422/G.703 interface
LED 5	Green: Operating voltage o.k.
Connectors	
Power supply	2-pole screw-type terminal
Alarm/ready contact	3-pole make/break contact
Serial G.703.1 interface	5-pole receive and transmit line
SUB-D connector	15-pin SUB-D connector for electrical X.21/RS422 interface
FO cable	820 nm, 2 ST connectors for TxD and RxD for 62.5/125 µm multi-mode FO (max. distance to protection unit 1.5 km)
Housing	
Aluminium die-cast housing	Dimensions 188 x 56 x 120 mm (WxHxD)
Weight	Approx. 0.8 kg
Degree of protection	According to EN 60529: IP41
For snap-on mounting onto 35 mm	EN 50022 rail

Technical data

Operating mode		
Synchronous operation with	7XV5662-0AA00 for 7SD52, 7SD6, 7SA52 and 7SA6	
	G.703.1: Interface selectable by jumper X30 in position 2 - 3	
	Setting in the protection unit	Setting in CC-XG by jumper
	64 kbit/s per parameter	64 kbit/s by jumper X20 = 1
	X.21/RS422: Interface selectable by jumper X30 in position 1 - 2	
	Setting in the protection unit	Setting in CC-XG by jumper:
	64 kbit/s per parameter	64 kbit/s by jumper X20 = 1
	128 kbit/s per parameter	128 kbit/s by jumper X22 = 1
	256 kbit/s per parameter	256 kbit/s by jumper X24 = 1
	512 kbit/s per parameter	256 kbit/s by jumper X26 = 1
Asynchronous operation with	7XV5662-0AA01 for 7SD51, 7XV5653 and units with asynchronous serial interface (no handshake supported, only serial TxD and RxD signals are supported)	
	G.703.1: Interface selectable by jumper X30 in position 2 - 3	
	Setting in protection unit	Setting in CC-XG by jumper
	max. 19.2 kbit/s	64 kbit/s by jumper X20 = 1
	X.21/RS422: Interface settable by jumper X30 in position 1 - 2	
	Setting in protection unit	Setting in CC-XG by jumper
	max. 19.2 kbit/s async.	64 kbit/s by jumper X20 = 1
	max. 38.4 kbit/s async.	128 kbit/s by jumper X22 = 1
	max. 57.6 kbit/s async.	256 kbit/s by jumper X24 = 1
	max. 115.2 kbit/s async.	512 kbit/s by jumper X26 = 1

Selection and ordering data

Description	Order No.
Communication converter for X.21/RS422/G.703.1 interface	*7XV5662 - 0AA0☐*
Converter to synchronous or asynchronous serial coupling of protection units with optical inputs/outputs with ST connector to communication devices with electrical X.21/RS422 or G.703.1 interface. Connection to protection unit via FO cable for 62.5/125 µm and 820 nm wavelength, max. distance 1.5 km, ST connectors Electrical with X.21/RS422 (15-pin SUB-D connector) or G.703.1 (screw-type terminal) Baud rate and interface type selectable by jumpers	
For synchronous operation with 7SD52, 7SD6, 7SA6, 7SA52	*0*
For asynchronous operation with 7SD51, 7XV5653 or serial devices	*1*

7XV5662-0AC00/7XV5662-0AC01 Communication Converter for Pilot Wires

Fig. 13/42
Communication converter for pilot wires

Description

The communication converter copper (CC-CO) is a peripheral device linked to the protection device which enables serial data exchange between two protection relays. It uses a single pair of copper wires (pilot wire) that may be part of a telecommunications cable or of any other suitable symmetrical communications cable (no Pupin cable). At the opposite side, the data are converted by a second communication converter so that they can be read by the second protection device. The communication converters (master/slave) thus allow two protection devices to communicate synchronously and to exchange large data volumes over considerable distances. Typical applications are the protection interfaces of differential protection and distance protection of the devices 7SD5, 7SD6, 7SA52 and 7SA6, where 7XV5662-0AC00 must be used (synchronous connection with 128 kbit/s). Should asynchronous serial data of differential protection 7SD5 or of the binary signal transducer 7XV5653 be transmitted, the device 7XV5662-0AC01 must be used (asynchronous from 300 bit/s to 38.2 kbit/s).

Interference-free connection to the protection device is achieved by means of a multi-mode fiber-optic cable, with ST connectors at the CC-CO. The maximum optical transmission distance is 1.5 km (0.93 mile). The data transfer between the protection devices is realized as a point-to-point connection that is bit-transparent. Data must be exchanged via dedicated pilot wires, not via switching points.

Function overview

- Optical interface with ST connector for connection to the protection unit
- Distance: 1.5 km with 62.5/125 µm multi-mode FO cable between CC-CO and the protection unit
- Electrical interface to the pilot wire (line) with 2 screw-type terminals. 5 kV isolated
- Synchronous data exchange for 7SD52, 7SD6, 7SA6 and 7SA52 via pilot wire (typ. 15 km) (CC-CO version -0AA00)
- Asynchronous data exchange for 7SD51, 7XV5653 or other units with asynchronous interface (CC-CO version -0AA01) (typ. 15 km)
- Loop test function selectable by jumpers in CC-CO
- Master or slave mode of the CC-CO selectable by jumper (one master and one slave device required at the end of the pilot wire, factory presetting: master mode)
- Wide-range power supply with self-supervision function and alarm contact

Application

The CC - CO can be used for two applications.
One application is the synchronous serial data exchange (converter version – 0AA00) between SIPROTEC 4 differential relays (7SD52, 7SD6) and/or the serial teleprotection between distance relays (7SA6 and 7SA52). The relays have to be equipped with an optical 820 nm plug-in module “FO5”.

Another application is the transmission of asynchronous serial data via pilot wires to the line differential protection relay 7SD51 or the binary signal transmitter 7XV5653. Other serial devices may also be used.

If the maximum distance between the protection units is longer than spanned by two CC-CO, the converters can be cascaded (see Fig. 13/44). A power supply between the two master units is required. If the isolation level is higher than 5 kV (provided by the pilot wire inputs of the units), external isolation transformers (barrier transformers) can be used on both sides. These transformers offer 20 kV isolation voltage and thus help to avoid hazardous high voltages at the inputs of the CC-CO, which might be induced by a short-circuit from a parallel power line or cable.

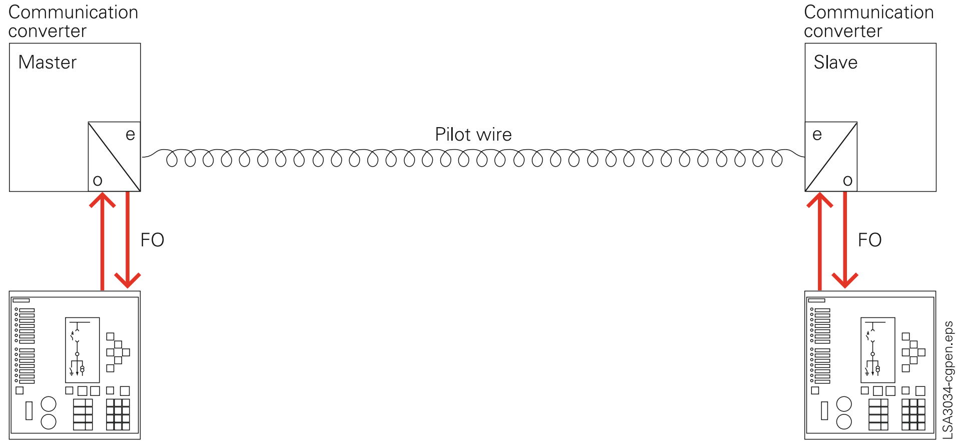


Fig. 13/43

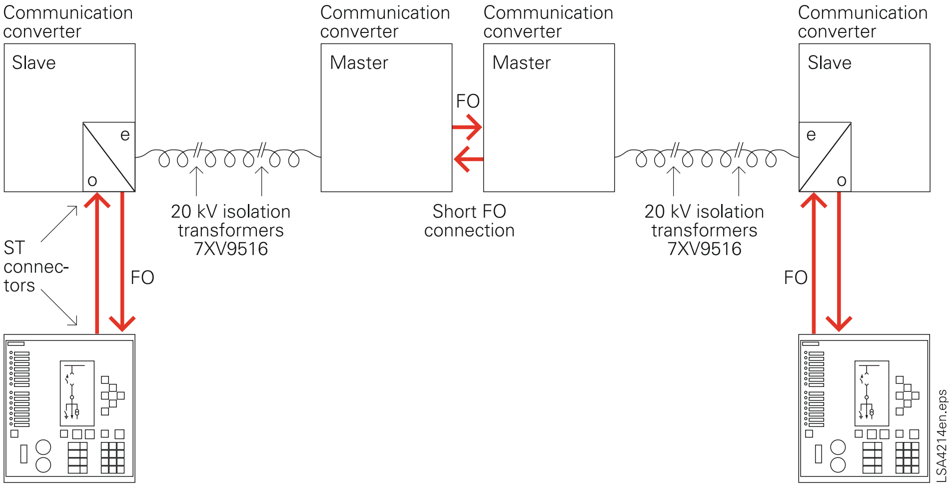


Fig. 13/44

Functions

The protection unit is optically linked to the CC-CO, which makes interference-free data transfer between the CC-CO and the protection unit possible. The communication converter is located close to the pilot wire. It converts serial data of the protection unit into a frequency-modulated signal. This signal is transmitted via one pair of copper wires of a pilot wire/communication line (bi-directional, full duplex operation).

By means of jumpers, one unit is defined as “master” and the other unit as “slave”. In a “training” during commissioning, the electrical characteristics of the pilot wire are measured by pressing a pushbutton, and the CC-COs are tuned to these characteristics.

The measured characteristics are used as parameters that will be adhered to for optimal data transfer. Digital data transfer makes a low insulation level of the pilot wire possible, because no high voltages are produced on the pilot wire during short-circuit conditions.

Data transfer between the protection units is effected on the basis of a point-to-point connection, furthermore it is a synchronous, bit-transparent transmission. Due to the telegram-backed data exchange, mal-operation is ruled out.

Technical data

Rated auxiliary voltage	
24 to 250 V DC	± 20 %
115/230 V AC	± 20 % without switchover
LEDs	
4 LEDs	
LED 1	Red: Line activation
LED 2	Yellow: Line transparent
LED 3	Yellow: Data transfer
LED 5	Green: Power ON
Connectors	
Power supply	2-pole screw-type terminal
Alarm/ready contact	3-pole make/break contact
Pilot wire	2-pole for pilot-wire connection 5-kV isolated inputs
FO cable	820 nm, 2 ST connectors for TxD and RxD for 62.5/125 µm multi-mode FO (max. distance to protection unit 1.5 km)
Pushbutton	
Measuring and training of parameters of the pilot wire	
Housing	
Aluminum die-cast housing	Dimensions 188 x 56 x 120 mm (WxHxD)
Weight	Approx. 0.8 kg
Degree of protection	According to EN 60529: IP41
For snap-on mounting onto 35 mm	EN 50022 rail
Operating mode	
Synchronous operation with	7XV5662-0AC00 for 7SD52, 7SD6, 75A52 and 7SA6 Setting in the protection unit: 128 kbit/s per parameter Setting in CC - CO: 128 kbit/s. No setting required
Asynchronous operation with	7XV5662-0AC01 for 7SD51, 7XV5653 and units with asynchronous serial interface (no handshake supported, only serial TxD and RxD signals are supported) Max. baud rate for protection unit: 38.4 kbit/s Max. baud rate for CC - CO 128 kbit/s. No setting required
Max. distance with pilot wire	AWG 22 / 0.33 mm^2 / 51.7 Ω/km: max. 11 km AWG 26 / 0.13 mm^2 / 137 Ω/km: max. 4.5 km Shielded twisted pair (STP) recommended. Max. loop resistance: 1400 Ω Attenuation < 40 dB at 80 kHz

Selection and ordering data

Description	Order No.
Communication converter for pilot wires	*7XV5662 - 0AC0☐*
Converter for synchronous or asynchronous serial coupling of protection units with optical inputs/outputs with ST connector to conventional pilot wires. 5-kV isolation of unit analog inputs towards the pilot wires. Connection to protection unit via FO cable for 62.5/125 µm and 820 nm wavelength, max. distance 1.5 km, ST connectors Synchronous serial data 128 kbit/s Asynchronous serial data rate max. 57.2 kbit/s	
For synchronous operation with 7SD52, 7SD6, 7SA6, 7SA52	*0*
For asynchronous operation with 7SD51, 7XV5653 for other units	*1*

7XV5662-0AD00
Two-Channel Serial Communication Converter G.703.6

Fig. 13/45
Communication converter

Function overview

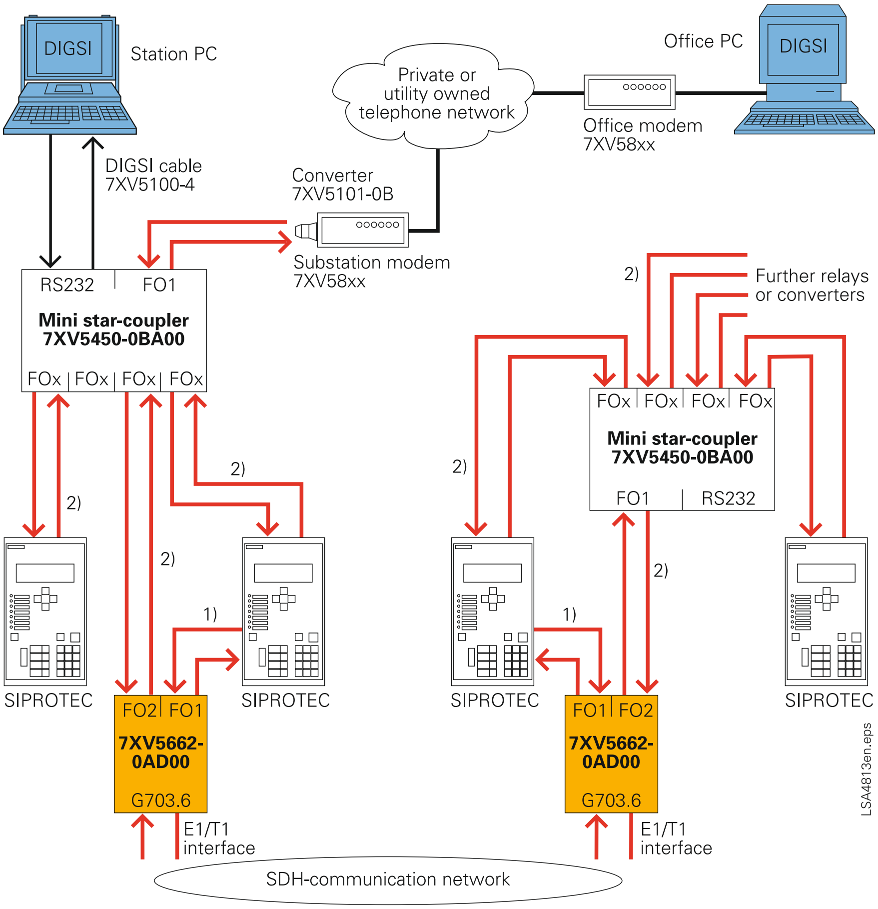
- Interference-free protection data transfer of two independent serial data signals, selectable either in synchronous or asynchronous mode.
- PC interface for operation of devices at the remote line end.
- Network interface as E1 or T1 format for connection to multiplexer.
- Wide range power supply from 24 V to 250 V DC and 115/230 V AC with failsafe relay.
- Indication of the data exchange via LED
- Integrated commissioning aid (loop test)

Description

The CC-2M communication converter is used for serial data transmission over long distances via a communication network. It converts synchronous or asynchronous serial 820 nm optical input signals at inputs FO1 and FO2 to a network interface and again returns these signals at the remote terminal via the latter's interfaces. FO1 and FO2 may be configured independently for either synchronous or asynchronous operation, but must be set to the same operating mode at both ends. In synchronous mode, the interface should only be used for exchanging the protection data of the 7SD5/7SD6 differential protection or 7SA52/7SA6 distance protection and is preconfigured for 512 kbit/s. In asynchronous mode, the interface can be used for connection of devices with baud rates between 1.2 to 115.2 kbit/s. A further asynchronous electrical RS232 interface is provided for max. 115.2 kbit/s. It provides for the connection of a serial PC interface with DIGSI and thereby the operations interface to SIPROTEC devices at the remote end. The G.703.6 network interface is provided in the form of 4-way screw terminals and can be configured as a 2-Mbit/s interface with European E1 format or as a 1.544-Mbit/s interface in the American T1 format. All settings of the device are made with jumpers, so that no special PC software is required.

Application

Two protection devices e.g. 7SD52/ 7SD610 differential protection or 7SA52/7SA6 distance protection, exchange protection data via FO1. Interference-free data exchange is performed via the communication network, the devices being connected synchronously with 512 kbit/s (connection 1; see Fig. 13/46). Protection remote control with DIGSI is connected to FO2 of the converter via a 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC on which DIGSI is installed. In this way, the remote protection devices can be remotely interrogated via FO2 (connection 2). The baud rate is optimally set to 57.6 kbit/s for SIPROTEC 4 devices, so that there is no difference from local operation. The data of the devices on the other substation can be changed and read out during commissioning and operation. Alternatively, it is possible to connect a substation control system or additional protection data transmission to FO2. This makes for optimum use of the 1.544/2 Mbit/s transmission channel for two separate serial connections. In addition, an asynchronous serial connection is available via the RS232 interface, which can be used to temporarily operate devices of the other substation with DIGSI.



1) Protection data transmission with 512 kBit/s (synchronous)
2) Remote control with DIGSI (asynchronous)

Fig. 13/46
Protection data transmission and remote control of a substation via a communication network

Technical data

Connections	
FO 1 / 2	ST plug/ 820 nm for 50/125 µm or 62.5/125 µm multi-mode FO cable (max. 1.5 km)
RS232	For asynchronous connection from 1.2 – 115.21 kbit/s
Power supply	2-pole screw-type terminal
Fail safe relay	3-pole screw-type terminal with NC/NO contact
Network E1/T1	4-pole screw-type terminal
Housing	
Aluminium housing 188 x 56 x 120 mm for mounting on 35 mm rail mounting according to EN 50032 weight 0.8 kg. Protection class according to EN 60529: IP41	
Power supply	
Wide range 24 to 250 V DC and 115/230 V AC, 50/60 Hz	
Displays	
4 LEDs	
Green	Power supply
Red	Fault alarm
2 yellow	Data transfer

Selection and ordering data

Description	Order No.
Two-channel serial 1.544/2 Mbit/s communication converter	*7XV5662 - 0A☐00*
Conversion of 2 independent serial FO interfaces with synchronous or asynchronous data to a E1 network interface with 2 Mbit/s (G.703.6) or T1 network interface (1.544 Mbit/s). Two independent serial optical input channels with ST connectors and 820 nm for multi-mode FO cable for a max. of 512 kbit/s/115.2 kbit/s for synchronous/asynchronous data. An electrical serial RS232 interface with a max. 115.2 kbit/s constructed as a 9-pin SUB-D socket for connection with DIGSI 7XV5104 cable. Connection from multiplexer to the E1/T1 network interface via a 4-pole screw-type terminal. Wide-range power supply of 24 V to 250 V DC and 115/230 V AC. A make/break fail safe contact for power supply faults or interruption of the data connection. All settings are made with jumpers in the device (presetting for E1 and synchronous serial data input).	*D*

7XV5662-6AD10
Resistance Temperature Detector (RTD-Box) TR1200

SIPV6-108.tif

Fig. 13/47a
7XV5662-6AD10 RTD-box TR1200

Description

The RTD-box TR1200 can capture up to 12 temperatures with 12 measuring inputs. 2- and 3-conductor Pt 100 sensors are supported. For the 2-conductor mode, the measured conductor resistance can be compensated for with a corresponding setting. The measurement of temperatures may be simulated for commissioning purposes.

The output of measured values to the protection device is compatible with TR600 and implemented with bus cable 7XV5103-7AAxx via a RS485 bus.

All settings are done via 3 push buttons on the front of the device. Entry can be blocked via a code.

The TR1200 has a wide-range power supply from 24 – 250 V DC and 115 / 230 V AC as well as an alarm relay. Sensor failure or sensor short-circuit are alarmed and transmitted via protocol to the SIPROTEC device.

Function overview

- 3-digit temperature display
- 12 inputs for temperature sensors, 1 to 12 sensors can be connected
- Pt 100 thermostats with 2- or 3-conductor technology
- 1 error relay (potential-free change-over contact)
- RS485 interface (ZIEHL standard protocol and MODBUS RTU protocol)
- LED signal the measuring channel, error state, relay funtion and RS485 activity
- Code lock prevents parameter manipulation
- TR600 compatible (to replace one TR600 with 6 sensors connected)
- Universal power-supply 24 to 240 V AC/DC
- Snap-on mounting onto 35 mm standard rail EN 60715

Application

Communication via RS485 bus

The RTD-box TR1200 is connected via a RS485 interface to one SIPROTEC 4 bay device with thermo function (e. g. 7SJ6, 7UT6, 7UM6) or to the compact protection 7SK80 via a serial RS485-interface (Port B).

The special cable 7XV5103-7AAxx is used for the connection. In the event of remote measuring locations, the connections may also be done using multi-mode fiber-optic conductors and the converter 7XV5650 (see Fig. 13/47b).

For detailed information please visit www.siemens.com/siprotec

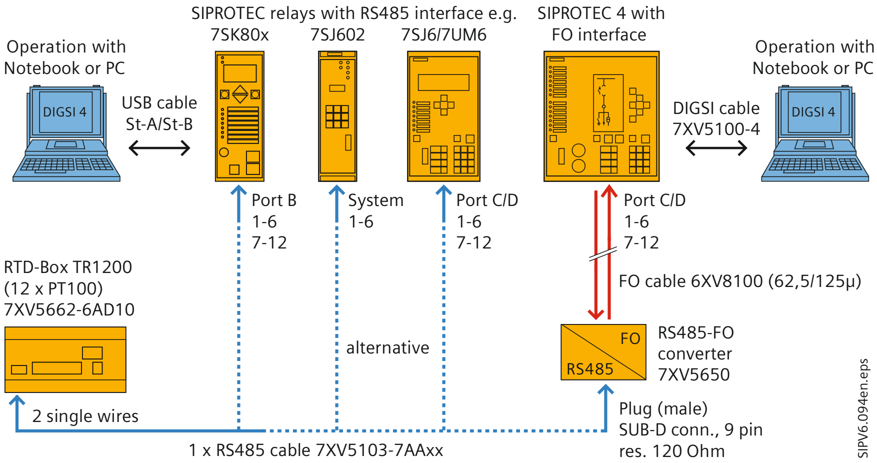


Fig. 13/47b
Connection of devices via a serial RS485 bus or FO cable

Technical data

Rated auxiliary voltage		
Auxiliary voltage V_S	24 – 240 V AC/DC, 0/45 – 65 Hz < 5 VA	
Tolerance	20.4 – 297 V DC, 20 – 264 V AC	
Relay output		
Number	1 changeover contact (CO)	
Switching voltage	Max. 415 V AC	
Switching current	Max. 5 A	
Switching power	Max. 2000 VA (ohmic load) Max. 120 W at 24 V DC	
De-rating factor with cos $\varphi = 0.7$	0.5	
U_L electrical ratings:	250 V AC, 3 A general use D300 1 A 240 V AC	
Rated operating current I_E AC 15	$I_E = 2$ A	$V_E = 250$ V
DC 13	$I_E = 2$ A	$V_E = 24$ V
	$I_E = 0.2$ A	$V_E = 125$ V
	$I_E = 0.1$ A	$V_E = 250$ V
Recommended fuse	T 3.5 A (gL)	
Contact service life, mech.	1 x 10^7 switching operations	
Contact service life, electr.	1 x 10^5 switching operations at 250 V AC / 5 A	
Sensor connection		
Number	12 x Pt 100 according to EN 60751	
Measuring cycle/measuring time	0.25 to 3 s (depending on the number of sensors)	
Measuring cycle/circuit resistance	0.25 to 30 s (per measuring cycle of sensor)	
Measuring range	-199 to 850 °C	
Resolution	1 °C	
Accuracy	± 0.5 % of measured value ± 1 K	
Sensor current	≤ 0.8 mA	
Temperature drift	< 0.04 °C / K	
Short circuit	< 15 Ohm	
Interruption	> 400	
Sensor resistance + circuit resistance	Max. 500 Ohm	
RS485 interface		
Device address	0 to 96	
Baud rate	4800, 9600, 19200 bit/s	
Parity	N, O, E (no, odd, even)	
Max. cable length	1000 m at 19200 bit/s	
Serial protocol	Serial RTD – Protocol Ziehl / SIPROTEC See manual for detailed protocol description	

Technical data

Test conditions	
Acc. to	EN 61010
Rated impulse voltage insulation	4000 V
Overvoltage category	III
Pollution rate	2
Rated insulation level V_i	300 V
Duty cycle	100 %
Perm. ambient temperature	- 20 °C to + 65 °C EN 60068-2-2 dry heat
Electrical isolation	Power supply – measuring inputs 3820 V DC
No electrical isolation	RS 485 interface – measuring inputs
EMC-tests	EN 61326-1
EMC test for noise emission	EN 61000-4-3
Fast transient disturbances/Burst	EN 61000-4-4 ± 4 kV Pulse 5/50 ns, $f = 5$ kHz, $t = 15$ ms, T = 300 ms
High-energy surge voltages (SURGE)	IEC 61000-4-5 ± 1 impulse: 1.2 / 50 µs (8/20 µs)
Electrostatic discharge	IEC 61000-4-2 ± 4 contact discharge, ± 8 kV air discharge
Housing	
Housing type	V8, distribution panel mounting
Size (W x H x D)	140 x 90 x 58 mm
Depth/Width	55 mm/8 TE
Circuit termination single strand	Per 1 x 1.5 mm^2
Braided conductor with crimp lug	Per 1 x 1.0 mm^2
Tightening torque of terminal screw	0.5 Nm (3.6 lb.in)
Protection class of housing/terminals	IP30 / IP20
Mounting vertical/horizontal	Optional
Affixing	Snap-on mounting onto standard rail mounting 35 mm acc. to EN 60715 or screw mounting (with 2 additional brackets)
Weight	Approx. 370 g

Selection and ordering data

Description	Order No.
Resistance temperature detector (RTD-box) TR1200	*7XV5662 - 6AD10*

Distributed input-box for 12 RTD-connections Pt100

Rail mounting plastic

Protection class IP21

1 serial interface RS485 for communication with SIPROTEC devices for measurements and fault reports.

Wide-range power supply 24 to 240 V AC/DC

Note: The device can be operated in a 7XV5662-2AD10 or 7XV5662-5AD10 compatible mode.

7XV5662-7AD10
Universal Relay/RTD-/20 mA-Box TR800 Web

Fig. 13/48a
7XV5662-7AD10 Universal relay / RTD-box TR800

Description

The universal relay TR800 Web has 8 measuring/sensor inputs and is able to capture 8 temperatures via PT100- (Ni100 and Ni120) elements. The measuring values 1 - 6 may be transmitted to SIPROTEC 4 devices with thermo function via protocol. Two universal relays with a total of 12 measuring inputs can be connected.

Connection is established via a serial RS485 interface (see Fig. 13/48d). The TR800 is protocol compatible with the TR600 (7XV5662-3AD10, 7XV5662-5AD10) on the serial RS485 interface, and transmits the 6 temperatures in the same format. In this mode, the TR800 can replace the TR600.

In the case of 7SK80 motor protection, the connection may alternatively be made via the Ethernet interface, if the system interface is (pre-)assigned (see Fig. 13/48b + 13/48c). The universal relay is operated and configured via the Ethernet interface with a Web browser. Three conductor thermo elements are supported. For the dual conductor connection the measured line resistance can be compensated for by a software setting. Furthermore, temperatures can be simulated to test the thermo-function in the SIPROTEC devices.

Alternatively to thermo sensors, 8 analog values 0/4 – 20 mA DC and 0 – 10 V DC may be measured. The output can be scaled and the designation (°C, V, A, %) can be adapted in the TR800. The transmission to the SIPROTEC – device however takes place via the RTD – protocol in temperature format. 6 of the 8 analog sensor values are available there. With 2 TR800 12 values are available. For example 5.5 mA is transferred with a temperature value of 55 in this way and may either be displayed as temperature in the SIPROTEC device or compared with a set limit via a threshold value. This allows for the processing of analog dimensions in SIPROTEC devices with thermo function or their transmission to a substation control unit (e.g. SICAM PAS). In the bay control unit 6MD66 V4.8 (available since 05/2009) all 8 measuring inputs are available.

The TR800 has a wide-range power supply from 24 V – 250 V DC and 115/230 V AC as well as an alarm relay. Sensor failure or sensor short-circuit are alarmed and transmitted via protocol to the SIPROTEC device.

Function overview

- 8 measuring inputs:
  - Pt 100, Pt 1000 in 2- or 3-conductor technology
  - KTY 83 or KTY 84
  - Thermocouples type B, E, J, K, L, N, R, S, T
  - 0 to 10 V DC, 0/4 to 20 mA DC
  - Resistance 500 Ohm, resistance 30 kOhm
- 4 relay-outputs (each potential-free changeover contact)
- Ethernet interface (http, https, UDP, MODBUS, Bonjour, UpNP, SNMP)
- RS485 interface (Standard Ziehl- and MODBUS RTU protocol)
- Universal power-supply 24 to 240 V AC/DC
- Integrated Web server for configuration, read-out of measured data, user-management email-alarms, data- and alarm-logging
- Time-dependent control (day/night)
- Real-time clock with synchronization with time server.

Application

Communication with one TR800 Web via Ethernet interface

If one universal relay TR800 is sufficient for the measured-value capturing, it may be connected directly to the protection device with a CAT5 patch cable (e.g. 7SK80x/ Port A). The setting of the TR800 Web is done prior to connection with the same cable via a PC using a Web browser. A TR800 can also be interrogated by two or more SIPROTEC devices. IP-address and the UDP-Port of the TR800 may be set in the SIPROTEC device. In this way, one SIPROTEC device may use temperatures 1 – 3 and another device can use the temperatures 3 – 6 for processing. Each device, however, reads in all 6 temperature values (Fig. 13/48b).

Communication with two TR800 Web via Ethernet interface

If two TR800 are applied on big motors for the purpose of measured-value capturing, a substation hardened switch (e.g. RUGGEDCOM RS900 or Hirschmann RSR20) must be used. The switch, the two TR800 Web relays, the protection device and the operating PC constitute an autonomous subnet when they are connected via patch cables (1:1). They may also be part of a larger Ethernet network.

DIGSI 4 and Web browser can run in parallel on the operating PC. Accordingly, one of the two TR800 Web and the protection device can be applied and read out during normal operation. (Fig. 13/48c).

Communication via RS485 bus

One or two TR800 may be connected via a RS485 interface to a SIPROTEC 4 device with thermo function (7SJ6, 7UT6, 7UM6), or the compact device 7SK80.

For connection purposes the special cables 7XV5103-7AAxx are used. In the case of remote measuring points a connection can also be established via a multi-mode FO cable and the converter 7XV5650.

For different applications, 3 modes of operation are available. All three modes are compatible with thermo box TR600 with 6 measuring inputs. The mode of operation is set via the RS485 address of the TR800 Web.

For detailed information please visit www.siemens.com/siprotec

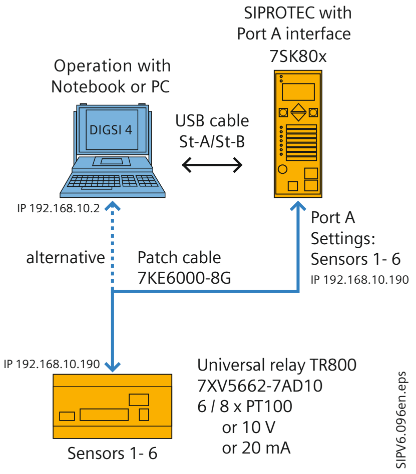


Fig. 13/48b
Connection of one device via Ethernet

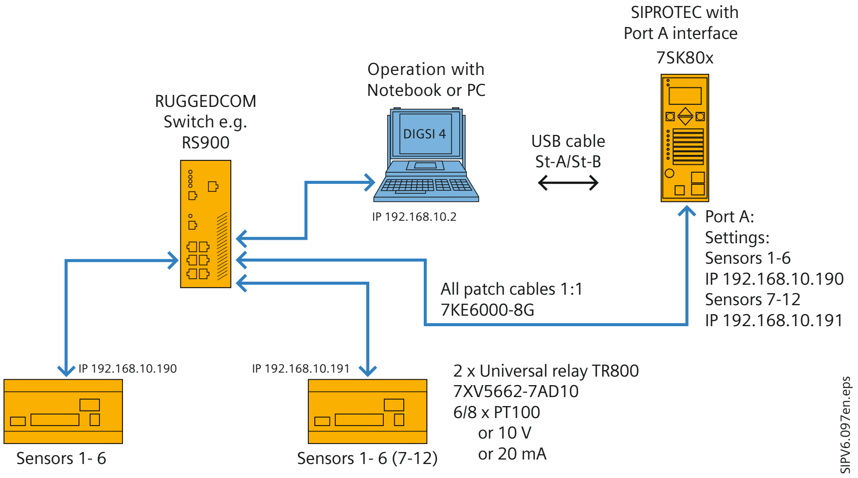


Fig. 13/48c
Connection of two devices via Ethernet

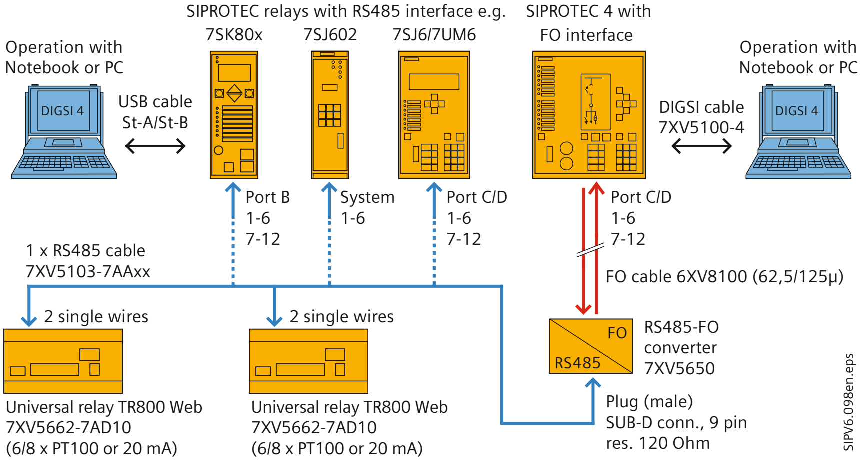


Fig. 13/48d
Connection via serial RS485 bus or FO cable

Technical data

Rated auxiliary voltage

Auxiliary voltage V_S:	24 to 240 V AC/DC, 0/45 to 120 Hz < 4 W < 8 VA
Tolerance	20.4 to 297 V DC, 20 to 264 V AC
Insulation	2000 V AC

Relay output

Number	4 x 1 changeover contact (CO)
Switching voltage	Max. 415 V AC
Switching current	Max. 5 A
Switching power	Max. 2000 VA (ohmic load) Max. 120 W at 24 V DC
De-rating factor with cos $\varphi = 0.7$	0.5
U_L electrical ratings:	250 V AC, 3 A general use 240 V AC 1/4 hp. 2.9 FLA 120 V AC 1/10 hp. 3.0 FLA C 300 D 300 1 A 240 V AC
Rated operating current I_E AC 15	$I_E = 3$ A $V_E = 250$ V
DC 13	$I_E = 2$ A $V_E = 24$ V
	$I_E = 0.2$ A $V_E = 125$ V
	$I_E = 0.1$ A $V_E = 250$ V
Recommended fuse	T 3.15 A (gL)
Contact service life, mech.	3 x 10^7 switching operations
Contact service life, electr.	1 x 10^5 switching operations at 250 V AC / 6 A

Real-time clock

	Buffered for 7 days. Continuous synchronization via SNTP on the Ethernet interface is possible

Test conditions

Acc. to	EN 61010-1
Rated impulse voltage insulation	4000 V
Pollution rate	2
Rated insulation level V_i	300 V
Duty cycle	100 %
Perm. ambient temperature	– 20 °C to + 65 °C EN 60068-2-1 dry heat
Seismic safety EN 60068-2-6	2 to 25 Hz ± 1.6 mm 25 to 150 Hz 5 g
Electrical isolation	Ethernet – measuring input min. 500 V DC
No electrical isolation	RS 485 interface – measuring inputs
EMC tests	EN 61326-1
EMC test for noise emission	EN 61000-4-3
Fast transient disturbances/Burst	EN 61000-4-4 ± 4 kV Pulse 5/50 ns, $f = 5$ kHz, $t = 15$ ms, T = 300 ms
High-energy surge voltages (SURGE)	IEC 61000-4-5 ± 1 impulse: 1.2 / 50 µs (8/20 µs)
Electrostatic discharge	IEC 61000-4-2 ± 4 contact discharge, ± 8 kV air discharge
Ethernet connection	10/100 MBit Auto-MDIX (no cross-over cable required)

Sensor connection

Measuring cycle/measuring time (for 8 measured values)	< 3 s

Pt100, Pt1000 according to EN 60751:

	Measured range °C		Short circuit Ohm	Interruption Ohm	Sensor resistance + circuit resistance Ohm
Sensor	min.	max.	<	>	max.
Pt 100	– 199	860	15	400	500
Pt 1000	– 199	860	150	4000	4100

When connecting Ni100 or Ni120 sensors, the conversion is done in the SIPROTEC device.
The TR800 is configured with Pt100 sensors.

Technical data

Sensor connection *(cont'd)*

Accuracy	± 0.5 % of measured value ± 0.5 K
Sensor current	≤ 0.6 mA
Temperature drift	< 0.04 °C/K

Voltage/current input

	Input resistance	Maximum input signal	Accuracy of final value
0 – 10 V	12 kΩ	27 V	0,1 %
0/4 – 20 mA	18 Ω	100 mA	0.5 %

Temperature drift	< 0.02 %/K

Resistance measurement

Accuracy 0.0 ... 500.0 Ω	0.2 % of measured value ± 0.5 Ω
Accuracy 0 ... 30.00 kΩ	0.5 % of measured value ± 2 Ω
Sensor current	≤ 0.6 mA

Housing

Housing type	V8, distribution panel mounting
Size (W x H x D)	140 x 90 x 58 mm
Depth/Width	55 mm/8 TE
Circuit termination single strand	Per 1 x 1.5 mm^2
Braided conductor with crimp lug	Per 1 x 1.0 mm^2
Tightening torque of terminal screw	0.5 Nm (3.6 lb.in)
Degree of protection of housing/terminals	IP30 / IP20
Mounting vertical/horizontal	Optional
Affixing	Snap-on mounting onto standard rail mounting 35 mm acc. to EN 60715 or screw mounting (with 2 additional brackets)
Weight	Approx. 370 g

Selection and ordering data

Description	Order No.
Universal relay/RTD-box TR800	*7XV5662 - 7AD10*

Distributed input-box for 6/8 RTD-connections (RTD-box) or 6/8 x 20 mA, or 0 – 10 V

Rail mounting plastic

Protection class IP21

1 serial interface RS485 for communication of measurements

1 RJ45 interface for parameter setting via Web browser and communication of measurements

Wide-range power supply 24 to 240 V AC/DC

Note: The device can be operated in a 7XV5662-2AD10 or 7XV5662-5AD10 compatible mode.

7XV5662-8AD10
Resistance Temperature Detector (RTD-Box) TR1200 IP (Ethernet)

Fig. 13/49a
7XV5662-8AD10 RTD-box TR1200 IP (Ethernet)

Description

The RTD-box TR1200 IP has 12 sensor inputs which allow measurement of up to 12 temperatures by Pt100 sensors.

Three conductor sensors are supported. For two conductor operation compensation of the measured conductor resistance is possible via a corresponding setting.

All settings on the TR1200 IP can be done through 3 keys on the front of the device or in a Web browser (e.g. Internet Explorer).

If Ni100 or Ni120 sensors are applied, the measured values have to be adapted in the protection device. The 7SK80 supports this with its integrated RTD functionality.

The measured-value output to the protection device is done via Ethernet network with RJ45 connectors.

Note: The SIPROTEC 4 system interface with EN100 module does not support the temperature detection of the RTD-box TR1200 IP.

Function overview

- 3-digit digital display for the temperature of up to max. 12 measuring points
- 12 sensor inputs; 1 to 12 sensors can be connected
- PT100 in 2- or 3-conductor technology, when connecting Ni100 or Ni120, conversion to the correct temperature in the evaluation unit is required, SIPROTEC devices (e.g. 7SK80) support this function. The EN100 module in the SIPROTEC 4 units does not support the TR1200 IP
- 1 alarm relay (1 changeover contact)
- Electric 10 MBit/s Ethernet interface (RTD IP protocol from ZIEHL, or MODBUS IP protocol)
- Read-out display, configuration, simulation and firmware update via Web browser
- Tested with Mozilla Firefox 3.5 and Microsoft Internet Explorer 8.0
- LEDs for measurement allocation, error, relay status and Ethernet interface
- Code protection against manipulation of the setpoint values
- Wide-range power supply 24 to 240 V AC/DC
- Distributor housing for panel mounting 8 TE, front-to-back size 55 mm
- Mounting on 35 mm DIN EN 60715 standard rail.

Application

Measurerment of up to 12 measured values with a TR1200 IP

To get up to 12 measured values one RTD-box TR1200 IP is connected via a double screened CAT5 patch cable (1:1 or crossed-over) directly to the protection device (e.g. 7SK80x/Port A).

The protection device is set using DIGSI 4 progam running on a Notebook via the USB-front interface.

The RTD-box TR1200 IP is set either through the front keys or by using a Web browser running on the Notebook via the Ethernet interface. For this purpose the patch cable must be unplugged from the protection device and then re-plugged into the Notebook.

Tip: If during commissioning a common switch is temporarily inserted using three patch cables, the protection device can be set from a PC using DIGSI 4 in parallel with the TR1200 IP.

For detailed information please visit: www.siemens.com/siprotec

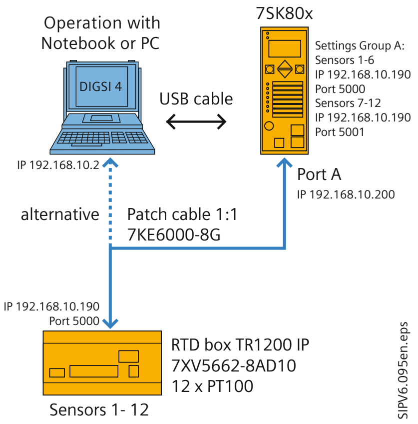


Fig. 13/49b
Connection of a device via Ethernet

Technical data

Rated voltage			
Control voltage V_S:		24 to 240 V AC/DC, 0/45 to 65 Hz < 5 VA 20.4 to 297 V DC, 20.4 to 264 V AC	
Relay output			
Number		1 changeover contact (CO)	
Switching voltage		Max. 415 V AC	
Switching current		Max. 5 A	
Breaking capacity		Max. 2000 VA (resistive load) Max. 120 W at 24 V DC	
Reduction factor at cos $\varphi = 0.7$		0.5	
U_L electrical ratings:		250 V AC, 3 A general use 240 V AC 1/4 hp. 2.9 FLA 120 V AC 1/10 hp. 3.0 FLA C 300 D300 1 A 240 V AC	
Rated operating current I_E			
	AC 15	$I_E = 1$ A	$V_E = 400$ V
		$I_E = 2$ A	$V_E = 250$ V
	DC 13	$I_E = 2$ A	$V_E = 24$ V
		$I_E = 0.2$ A	$V_E = 125$ V
		$I_E = 0.1$ A	$V_E = 250$ V
Recommended series fuse		T 3.15 A (gL)	
Contact service life, mech.		1 x 10^7 operating cycles	
Contact service life, electr.		1 x 10^5 operating cycles at 250 V AC / 5 A 2 x 10^5 operating cycles at 250 V AC / 3 A 6 x 10^5 operating cycles at 250 V AC / 1 A	
Temperature measurement			
Measurement time sensor		0.25 to 3 s (dependent on the number of sensors)	
Measurement time sensor		0.25 to 30 s (for measurement cycle of one sensor)	
Measurement range		–199 °C to 850 °C	
Resolution		1 °C	

Technical data

Sensor connection

12 x PT100 acc. to EN 60751, connection of Ni100 and Ni120 sensors possible. Conversion of the measured values must be performed in the evaluation unit.

	Measured range °C		Short circuit Ohm	Interruption Ohm	Sensor resistance + line resistance Ohm
Sensor	min.	max.	<	>	max.
Pt100	– 199	860	15	400	500

Tolerance	± 0.5 % of measurement ± 1 K
Sensor current	≤ 0.8 mA
Temperature drift	< 0.04 °C/K
Ethernet interface	
Transmission speed	10 MBit/s
IP adress	Standard: 192.182.1.100, adjustable
Subnetwork mask	Standard: 255.255.255.0, adjustable
UDP port	Standard: 5000 (5001), adjustable
Max. cable length	20 m when using CAT 5 patch cable
Max. response time RTD/MODBUS	< 700 μs
Test conditions	
Acc. to	EN 61010
Rated impulse withstand voltage	4000 V
Surge category	III
Pollution level	2
Rated insulation voltage V_i	300 V
Operating time	100 %
Permissible ambient temperature during operation	– 20 °C to + 65 °C EN 60068-2-2 dry heat
EMC – noise immunity	EN 61000-6-2
EMC – noise emission	EN 61000-6-4
Galvanic insulation Control voltage – measurement input	3820 V DC
Ethernet – control voltage – measurement input	500 V DC
Housing	
Housing type	V8, distribution panel mounting
Dimensions (W x H x D)	140 x 90 x 58 mm
Front-to-back size/Width 55 mm/8 TE	
Wiring connection single strand	Each 1 x 1.5 mm^2
Finely stranded with wire end ferrule	Each 1 x 1.0 mm^2
Starting torque of the terminal screw	0.5 Nm (3.6 lb.in)
Protection class housing/terminals	IP30 / IP20
Mounting position	Arbitrary
Mounting	Snap-on mounting onto standard rail 35 mm acc. to EN 60715 or screw mounting (with 2 additional bars)
Weight	Approx. 350 g

Selection and ordering data

Description	Order No.
Resistance temperature detector (RTD-box) TR1200 IP (Ethernet)	*7XV5662 - 8AD10*

Distributed input-box for 12 RTD-connections Pt100

Rail mounting plastic

Protection class IP21

1 Ethernet interface for communication with SIPROTEC devices for measurement and fault reports.

Wide-range power supply 24 to 240 V AC/DC

7XV5664 /7XV5654 GPS/DCF77 Time Synchronization System

GPS-time signal receiver

7XV5654 time synchronization unit (sync.-transceiver)

Fig. 13/50
GPS/DFC77 time synchronization system

Description

With the GPS-time signal receiver 7XV5664 and additional components wide-range power supply 7XV5810, mini star-coupler 7XV5450 and sync-transceiver 7XV5654, a comprehensive solution for time synchronization of any number of SIPROTEC protection devices is possible. A simple PC-Software (included in the scope of delivery) facilitates the setting of the receiver via a RS232 interface. The transmission of the time signals (telegrams or impulses) takes place, immune to disturbances, via a FO cable to the protection cubicles, where the time signals are electrically converted with the Sync-Transceiver. The standard version can, with the output of special protocols, also be used for the synchronisation of further devices, e.g. Reyrolle ARGUS 1 or SIMEAS Q80. For the SIPROTEC line differential protection 7SD52 or for SIMEAS R-PMU, the special version provides a highly accurate pulse per second. The GPS antenna with 25 m cable to the receiver is included in the scope of delivery. Lightning protection is optionally available.

Features / function overview

- GPS exterior antenna with wall mounting and 25 m cable RG59, lightning protection is optional
- GPS-antenna input (BNC-plug)
- PC-input, RS232 (9-pol. Sub-D plug) with operating program and 1m connection cable
- 2 optical signal outputs FL1/2 for FO cable 62,5/125 µm and ST-plug for disturbance free transmission of the signals
- Auxiliary voltage 18-60 V DC / optionally with wide-range power supply 7XV5810-0AA10, 24-250 V DC / 100-230 V AC.
- Aluminium housing for rail mounting.

Standard Version 7XV5664-0CA00:

- Signal outputs FL1/2: telegrams selectable IRIG-B, DCF77-, NMEA, IEC60870-5-103, second or minute impulses.
- 3D-mode with at least 4 satellites or Fix-mode with at least 1 satellite.

Special Version 7XV5664-0AA00:

- Signal outputs FL1/2: fixed telegrams
  FL 1 = highly accurate second impulse
  FL 2 = IRIG-B or DCF77
- Only 3D-mode with at least 4 satellites.

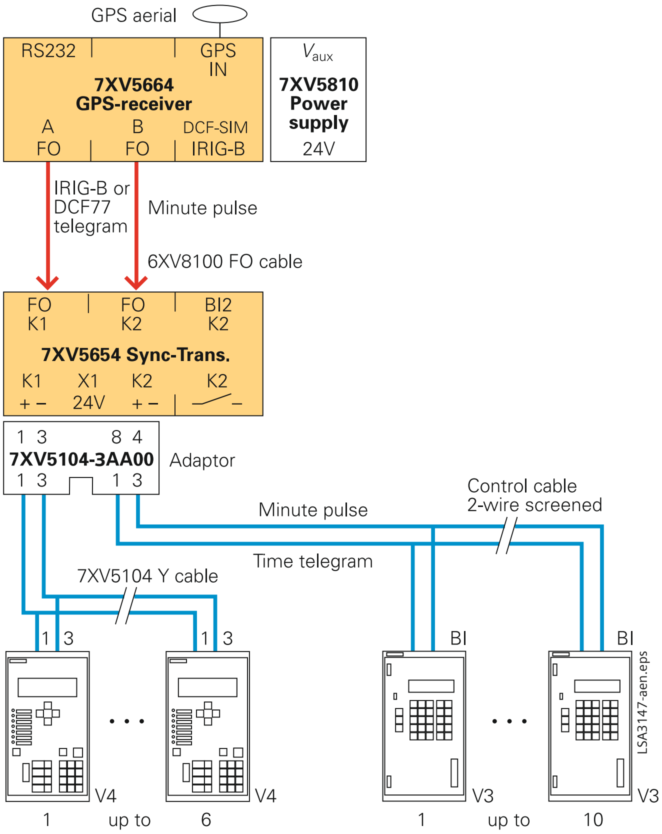


Fig. 13/51 SIPROTEC 4 protection unit with GPS-time synchronization

Application

The "Normal Time" standard application

With the GPS-time signal receiver 7XV5664-0CA00 all connected protection devices are synchronized to "Normal Time". In this way, the internal clock of the protection devices is synchronized by a standardized telegram e.g. IRIG-B, DCF77, IEC60870-5-103, NMEA or a minute impulse.

For this purpose the protection devices provide suitable interfaces e.g. SIPROTEC 4 provides Port A.

The antenna is mounted to an outside wall with free sight to the sky and the optional lighting protection is looped into the antenna cable.

The GPS-time signal receiver is mounted close to the antenna, and is either supplied with auxiliary voltage via the optional wide-range power supply from the AC mains, or the substation battery.

The transmission of the time telegrams or synchronizing impulses takes place, immune to interference, with FO cable to the protection devices distributed in the plant. An extension of the optical star structure can be implemented with the mini star-coupler 7XV5450. For the conversion of the FO signals to 24 V signals as required by the SIPROTEC 4 time synchronization interfaces (Port A), sync-transceivers 7XV5654 are implemented.

Detailed application examples may be found in the manual of the sync-transceivers 7XV5654.

The SIPROTEC 4 protection devices are connected to the sync-transceiver 7XV5654 via "Port A" with the specially designed bus cable system 7XV5104 (see Fig.13/51). Note: No bus termination resistance is required here.

All SIPROTEC protection devices with internal clock

may be synchronized with the minute impulse from the GPS receiver via a binary input. For this purpose the internal clock of the protection device is set at each full minute to the exact beginning of the new minute. A pre-condition for this method is that the internal clock of the protection device is set correctly once, and the auxiliary voltage is buffered against failure. If the time tracking fails for a longer period, the difference between the internal clock of the protection device and the normal time must be smaller than one minute. Daylight saving time must, if desired, be set manually.

Protection devices are fitted with a binary input, which captures the minute impulse using a corresponding voltage (24-60 or wide range 24-250 V DC) and provides this to the internal clock. The distribution of the impulse to the protection devices takes place via a 2-wire bus, which must consist of a screened twisted pair. All devices must be located in the same earthed system, the cable screens must be connected to the housing on both sides.

If both channels of the GPS-receiver are set to the minute impulse, up to 20 SIPROTEC 3 devices may be connected. Alternatively, a coupling of both output channels of the sync-transceivers with the DIL-switches S1/3 is possible.

Selection and ordering data

Description	Order No.
GPS-time signal receiver	*7XV5664-0☐A00*
GPS-timing signal receiver "Special Version" for the time synchronization of SIPROTEC 4 differential prot. devices or SIMEAS R-PMU (Phasor Measurement Unit), with 25 m coaxial cable, PC software with cable (without wide range power supply unit 7XV5810-0BA00)	*A*
GPS-timing signal receiver "Standard-Version" for the time synchronization of SIPROTEC 4 protection devices, with 25 m coaxial cable, PC software with cable (without wide range power supply unit 7XV5810-0BA00)	*C*
Lightning protection with plugs for connection to the antenna cable	*L*
Additional accessories for time synchronisation	
Wide-range power supply (universal) Universal supply voltage (48...250 V DC ± 20 %, 60...230 V AC ± 20 %) Output voltage 24 V DC / 6 W, short-circuit proof, alarm contact	*7XV5810-0BA00*
Sync-transceiver Sync-transceiver for conversion of 2 optical timing signals to 24 V DC for the time synchronizing interface of SIPROTEC 4 (Port A) 2 optical inputs with ST-plugs and 2 electrical outputs for max. 12 SIPROTEC 4 relays or 20 SIPROTEC 3 relays. Minute or second pulse for special applications is also supported.	*7XV5654-0BA00*
Y-bus cable for time synchronizing SIPROTEC 4 (standard)	*7XV5104-0AA☐☐*
Y-bus cable 2-core screened with 9 pole sub-D connector and metallic housing for clock synchronization SIPROTEC 4 Length 1 m	*0 1*
Length 3 m	*0 3*
Length 5 m	*0 5*
Length 10 m	*1 0*
Bus length extension cable (standard) Cable for the bus length extension. Copper cable with 2-wires, shielded with 9-pole sub-D plugs. Length 10 m	*7XV5104-1AA10*
Adapter cable to sync.-transceiver 7KE6000-8 (standard) Adapter cable to sync.-transceiver 7KE6000-8Ax. Length 0,3 m. Shielded, 2-wires with crimp lugs to 9-pole sub-D plug (female)	*7XV5104-2AA00*
Adapter cable for 2 busses (standard) Adapter cable 2 core screened for sync-transceiver 7XV5654-0BA00 for distribution of 2 busses for each 6 SIPROTEC 4 relays	*7XV5104-3AA00*
Y-bus cable for time synchronizing SIPROTEC 4 *Diff.-protection and SIMEAS R-PMU (special)*	*7XV5105-0AA☐☐*
Y-bus cable 2-core screened with 9 pole sub-D connector and metallic housing for clock synchronization SIPROTEC 4, e.g. 7SD5 Length 1 m	*0 1*
Length 3 m	*0 3*
Length 5 m	*0 5*
Length 10 m	*1 0*
Bus length extension cable (special) Cable for the bus length extension. Copper cable with 4-wires, shielded with 9-pole sub-D plugs. Length 10 m	*7XV5105-1AA10*

7XV5673
I/O-Unit with 6 Binary In-/Outputs

Fig. 13/52
7XV5673 I/O-Unit – binary I/O mirror, -binary I/O expansion, -contact multiplier

Description

I/O-Unit 7XV5673 is a binary input/output device and is designed for substations and increased industrial environment requirements. The I/O-Unit allows the transmission of binary inputs to binary outputs locally or via long distances. It can be used for protection applications, e.g. overcurrent protection, signal comparison, teleprotection or as I/O-expansion in substation automation systems.

Function

Via binary inputs, all kinds of binary signals of switchgear/ protection scheme (for example tripping commands, switch position signal, fault and status indications) are securely detected. This information can directly be distributed at this I/O-Unit via contacts, or be transmitted via communication links to further I/O-Units or to automation systems.

Secured telegrams are used for the communication via Ethernet or serial connections. The parameter setting of the I/O-Unit is simply carried out with a standard Web browser at the PC which is connected by the Ethernet interface.

The I/O-Unit can be set as:

- I/O mirror: Point-to-point transfer of binary signals between two I/O-Units via Ethernet or a serial connection. Signal inputs and outputs assignable by the user.
- I/O expansion: Expansion of substation controllers by binary inputs and outputs using standard protocols.
- Contact multiplier: Distribution of signals on one or several binary inputs via relay contacts of the same I/O-Unit, e.g. for isolation between different voltage levels.

Feature overview

- Binary inputs
  - 6 ruggedized EMC – hardened binary inputs
  - Pickup voltage threshold settable to 19 V DC, 88 V DC or 176 V DC for different station battery voltages
- Binary outputs
  - 6 command relay outputs
  - Safe state of contacts after loss of connection settable by the user
- Signal/Alarm outputs
  - 4 LED
- Wide-range power supply
  - 24-250 V DC +/- 20 % and 100-230 V AC 45-65 Hz
- Electrical RJ45 Ethernet interface
  - Cascading many devices without additional costs by the use of the integrated switch
- Serial fiber-optic interface (optional)
  - ST-connector, 820 nm for multi-mode fiber 62.5/ 125 µm, typical range 2000 m using fiber 62.5 µm/125 µm, baud rate 1.2 kBit/s – 187.5 kBit/s settable per software
- Serial RS485-interface (optional) Sub-D plug, 9-pole female
- Protocols, communication
  - MODBUS TCP or MODBUS RTU for connection to a substation controller
  - MODBUS UDP for point-to-point connections between two I/O-Units
  - SNTP for time synchronization
  - IEC 61850* (GOOSE and Reporting)
- Housing IP20 rail mounting
- Standards CE, UL, IEC 60255, IEEE 61000 ...
- Environmental conditions
  - EMC hardened binary I/O for substation environment
  - Extended high temperature range up to 85 °C (16 h/day).

Operation features

- Easy parameterization with a standard Internet browser (no special software required)
- Password protection against unauthorized access
- Monitoring of data errors, loss of connection, transfer time and the state of BI, BO.
- Time synchronization with SNTP-Protocol with 1 ms resolution from an external time server over Ethernet. Redundant time servers are supported
- Buffer battery changeable from the front
- Fast I/O mirror: Fast transmission time from BI pickup to contact closing between two I/O-Units typically 11 ms for high bandwidth connection
- Connection to a substation controller over MODBUS TCP, MODBUS RTU or IEC 61850 protocol *
- Blocking of data transmission with a binary input for testing
- Battery buffered operational event log with 1 ms resolution time stamp
- Assignment of BI / BO signals which shall be logged into the operational buffer
- Integration into network management systems with SNMP – protocol and provided MIB – files.

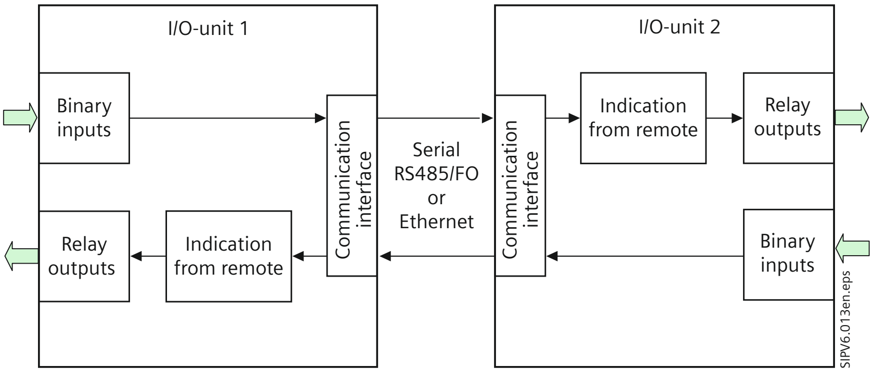


Fig. 13/53 I/O mirror, bi-directional transmission between two devices

Application

I/O mirror function

When using the I/O-Units as I/O mirror according to Fig. 13/53, the devices transmits the binary signals bi-directional. The transmission takes place between the two devices over serial links (option) or over Ethernet networks.

Via the relay output contacts voltages up to 250 V AC/DC and currents up to 5 A AC/DC can be switched. The pick threshold of the binary inputs can be set by the user on different levels.

Signal inputs and outputs can be assigned by the user.

Extension of the transmission distance

An extension of the transmission distance is possible. The following devices can be used:

- With serial optical repeater 7XV5461 scalable up to 170 km
- RS485-FO Converter 7XV5650 for cascading devices
- With different communication converters.

---

* In preparation

Application

Uni-directional binary signal transmission

When using the I/O-Units for uni-directional binary signal transmission according to Fig. 13/54, the devices transfer binary signals unidirectional from one device to several devices. In this application, the transmission only takes place in one direction. Input signals (max. 6) from the left unit are sending to output contacts of one or more units on the right side.

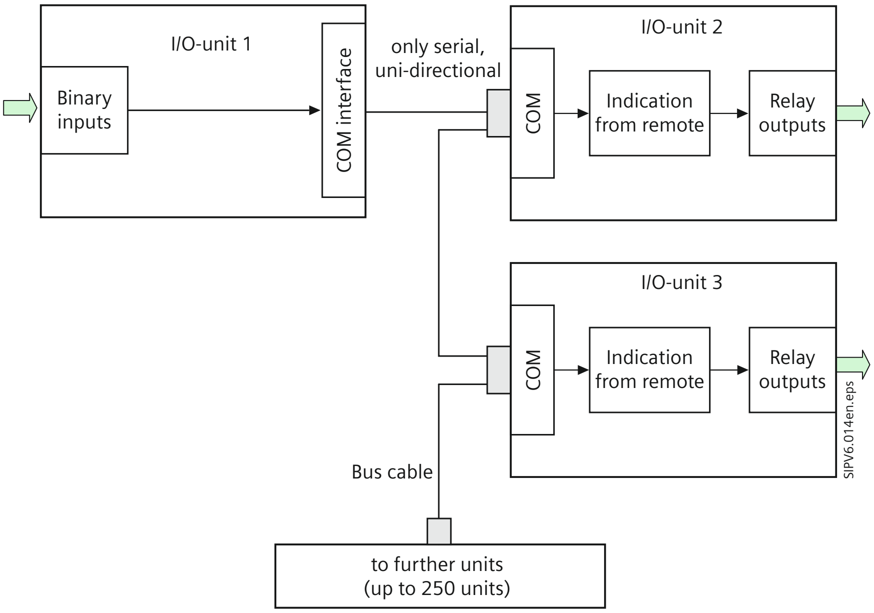
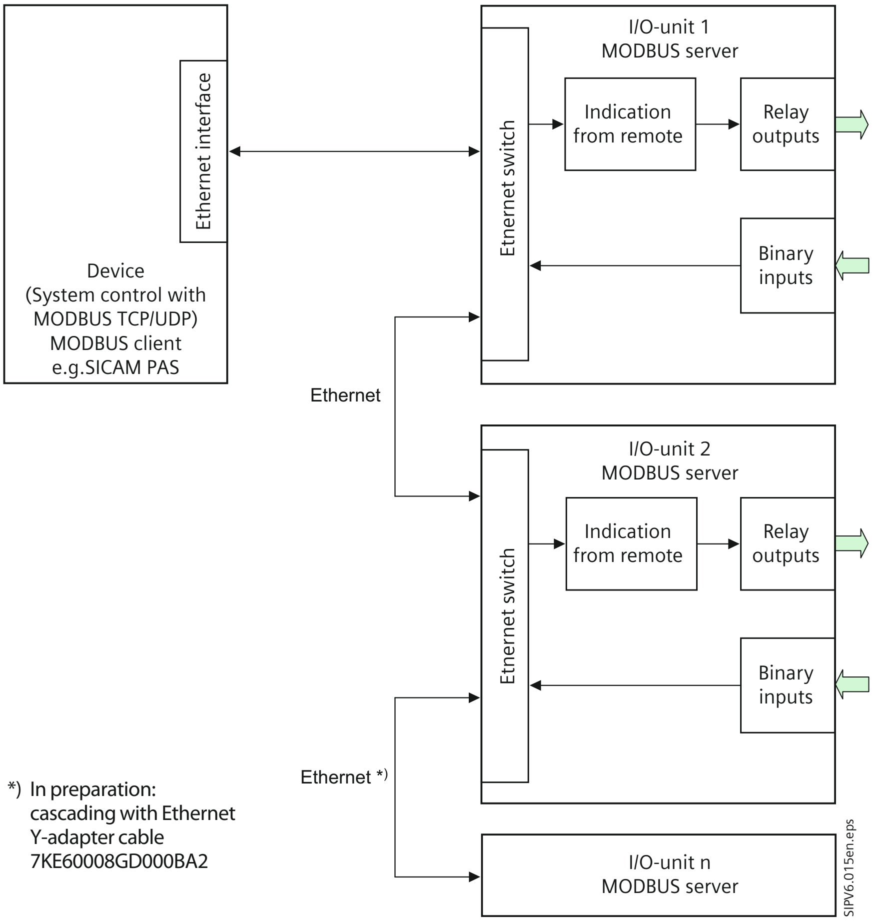


Fig. 13/54 I/O mirror, uni-directional transmission from one to multiple I/O-Units

I/O expansion of a substation controller

The I/O-Unit is used as I/O expansion, according to Fig. 13/55. Binary signals are exchanged between a substation controller (e.g. SICAM PAS) and the I/O-Units by using the MODBUS TCP protocol over an Ethernet network. If the integrated switch in the I/O-Unit is used, the units can be operated in a line without using additional external switches as shown in Fig. 13/85. Also IEC 61850 client server communication will be provided in future.



*) In preparation: cascading with Ethernet Y-adapter cable 7KE60008GD000BA2

Fig. 13/55 I/O expansion of a substation controller with binary inputs and outputs

Application

Instead of using an Ethernet network there is also the option of serial connection with MODBUS RTU protocol. The link can be done by a RS485-bus line structure or an optical star network.

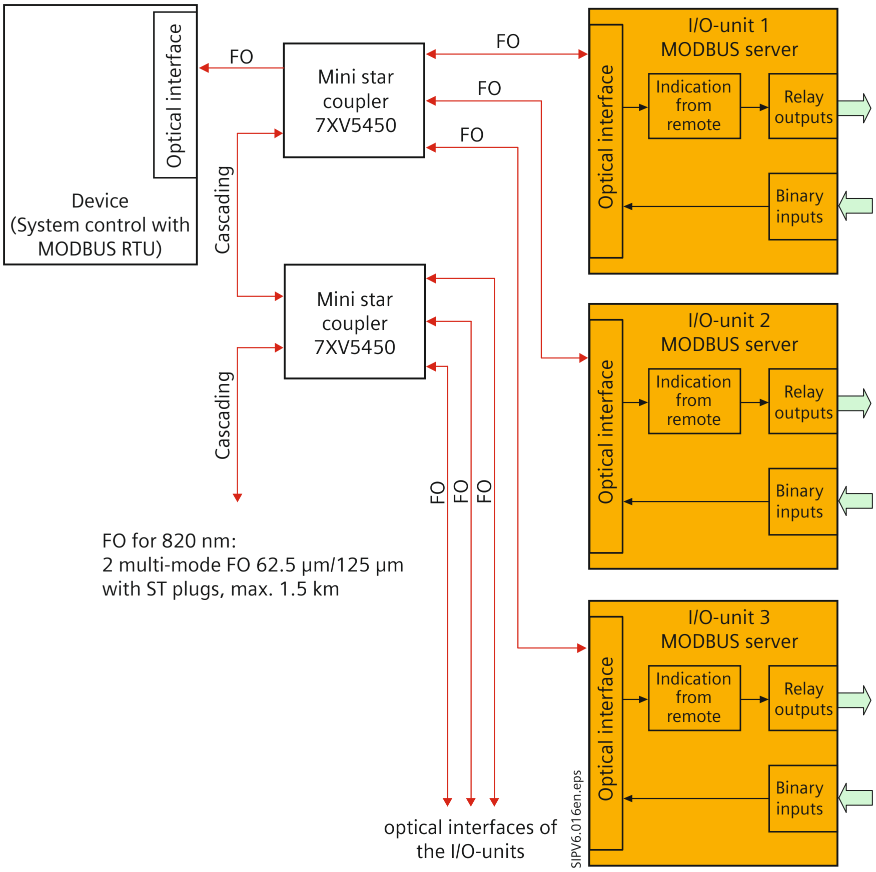


Fig. 13/56 I/O expansion for the connection to substation controller using a serial optical star topology

Application

Contact multiplier

Input signals on one or more binary inputs can be assigned to binary outputs of the local device (Fig. 13/57)

- 1 binary signal on up to 6 relay outputs
- Several binary signals to several relay outputs assignable by the user
- Different voltage levels for inputs and outputs in a wide voltage range to isolate between different voltage levels.

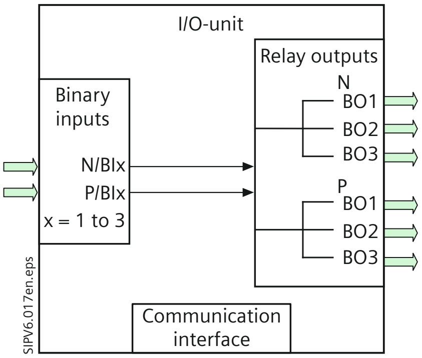


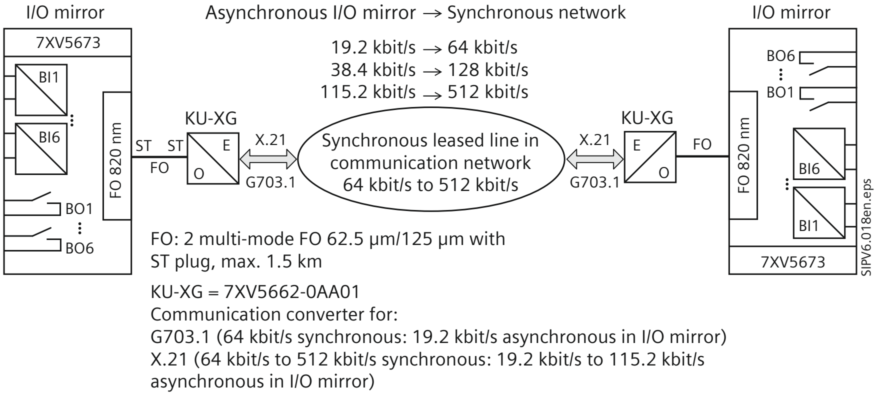
Fig. 13/57 Contact multiplier

Applications for remote transmission of binary signals

Binary signal transmission via communication networks using a G.703.1/X.21 interface

The picture shows the optical connection of an I/O-Unit to a communication converter (KU-XG) 7XV5662-0AA01, which establishes a connection to a multiplexer with G.703.1 or X.21 interface. This allows the use of this communication converter to transfer the signals via communication network. The average delay time in the network and the signal quality is monitored by the I/O-Unit. Also loss of connection is indicated. In this case, the state of the binary outputs can be set by the user to a safe condition depending on the application.

A maximum of 6 binary single signals can be transmitted bi-directional via the communication network.



FO: 2 multi-mode FO 62.5 µm/125 µm with ST plug, max. 1.5 km

KU-XG = 7XV5662-0AA01
Communication converter for:
G703.1 (64 kbit/s synchronous: 19.2 kbit/s asynchronous in I/O mirror)
X.21 (64 kbit/s to 512 kbit/s synchronous: 19.2 kbit/s to 115.2 kbit/s asynchronous in I/O mirror)

Fig. 13/58 Binary signal exchange over a communication converter with G.703.1/X.21 interface via a communication network

Application

Binary signal transmission via two-wire copper cable with blocking

The picture shows the optical connection of an I/O-Unit to a communication converter 7XV5662-0AC01, which establishes a connection via pilot wire. Only one pair is necessary for bi-directional signal exchange.

An additional isolation transformer allows 20 kV isolation from the pilot wire connection.

A maximum of 6 binary single signals can be transmitted bi-directionally over the pilot wire. The additional delay caused by the transfer over the communication converter and pilot wire is less than 1 ms.

A typical application is the signal comparison of a directional overcurrent protection device via pilot wires. In this case, the definite time-overcurrent protection device is connected to the I/O-Unit via contacts and binary inputs and directional signals are transferred.

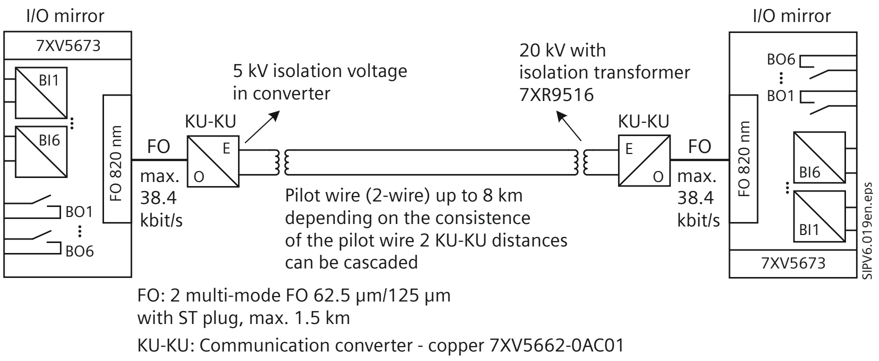


Fig. 13/59 Binary signal exchange of 6 signals via pilot wire connection

Binary signal exchange of over long fiber optic links

The figure shows the optical connection of an I/O-Unit to a serial optical repeater 7XV5461-0BX00, which establishes a connection to multi-mode or single-mode fiber cables. A max. distance of 170 km can be reached with this application without additional amplifiers.

A maximum of 12 binary signals can be exchanged via long fiber optical connections because the repeater allows connecting two I/O-Units.

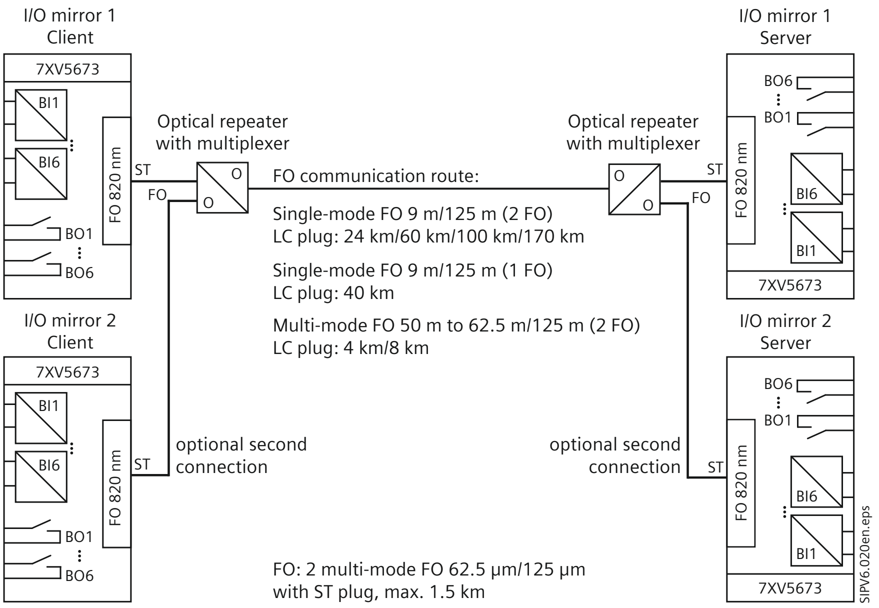


Fig. 13/60 Binary signal exchange of up to 12 signals over long fiber optic links

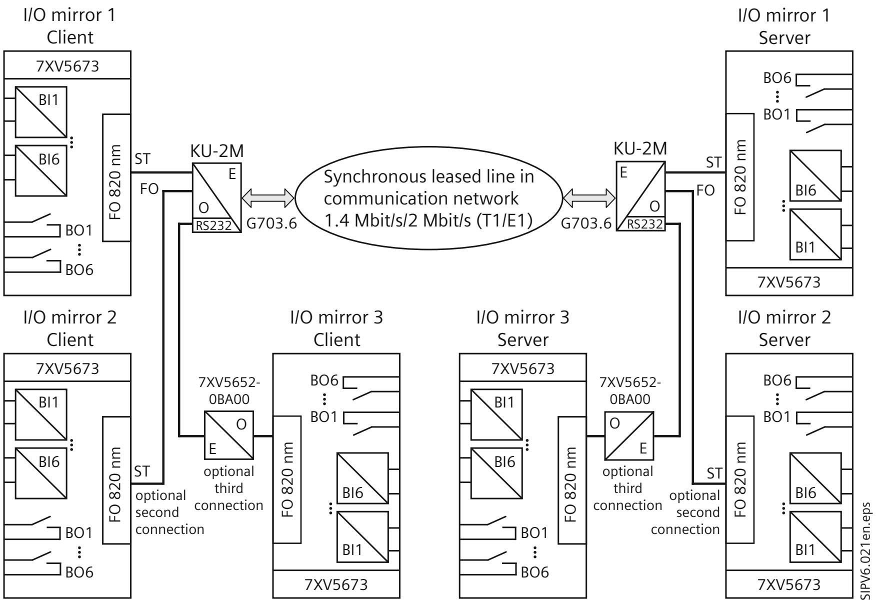
Application

Binary signal transmission via a communication networks using a G.703.6 interface

The figure shows the optical connection of one up to three I/O-Units to a communication converter KU-2M 7XV5662-0AD00, which establishes a connection to a multiplexer with a G.703.6 interface (1.44 kbit/s/2 Mbit/s, E1/T1).

A maximum of 18 binary single signals can be transmitted bi-directionally over the communication network. The KU-2M is provided with two optical and one electrical RS232 interface. Two I/O-Units can be directly connected by an optical cable to the KU-2M. On the RS232 interface, an additional I/O-Unit can be connected via an optoelectronic converter. Using all input interfaces (2 FO, 1 RS232) of the KU-2M, a maximum of 18 signals can be exchanged bi-directionally.

For long distance connections via Ethernet media converters or Ethernet networks can be used. The I/O-Unit supports IP – address settings and settings for a standard gateway. The electrical Ethernet interface of the I/O-Unit is connected to a media converter or switch which transfer the signals of the units over long distance Ethernet connections. The average delay time in the network is measured by the I/O-Unit.



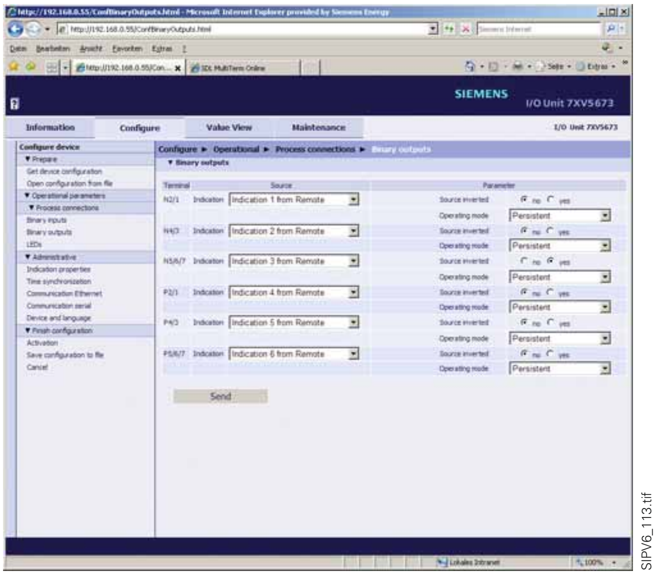
FO: 2 multi-mode FO 62.5 µm/125 µm with
ST plug, max. 1.5 km

KU-2M = 7XV5662-0AD00
Communication converter for:
G703.6 (2 Mbit/s synchronous: 115.2 kbit/s asynchronous in I/O mirror)

Fig. 13/61 Binary signal exchange with G.703.6 interface via a communication network

Device configuration

The I/O-Unit is equipped with an integrated Web Server which allows easy setting using standard Internet-Browsers. Fig. 13/62 shows the User interface. All settings are done with the Browser. Also operational log and commissioning aid are supported by the Browser like the indication of the actual state of the inputs and outputs.



Configure ► Operational ► Process connections ► Binary outputs

▼ Binary outputs

Terminal		Source	Parameter	
N2/1	Indication	Indication 1 from Remote	Source inverted	● no ○ yes
			Operating mode	Persistent
N4/3	Indication	Indication 2 from Remote	Source inverted	● no ○ yes
			Operating mode	Persistent
N5/6/7	Indication	Indication 3 from Remote	Source inverted	○ no ● yes
			Operating mode	Persistent
P2/1	Indication	Indication 4 from Remote	Source inverted	● no ○ yes
			Operating mode	Persistent
P4/3	Indication	Indication 5 from Remote	Source inverted	● no ○ yes
			Operating mode	Persistent
P5/6/7	Indication	Indication 6 from Remote	Source inverted	● no ○ yes
			Operating mode	Persistent

Fig. 13/62 Configuration screen of the I/O-Unit in the Browser

Selection and ordering data

Description	Order No.
I/O-Unit with 6 binary in- and outputs	*7XV5673-0 J J☐0 - 1 A A 1*
I/O-Unit with Ethernet interface and	
RS485-interface	*1*
optical interface	*2*

7XV5700
RS232 – RS485 Converter

Fig. 13/63
RS232 – RS485 converter

Function overview

- Minimum baud rate: 9600 baud
- Maximum baud rate: 115 kbaud
- No setting of baud rate necessary
- Compact plug casing
- Power supply via plug in PSU
- Maximum 31 relays at RS485 bus
- Complete set for connecting 1 relay to RS485 bus

Description

Up to 31 SIPROTEC 4 relays with an electrical, bus-capable RS485 interface to a PC for centralized control can be connected via the RS232↔RS485 converter.

The converter is housed in an expanded plug casing. The interfaces are connected to 25-pin female connectors. The auxiliary voltage is supplied via a plug-in power supply unit attached to the side. Auxiliary voltages of 110 or 230 V AC make operation with all common AC networks possible.

A twisted and shielded cable with two wires is required for the RS485 bus. The protection relays are connected to the bus in series. Data transmission at a speed of 19.2 kbaud with a bus length of up to approximately 1000 m is possible.

The converter, plug-in power supply unit and the connecting cable to the first relay are included in the scope of supply.

Applications

The RS232↔RS485 converter allows up to 31 SIPROTEC 4 protection relays with electrical busable RS485 interfaces to be connected to a PC notebook.

The converter is housed in an expanded plug casing. The interfaces are connected to 25 pin female connectors. The RS485 interface has a terminating resistor. The auxiliary voltage is supplied via a plug-in power supply unit attached to the side. Auxiliary voltages of 110 V or 230 V AC make operation with all common AC networks possible.

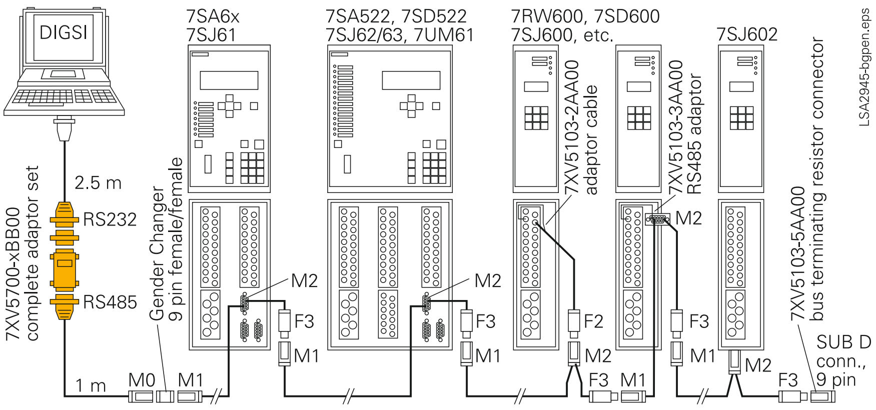


Fig. 13/64 Protection units connected to the RS485 bus

Note

The converter may not be used with a substation modem due to non-existing isolation. It is recommended to use the 7XV5650 and 7XV5651 converters in conjunction with the substation modem.

Functions

The converter works according to the master/slave principle. In idle state, the RS232 interface is inactive while the RS485 interface is switched to the receiving mode. During communication, the PC (master) sends data to the RS232 interface, which are transmitted (half duplex) to the protection unit (slave) by the converter at the RS485 interface. After data transmission, the RS485 interface is once again switched to the receiving mode. Vice versa, data supplied by the protection unit are sent back by the converter to the RS232 interface and to the PC.

No handshake signals are being processed during communication. This means that data sent by the PC are mirrored, which may cause problems in special applications.

Connections

The PC is connected to the converter by means of a DIGSI cable e.g. 7XV5100-2.

A twisted and shielded cable with two wires is required for the RS485 bus. The conductor cross section has to be adapted to the ring cable lugs and the SUB-D connectors. The individual wires protruding from the shield should be kept as short as possible. The shield is connected to the housing earth at both ends. The protection units are connected in series to the bus. The shield between the converter and the protection units, or between the protection units, is connected at both sides. Whenever substantial cable lengths or high baud rates are involved, a terminating resistor of 220 ohm should be applied between signal lines A and B at the last protection unit. Data transmission at a speed of 19.2 kbit/s, with a bus length of up to approx. 1000 m, is possible.

Technical data

Design	
Plug chassis	Plastics
Dimensions	63 x 94 x 16 mm (W x H x D)
Degree of protection	IP20
Power supply	
Power supply	110 or 230 V AC
Via	Plug-in power supply unit
Electrical interfaces	
Type	RS232 to RS485 (non-isolated)
Assignment	See Fig. 13/64
CE conformity, standards	
This product is in conformity with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to the electromagnetic compatibility (EMC Council Directive 89/336/EEC).	Conformity is proved by tests performed by Siemens AG in accordance with the generic standards EN 50081-1 and EN 50082-2.

Selection and ordering data

Description	Order No.
7XV5700 RS232 – RS485 converter	*7XV5700-☐☐☐00*
Rated auxiliary voltage	
Via plug-in auxiliary power supply unit (PSU) 230 V / 50 Hz AC	*0*
Via plug-in auxiliary PSU 110 V / 60 Hz AC	*1*
Connecting cable	
With RS485 connecting cable for 7SJ60, 7RW60, 7SD6, 7SV60, length 1 m	*A*
With RS485 connecting cable for SIMEAS Q and SIPROTEC 4, length 1 m	*B*
With RS485 connecting cable for SIMEAS T, length 1 m	*C*
Without RS232 connecting cable	*A*
With RS232 connecting cable 7XV5100-2 for PC/notebook, 9 pin	*B*
With RS232 adaptor, 25-pin connector (male) to 9-pin connector (female) for PC / notebook	*C*

7XV5710
USB – RS485 Converter Cable

Fig. 13/65 USB – RS485 converter cable

Function overview

- Compact connector housing
- USB 2.0 / 1.1 interface Type A
- RS485 interface 9-pin SUB-D
- Max. bus length 800 m
- Termination resistances switchable
- Baudrates 300 to 115000 baud
- Indicated data transfer (data LED)
- Protocol transparency (not only for PROFIBUS)
- Power supply via USB connector (no galvanic separation)
- Compatible with 7XV5103 bus system (with gender changer 9-pin female/ female)

Description

The USB converter cable with its special pin assignment allows temporary connection of up to 31 Siemens protection devices having an electrical RS 485 interface to a PC with a USB interface for direct or central control with DIGSI 4.

The converter is connected directly to the PC via a standard USB connector (type A). The RS485 connector (9-pin SUB-D male) may be used for direct connection to SIPROTEC 4 devices with RS485 interface modules. To connect individual compact devices with an RS485 interface on terminals, e.g. 7SJ600, 7SD600, 7RW600, etc., the 7XV5103-2AA00 or -3AA00 adapter is required. Using the gender changer (female-female), which is included, the converter may also be connected to the 7XV5103 bus system, which enables communication with all the devices connected to the bus. Because the cable includes a switchable bus termination, it may be connected at either end or in the middle of the bus. The converter draws all the power it needs via the USB interface of the PC.

Application

Data transfer

Before the converter cable is first used, a USB driver must be installed from the CD supplied. The driver creates a new virtual COM port, which may then be selected by the application, e.g. DIGSI 4. The converter works in half-duplex mode on the master/slave principle.

In the quiescent state, the USB interface is inactive and the RS485 interface is ready to receive. For communication, the PC, acting as the master, transmits its data to the USB interface, which in turn forwards the data from the converter at the RS485 interface to the protection device (slave). Following this, the RS485 interface is switched back to receive. Data coming from the protection is now transmitted in the other direction to the USB interface and PC by the converter. A data LED indicates when data transfer is active.

Connection of the compact devices, e.g. 7SJ600 with terminals (without bus cables 7XV5103)

A shielded twisted pair (STP) cable must be used for the RS485 bus. The conductor cross-section must be suitable for termination with ring lugs or SUB-D connectors. The protection devices are connected to the bus in line (not in star or ring topology). The core ends protruding from the shield should be kept as short as possible.

The shield must be connected to the housing ground at both ends. At the last protection device, a 220-Ω terminating resistor is connected between data cores A and B.

Termination of the RS485 bus

The RS485 bus is a two-wire bus (half duplex) over which up to 32 devices (participants) can exchange their data on the master/slave principle. All devices are connected to the bus in line (not in star or ring topology). At the first and last devices, a 220-Ω bus terminating resistor is connected between pin 3 (A) and pin 8 (B), irrespective of whether this is a master or slave device.

The SIPROTEC protection devices are preferably connected to the bus as a slave behind a master, e.g. 7XV5710 or 7XV5650/51 RS484 converter. In these converters (1st device) the terminating resistor may be implemented by additional pull-up/pull-down resistors via DIL switches (S1, S2). The “low-resistance” pull-up/pull-down resistors are essential in various SIPROTEC bus applications, i.e. the use of other converters may result in problems.

In the protection devices, the terminating resistor must only be activated at the last device on the bus using the jumpers provided for that purpose. If this is not possible in the device, an external terminating resistor, e.g. 7XV5103-5AA00 must be applied behind the last device (see Fig. 13/66).

In this example, the terminating resistors of the converter cable are active (default), the terminating resistors that are available at some of the protection devices remain inactive. The bus is terminated after the last device with the 7XV5103-5AA00 bus terminating connector or an external resistor (220 Ω). If the last protection device has a switchable terminating resistor, this may also be activated to ensure termination.

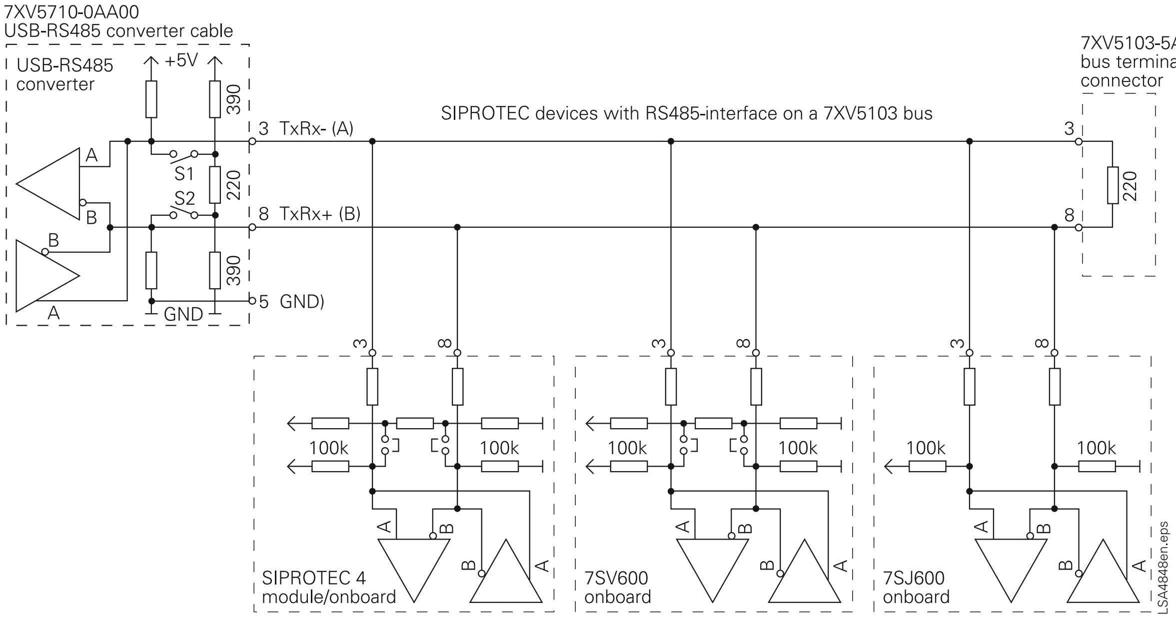


Fig. 13/66
RS485 bus with USB converter cable 7XV5710 and several SIPROTEC devices (connection diagram)

Application

Application example

A number of SIPROTEC 3 and 4 protection devices can be centrally operated via their interface with DIGSI via the 7XV5710 USB converter cable. Suitable cables and adapters are available for the various connection types of the SIPROTEC devices. For more information, please refer to catalog sheet 7XV5103. SIPROTEC 4 devices with an RS485 interface may be directly connected and operated with DIGSI 4.

For the connection of individual compact protection devices with the RS485 interface on terminals e.g. 7SJ600, 7SD600, 7RW600, etc.., the adapter cable 7XV5103-2AA00 or the adapter 7XV5103-3AA00 is required (see Fig. 13/67).

The converter cable must only be used on a non-permanent basis because of the lack of galvanic separation. For permanent operation, the FO converters 7XV5652 and 7XV5650/51 should be used. The FO conductor ensures complete galvanic separation between PC and SIPROTEC devices. Corresponding applications may be found at: www.siprotec.com/accessories/7XV56…

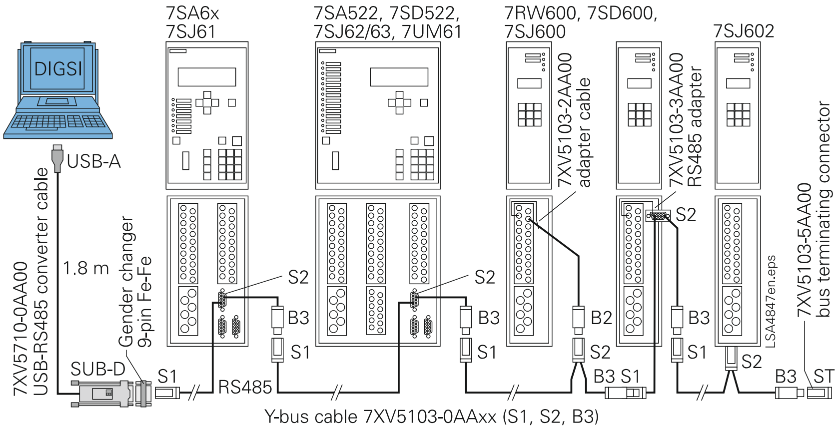


Fig. 13/67 Central operation via the RS485 bus

Technical data

Product	**USB converter cable 7XV5710-0AA00**
Driver	Included on CD or on the Internet at: www.siprotec.com/accessories/7XV5710
Installation	Plug & Play
Cable length	1.8 m
USB interface	Virtual COM port
Connection 1	USB 2.0 (1.1) connector type A
Connection 1 pin assignment	Pin 1 – Vcc Pin 2 – D- Pin 3 – D+ Pin 4 – GND
Connection 2	SUB-D 9-pin connector (male) with securing screws
Connection 2 pin assignment	Pin 3 – Tx/Rx- (A) Pin 5 – GND Pin 8 – Tx/Rx+ (B) All other pins are not connected (nc)
Terminating resistors	Selectable (S1, S2 ON = terminating resistor selected) +5 V – Pin 3 = 390 Ω Pin 3 – Pin 8 = 220 Ω Pin 8 – Pin 5 = 390 Ω

Connection 2 protection	Receiver: +/- 15 kV human body model +/- 6 kV IEC 1000-4-2, contact discharge +/- 12 kV IEC 1000-4-2, air-gap discharge Permitted: up to 128 receivers on the bus True-fail-safe receiver -7 V ... +12 V Common-mode range Thermal protection against output short circuit Driver: +/- 9 kV human body model Slew-rate limited for errorless data transmission -7 V ... +12 V common-mode range Current limiting Thermal shutdown for driver-overload protection
Handshake	None
TX/RX switchover	Automatic
Serial data transmission channels	Half-duplex 2-wire
Power supply	+5 V via USB (max. 80 mA) Module logs on with 96 mA at the USB Max. 38 mA ready (converter on, no data transmission) Max. 80 mA full-duplex 4-core operation, (max. data rate)
Serial transmission rates	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 bits/s
Status indication	Tx and Rx - 3 mm LED red
Operating temperature	-5 up to +70°C
Driver software	Windows 98, Windows 98 SE, Windows 2000, ME, XP, Vista 32/64, Windows 7 32/64. No administrator rights required.
Certification	CE-compliant / RoHS-compliant
Application	Non-permanent installation with SIPROTEC – devices

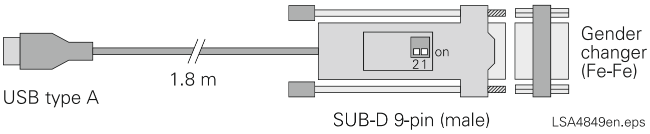


Fig. 13/68 USB converter cable with connector.
Default switch position:
S1+S2 ON = terminating resistor active
Dimensions: 75 x 32 x 15 (l x w x h)

Selection and ordering data

Description	Order No.
USB – RS485 converter cable	*7XV5710 - 0AA00*

USB 2.0 /1.1 with connector type A to RS485 with 9-pin SUB-D male connector,
pin assignment for SIPROTEC 4 and SIMEAS Q,
bus termination switchable, power supply via USB interface,
incl. 9-pin female-female gender changer and driver CD
For the connection of individual compact protection devices with the RS485 interface on terminals, e.g.. 7SJ600, 7SD600, 7RW600, etc.,
the 7XV5103-2AA00 adapter cable or the 7XV5103-3AA00 adapter is required

7XV5820
Industrial Modem and Modem-Router with Switch

Modem 56k/ISDN TA

Modem/ISDN Router

Pocket Modem/ISDN

Fig. 13/69
Industrial modems

Description

Depending on the available infrastructure and transmission requirements, various modems and routers are available for the remote communication with SIPROTEC protection devices using DIGSI.

The existing infrastructure may consist of analog or digital (ISDN) transmission networks, which may be private (internal telephone system) or a leased line. This may determine the corresponding combinations of the modems or routers. A suitable combination usually consists of a desktop device with plug adapter in the office, and a rail-mounted device in the substation (see Application). The rail-mounted devices may be operated with an optional wide-range power supply adapter with all alternating current networks as well as station batteries.

The desktop analog modem “Pocket 56k” as the office device and the rail-mounted “Modem 56k” in the substation ensure a secure serial data communication with SIPROTEC 3 devices using 8E1 (with parity bit) up to 19.2 kbit/s, or with SIPROTEC devices using 8N1 up to 57.6 kbit/s.

With the same analog modem “Pocket 56k” in the office it possible to establish a connection to SIPROTEC 4 devices with EN100 interfaces in a local Ethernet network using the rail-mounted modem router “MoRoS Modem 56k” in the substation.

Using the digital modem “Pocket ISDN” as a desktop device in the office and the “ISDN TA” as a rail-mounted device in the substation ensures secure serial data communication with SIPROTEC 3 devices using 8E1 (with parity bit) up to 19.2 kbit/s, or with SIPROTEC 4 devices using 8N1 up to 57.6 kbit/s.

With the same digital modem “Pocket ISDN” in the office, it is also possible to communicate with SIPROTEC 4 devices with an EN100 interface module in a local Ethernet network using a rail-mounted ISDN router “MoRoS ISDN” in the substation.

Other combinations, especially with devices from other manufacturers are strictly not recommended.

All versions are suitable for application in control systems, and substations as well as in areas of energy supply and distribution. The modems can be deployed internationally (certificates of approval see “Technical Data”). As a rule, no certification is required for use in internal networks.

Application

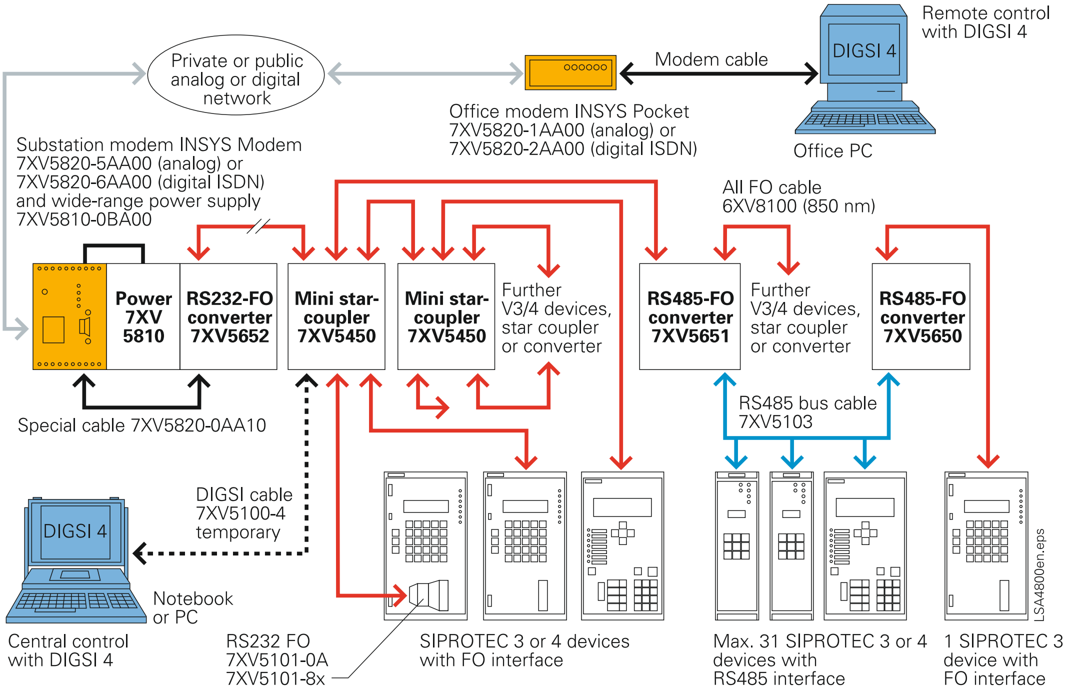


Fig. 13/70 Remote control of SIPROTEC 3 and 4 devices over INSYS Pocket to INSYS Modem, mini star-coupler or RS485 bus with DIGSI 4

Example 1: Remote operation of SIPROTEC 3 devices via modem

This application example illustrates remote operation of SIPROTEC 3 protection devices with an optical interface and compact protection devices with an RS485 interface using analog modems (7XV5820-1 and -5) or digital ISDN modems (7XV5820-2 and -6). Connection to protection or bay control RTUs via an optical interface is achieved with a star configuration using cascadable star couplers. The compact protection devices with RS485 interface are connected via a FO-RS485 converter and the RS485 bus system 7XV5103. SIPROTEC 4 devices may be connected optically or electrically, depending on the available service interface.

To ensure secure lightning protection, galvanic separation between the substation modem and the protection devices must be implemented by means of an optical barrier. The substation modem with the 7XV5652 RS232-FO converter is preferably located in a communication or control room while the 7XV5450 star coupler or 7XV5650/51 FO-RS485 converter is located in the first protection cubicle. If the protection devices are to be controlled centrally in the substation using a notebook, this is achieved by plugging a DIGSI cable into the first star coupler, which disables the optical interface and enables the RS232 connection.

Communication with the modems is transparent. Secure data transfer to the SIPROTEC 3 devices is achieved with the data format 8E1 (with parity bit). The data transmission rate depends on the slowest device (9.6 kbit/s or 19.2 kbit/s) and must be set to be equal for all devices. The SIPROTEC 4 devices can then only be operated with this data rate which is relatively slow for SIPROTEC 4.

Application

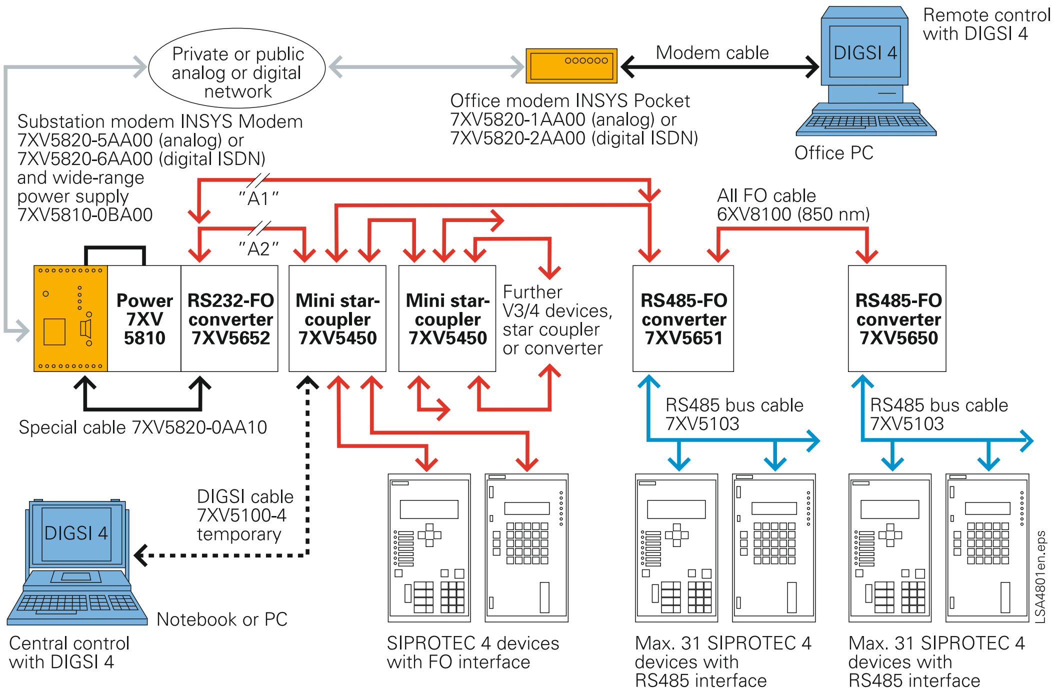


Fig. 13/71 Remote control of SIPROTEC 4 devices over INSYS Pocket to INSYS Modem, mini star-coupler or RS485 bus with DIGSI 4

Example 2: Remote operation of SIPROTEC 4 devices via modem

This application example illustrates remote operation of SIPROTEC 4 devices with an optical or RS485 interface via analog modems (7XV5820-1 and -5) or the very much faster digital ISDN modems (7XV5820-2 and -6). Connection of the protection or RTU devices with optical interface is achieved via cascadable star couplers. The devices with RS485 interfaces are connected via the FO-RS485 converter and the RS485 bus system 7XV5103.

To ensure secure lightning protection of the RS485 bus, galvanic separation should always be implemented between the substation modem and the protection devices by means of an optical barrier. The substation modem with the RS232-FO converter 7XV5652 is preferably located in a communication or control room while the first FO-RS485 converter 7XV5651/50 is located in the first protection cubicle ("A1").

If the protection devices are to be centrally controlled in the substation, an additional star coupler must be used ("A2"). By plugging the DIGSI cable into the first star coupler, the optical interface is disabled and the RS232 connection is established. If no mini star coupler is used, central operation is only possible via the electrical interface of the RS232-FO converter. The modem plug must be disconnected for this purpose.

A secure communication via the modems is possible with the standard data format 8N1, with data compression and error correction. The data transmission rate is determined by the slowest device (38.4 kbit/s or 57.6 kbit/s) and must be set to be the same on all devices.

Application

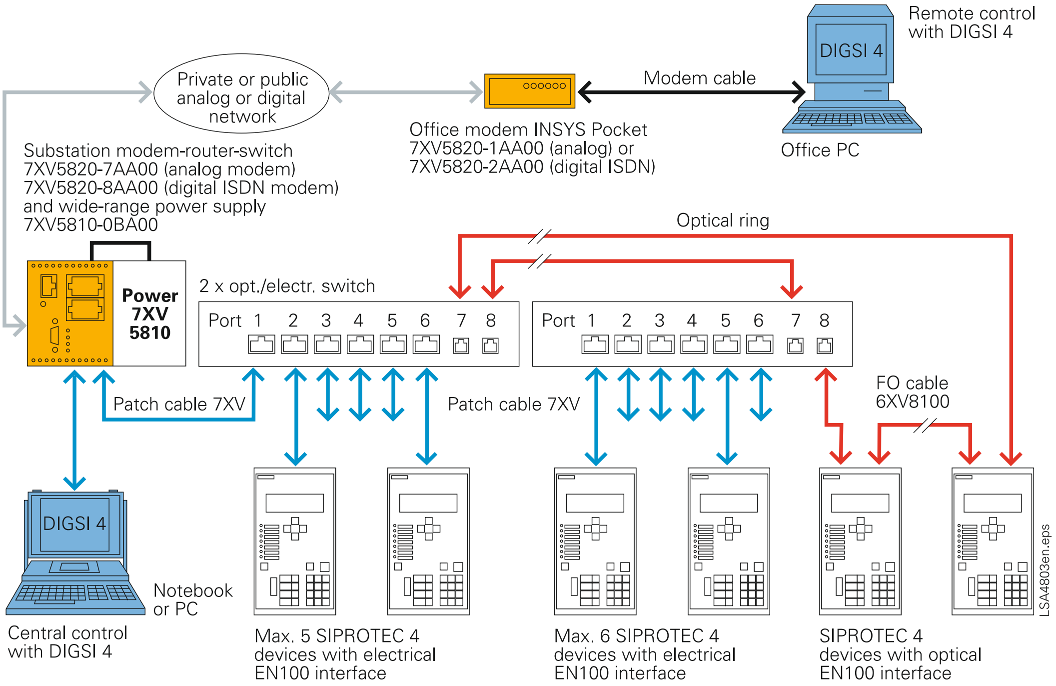


Fig. 13/72 Remote control of SIPROTEC 4 devices with EN100 Ethernet module with DIGSI 4 over INSYS Pocket Modem/ISDN to INSYS Modem/ISDN router with switch and external optical/electrical Switch

Example 3: Remote operation of SIPROTEC 4 devices with Ethernet interfaces via a modem-router

This application example shows remote operation of SIPROTEC 4 protection devices with an optical or electrical EN100 Ethernet interface via an analog or digital ISDN office modem, (7XV5820-1 or -2), to a modem or digital ISDN router (7XV5820-7 and -8). This router with an integrated 4-way switch together with the RUGGETCOM switches connected via a patch cable form a local subnet.

The protection or RTU devices with optical EN100 interface are connected to the RUGGETCOM switches in a ring structure. The protection / RTU devices with an electrical EN100 interface are directly connected to the modem-router and switch or to the electrical interfaces of the RUGGETCOM switches by means of double-shielded patch cables. To minimize any possible interference, the electrical connections with patch cables should be kept as short as possible.

Remote connection from the office to the substation is established by means of a password-protected DUN connection under Windows. The connection is then “transparent” and the protection devices can be operated with DIGSI 4 in the local subnet with their own IP addresses.

If the protection devices are to be conveniently centrally controlled using a notebook in the substation, the notebook with an Ethernet interface can be logged into the local subnet with a patch cable.

Secure communication via modems is performed at 57.6 kbit/s, with standard data format 8N1 with data compression and error correction.

7XV5810-1AA00 and 7XV5820-2AA00 INSYS Pocket Modem

Description

Data communication in the private, commercial and industrial applications is becoming ever more important.

INSYS Pocket Modem 56k and INSYS Pocket ISDN TA fascinate with their sophisticated engineering and their shapely compact metal housing.

The devices are ideal as remote stations for our DIN rail series.

Fig. 13/73 7XV5810/7XV5820 pocket modem

Technical Data

Modem	***7XV5820-1AA00***	***7XV5820-2AA00***
Network interface, line requirement	Analog telephone network	ISDN net, S0/I.430 Euro ISDN DSS1
Data transmission rate	Up to 56 kbits/s	64 kbit/s
Software update	Flash	Flash
Approvals	R & TTE, CTR21	R & TTE, CTR3
Application	For international use	Europe
Standards	Developed according to CE directives, manufactured according to ISO 9002	Developed according to CE directives, manufactured according to ISO 9002
Features		
Configuration	Remote configuration, AT commands	Local, via PC terminal, remote via ISDN
Connection	Auto answer mode, hardware-handshake Speed adjustable, sleep mode, auto-bauding, display caller ID	Auto answer mode with optional phone number verification
Data format	10 and 11 bit: 7E1, 7O1, 7N2, 7E2, 7O2, 8N1, 8E1, 8O1, 8N2	B channel: V.110, X.75, V.120, X.25/X.31, HDLC (PPP), T70NL, T90NL D channel: 1TR6 DSS1, VNx
Protocols	V.92, V.90, V.34+, V.34, V.32bis, V.32, V.23, V.22bis, V.22, V.21, Bell Norm 103/212, Fax class 1/2	–
Compression	MNP5, V.42 bis, MNP 10, 10 EC, V.44	–
Error correction	MNP 2/3/4 and V.42	–
Security functions	Security call-back, alarm transmission, SMS to fixed network or as fax over AT command, selective call answer, line-in-use detection, selectable key-abort	Access protection via approved phone number (accessable), password protection of remote configuration
Electrical features		
Power supply	9 ... 10 V DC (with plug power supply 230 V AC)	5 V DC (with plug power supply 100 to 230 V AC)
Consumption	Approx. 140 mA DC	Max. 100 mA at 5 V/500 mW
Interface to application	RS232, 9-pin SUB-D jack	RS232, 9-pin SUB-D jack
Interface to network	RJ-12 (Western)	RJ-45 connector
Physical features		
Size in mm (w x d x h)	71 x 128 x 22	71 x 128 x 22
Temperature range	0 to 55 °C	0 to 55 °C
Humidity	0 to 95 % (non-condensing)	0 to 95 % (non-condensing)

Fig. 13/74 7XV5820 modem

7XV5820 INSYS Modem 56k Profi
7XV5820 INSYS ISDN TA Profi

Description

With the INSYS Modem 56k Profi any application can be connected to the analog telephone network, which is available worldwide. The INSYS ISDN 4.0 can easily be connected to the digital ISDN network.

Both modems enhance pure data communication with alarming and security functions: alarms with a user-defined text as an SMS, fax or e-mail are triggered by digital inputs. Data connections (INSYS Modem 56k) and remote control are protected by passwords. The INSYS 56k modem establishes a connection only to a predefined number in response to an incoming call if the security call-back is activated. Selective call answer allows only data calls from specified numbers.

The digital outputs can be controlled remotely. The INSYS 56k modem controls these outputs by data connection as well as by DTMF tones from a tone dial phone. The digital outputs can be configured to display the connections status.

Technical data

Modem	***7XV5820-5AA00***	***7XV5820-6AA00***
Network interface	2-wire leased or dial-up line	S0/1.430 Euro ISDN network, DSS1
Data transmission rate	Max. 56 kbit/s	Max. 68 kbit/s (channel building 128 kbit/s)
Digital in-/outputs	2 alarm inputs/2 control outputs	
Watchdog	Yes	–
Software update	–	Flash update
Approvals	–	R & TTE, CTR3
Application	–	Europe
Standards	–	Developed according to CE directives
Features		
Configuration	AT commands via serial line, remote configuration	AT commands, configuration over serial line, remote configuration, CAPI
Connection	Auto-answer mode, idle connection ctrl, auto-bauding, number storage, hard-/software handshake	
	International settings, caller ID presentation, SMS to fixed-line telephone network, fixed serial speed, sleep mode	
Alarm functions	Triggered by alarm input or AT command: send SMS, (send fax and collective fax message 7XV5820-5AA00), establish data connection, transmit message over data connection	
Output control	AT command (local & remote) DTMF	AT command, configurator, connection status
Security functions	Password protection for connection, remote control and security callback	
	Selective call answer, watchdog	Number identification (CLIP)
Data formats	10 and 11 bit: 7E1, 7O1, 7N2, 7E2, 7O2, 8N1, 8E1, 8O1, 8N2	
	Bit transparent	
Protocols, error correction, compression	V.32bis, V.32, V.23, V.22, V.22bis, V.21, V.34+, V.90, V.92, Bell Norm 103/212, Fax Class ½, MNP 2/3/4, V.42, MNP 10, MNP 10 EC, MNP 5 V.42bis	B channel: X.75, X.25/X.31, HDLC/PPP, V.110, V.120 asynchronous; D channel: X.31
Electrical features		
Supply voltage	10 to 60 V DC	10 to 60 V DC
Current consumption	Transmission: 200 mA (at 12 V) Standby: 160 mA (at 12 V)	40 mA
Inuts/outputs	SPDT (single-pole double-throw) switches by galvanically isolated relays, max. voltage 30 V DC/42 V AC, max. current: 1 A DC/0.5 A AC	
Serial line speed	300 bit/s to 115.2 kbit/s	1.2 to 230.4 kbit/s
Physical features		
Housing size	55 x 110 x 75 (w x d x h) in mm	
Ambient temperature	0 to 55 °C	0 to 70 °C
Humidity	0 to 95 % (non-condensing)	0 to 90 % (non-condensing)

7XV5820-7/-8AA00
Modem-Router-Switch (MoRoS)

Description

Modem-**Ro**uter-**S**witch by INSYS combines a modem, a router and a 4-port switch. The dial-in and dial-out functionality enables remote maintenance and operation of devices in an Ethernet network.

The MoRoS device is available with an integrated analog modem or with ISDN-TA. The integrated 4-port switch allows for direct connection of up to four network devices. The MoRoS device has an international 56k modem for global application. The configuration of the MoRoS device is easy and fast via a web interface.

MoRoS by INSYS is a device that combines modem, router and switch functions for the remote maintenance of Ethernet-enabled products, e.g. PLC, HMI, etc.

Fig. 13/75 7XV5820 Modem-Router-Switch (MoRoS)

Function overview

- Integrated communication module (analog modem or ISDN-TA)
- Dial-in
- Dial-out (dial-on-demand)
- 4-port switch with 10/100 Mbits/s
- DHCP server and client
- Integrated configuration interface with help function
- Authentication for up to 10 users (dial-in)
- Dialing filter for dial-out
- Authentication via PAP, CHAP, MS-CHAP, MS-CHAP 2
- Easy configuration
- Local or remote configuration
- Firmware update (local and remote)
- 2 digital inputs and outputs
- Buffered RTC (real time clock)
- Full NAT
- DNS relay
- Serial Ethernet Server 1)
- VPN 1)
- Firewall 1)

1) version MoRoS PRO only

Technical data

Modem	***7XV5820-7/-8AA00 MoRoS***
Certifications	R & TTE, CTR2 (dial-up line), CTR3 (ISDN), CE
Dial-up line	Transmission rate 56 kbits/s
ISDN	Transmission rate 64 kbits/s
Configuration	Web interface, AT command (via web interface), local and remote
Router	
Function	Dial-in, dial-out
Authentication	10 users for dial-in, authentication via PAP, CHAP, MS-CHAP, MS-CHAP 2
Dialing filter (dial-out)	Filtering of IP addresses and/or ports
Configuration	Web interface, AT command (via web interface), local and remote
DHCP server and client	
Watchdog (ext. hardware watchdog)	
RTC (buffered real time clock)	
Full NAT	
VPN 1)	
Firewall 1)	
Serial Ethernet server 1)	
Switch	
Ports	4
Operating mode	10/100 Mbits/s for full and half duplex operation
Auto detect	Automatically recognizes patch and cross-over cables; automatic speed adjustment
Configuration	
Web interface	Local/remote
Additional features	Digital inputs and outputs, firmware update local/remote
Supply	
Voltage	10 V to 60 V DC
Power input	Approx. 2.5 W (during connection)
Physical features	
Housing size	70 x 110 x 75 mm
Operating temperature	0 to 55 °C
Humidity	0 to 95 % (non-condensing)
Weight	10.58 oz

Selection and ordering data

Description	Order No.
7XV5820 modem/modem-router	*7XV5820-□AA00*
Analog Pocket Modem 56k Desktop device, with plug-in power supply 230 V AC	*1*
Digital Pocket Modem ISDN 64k Desktop device, with plug-in power supply 100 to 230 V AC	*2*
Analog Modem 56k for DIN rail-mounting, power supply 10 to 60 V DC	*5*
Digital Modem ISDN 64k for DIN rail-mounting, power supply 10 to 60 V DC	*6*
Analog Modem-Router with 4-way switch for DIN rail-mounting, power supply 10 to 60 V DC	*7*
Digital ISDN Router with 4-way switch for rail-mounting 10 to 60 V DC	*8*
Modem/Modem-Router Accessories	*7XV5820-0AA10*
Data cable from modem to 7XV5300, 7XV5450, 7XV5550, 7XV5652 2 x SUB-D connector, 9-pin female, length 2 m	

7XV5850
Ethernet Modems for Office Applications

Fig. 13/76
7XV5850 Ethernet modem

Function overview

- DIGSI supports the administration and the setting-up of connections via the Ethernet network.
- RS232 interfaces for data transfer and configuration of the modem.
- Serial baud rate and data format (RS232) for the terminal devices is selectable from 2400 Bd up to 57.6 kBd with data format 8N1, 8E1.
- An Ethernet interface LAN to the 10/100 Mbit network.
- Better security with password protection and IP address selection is possible.

Description

A control PC and protection units can exchange serial data via an Ethernet network using two Ethernet modems 7XV5850 and 7XV5655. Connection to the Ethernet modem is in each case made via the asynchronous serial interface of the terminal units. In the modem, the serial data is packed into the secure IP protocol as information data, and is transferred between the modems using the Ethernet connection. Conformity with the standard and gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams via the network is ensured by the modem which receives the serial telegram communication and packs the serial IEC telegrams into blocks for communication via the Ethernet. The data is transmitted in full duplex mode; serial control wires are not supported. Connec- tion is established between the IP address of the dialing modem in the office and the IP address of the pick-up modem in the substation, and is configured prior to dialing up with DIGSI by means of AT commands via the RS232 interface.

The substation modem may be configured to have password protection, and provides the additional security feature, whereby access is only permitted from defined IP addresses, e.g. only that of the office modem. The modem is accessed with DIGSI Remote like a normal telephone modem with the exception that instead of telephone numbers, IP addresses are assigned by the network administrator for each modem.

Application

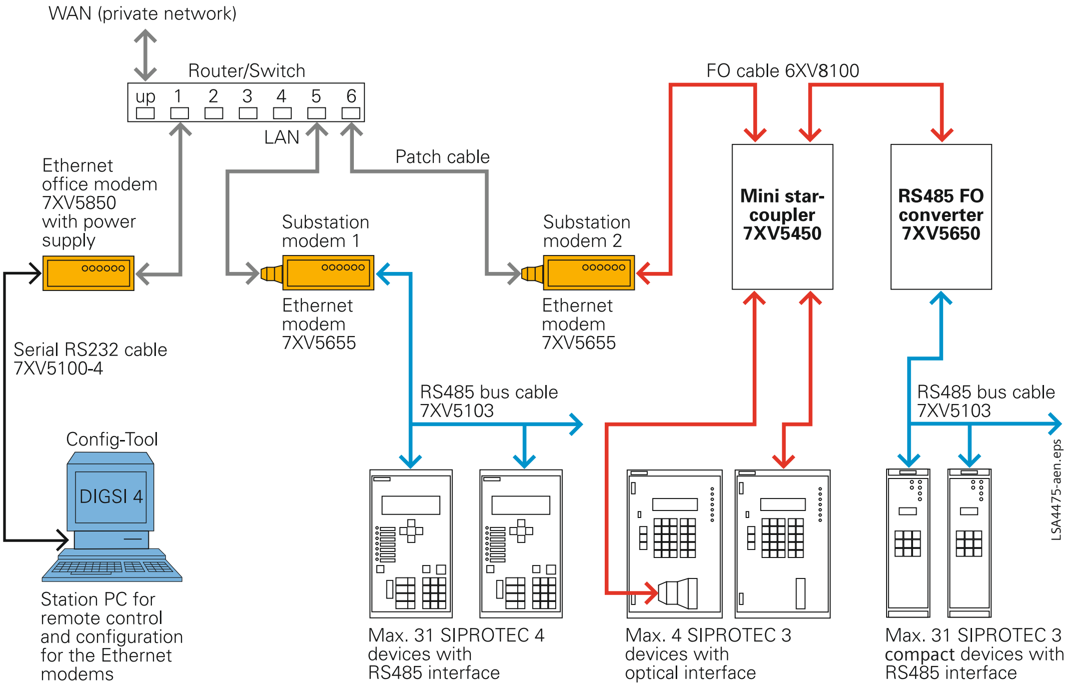


Fig. 13/77 Operation of various SIPROTEC protection unit generations via Ethernet modems

Using the office computer and DIGSI 4, both substation 1 and 2 may be dialed up via Ethernet modems. A TCP/IP point-to-point data connection is established between the office modem and corresponding substation modem when dialed up via the network. This is maintained until the office modem terminates the connection. The serial data exchange takes place via this data connection, with the modem converting the data from serial to Ethernet with full duplex mode. Between the office modem and the office PC, the highest baud rate is always used, e.g. 57.6 kB for SIPROTEC 4 units. The serial baud rate of the substation modem is adapted to the baud rate required by the protection relays, e.g. substation modem 1 with 57.6 kB for SIPROTEC 4 and substation modem 2 with 9.6 kB for SIPROTEC 3 units. These settings are only defined once in the modem. The Ethernet modems are integrated in DIGSI 4 similar to telephone modems. Instead of the telephone number, the preset IP address assigned to the modem is selected.

If later an Ethernet connection is available in the substation, the existing modem can be replaced by an Ethernet modem. The entire serial bus structure and cabling may remain unchanged.

Technical data

Connections

RS232 interface 9-pin, SUB-D connector
Ethernet 10BaseT, 10/100 Mbit, RJ45
Power supply (see below)

Desktop device for office use 7XV5850-0AA00

Housing	Desktop housing, plastic, charcoal grey, 46 x 109 x 74 (W x H x D) in mm
Supply	Wide-range plug-in power supply, auxiliary voltage 100 – 240 V AC
Scope of supply	With RS232 cable for Notebook/PC. With Ethernet cable (cross-over) 2 m

Indication (8 x LED)

Power	Operating voltage o.k.
RS232 TxD	Transmitting data to RS232
LAN Tx	Transmitting data to LAN
Error	Error on RS232
System	RS232 connection established
RS232 RxD	Receiving data from RS232
LAN Rx	Receiving data from LAN
Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
Ethernet Modem	*7XV5850 - 0AA00*
Ethernet modem for serial, asynchronous transmission of data up to 57.6 kbit via the 10/100 Mbit Ethernet and configuration software Desktop device (office version) Connection to Ethernet via RJ45 connector, serial connection SUB-D 9-pin socket including wide-range power supply 100/240 V AC With cross-over Ethernet patch cable 2 m for configuration With serial connection cable to PC 2 m	

Accessories for Communication

6XV8100 F.O. Cable

Selection and ordering data

Description	Order No.
F.O. cable for indoor application with FSMA or ST connectors	*6XV8100-0DA☐ 1-0A☐☐* 1)

Plastic F.O. link cable W/2 Fibers for links inside a cubicle,
fiber type PMMA S980/1000PE-insulation diam. = 2.2 mm black good resistance to oil, petrol, acid and leach, cable for simple systems of loads,
base material L46916-U2-U19, V-2x 1S980/1000PE

Connector	
Not used	
Not used	
Both sides with FSMA connectors prefabricated	*2*
Not used	
Both sides with ST connectors prefabricated	*4*
Not used	

F.O. duplex cable for indoor and outdoor application with FSMA , LC or ST connectors	*6XV8100-0BD☐ 1-☐☐☐☐* 1)

Fiber-optic duplex data line for in- and outdoors, 2 break-out elements
fiber type glas 62.5/125 μm, halogen-free and flame-retardant, non-metallic rodent prot.
external diam. = 8.3 mm, black; internal diam. = 1.8 mm, orange;
base material L46900-G2-J1, AT-VHBH 2G62.5/125 3.2B200/0.9F500

Connector	
None	*0*
One side with FSMA connectors	*1*
Both sides with FSMA connectors	*2*
One side ST, other side LC connectors	*3*
Both sides with ST connectors	*4*
One side FSMA, other side ST connectors	*5*
Both sides with LC connectors	*6*

F.O. duplex cables for indoor application with FSMA , LC or ST connectors	*6XV8100-0BE☐☐-☐☐☐0* 1)

Fiber-optic duplex data line for indoors, 2 break-out elements
fiber type glas 62.5/125 μm, halogen-free and flame-retardant,
internal diam. = 1.7 mm, orange; external diam. = 2.8 x 4.5 mm, orange;
base material I-VHH 2 x 1 x G62.5/125

Connector		
Without	*0*	*1*
One side with FSMA connectors	*1*	*1*
Both sides with LC connectors	*1*	*4*
One side ST, other side LC connectors	*1*	*7*
Both sides with FSMA connectors	*2*	*1*
Both sides with ST connectors	*4*	*1*
One side FSMA, other side ST connectors	*5*	*1*

---

1) For complete Order No. visit www.siemens.com/siprotec

Accessories for Communication

6XV8100 F.O. Cable

Selection and ordering data

Description	Order No.
F.O. duplex cables for indoor and outdoor application with MTRJ and ST connectors	*6XV8100-0BF☐ 1-☐☐A☐* 1)

Fiber-optic duplex data line for in- and outdoors, 2 break-out elements
fiber type glas 62.5/125 μm, halogen-free and flame-retardant, non-metallic rodent prot.
external diam. = 8.3 mm, black; internal diam. = 1.8 mm, orange;
base material AT-VHBH 2G62.5/125

Connector

One side with MTRJ connector, other side prepared for ST connector	*2*
Both sides with MTRJ connector	*3*

F.O. duplex cables for indoor application with MTRJ and ST connectors	*6XV8100-0BG☐ 1-☐☐☐0* 1)

Fiber-optic duplex data line for indoors, 2 break-out elements
fiber type glas 62.5/125UM, halogen-free and flame-retardant
internal diam. = 1.7 mm, orange; external diam. = 2.8 x 4.4 mm, orange;
base material I-VHH 2 x 1 x G62.5/125

Connector

One side with MTRJ connector, other side prepared for ST connector	*2*
Both sides with MTRJ connector	*3*

7KE600 Ethernet Patch Cable

Selection and ordering data

Description	Order No.
Ethernet patch cable with double shield (SFTP) LAN connector on both sides	*7KE6000-8GD0☐-☐AA☐*

SIMEAS R <----> HUB
HUB <----> PC

Length 0.5 m	*0*	*0*	*5*
Length 1.0 m	*0*	*1*	*0*
Length 2.0 m	*0*	*2*	*0*
Length 3.0 m	*0*	*3*	*0*
Length 5.0 m	*0*	*5*	*0*
Length 10.0 m	*1*	*0*	*0*
Length 15.0 m	*1*	*5*	*0*
Length 20.0 m	*2*	*0*	*0*

Ethernet patch cable, cross-over connection with double shield (SFTP) LAN connector on both sides	*7KE6000-8GE0☐-☐AA☐*

HUB <----> HUB
SIMEAS R <----> PC

Length 0.5 m	*0*	*0*	*5*
Length 1.0 m	*0*	*1*	*0*
Length 2.0 m	*0*	*2*	*0*
Length 3.0 m	*0*	*3*	*0*
Length 5.0 m	*0*	*5*	*0*
Length 10.0 m	*1*	*0*	*0*
Length 15.0 m	*1*	*5*	*0*
Length 20.0 m	*2*	*0*	*0*

---

1) For complete Order No. visit www.siemens.com/siprotec

Test Equipment and Accessories

Page

7XV75 Test Switch

Fig. 14/1 7XV75 test switch

Description

The 7XV75 test switch serves for testing protection relays including CT circuits and command contacts. With the help of the switches located on the front side, the current and voltage inputs as well as the circuits of the protection relay to be tested are interrupted and applied to the front side. Via this plug-in connector, currents and voltages can be fed by an injection test set and the different commands and indications can be tested.

Function overview

The following versions are available in a flush-mounting housing:

- For feeder protection without an open star point
- For feeder protection without an open star point and with additional contacts
- For feeder protection without an open star point for two CT cores or separate earth-fault CT
- For feeder protection with an open star point
- For feeder protection with an open star point and independently switchable trip and CT circuits
- For a 3-winding transformer differential protection
- For feeder protection without an open star point with 4th CT and 4th VT input (three-stage test switch)

Technical data

Test switch	
Rated operating voltage V_n	400 V AC
Rated operating current I_n	6 A
Test current capacity	for 1 s 150 A for 10 s 60 A
Unit design	
Metal housing	7XP20
Dimension	1/6 of 19” wide
Weight	Approx. 3.4 kg

Selection and ordering data

Description	Order No.
7XV75 test switch	*7XV750☐-☐CA00*
Without open star point for feeder protection	*0*
With open star point for feeder protection	*1*
For 3-winding transformer differential protection	*2*
Without open star point for two CT cores or separate earth-fault CT	*3*
Without open star point for feeder protection with 4th CT and 4th VT input (three-stage test switch)	*6*
Without open star point for feeder protection and with additional contacts	*7*
With open star point and independently switchable trip and CT circuits for feeder protection	*8*
Front test plug connection	
With 16-pin Harting connector	*0*
With 16 banana connectors (not available for 7XV7506)	*1*
Connecting cable 7XV6201 for 7XV75 test switch with 2 meter cable	
with 16-pin Harting connector and 17 isolated banana connectors 4 mm with cable marks	*7XV6201-5*
with 16-pin Harting connector and 17 cable end sleeves with cable marks	*7XV6201-6*

7PA22/23
Auxiliary Relays for Various Applications

Fig. 14/2 7PA2 auxiliary relays

Description

Due to their quality, reliability and design, these relays are optimal for applications requiring high reliability and availability such as power stations, substations, railway and industrial plants. Typical examples include petrochemical industry, chemical industry, cement industry, rolling mills etc.

The relays comply with the IEC, EN, IEEE standards (type and routine test) and bear the CE mark.

The robust switch contacts are characterized by high make/break capacity, overload capability and continuous current intensity capacity; thus perfect insulation is obtained. Direct control of high-voltage and medium-voltage switchgear is possible.

Their high degree of protection and the transparent cover ensure reliable operation in tropical and/or salty sea air ambient conditions.

Technical data for 7PA22 and 7PA23

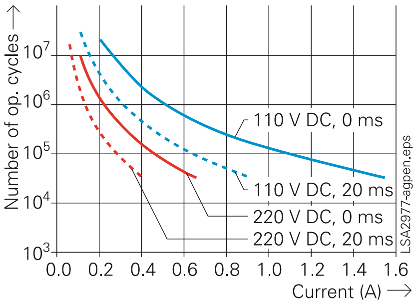
Switching contacts	
Continuous current	10 A
Overload capability	80 A/200 ms 150 A/10 ms
Switching current/voltage	40 A/0.5 s/110 V DC

Breaking capacity for 10^5 operating cycles

	Non-inductive		Inductive, 20 ms	
	1 contact	2 contacts in series	1 contact	2 contacts in series
V DC	A	A	A	A
24	6.6	12.7	3.2	6.0
60	2.6	4.9	1.4	2.7
125	1.2	2.2	0.6	1.1
220	0.6	1.1	0.3	0.6

For details see characteristics

V_{max}, open contact	250 V DC/400 V AC
Mechanical service life	10^7 operating cycles
Operating temperature	- 10 °C to + 55 °C 14 °F to 131 °F
Max. permissible humidity	93 % at 40 °C/104 °F
Seismic stress class according to IEEE 501	
Degree of ZPA	3 *g* acceleration at 33 Hz



Standards

Electrical tests performed according to IEC 60255

- Dielectric test	2 kV/50 Hz/ 1 min
- Surge withstand test	5 kV/1.2/50 µs
- Insulation	> 2000 MΩ/ 500 $V_{peak-to-peak}$

Flammability tests according to IEC 60692-2-1

Plastic materials	UL 94: VO, IEC 60695: 850 °C/30 s 1562 °F/30 s
Degree of protection acc. to IEC 60529	Relay: IP 40 With socket cover: IP 50

Climatic stress test according to

- IEC 60255-7 dry heat	Non-dissipating unit +70 °C/96 h 158 °F/96 h Dissipating unit +55 °C/96 h 131 °F/96 h
- IEC 60068-2-30 cyclic humid heat	+55 °C/12 h 131 °F/12 h
- IEC 60068-2-1 cold	100 cycles Non-dissipating unit -10 °C/2 h 14 °F/2 h
- IEC 60255-7 thermal aging test	At rated voltage V_N +55 °C/1440 h 131 °F/1440 h

7PA22
Fast-acting lockout relay

Description

The bistable 7PA22 is a fast-acting lockout relay with eight changeover contacts and is plugged into a mounting frame equipped with a plug-in socket (type 7XP9010) with screw-type terminals at the rear.

Functions

No continuous power consumption. Position indication on the front side. Mechanical reset pushbutton.
Position memory with two positions (e.g. for yes/no, open/close, auto/manual, local/remote etc.).

Technical data

While the auxiliary voltage is being supplied to the SET coil, the reset pushbutton must not remain pushed longer than 20 s.

Rated voltages and consumption

V_N	Voltage range	Consumption while switching
V DC	V DC	
24	19 – 26	≤ 48 W
30	24 – 33	
60	48 – 66	
110	88 – 121	
125	100 – 137	
220	176 – 242	

Pick-up time: < 10 ms

General description see page 14/5.
Refer to part 15 for dimension drawings.

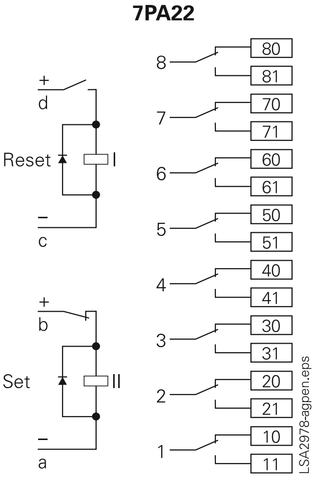


Fig. 14/3 Connection diagram

Selection and ordering data

Description	Order No.
7PA22 fast-acting lockout relay	*7PA22☐1-☐*
Auxiliary voltage	
24 V DC	*1*
60 V DC	*2*
110 V DC	*3*
220 V DC	*4*
125 V DC	*5*
30 V DC	*6*
Socket	
without socket	*0*
with flush-mounting socket 7XP9010-1	*1*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9010-1*
Surface mounting	*7XP9012-0*

7PA23
Fast-acting lockout relay

Description

The bistable 7PA23 is a fast-acting lockout relay with four changeover contacts and is plugged into a mounting frame equipped with a plug-in socket (type 7XP9011) with screw-type terminals at the rear.

Functions

No continuous power consumption. Position indication on the front side. Mechanical reset pushbutton.
Position memory with two positions (e.g. for yes/no, open/close, auto/manual, local/remote etc.).

Technical data

While the auxiliary voltage is being supplied to the SET coil, the reset pushbutton must not remain pushed longer than 20 s.

Rated voltages and consumption

V_N	Voltage range	Consumption while switching
V DC	V DC	
24	19 – 26	≤ 24 W
30	24 – 33	
60	48 – 66	
110	88 – 121	
125	100 – 137	
220	176 – 242	

Pick-up time: < 8 ms
General description see page 14/5.
Refer to part 15 for dimension drawings.

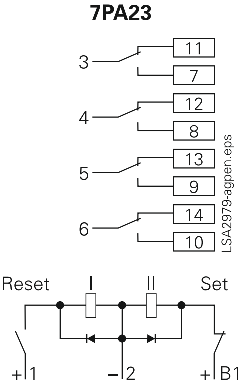


Fig. 14/4 Connection diagram
Contacts represented in position RESET

Selection and ordering data

Description	Order No.
7PA23 fast-acting lockout relay	*7PA23☐1-☐*
Auxiliary voltage	
24 V DC	*1*
60 V DC	*2*
110 V DC	*3*
220 V DC	*4*
125 V DC	*5*
30 V DC	*6*
Socket	
without socket	*0*
with flush-mounting socket 7XP9011-1	*1*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9011-1*
Surface mounting	*7XP9013-0*

7PA26/27/30
Auxiliary Relays for Various Applications/Trip Circuit Supervision

Fig. 14/5 7PA2 auxiliary relays

Description

Due to their quality, reliability and design, these relays are optimal for applications requiring high reliability and availability such as power stations, substations, railway and industrial plants. Typical examples include petrochemical industry, chemical industry, cement industry, rolling mills etc.

The relays comply with the IEC, EN, IEEE standards (type and routine test) and bear the CE mark.

The robust switch contacts are characterized by high make/break capacity, overload capability and continuous current intensity capacity; thus perfect insulation is obtained. Direct control of high-voltage and medium-voltage switchgear is possible.

Technical data for 7PA26 and 7PA27

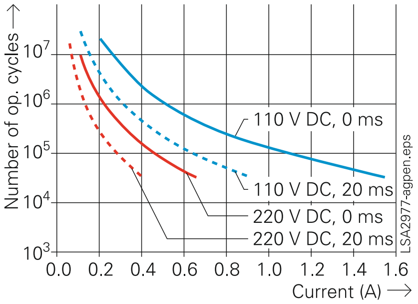
Switching contacts	
Continuous current	10 A
Overload capability	80 A/200 ms 150 A/10 ms
Switching current/voltage	40 A/0.5 s/110 V DC

Breaking capacity for 10^5 operating cycles

	Non-inductive		Inductive, 20 ms	
	1 contact	2 contacts in series	1 contact	2 contacts in series
V DC	A	A	A	A
24	6.6	12.7	3.2	6.0
60	2.6	4.9	1.4	2.7
125	1.2	2.2	0.6	1.1
220	0.6	1.1	0.3	0.6

For details see characteristics

V_{max}, open contact	250 V DC/400 V AC
Mechanical service life	10^7 operating cycles
Operating temperature	- 10 °C to + 55 °C 14 °F to 131 °F
Max. permissible humidity	93 % at 40 °C/104 °F



Technical data for 7PA30

Contacts	
Permanent current	8 A
Instantaneous current	15 A
Making capacity	15 A/4 s/110 V DC
Breaking capacity	0.3 A/110 V DC
U_{max} opened contact	250 V DC/400 V AC
Mechanical life	10^7 operations
Operating temperature	-10 °C +55 °C
Storage temperature	-30 °C +70 °C
Operating humidity	93 %/40 °C

Standards

Electrical test performed acc. to IEC 60255-5	
Dielectric test	2 kV / 50 Hz / 1 min
Surge withstand test	5 kV / 1.2 / 50 µs
Insulation	>100 MΩ / 500 V DC
Inflammability tests Plastic materials	UL94: VO
Degree of protection acc. to IEC 60529	Relay: IP40
Climatic stress test acc. to IEC 60068-2	
Dry cold, operation	- 10 °C
Dry heat, operation	+ 55 °C
Storage and transport	- 25 °C + 70 °C

Constructions standards (Cont'd)

Immunity test EMC

EN 60255-22-1	High frequency 1 MHz burst disturbance test: Test level: 1 MHz, 400 imp/s, 2 s Common mode: 2,5 kV Differential mode: 1 kV
EN 61000-4-4	Electrical Fast transient burst: Test level 4 kV, 2.5 kHz, 1 min · 2 kV, 5 kHz, 1 min
EN 61000-4-5	Surge 8/20 µs (current) 1.2/50 µs (voltage) Common mode: 2 kV- Differential mode: 1 kV
EN 61000-4-3	Radiated electromagnetic field: Test level: 80-1000 MHz, 10 V/m, 80 % AM (1 kHz)
EN 61000-4-3	Digital telephones radiated electromagnetic field: Test level: 900 ± 5 MHz, 10 V/m, 50 % (200 Hz) 1.89 GHz ± 10 MHz, 10 V/m, 50 % (200 Hz)
EN 61000-4-6	Conducted disturbances induced by radio frequency fields. Test level: 0.15-80 MHz, 10 V, 80 % AM (1kHz)
EN 61000-4-2	Electrostatic discharges: Test level: Contact ± 15 kV; Air mode ± 15 kV
EN 61000-4-8	Power frequency magnetic field: Test level: 100 A/m 1 min · 1000 A/m 1 s
EN 55011 Class A	Emission test: Test level: Cover: 30-230 MHz, 40 dB(µV/m) (quasi peak)-10 m 230-1000 MHz, 47 dB(µV/m) (quasi peak)-10 m Power supply: 0.15-0.5 MHz, 79 dB(µV) (quasi peak)/ 66 dB average val. 0.5-5 MHz, 73 dB(µV) (quasi peak)/ 60 dB average val. 5-30 MHz, 73 dB(µV) (quasi peak)/ 60 dB average val.

7PA26 Monostable fast-acting relay

Description

The monostable 7PA26 has eight changeover contacts.

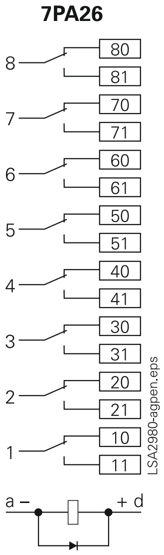


Fig. 14/6 Connection diagram

Technical data

Rated voltages and consumption

V_N	Voltage range	Consumption
V DC	V DC	mA
7PA26□20		
24/30	20 – 33	278
60	48 – 66	100
110/125	88 – 138	55
220	176 – 242	28

		Consumption	
7PA26□21		Normal	Peak
24/30	19 – 36	50	0.8 A|20 ms
60	42 – 72	20	
110/125	77 – 150	14	0.3 A|20 ms
220	154 – 264	7	

- Pick-up time: 7PA26□20 < 20 ms
  7PA26□21 < 10 ms
- Drop-out time: < 40 ms

General description see page 14/5.
Refer to part 15 for dimension drawings.

Selection and ordering data

Description	Order No.
7PA26 monostable relay with 8 changeover contacts	*7PA26□2-□AA00-□*
Auxiliary voltage	
24 /30 V DC	*1*
60 V DC	*2*
110/125 V DC	*3*
220 V DC	*4*
Standard, 20 ms	*0*
Fast, 10 ms	*1*
Socket	
without socket	*0*
with flush-mounting socket 7XP9010-3	*1*
with surface-mounting socket 7XP9012-0	*2*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9010-3*
Surface mounting	*7XP9012-0*

7PA27 Monostable fast-acting relay

Description

The monostable 7PA27 is a fast-acting relay with four changeover contacts.

Technical data

Rated voltages and consumption

V_N	Voltage range	Consumption Normal	Peak
V DC	V DC	mA	
24/30	19 – 36	28	1 A/20 ms
60	42 – 72	12	1 A/20 ms
110/125	77 – 150	8	0,3 A/20 ms
220	154 – 264	6	0,3 A/20 ms

- Pick-up time: < 8 ms
- Drop-out time: < 40 ms

General description see page 14/5.
Refer to part 15 for dimension drawings.

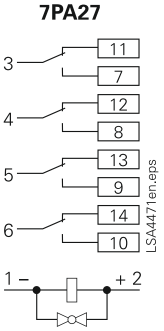


Fig. 14/7 Connection diagram

Selection and ordering data

Description	Order No.
7PA27 monostable fast-acting relay	*7PA27☐2-0AA00-☐*
Auxiliary voltage	
24 / 30 V DC	*1*
60 V DC	*2*
110 / 125 V DC	*3*
220 V DC	*4*
Socket	
without socket	*0*
with flush-mounting socket 7XP9011-2	*1*
with surface-mounting socket 7XP9013-0	*2*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9011-2*
Surface mounting	*7XP9013-0*

7PA30 Three-phase Trip circuit supervision

Description

The relay is for supervision of the trip circuit of a circuit breaker with three selective trip coils. The trip circuit wiring is supervised from the positive supply to the negative supply whilst the circuit breaker is open or closed.

Functions

The design, quality and rugged construction of the relay make it suitable for applications requiring high levels of reliability/dependability. The high degree of protection guarantees reliable operation over a wide temperature range, even under extreme environmental conditions.

The relay has been tested in accordance with IEC, EN and IEEE standards. The relay is CE marked. The supervision current is always less than 1.4 mA thus avoiding unwanted operation of the trip coil. Correct operation is shown via a green LED.

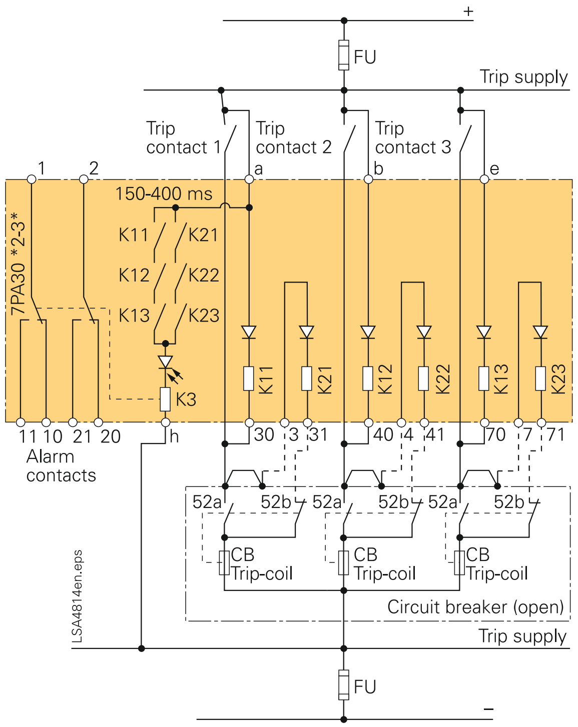


Fig. 14/8 Connection diagram for 3-phase relay

Standard voltages and consumption

V_N	Voltage range	Consumption	Impedance per phase	Pickup Drop out Voltage	
V DC	V DC	mA	kΩ/s	V DC	
24/30	18 - 33	35	20	between	12 and 18
60	42 - 66	20	44		36 and 42
110/125	77 - 138	20	94		66 and 77
220	154 - 275	15	200		132 and 154

Drop-out time: between 150 ms and 400 ms

Selection and ordering data

Description	Order No.
7PA30 trip circuit supervision (three-phase)	*7PA30□2-3AA00-□*
Auxiliary voltage	
24/30 V DC	*1*
60 V DC	*2*
110/125 V DC	*3*
220 V DC	*4*
Socket	
without socket	*0*
with flush-mounting socket 7XP9010-4	*1*
with surface-mounting socket 7XP9012-0	*2*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9010-4*
Surface mounting	*7XP9012-0*

7PA30 Single-phase Trip circuit supervision

Description

The relay is for supervision of the trip circuit of a circuit breaker with one trip coil. The trip circuit wiring is supervised from the positive supply to the negative supply whilst the circuit breaker is open or closed.

Functions

The design, quality and rugged construction of the relay make it suitable for applications requiring high levels of reliability/dependability. The high degree of protection guarantees reliable operation over a wide temperature range, even under extreme environmental conditions.

The relay has been tested in accordance with IEC, EN and IEEE standards. The relay is CE marked. The supervision current is always less than 1.4 mA thus avoiding unwanted operation of the trip coil. Correct operation is shown via a green LED.

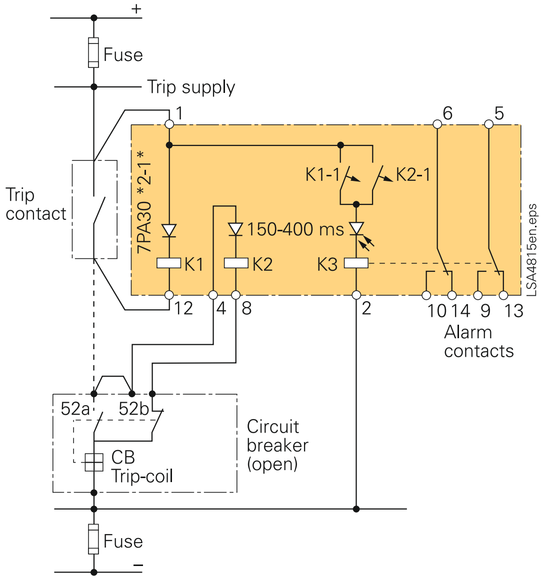


Fig. 14/9 Connection diagram for 1-phase relay

Standard voltages and consumption

V_N	Voltage range	Consumption	Impedance per phase	Pickup Drop out Voltage	
V DC	V DC	mA	kΩ/s	V DC	
14/30	18 - 33	32	20	between	12 and 18
60	42 - 66	18	44		36 and 42
110/125	77 - 138	18	94		66 and 77
220	154 - 275	13	200		132 and 154

Drop-out time: between 150 ms and 400 ms

Selection and ordering data

Description	Order No.
7PA30 trip circuit supervision (single-phase)	*7PA30☐2-1AA00-☐*
Auxiliary voltage	
24/30 V DC	*1*
60 V DC	*2*
110/125 V DC	*3*
220 V DC	*4*
Socket	
without socket	*0*
with flush-mounting socket 7XP9011-0	*1*
with surface-mounting socket 7XP9013-0	*2*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9011-0*
Surface mounting	*7XP9013-0*

7TS16 Annunciation Relay

Fig. 14/10 7TS16 annunciation relay

Description

The 7TS16 relay features auxiliary trip indication for local and remote signaling. It has four independent output contacts and LED indication. The relay complies with the IEC and EN standards and bears the CE mark.

The 7TS16 is a reliable and versatile high-speed relay with four signal inputs. It has four local LEDs and auto-resetting output contacts, used in SCADA controls. Additionally, it features two diode tripping circuits.

Reset is possible via remote input and via local reset push button.

The reset should not be permanently switched on.

Function overview

- Indications: Four LEDs, latching type, signaling until reset.
- Inputs: Four alarm/trip inputs
  - Input for remote reset
  - Push button for local reset
- Outputs: For each alarm/trip input:
  - One diode 2.5 A
  - One potential free changeover contact
  - One potential free NO contact
  - One common tripping output through diode (2.5 A; V_{max} 220 V DC)
- Contacts:
  - Permanent current 8 A
  - Instantaneous current 15 A
  - Making capacity 15 A /4 s /110 V DC
  - Breaking capacity 0.3 A /110 V DC

Technical data

- Rated voltages (V_N):
  24/30, 110/125, 220 V DC
- Voltage range V_N +10 % – 30 %
- Operating temperature -10 to +55 °C
- Operating humidity 93 %/40 °C
- Pickup time < 5 ms
- Consumption

For one trip

V_N	
24/30 V DC	1 A/3 ms
110/125 V DC	3 A/3 ms
220 V DC	4 A/3 ms

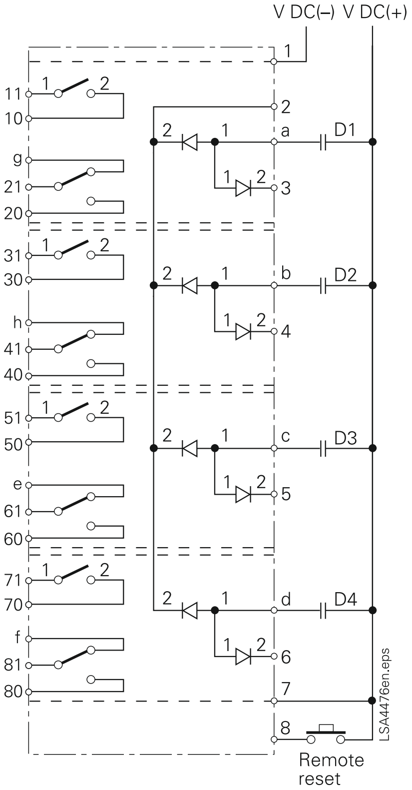
For a permanent trip

V_N	mA
24/30 V DC	21
110/125 V DC	8
220 V DC	6.5

For a latched LED

V_N	mA
24/30 V DC	1
110/125 V DC	3
220 V DC	5

Connection diagram



2	Direct common trip output
3, 4, 5, 6	Direct trip output
1(-), 7(+)	Auxiliary supply
D	External relay contact

Fig. 14/11 Connection diagram
Contacts represented without auxiliary supply in the relay

Standards

Electrical tests performed acc. to IEC 60255-5
- Dielectric test 2 kV/50 Hz/ 1 min
- Surge withstand test 5 kV/1.2/50 µs

High-frequency test acc. to IEC 60255-22-1
- Common mode 2.5 kV / 1 MHz
- Differential mode 1 kV / 1 MHz

Inflammability tests Plastic materials UL94: VO

Degree of protection acc. to IEC 60529 Relay: IP40

Climatic stress test acc. to IEC 60068-2
Dry cold, operation - 10 °C
Dry heat, operation + 55 °C
Storage and transport - 30 °C + 70 °C

Selection and ordering data

Description	Order No.
7TS16 annunciation relay with 4 LEDs	*7TS16☐2-0AA00-☐*
Rated auxiliary voltage	
24/30 V DC	*1*
110/125 V DC	*3*
220 V DC	*4*
Socket	
Without socket	*0*
With flush-mounting socket 7XP9010-2	*1*
With surface-mounting socket 7XP9012-0	*2*

Accessories

Socket as spare part	
Flush mounting	*7XP9010-2*
Surface mounting	*7XP9012-0*

3RV16 Voltage Transformer Circuit-Breaker

Fig. 14/12
3RV16 voltage transformer circuit-breaker

Function overview

Application

- Protection of voltage-transformer secondary circuits for the connection of protection relays with voltage-dependent starting element

Functions

- Auxiliary contact of 3RV16 prevents the distance protection tripping via the underimpedance starting in case of a fault in the voltage transformer circuits
- Tripping time of instantaneous element in few milliseconds

Construction

- Snap-on mounting on 35-mm mounting rail, or screw mounting

Description

The voltage transformer circuit-breaker protects the secondary side of voltage transformers used to connect protection relays with voltage-dependent starting. The switch is used for distance protection with low-impedance starting. Special auxiliary contacts reliably prevent low-impedance starting from triggering distance protection if only one error has occurred in the converter line.

The voltage transformer circuit-breaker can also be used to safely disconnect the distance protection relay from the voltage transformer. In this case the special auxiliary contacts also prevent erratic triggering of the distance protection.

Additional fuses are not required. A “Fuse Failure Monitor” (FFM) is also not required.

The circuit-breakers are snap-mounted on a 35-mm mounting rail to EN 50022. Push-in lugs are available for screw-type connection of the circuit-breakers.

The circuit-breaker for voltage transformers also incorporates 2 auxiliary contacts (normally 1 NO + 1 NC). During the closing operation, contact making via the NO contact of the control switch takes place later than via the main contacts, whereas during the opening operation the auxiliary circuits are interrupted at the same time as the main circuits, if not before. This adjustment has the effect of preventing the opening of the circuit-breaker from producing a tripping command via the underimpedance starting of the distance protection relay.

The auxiliary voltage for blocking voltage-dependent starting (underimpedance) must always be routed via the NO contact 11-14.

Functions

The voltage transformer circuit-breaker largely corresponds with the circuit-breaker 3RV1, SIRIUS, size S00. Two special characteristics are taken into account for safe prevention of faulty triggering of the distance protection relay.

Auxiliary switch for blocking the distance protection

The main contacts of the circuit-breaker open if the voltage transformer circuit-breaker is tripped or switched off. The distance protection would falsely interpret low impedance as a fault, which results in immediate power cut-out within only a few milliseconds.

To prevent this fault response, special auxiliary contacts with a time-dependent assignment to the circuit-breaker's main contacts (see Technical data) must be provided. The distance protection is blocked with the help of these auxiliary contacts, and thus prevents faulty triggering.

An auxiliary switch for blocking the distance protection relay is available, equipped with 1 changeover contact fitted permanently in the voltage transformer circuit-breaker. This changeover contact can be used as 1 NO (11-14) or 1 NC (11-12) contact. Due to the high contact stability of these auxiliary contacts at the lowest possible rated operational currents I_e/AC-15 ≥ 0.5 mA at 230 V, it is also suitable for modern solid-state distance protection relays.

The laterally mountable auxiliary switches of the SIRIUS range can be used for signaling functions. They cannot be used for blocking the distance protection relay.

Impedance across the main contacts

There is only minor current flow across the main contacts of the voltage transformer circuit-breaker. To ensure reliable functioning of the distance protection, main contact resistance must be minimal and nearly constant throughout the service life of the circuit-breaker.

This is realized with suitable contacts and contact materials for the 3RV16 voltage transformer circuit-breaker.

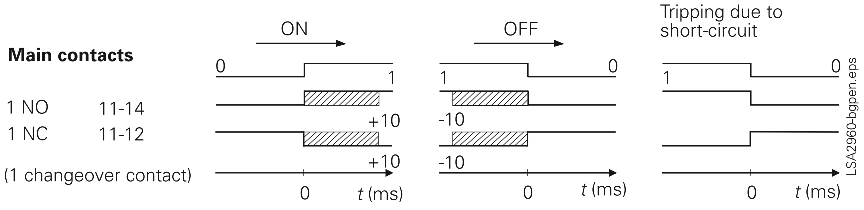
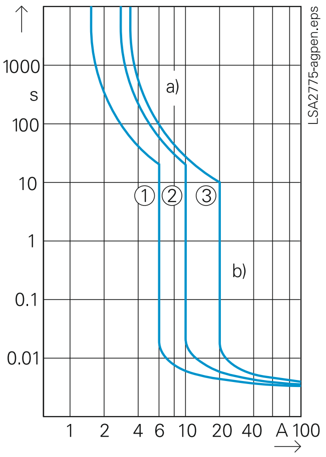


Fig. 14/13 Timing diagram of auxiliary switches for blocking distance protection

Characteristics

The specified tripping characteristics of the thermal overload pickup (a) correspond to the mean value of the leakage bandwidth in cold state; at operating temperature these times are reduced to approx. 25 % of the specified values. The characteristics below are schematic representations. Precise characteristics are available from "Technical Assistance" (E-mail: nst.technical-assistance@siemens.com).



① 1.4 A/6 A
② 2.5 A/10.5 A
③ 3 A/20 A
a) Thermal overload pickup
b) Instantaneous electromagnetic surge trip

Fig. 14/14 Characteristics

Connection diagrams

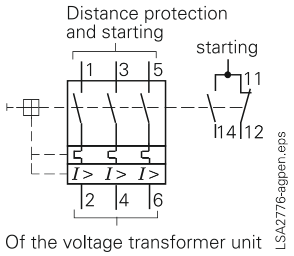


Fig. 14/15 Internal connections

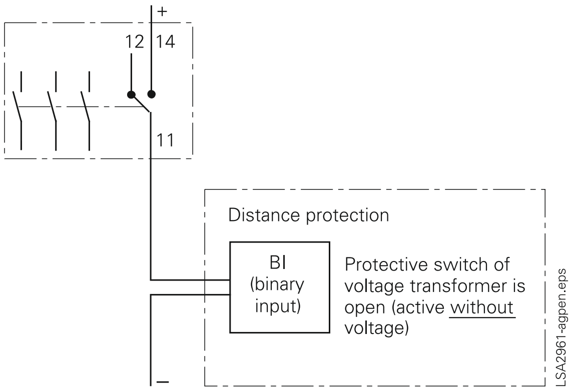


Fig. 14/16 Typical connections

Note:
When using the NC contact to connect the voltage transformer circuit-breaker, the binary input of the distance protection device (Siemens 7SA xxx) should be set to "active without voltage". This type of connection is used for additional monitoring of correct wiring.

Technical data

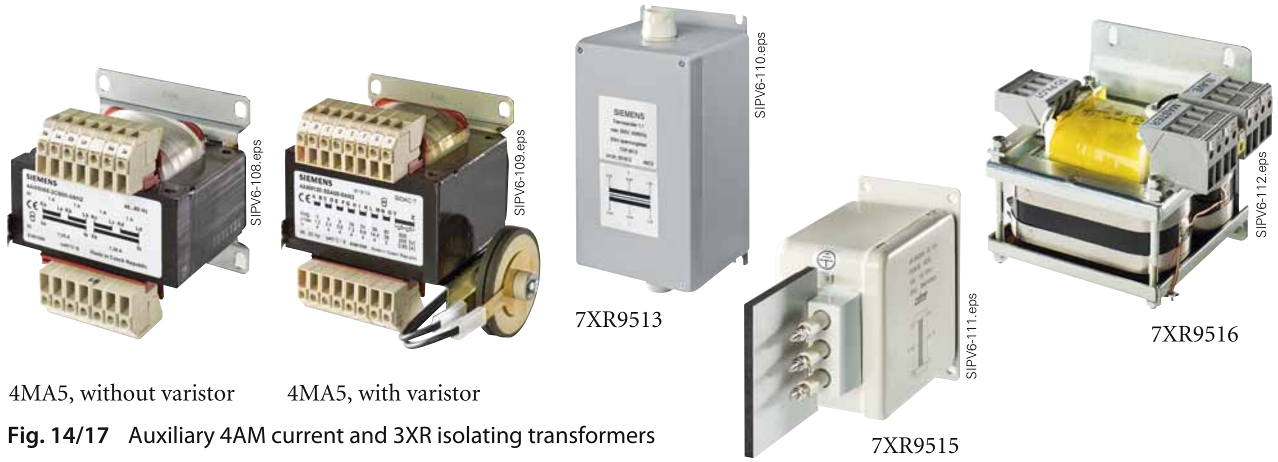
Conductor cross-sections, main circuit, 1 or 2 conductors			
Type	3RV1611- 1AG14	1CG14	1DG14
Terminal type	Screw connection		
Terminal screw	Prozidriv size 2		
Solid	2 x (0.5 to 1.5 mm^2); 2 x (0.75 to 2.5 mm^2); (max. 4 mm^2);		
Finely stranded with end sleeve	2 x (0.5 to 1.5 mm^2); 2 x (0.75 to 2.5 mm^2)		
Stranded	2 x (0.5 to 1.5 mm^2); 2 x (0.75 to 2.5 mm^2); (max. 4 mm^2)		
Auxiliary switch for blocking the distance protection			
With defined time-dependent assignment for blocking distance protection	1 changeover contact, solid-state compatible (usable as 1 NO or 1 NC)		
Rated operational current I_E/ rated operational voltage V_E	AC-14 0.5 A/V_E 250 V AC-14 1 A/V_E 125 V DC-13 0.27 A/V_E 250 V DC-13 0.44 A/V_E 125 V		
Short-circuit protection for auxiliary circuit			
Fusible link, gL/gG	max. 10 A		
Miniature circuit-breaker, C characteristic	max. 6 A		

General technical data			
Type	3RV1611- 1AG14	1CG14	1DG14
Rated current	1.4	2.5	3
Permissible ambient temperature During storage/transport During operation	-50 to +80 °C -20 to +60 °C (up to 70 °C possible with current reduction)		
Rated operational voltage V_E	400 V		
Rated frequency	16.7 to 60 Hz		
Rated insulation voltage V_I	690 V		
Short-circuit breaking capacity at 400 V AC, short-circuit proof up to	50 kA		
Current setting of the thermal overload release	1.4 A	2.5 A	3 A
Operating value of the instantaneous electromagnetic overcurrent release	6 ± 20 %	10.5 ± 20 %	20 ± 20 %
Tripping time of the instantaneous electromagnetic overcurrent release	Approx. 6 ms at 12 A	6 ms at 20 A	6 ms at 40 A
Disconnection life:			
short-circuit current I_p	Max. short-circuit disconnections		
≤ 0.1 kA 0.1 to 2 kA 2 kA to 50 kA	≤ 10 ≤ 3 1		
Internal resistance in cold state in heated state	> 0.25 Ω ± 6.5 % > 0.30 Ω ± 6.5 %		
Shock resistance acc. to IEC 60068, Part 2-27	15 *g*		
Degree of protection acc. to IEC 60529	IP 20		
Touch protection acc.to DIN VDE 0106 Part 100	Safe against finger touch		
Service life mechanical electrical	Operating cycles 10000 10000		
Permissible mounting position	any		

Selection and ordering data

Description	Order No.
3RV16 voltage transformer circuit-breaker	
with 1 auxiliary contact, 1 changeover	
1.4/ 6 A	*3RV1611-1AG14*
2.5/10.5 A	*3RV1611-1CG14*
3/20 A	*3RV1611-1DG14*
Laterally mountable auxiliary switches 1 NO/NC	*3RV1901-1A*

4AM□□Auxiliary Current Transformers
7XR□□Isolating Transformers



7XR9513

7XR9516

4MA5, without varistor

4MA5, with varistor

7XR9515

Fig. 14/17 Auxiliary 4AM current and 3XR isolating transformers

Overview

Application	Comment	Climatic requirements according to former DIN 40040	Features
Matching current transformer	Multi-tap aux. current transformer to match different current transformer ratios.		Numerous ratios can be selected using terminal connections (next page) f_N = 45 to 60 Hz
	4AM51 70-7AA: Standard version, primarily for transformer differential protection.	HKG	
	4AM52 72-2AA: Version with double thermal withstand capability, e.g. when connecting to wide-range current transformer (continuous rating 2 x I_N).	HKG	
	4AM52 72-3AA: Version with higher saturation factor (mainly for the busbar differential protection). Greater overcurrent factor because of higher voltages	HKG	
Input and matching current transformer	Input and matching current transformer for phase selective busbar differential protection (a.o. for 7SS60, 7UT6)		f_N = 45 to 60 Hz with varistor
	4AM51 20-1DA: For 1 A C.T.s	HKG	
	4AM51 20-2DA: For 5 A C.T.s 1)	HKG	
3-phase summation input C.T.	Input 3-phase summation current transformer for busbar differential protection (a.o. for 7SS60).		f_N = 45 to 60 Hz with varistor
	4AM51 20-3DA: For 1 A C.T.s	HKG	
	4AM51 20-4DA: For 5 A C.T.s	HKG	
	for line differential protection (a.o. for 7SD600)		f_N = 45 to 60 Hz with varistor
	4AM49 30-6DA: For 5 A	HKG	
	4AM49 30-7DA: For 1 A	HKG	
Aux. C.T. for C.T. powered tripping circuits	Auxiliary current transformer for C.T. powered trip coils in stations where no battery supply can be made available.		Unlike transducers, no defined rated power or class accuracy required. f_N = 45 to 60 Hz
	4AM50 65-2CB: For 1 A C.T.s	HKD	
	4AM50 70-8AB: For 5 A C.T.s	HKD	
	Suitable for tripping coils with $I_N \leq 0.5$ A or 1 A, $V_N \leq 40$ V or 20 V, $P \leq 20$ VA.		
Isolating transformer	Isolating transformer for pilot wire differential protection. Provides galvanic isolation between pilot wires and relays.		
	7XR9 513: For differential protection with 1 pair of pilot wires (a.o. for 7SD600)	HKG	20 kV insulation
	7XR9 515: For differential protection with 1 pair of pilot wires (a.o. for 7SD600)	HKG	5 kV insulation
	7XR9 516: For communication converter 7XV5662-0AC00 (a.o. for SIPROTEC 4 device 7SA522, 7SA6, 7SD52, 7SD61)	–	20 kV insulation

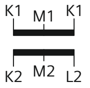
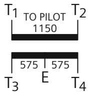
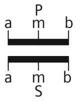
Climatic requirements: HKG = –25 °C to +125 °C relative humidity max. 75 %; annual average < 65 % on 60 days of the year up to 85 % (equally distributed over the year); condensation not permissible

HKD = –25 °C to +125 °C relative humidity max. 90 %; annual average < 80 % on 30 days of the year up to 100 % (equally distributed over the year); condensation permissible

---

1) If increased thermal withstand is required type 4AM51 20-4DA is recommended.

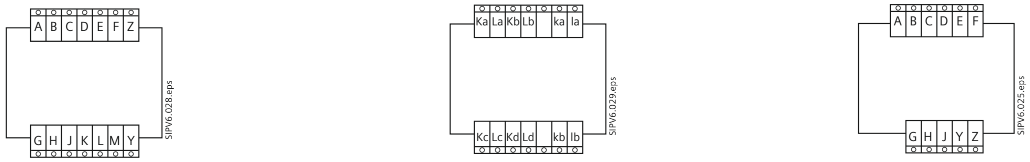
Order No. and Technical data

Order No.			Windings of auxiliary current transformers								Weight, approx.
4AM49 30-6DB00-0AN2	Number of windings		A B 1	C D 2	E F 3	G H 6	I K L M 6 6 12	Y Z 1736			
	Max. current, continuously	A	28	28	28	28	6.5	0.2			1.9 kg
	Max. voltage	V	0.23	0.46	0.69	1.38	(5.6)	400			
	Number of windings		A B 5	C D 10	E F 15	G H 30	I K L M 30 30 60	Y Z 1736			
4AM49 30-7DB00-0AN2	Max. current, continuously	A	4.5	4.5	4.5	4.5	1.2	0.2			2 kg
	Max. voltage	V	1.15	2.3	3.5	7	(20)	400			
	Number of windings (in relation to each other)		A B 1	C D 2	E F 7	G H 16	I K 1	L M 2	N O 7	P Q 16	
4AM51 70-7AA00-0AN2	Rated current I_N 1)	A	5	5	5	1	5	5	5	1	3.6 kg
	Max. voltage	V	2	4	14	32	2	4	14	32	
4AM52 72-2AA00-0AN2	Rated current I_N 1)	A	10	10	10	2	10	10	10	2	5.4 kg
	Max. voltage	V	2	4	14	32	2	4	14	32	
4AM52 72-3AA00-0AN2	Rated current I_N 1)	A	5	5	5	1	5	5	5	1	5.4 kg
	Max. voltage	V	4	8	28	64	4	8	28	64	
4MA50 65-2CB00-0AN2	Rated current I_N 1)	A	1	1	1	1					2.9 kg
	Number of windings		K_a L_a 110	K_b L_b 110	K_c L_c 110	K_d L_d 110	Primary windings				
	Number of windings		k_a l_a 88		k_b l_b 88		Secondary windings				
	Rated current I_N 1)	A	1.25		1.25						
4MA50 70-8AB00-0AN2	Rated current I_N 1)	A	5	5	5	5					2.9 kg
	Number of windings		K_a L_a 22	K_b L_b 22	K_c L_c 22	K_d L_d 22	Primary windings				
	Number of windings		k_a l_a 88		k_b l_b 88		Secondary windings				
	Rated current I_N 1)	A	1.25		1.25						
	Number of windings		A B C 1 2	D E F 4 8	G H I 16 32	Y Z 500					
4AM51 20-1DA00-0AN2	Max. current, continuously	A	6.8	6.8	6.8	0.85					3.6 kg
	Max. voltage	V	0.4 0.8	1.6 3.2	6.4 12.5	200					
4AM51 20-2DA00-0AN2	Max. current, continuously	A	26	26	not	0.85					3.6 kg
	Max. voltage	V	0.4 0.8	1.6 3.2	fitted	200					
4AM51 20-3DA00-0AN2	Number of windings		A B 3	C D 6	E F 9	G H 18	I K 24	L M 36	N O 90	Y Z 500	3.6 kg
	Max. current, continuously	A	4	4	4	4	4	4	2	0.85	
	Max. voltage	V	1.2	2.4	3.6	7.2	9.6	14.4	36	200	
4AM51 20-4DA00-0AN2	Number of windings		A B 1	C D 2	E F 3	G H 4	I K 6	L M 8	N O 12	Y Z 500	3.6 kg
	Max. current, continuously	A	17.5	17.5	17.5	17.5	17.5	17.5	8	0.85	
	Max. voltage	V	0.4	0.8	1.2	1.6	2.4	3.2	4.8	200	
7XR9 513	Isolating transformer for differential protection with 1 pair of pilot wires			Isolating transformer 1:1, max. 550 V 0.4 A continously, 3 A 10 s, 10 A 1 s test voltage 20 kV, 50 Hz, 1 min							5 kg
7XR9 515	Isolating transformer for differential protection with 1 pair of pilot wires			Isolating transformer 1:1, max. 450 V test voltage 5 kV, 50 Hz, 1 min							2 kg
7XR9 516	Isolating transformer for communication converter			Isolating transformer 1:1, max. test voltage 20 kV, 50 Hz, 1 min							1.4 kg

---

1) Thermal withstand with simultaneous loading of all the windings: 1.2 x I_N/ continuously; 10 x I_N/ 10 s; 25 I_N/ 1 s.

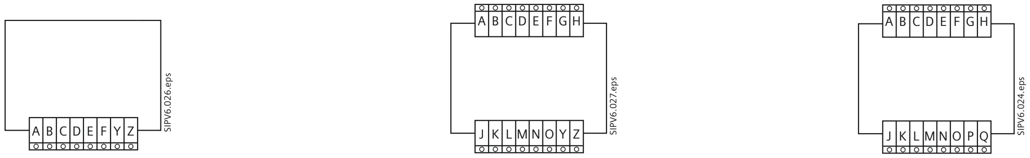
Order No. and Technical data



4AM49 30-6DB
4AM49 30-7DB

4AM50 65-2CB
4AM50 70-8AB

4AM51 20-1DA



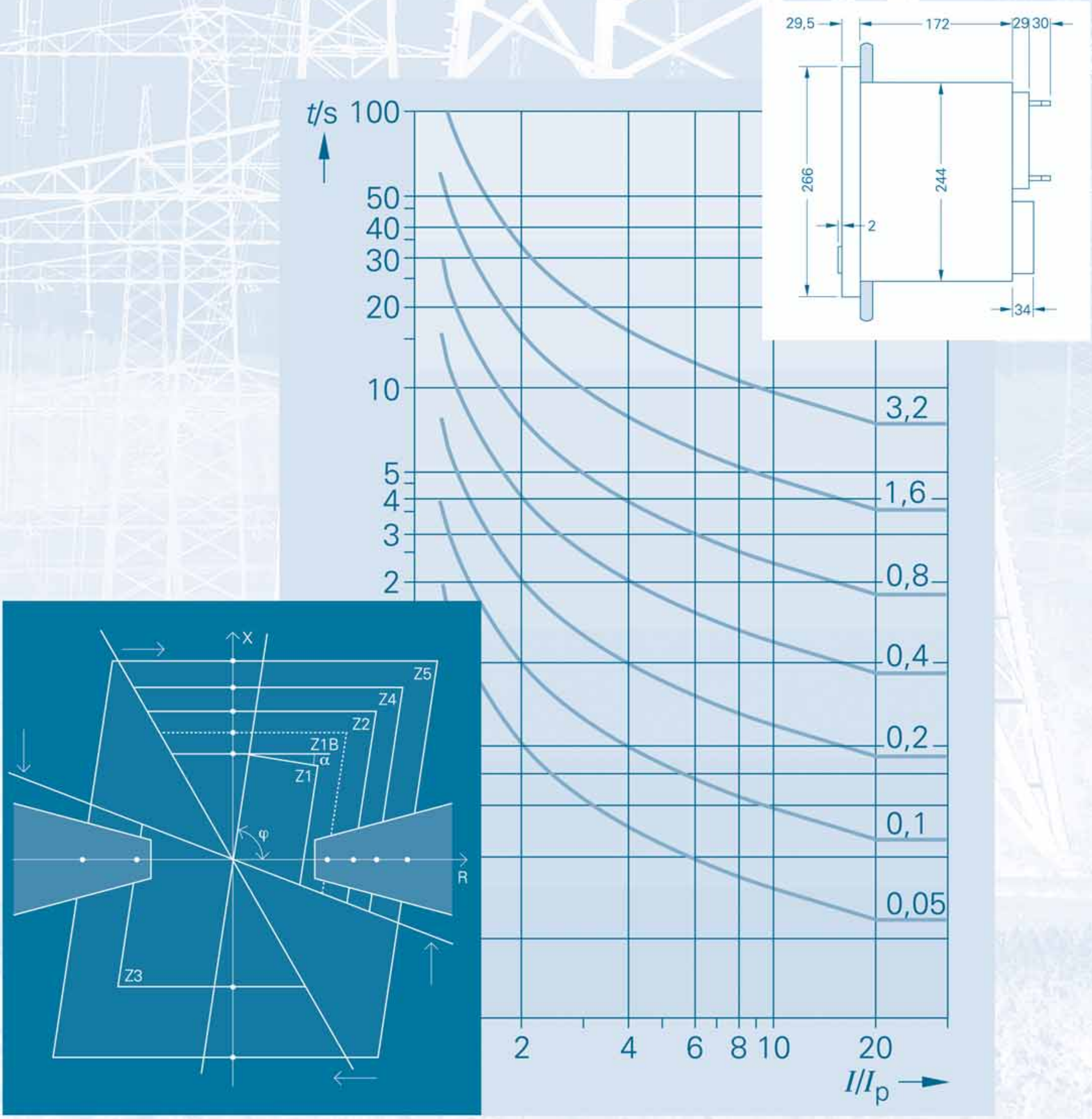
4AM51 20-2DA

4AM51 20-3DA
4AM51 20-4DA

4AM51 70-7AA
4AM52 72-2AA
4AM52 72-3AA

Fig. 14/18 Connection of windings

Appendix



t/s
100
50
40
30
20
10
5
4
3
2
3,2
1,6
0,8
0,4
0,2
0,1
0,05
2
4
6
8
10
20
I/Ip
29,5
172
29
30
266
244
2
34
X
R
Z5
Z4
Z2
Z1B
Z1
α
φ
Z3

Relay characteristics

Inverse-time characteristics of TOC relays

	IEC 60255-3				ANSI/IEEE						
	Normal inverse	Very inverse	Extremely inverse	Long inverse	Inverse	Short inverse	Long inverse	Definite inverse	Moderately inverse	Very inverse	Extremely inverse
Fig.	15/1	15/2	15/3	15/4	15/5	15/6	15/7	15/8	15/9	15/11	15/13
Relay											
7SD5	■	■	■	■	■	■	■	■	■	■	■
7SD610	■	■	■	■	■	■	■	■	■	■	■
7SJ450*-***00-0	■	■	■								
7SJ450*-***00-1									■	■	■
7SJ460*-***00-0	■	■	■								
7SJ460*-***00-1									■	■	■
7SJ600	■	■	■	■	■	■	■	■	■	■	■
7SJ602	■	■	■	■	■	■	■	■	■	■	■
7SJ61	■	■	■	■	■	■	■	■	■	■	■
7SJ62	■	■	■	■	■	■	■	■	■	■	■
7SJ63	■	■	■	■	■	■	■	■	■	■	■
7SJ64	■	■	■	■	■	■	■	■	■	■	■
7UM61	■	■	■		■			■	■	■	■
7UM62	■	■	■		■			■	■	■	■
7UT612	■	■	■	■	■	■	■	■	■	■	■
7UT613	■	■	■	■	■	■	■	■	■	■	■
7UT63	■	■	■	■	■	■	■	■	■	■	■

Relay characteristics

Inverse-time overcurrent protection characteristics according to IEC 60255 and BS142.

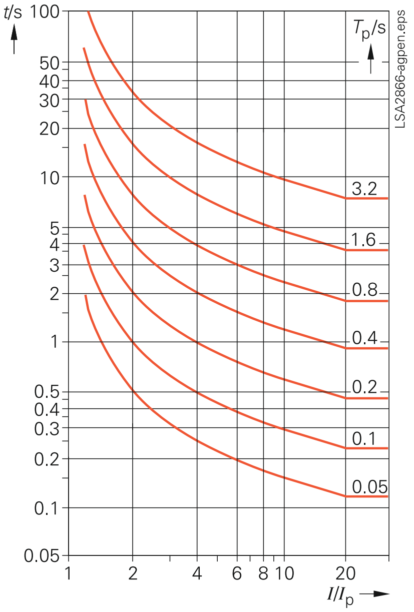


Fig. 15/1

Inverse

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p$$

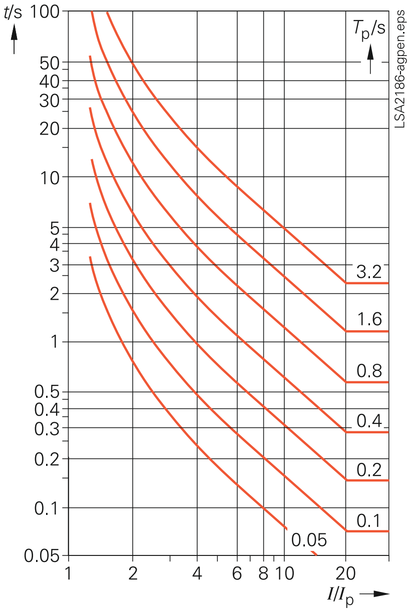


Fig. 15/2

Very inverse

$$t = \frac{13.5}{(I/I_p) - 1} \cdot T_p$$

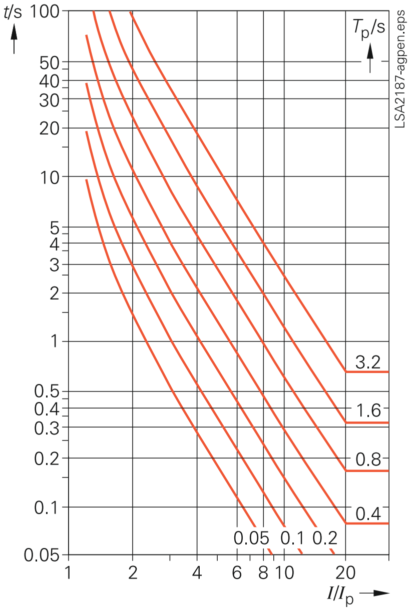


Fig. 15/3

Extremely inverse

$$t = \frac{80}{(I/I_p)^2 - 1} \cdot T_p$$

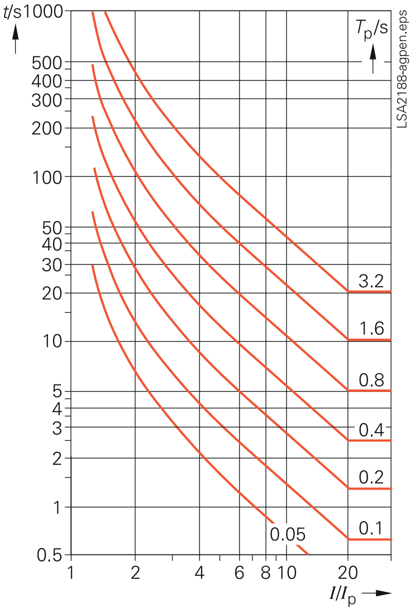


Fig. 15/4

Long inverse

$$t = \frac{120}{(I/I_p) - 1} \cdot T_p$$

I = current

t = tripping time

I_p = pickup setting

T_p = time multiplier setting

Relay characteristics

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

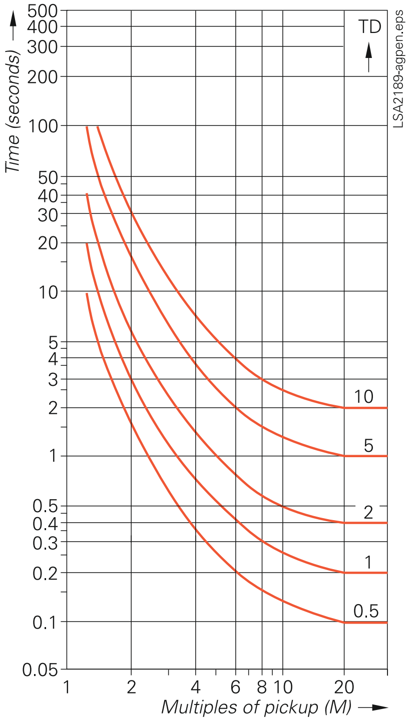


Fig. 15/5
Inverse

$$t = \left(\frac{8.9341}{M^{2.0938}-1} + 0.17966\right) \cdot TD$$

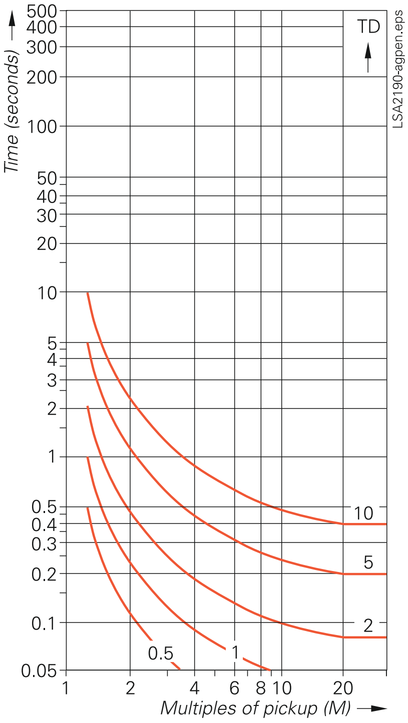


Fig. 15/6
Short inverse

$$t = \left(\frac{0.2663}{M^{1.2969}-1} + 0.03393\right) \cdot TD$$

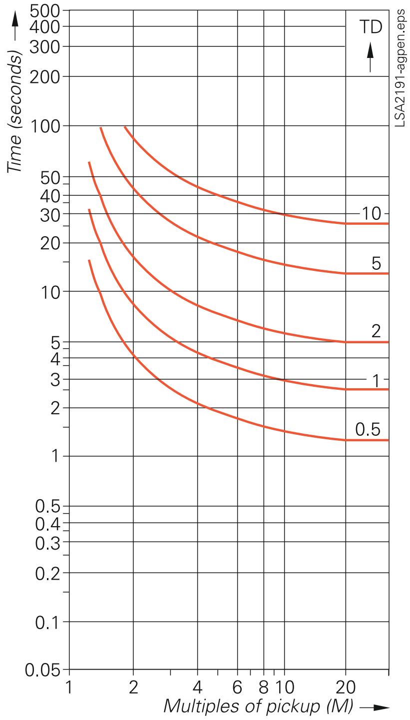


Fig. 15/7
Long inverse

$$t = \left(\frac{5.6143}{M-1} + 2.18592\right) \cdot TD$$

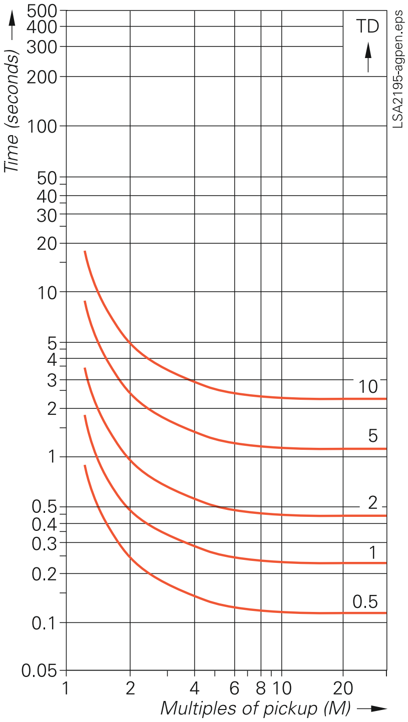


Fig. 15/8
Definite inverse

$$t = \left(\frac{0.4797}{M^{1.5625}-1} + 0.21359\right) \cdot TD$$

t = tripping time in seconds

M = current in multiples of pickup setting (I/Ip) range 0.1 to 4

TD = time dial

Relay characteristics

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

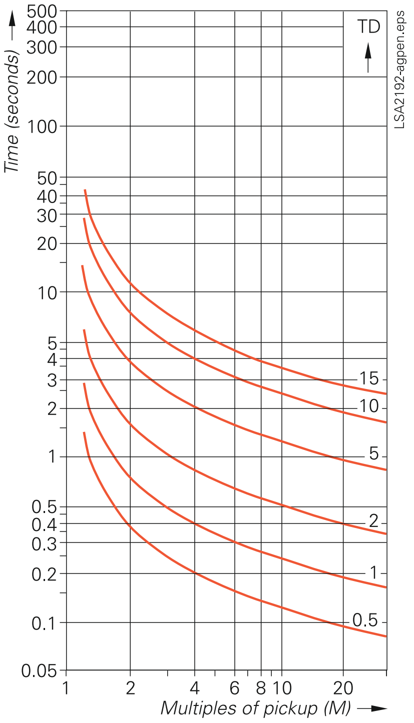


Fig. 15/9

Moderately inverse

$$t = \left(\frac{0.0103}{M^{0.02} - 1} + 0.0228\right) \cdot TD$$

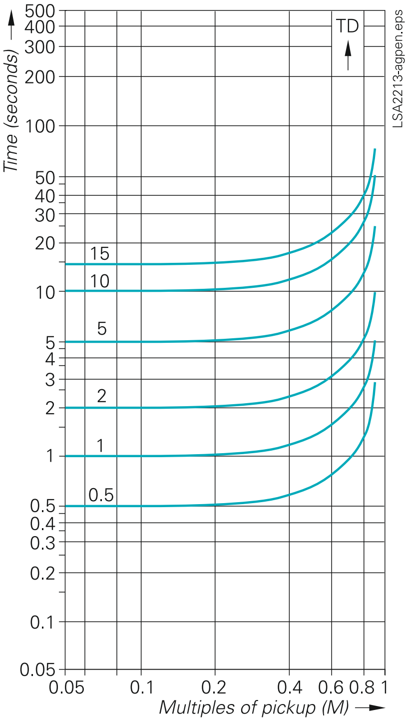


Fig. 15/10

Reset moderately inverse

$$t_{\text{reset}} = \frac{0.97 \cdot TD}{M^2 - 1}$$

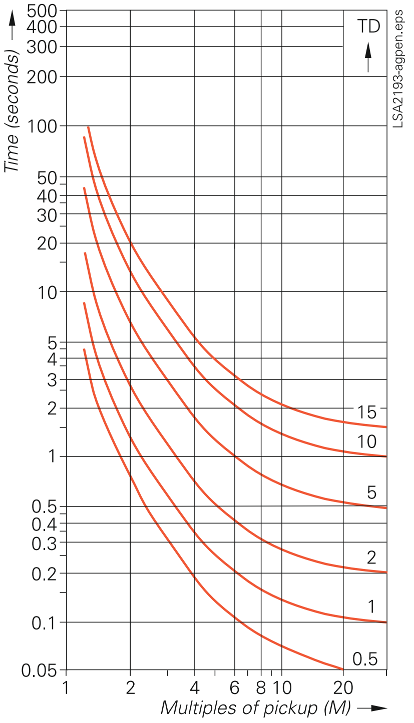


Fig. 15/11

Very inverse

$$t = \left(\frac{3.922}{M^2 - 1} + 0.0982\right) \cdot TD$$

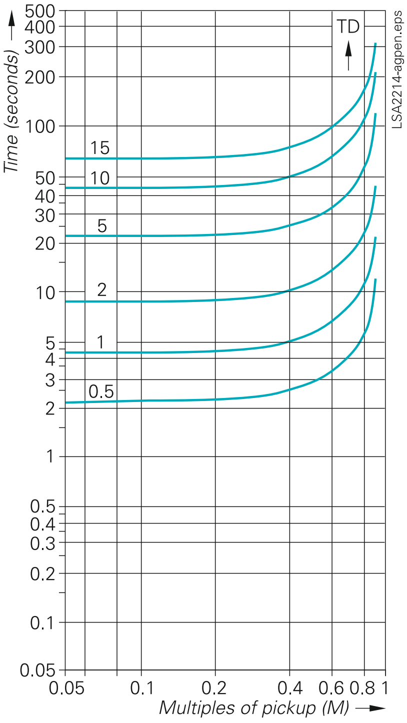


Fig. 15/12

Reset very inverse

$$t_{\text{reset}} = \frac{4.32 \cdot TD}{M^2 - 1}$$

t = tripping time in seconds

M = current in multiples of pickup setting (I/Ip) range 0.1 to 4

TD = time dial

Relay characteristics

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

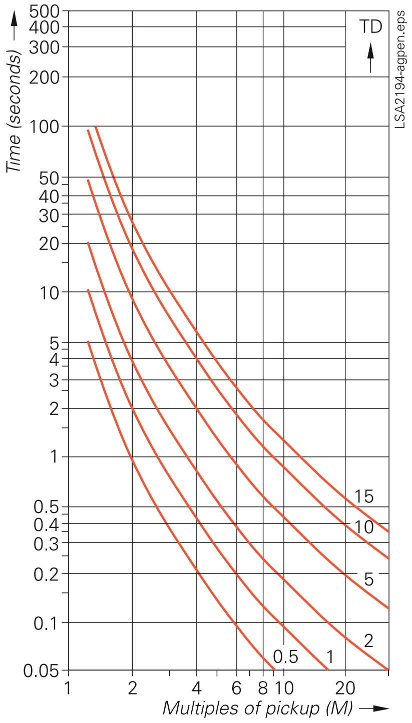


Fig. 15/13

Extremely inverse

$$t = \left(\frac{5.64}{M^2 - 1} + 0.0243\right) \cdot TD$$

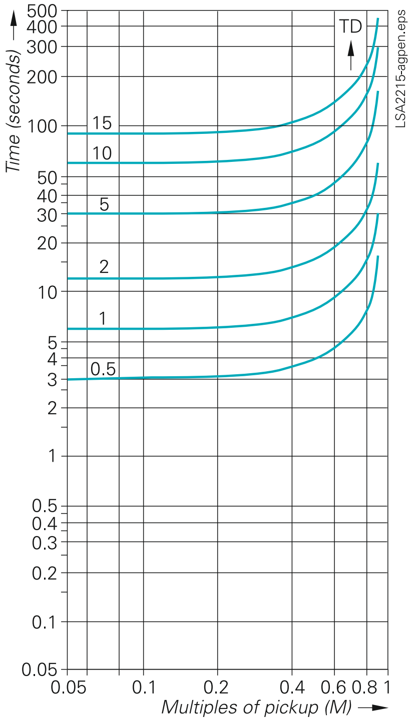


Fig. 15/14

Reset extremely inverse

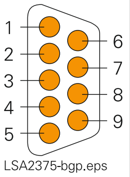
$$t_{\text{reset}} = \frac{5.82 \cdot TD}{M^2 - 1}$$

t = tripping time in seconds

M = current in multiples of pickup setting (I/Ip) range 0.1 to 4

TD = time dial

Pinout of communication port

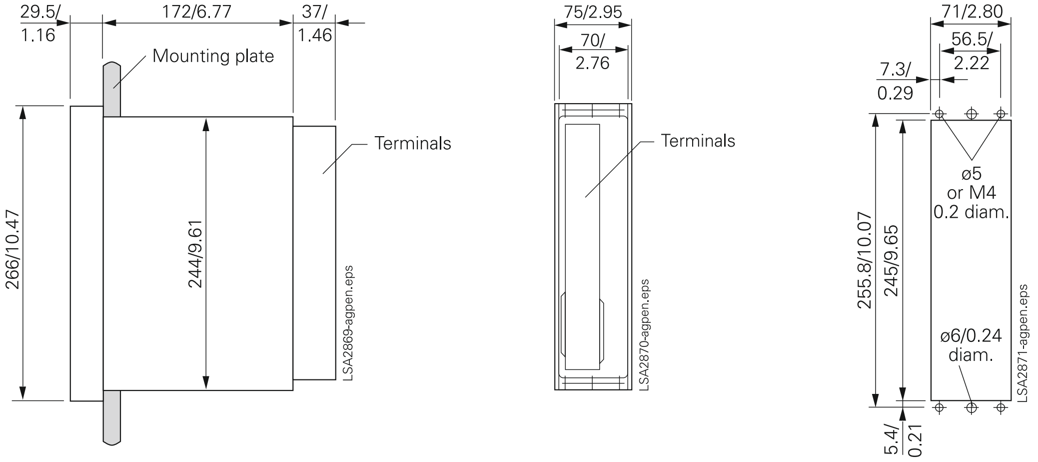
		Port A: **Time synchronisation**	Port B: System interface				Port C/D Rear service interface or protection data interface	
Pin no.  LSA2375-bgp.eps	**PC interface at front**		RS232 IEC 60870-5-103	RS485 IEC 60870-5-103	RS485 PROFIBUS-FMS Slave, PROFIBUS-DP Slave	RS485 MODBUS, DNP 3.0	RS232	RS485
1	–	P24 input 24 V	Shield (with shield ends electrically connected)					
2	R x D	P5 input 5 V	R x D	–	–	–	R x D	–
3	T x D	common return	T x D	A/A' (RxD/TxD-N)	B/B' (RxD/TxD-P)	A	T x D	A
4	–	–	–	–	CNTR-A (TTL)	RTS (TTL level)	–	–
5	GND	Shield	GND	C/C' (GND)	C/C' (GND)	GND1	GND	C (GND)
6	–	–	–	–	+ 5 V voltage supply (max. Load < 100 mA)	VCC1	–	–
7	$\overline{\text{RTS}}$	P12 input 12 V	$\overline{\text{RTS}}$	–*)	–*)	–	$\overline{\text{RTS}}$	($\overline{\text{RTS}}$ RS232 used)
8	$\overline{\text{CTS}}$	–	$\overline{\text{CTS}}$	B/B' (RxD/TxD-P)	A/A' (RxD/TxD-N)	B	$\overline{\text{CTS}}$	B
9	–	Shield	–	–	–	–	–	–

Dimension drawings • Reference table

Relay	Flush/cubicle-mounting version		Surface-mounting version		Detached HMI	
	Page	Fig.	Page	Fig.	Page	Fig.
4AM4	-	-	15/24	15/57	-	-
4AM5	-	-	15/24	15/55, 15/56	-	-
6MD61	15/16	15/28	-	-	-	-
6MD63	15/12, 15/14	15/24, 15/26	15/14, 15/15	15/27	15/16	15/28
6MD66	15/14	15/26	15/15	15/27	15/16	15/28
7PA22	15/21	15/39, 15/41	15/21, 15/22	15/39, 15/47	-	-
7PA23	15/21, 15/22	15/40, 15/42	15/21, 15/22	15/40, 15/48	-	-
7PA26	15/23	15/49, 15/50	15/22	15/47	-	-
7PA27	15/22	15/43, 15/46	-	-	-	-
7PA30	15/21, 15/22	15/41, 15/42, 15/44, 15/45	15/22	15/44, 15/45, 15/47, 15/48	-	-
7RV16	15/21	15/37	15/21	15/37	-	-
7RW600	15/8	15/15	15/8, 15/9	15/16, 15/17	-	-
7SA522	15/12, 15/14	15/24, 15/26	15/15	15/27	-	-
7SA61	15/11, 15/12, 15/13, 15/14	15/22, 15/24, 15/25, 15/26	15/11, 15/15	15/23, 15/27	-	-
7SA63	15/11, 15/12, 15/14	15/22, 15/24, 15/26	15/11, 15/15	15/23, 15/27	-	-
7SA64	-	-		-	15/16	15/28
7SD5	15/12, 15/14	15/24, 15/26	15/15	15/27	-	-
7SD600	15/8	15/15	15/8, 15/9	15/16, 15/17	-	-
7SD610	15/11	15/22	15/11	15/23	-	-
7SJ45	15/9	15/18	15/9	15/19	-	-
7SJ46	15/9	15/18	15/9	15/19	-	-
7SJ600	15/8	15/15	15/8, 15/9	15/16, 15/17	-	-
7SJ602	15/10	15/20	15/10	15/21	-	-
7SJ61	15/11	15/22	15/11	15/23	-	-
7SJ62	15/11	15/22	15/11	15/23	-	-
7SJ63	15/12, 15/14	15/24, 15/26	15/15	15/27	15/16	15/28
7SJ64	15/11, 15/12, 15/14	15/22, 15/24, 15/26	15/11, 15/15	15/23, 15/27	15/16	15/28
7SN600	15/8	15/15	15/8, 15/9	15/16, 15/17	-	-
7SS522 central unit	15/18	15/32	15/18	15/32	-	-
7SS523 bay unit	15/17	15/29	15/17	15/30	-	-
7SS525	15/18	15/31		-	-	-
7SS60	15/8, 15/20	15/15, 15/36		-	-	-
7SV600	15/8	15/15	15/8, 15/9	15/16, 15/17	-	-
7TS16	15/22	15/45	15/23	15/45, 15/47	-	-
7UM61	15/11, 15/12	15/22, 15/24	15/11, 15/15	15/23, 15/27	-	-
7UM62	15/12, 15/14	15/24, 15/26	15/15	15/27	-	-
7UT6	15/11, 15/12, 15/14	15/22, 15/24, 15/26	15/11, 15/15	15/23, 15/27	-	-
7VE61	15/11	15/22	15/11	15/23	-	-
7VE63	15/12	15/24	15/15	15/27	-	-
7VK610/7VK611	15/11, 15/12	15/22, 15/24	15/11, 15/15	15/23, 15/27	-	-
7XR9	-	-	15/23	15/52, 15/53, 15/54	-	-
7XV5450	15/19	15/34	15/19	15/34	-	-
7XV5461	-	-	15/19	15/34	-	-
7XV5550	15/19	15/33	15/19	15/33	-	-
7XV5650/51/52/53/55	15/19, 15/21	15/33, 15/38	15/19, 15/21	15/33, 15/38	-	-
7XV5662	-	-	15/19, 15/21	15/34, 15/38	-	-
7XV5673	-	-	15/23	15/51		
7XV75	15/20	15/35	-	-	-	-

Dimension drawings in mm / inch

Dimension drawings for 1/6 x 19" housing (7XP20)

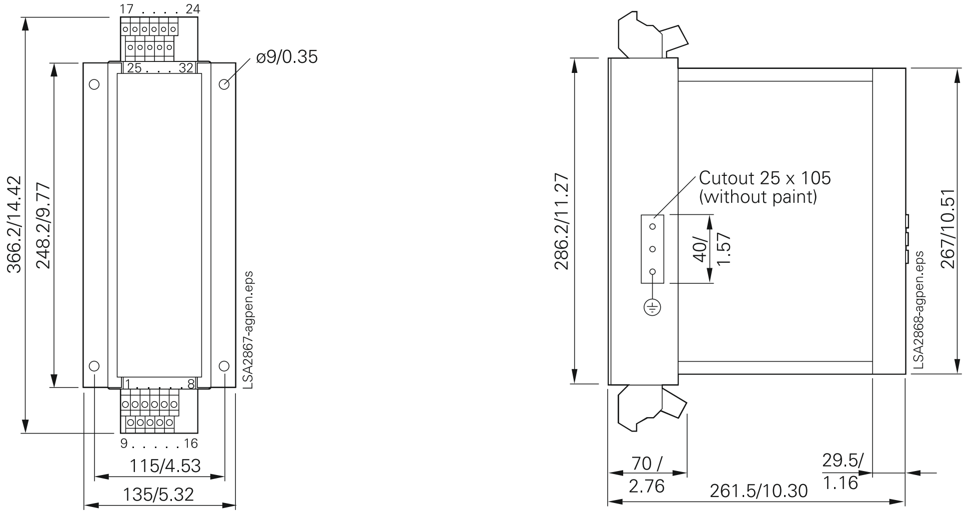


Side view

View from the rear

Panel cutout

Fig. 15/15
Housing for panel flush mounting/
cubicle mounting, terminals at rear (1/6 x 19")



Front view

Side view

Fig. 15/16
Housing for surface mounting,
terminals at top and bottom (1/6 x 19")

Dimension drawings in mm / inch

Dimension drawings for 1/6 x 19" housing (7XP20)

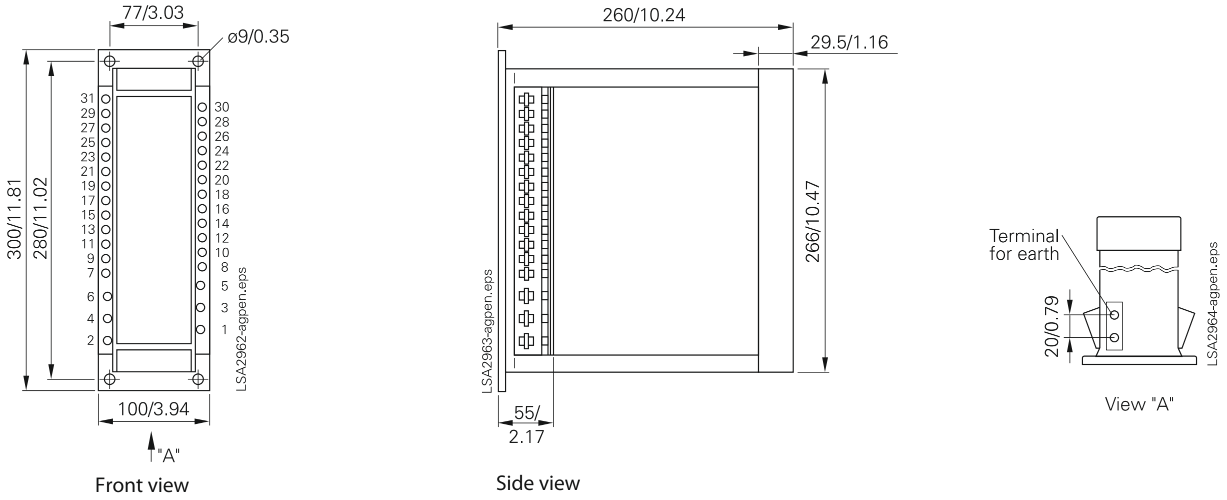


Fig. 15/17
Housing for panel surface mounting, terminals on the side (1/6 x 19")

Dimension drawings for SIPROTEC easy

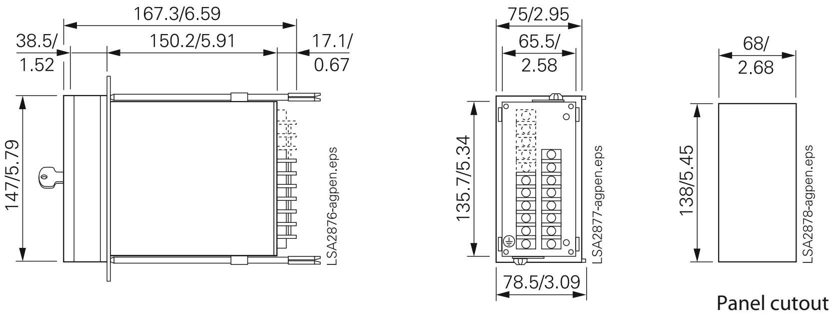


Fig. 15/18
7SJ45, 7SJ46 housing for panel flush mounting

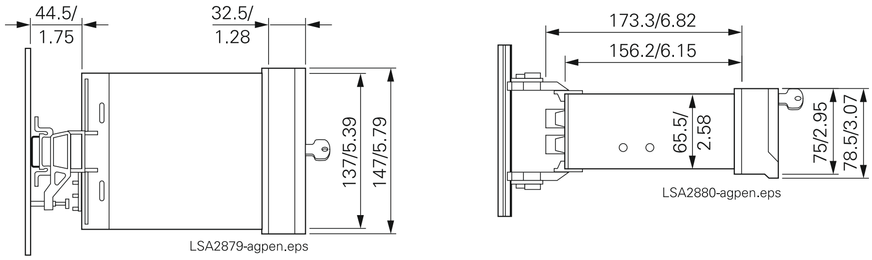
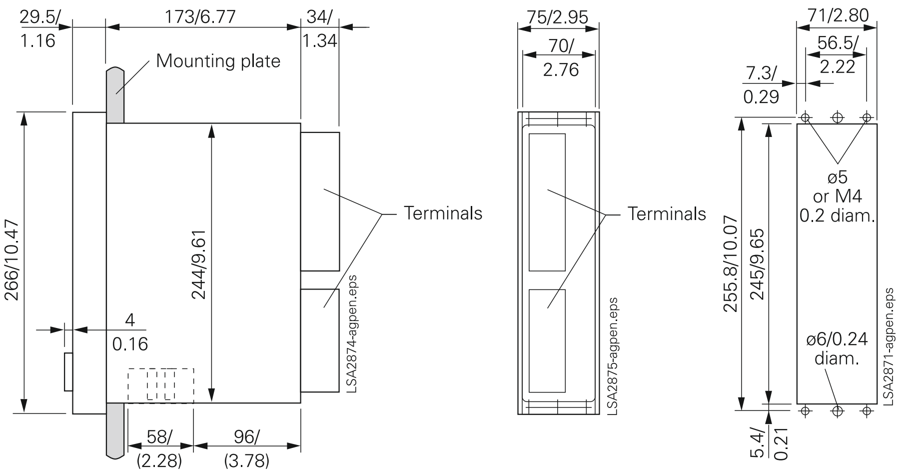


Fig. 15/19
7SJ45, 7SJ46 housing for rail mounting

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 7SJ602



Side view / screw-type terminals

View from the rear

Panel cutout

Fig. 15/20
7SJ602 with7XP20 housing
for panel flush mounting/cubicle mounting,
terminals at rear

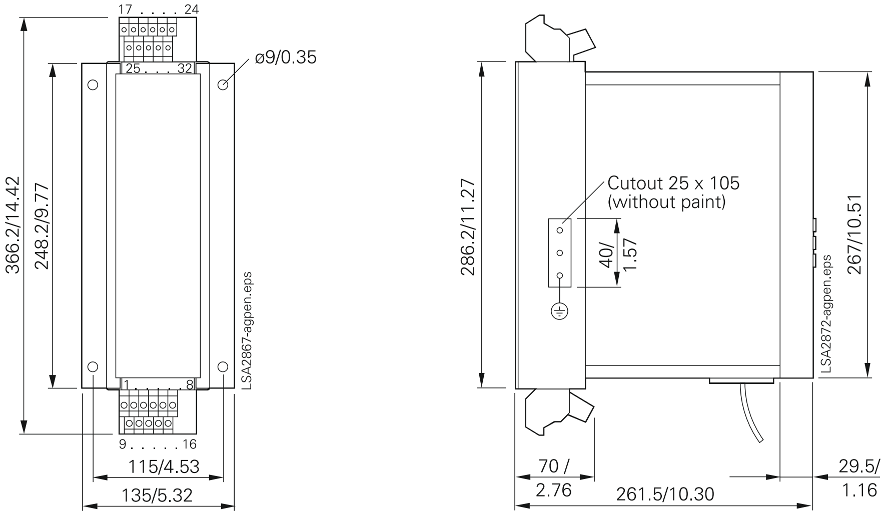
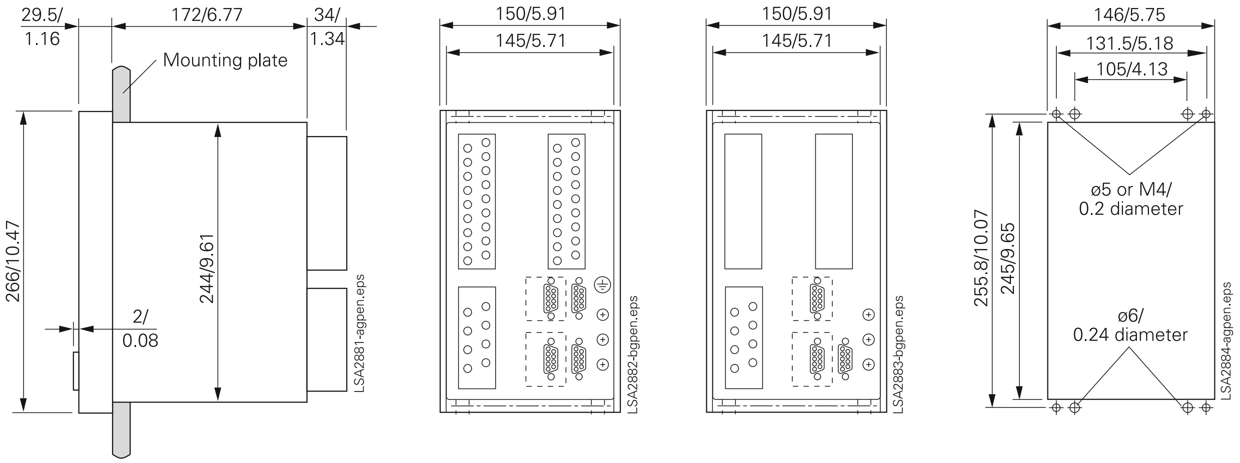


Fig. 15/21
7SJ602 with 7XP20 housing
for surface mounting,
terminals at top and bottom

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 4
1/3 x 19" housing (7XP20)



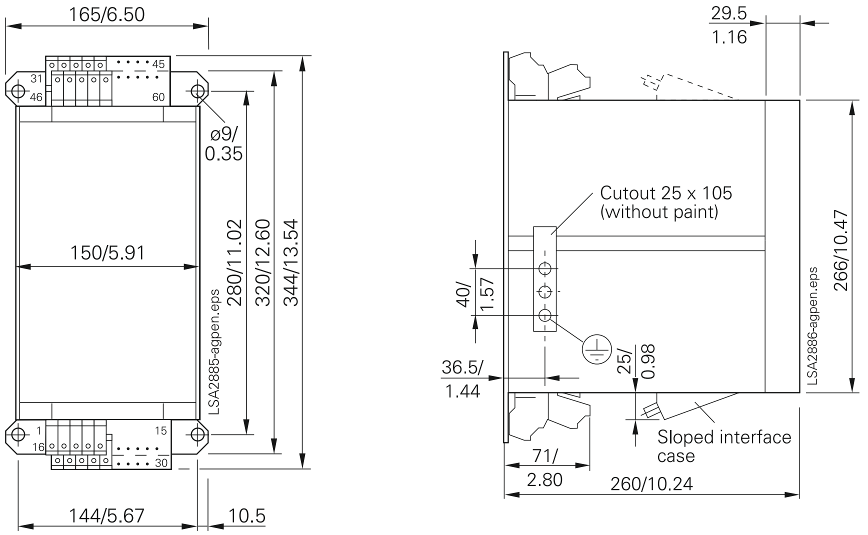
Side view

Rear view
7SA610, 7SD61, 7SJ64

Rear view
7SJ61, 7SJ62, 7UT612,
7UM611

Panel cutout

Fig. 15/22
Housing for panel flush mounting/
cubicle mounting (1/3 x 19")



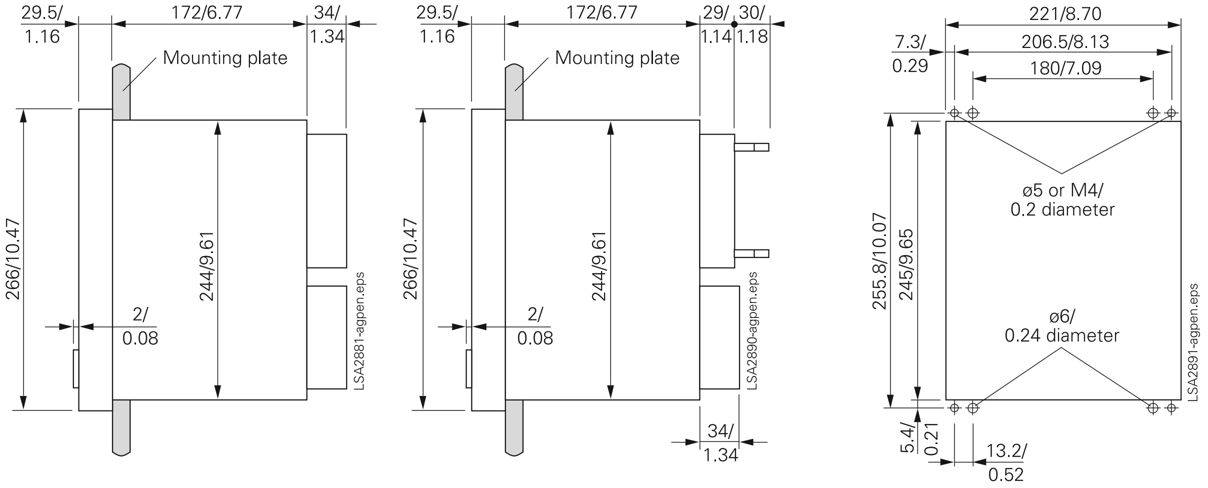
Front view

Side view

Fig. 15/23
1/3 x 19" surface-mounting housing,
terminals at top and bottom

Dimension drawings in mm / inch

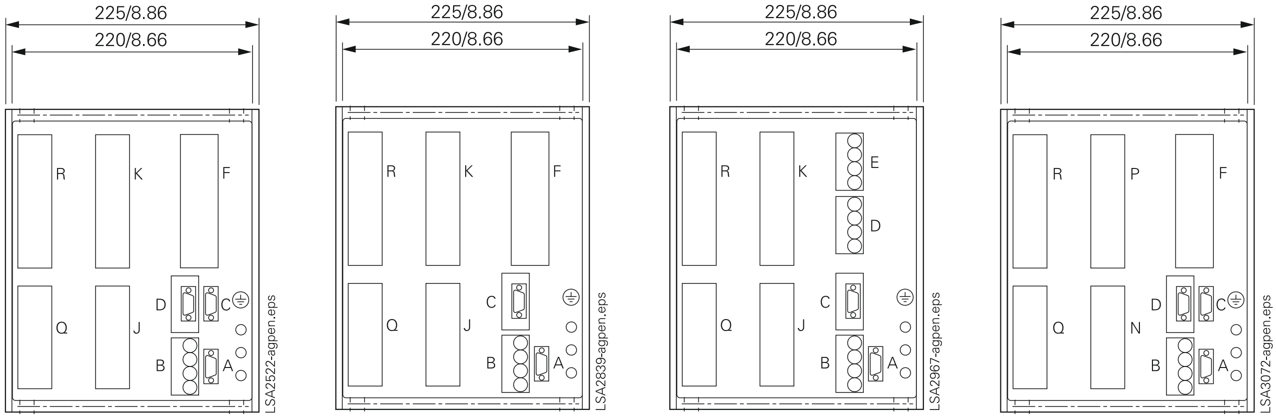
Dimension drawings for SIPROTEC 4 1/2 x 19" flush-mounting housings (7XP20)



Side view 1

Side view 2

Panel cutout



Rear view 1
7SA61/63, 7UM621, 7UM623,
7SJ64

Rear view 2
7SJ63, 7UM612, 6MD63

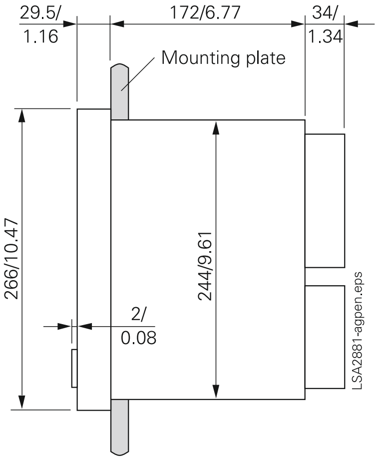
Rear view 3
7SA522, 7SD52/53

Rear view 4
7UT613

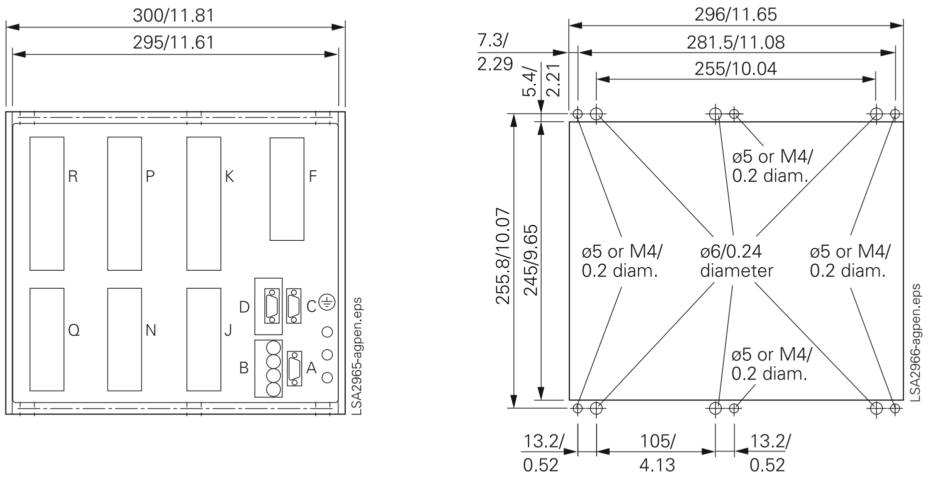
Fig. 15/24
1/2 x 19" flush-mounting housing

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 4 2/3 x 19" flush-mounting housings (7XP20)



Side view



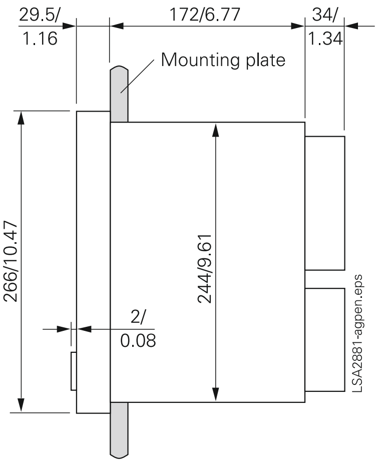
Rear view

Panel cutout

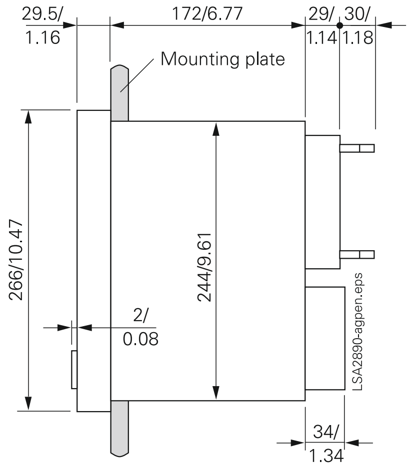
Fig. 15/25
2/3 x 19" flush-mounting housing for 7SA613

Dimension drawings in mm / inch

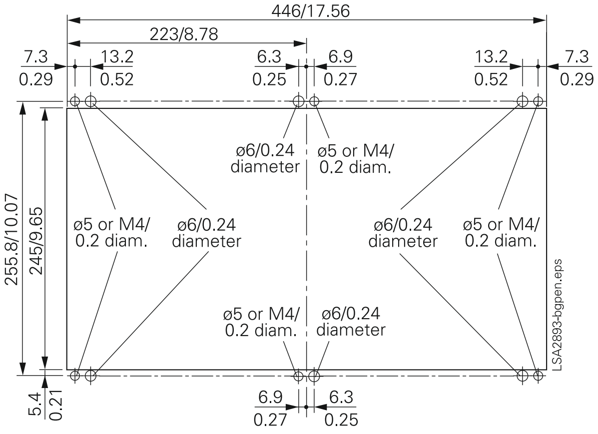
Dimension drawings for SIPROTEC 4 1/1 x 19" flush-mounting housings (7XP20)



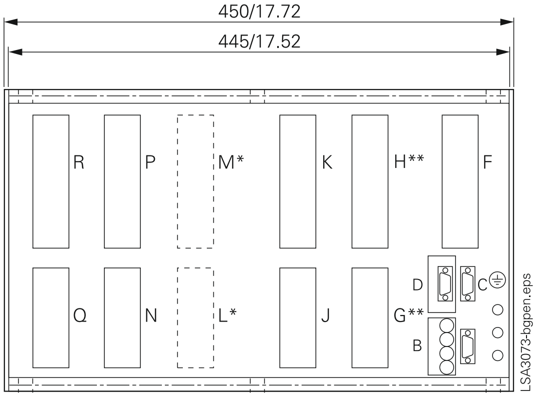
Side view 1



Side view 2



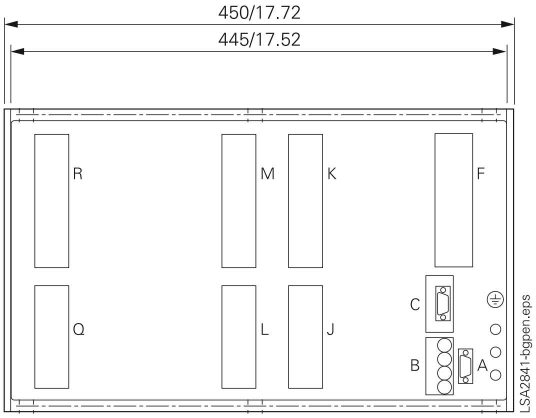
Panel cutout



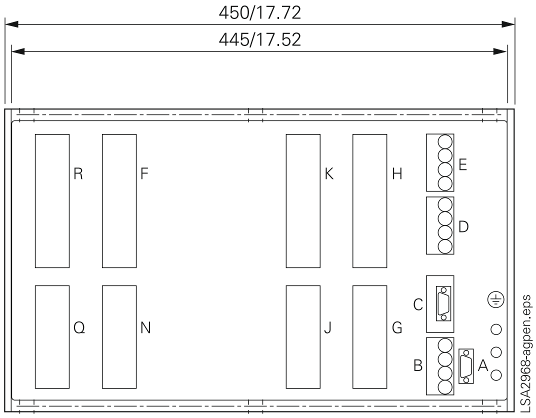
* Terminals M and L additionally for 7UT635 and 7SJ647 only

** Terminals H and G not for 7SJ645 and 7SJ647

Rear view 1
7SA6, 7UM622, 7SJ64, 7UT633, 7UT635



Rear view 2
7SJ63, 6MD63

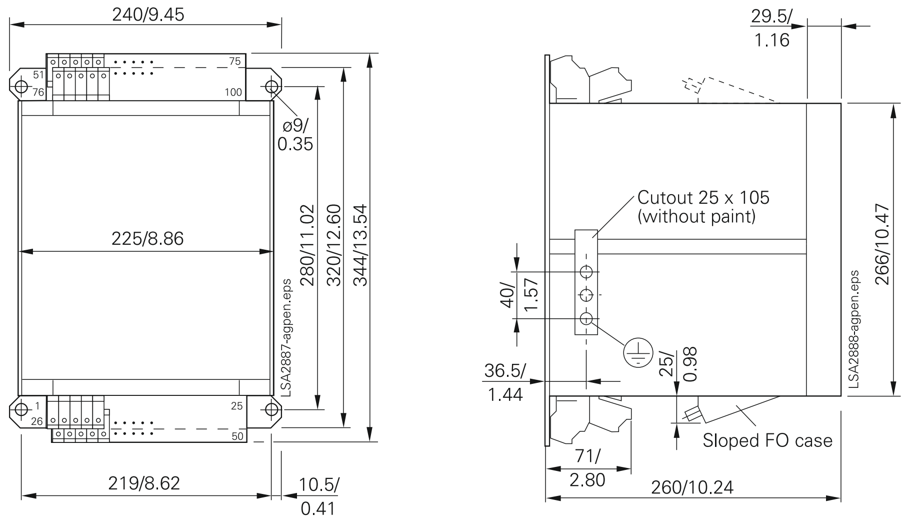


Rear view 3
7SA522, 7SD52/53

Fig. 15/26
in 1/1 x 19" flush-mounting housing

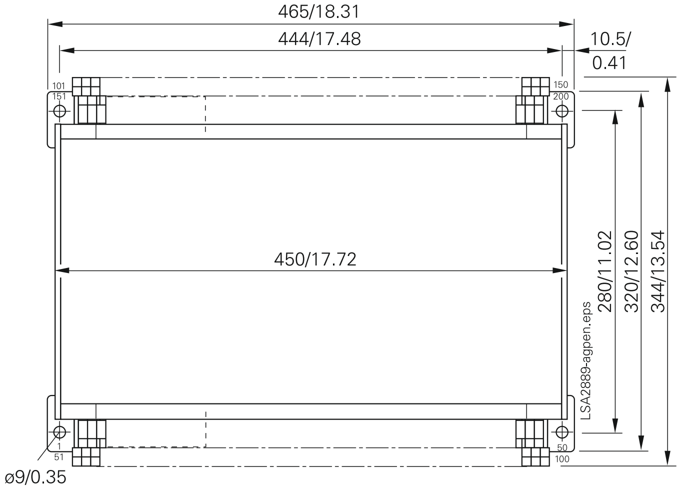
Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 4 1/2 and 1/1 x 19" surface-mounting housings (7XP20)



Front view
1/2 x 19" surface-mounting,
terminals at top and bottom
housing 7XP20

Side view



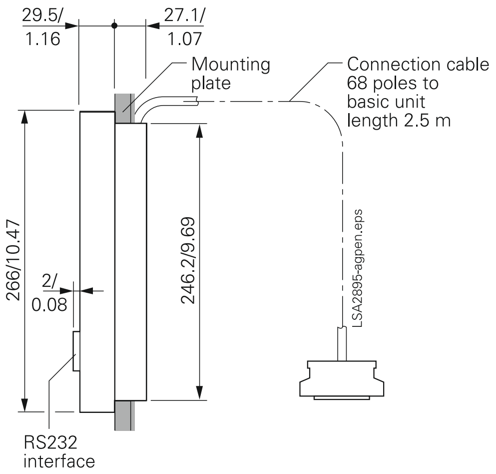
Front view
1/1 x 19" surface-mounting housing 7XP20
(without sloped FO case)

Fig. 15/27

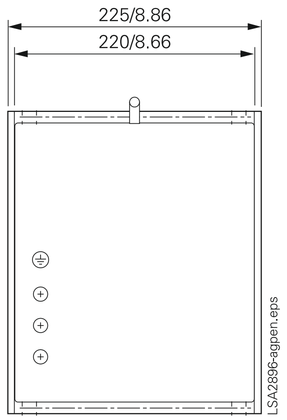
1/2 and 1/1 x 19" surface-mounting housing

Dimension drawings in mm / inch

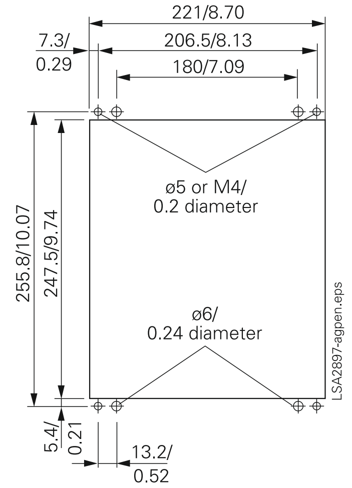
Dimension drawings for SIPROTEC 4 1/2 and 1/1 x 19" housings with detached operator panel



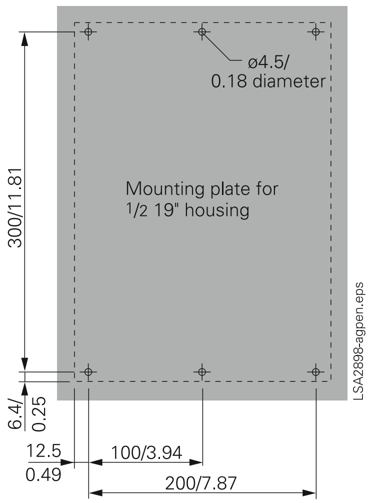
Detached operator panel (side view)

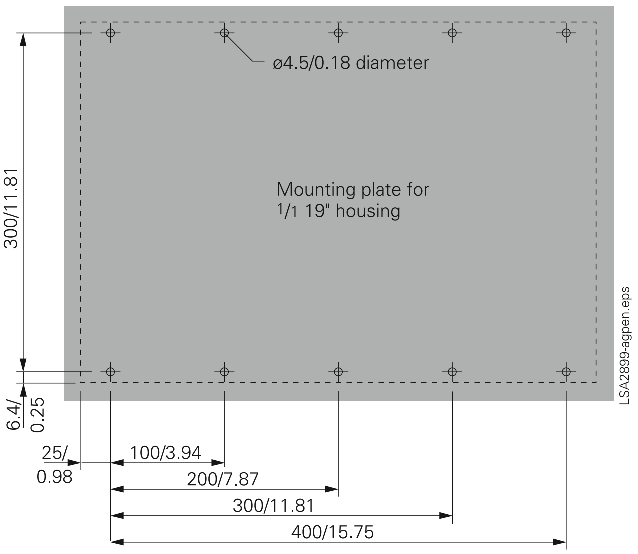


Rear view



Panel cutout





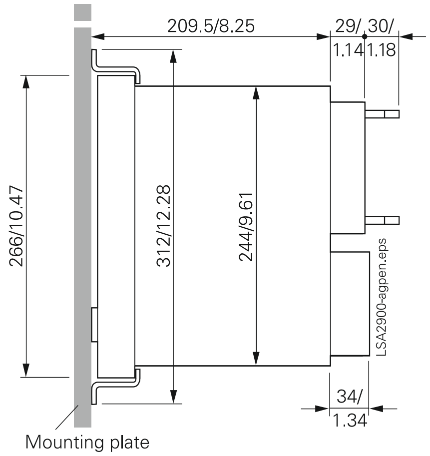
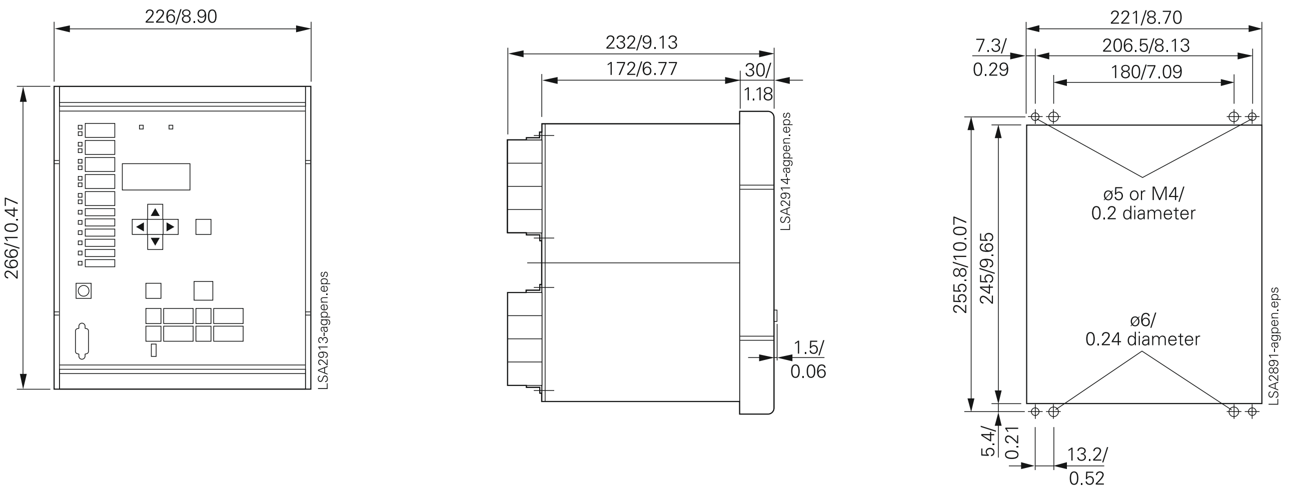


Fig. 15/28
Housing with detached or no operator panel

Dimension drawings in mm / inch

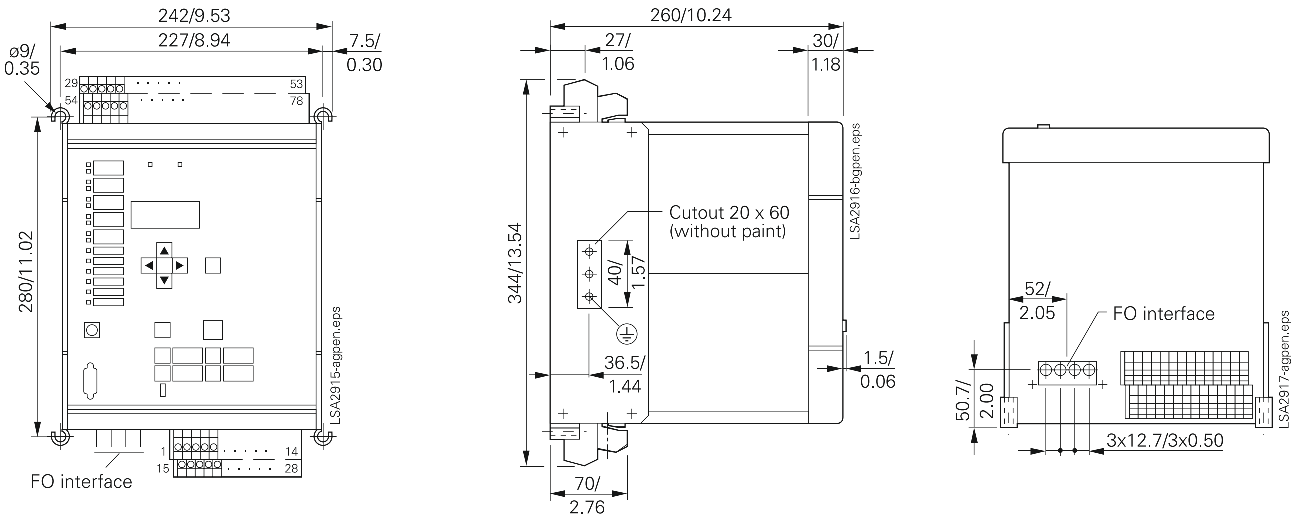


Front view

Side view

Panel cutout

Fig. 15/29
7SS523 bay unit in 7XP2040-2 housing
for panel flush mounting/cubicle mounting



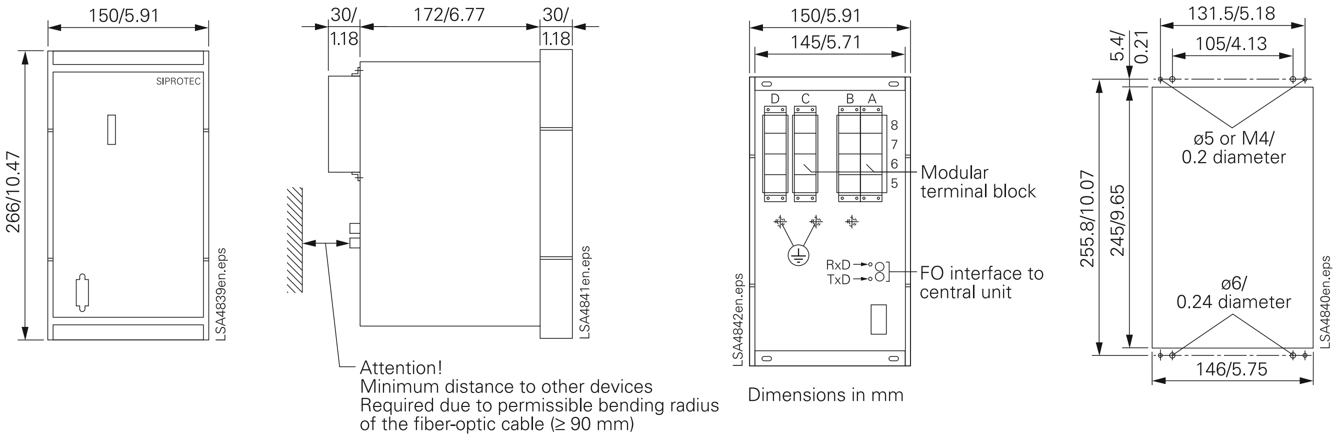
Front view

Side view

View from below

Fig. 15/30
7SS523 bay unit in 7XP2040-1 housing for
panel surface mounting

Dimension drawings in mm / inch



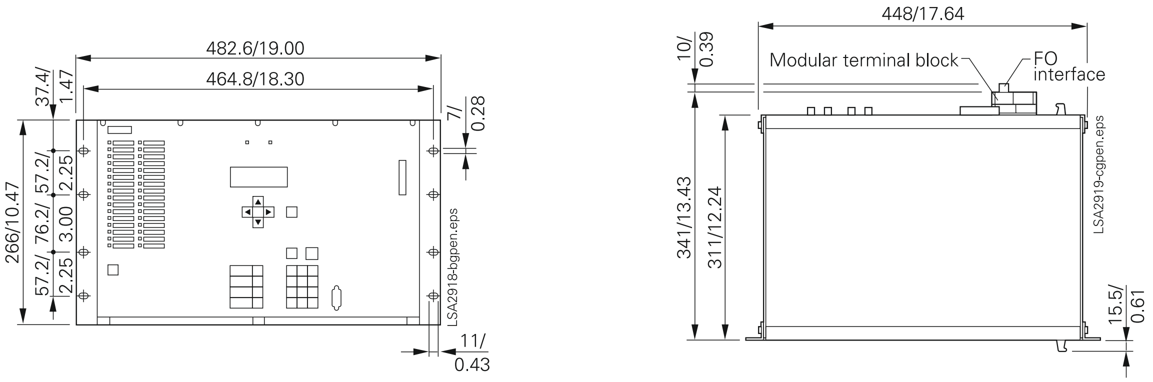
Front view

Side view

Rear view

Panel cutout

Fig. 15/31
7SS525 busbar and breaker failure protection unit
for panel flush mounting/cubicle mounting
with housing for wall mounting



Front view

Top view

Fig. 15/32
7SS522 central unit in SIPAC subrack

Dimension drawings in mm / inch

Fig. 15/33
Converter devices for rail mounting

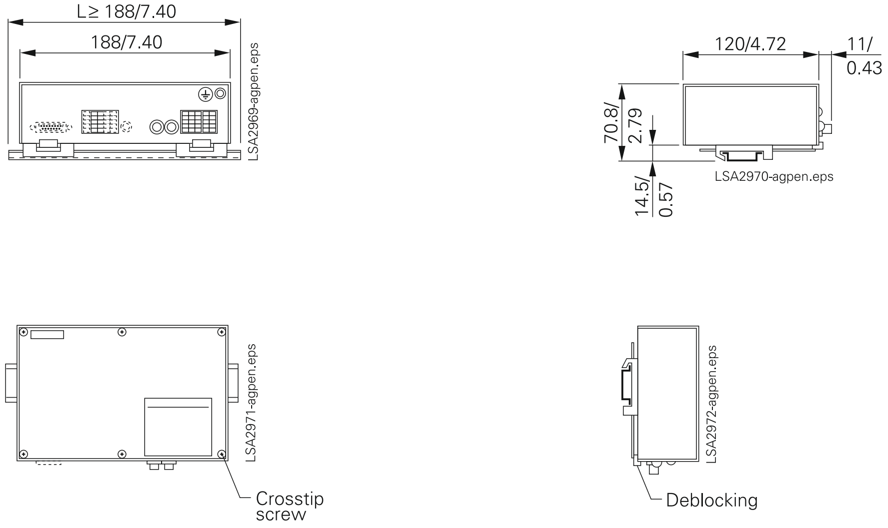
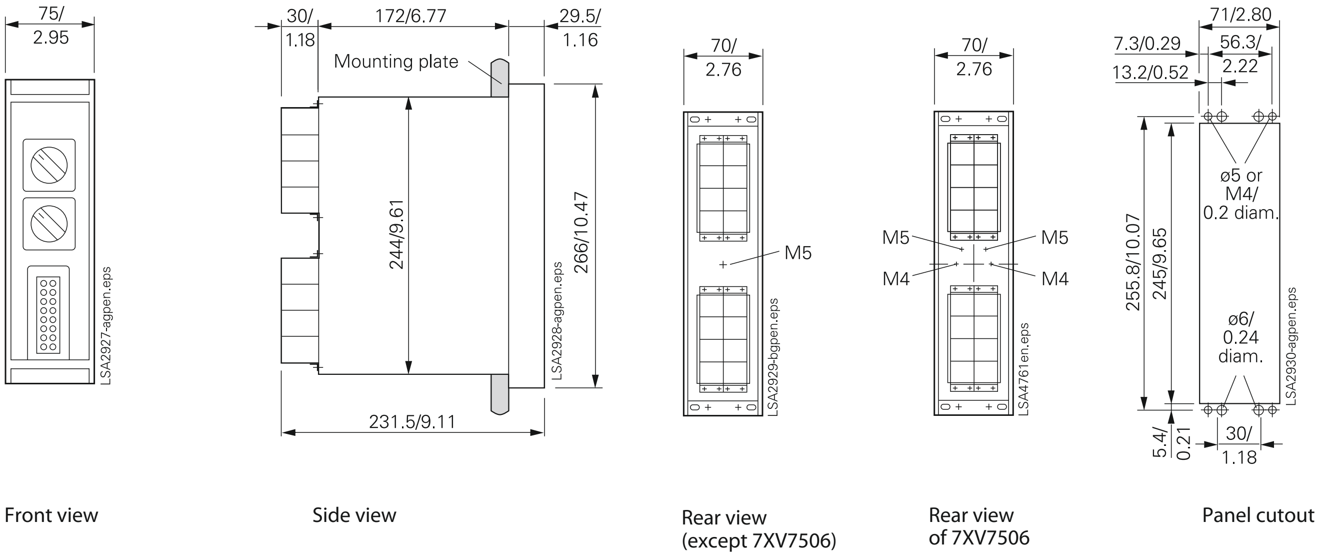


Fig. 15/34
7XV5662 communication converter

Dimension drawings in mm / inch



Front view

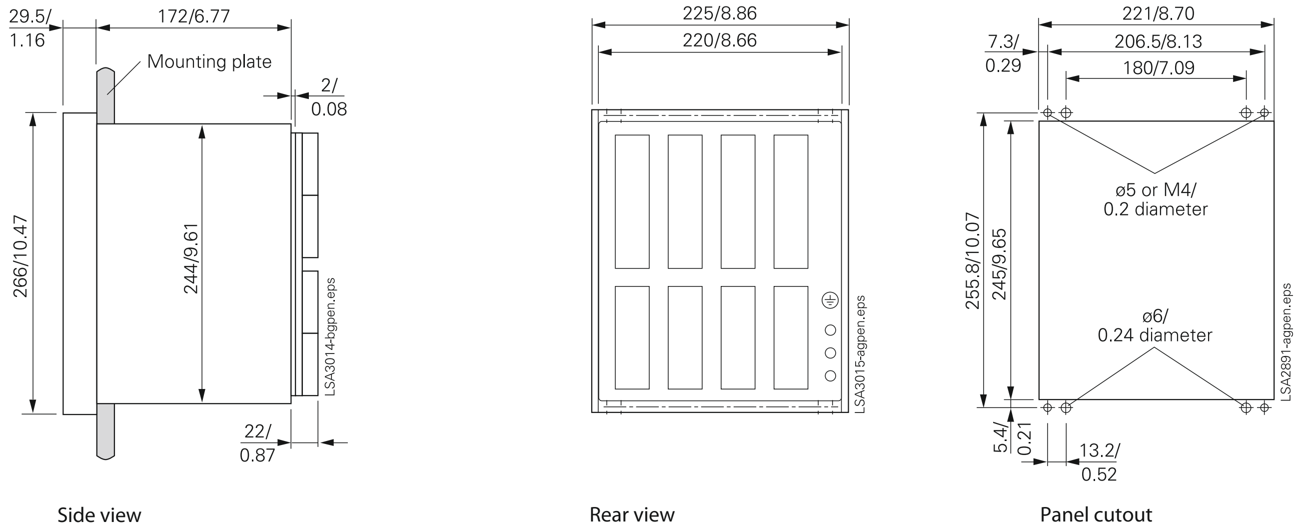
Side view

Rear view
(except 7XV7506)

Rear view
of 7XV7506

Panel cutout

Fig. 15/35
7XV75 with housing 7XP2020-2
(for panel flush mounting)



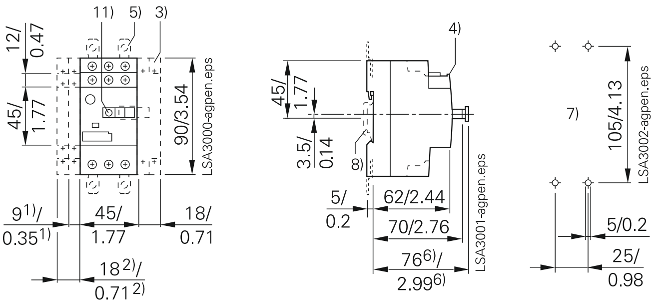
Side view

Rear view

Panel cutout

Fig. 15/36
Housing 7XP204 of the peripheral modules (7SS60)
for panel or cubicle flush mounting

Dimension drawings in mm / inch



7RV16 circuit-breaker

Fig. 15/37

1) Auxiliary switch, 2-pole, located on the side.
2) Auxiliary switch, 4-pole, located on the side.
3) Auxiliary release.
4) Auxiliary switch transverse position.
5) Link for screw fixing.
6) Only with undervoltage release combined with leading auxiliary switch.
7) Drilling diagram.
8) Monitoring rail 35 mm, acc. to EN 50022.
11 Lockable in OFF position with padlock, bracket diameter 3.5 to 4.5 mm

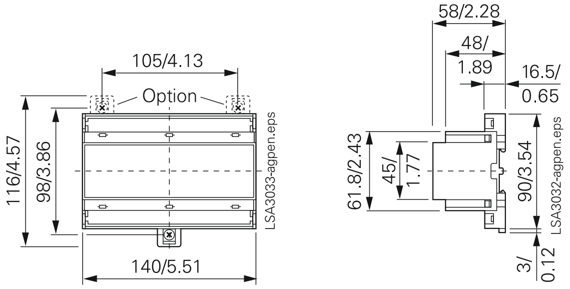


Fig. 15/38
Resistance temperature detector (RTD-box)

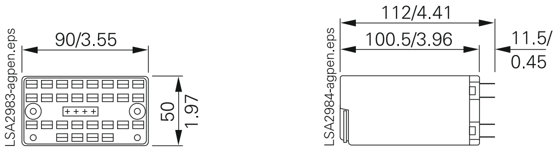


Fig. 15/39
7PA22 auxiliary relay

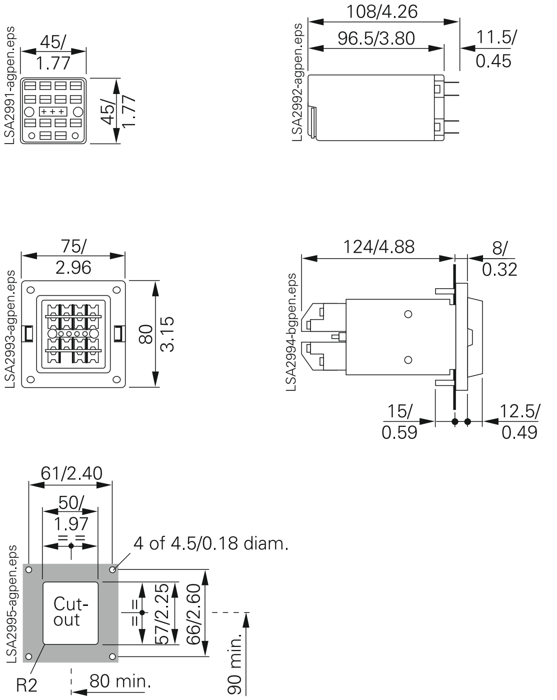


Fig. 15/40
7PA23 auxiliary relay +
flush mounting socket 7XP9011-1

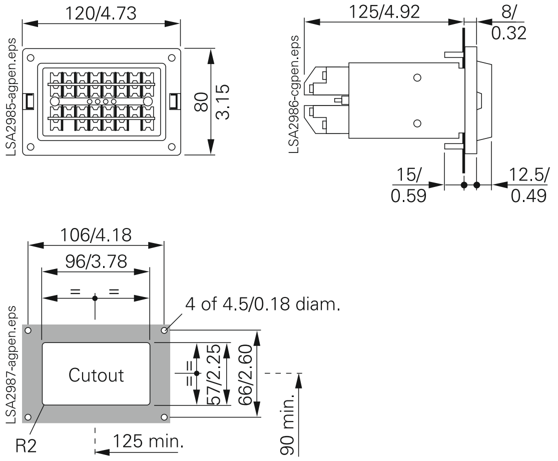


Fig. 15/41
Flush mounting sockets 7XP9010-1, 7XP9010-2,
7XP9010-4 for 7PA22 auxiliary relay
7TS16 indication relay
7PA30 three-phase trip circuit supervision

Dimension drawings in mm / inch

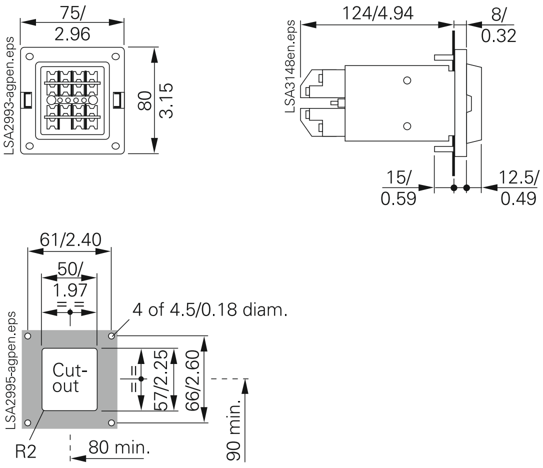


Fig. 15/42
Flush mounting sockets 7XP9011-0, 7XP9011-1
for 7PA23 auxiliary relay
7PA30 trip single-phase circuit supervision

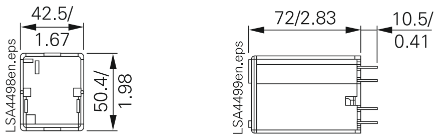


Fig. 15/43
7PA27

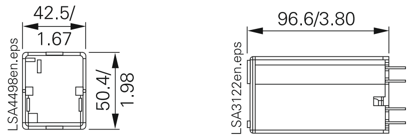


Fig. 15/44
7PA30 single-phase

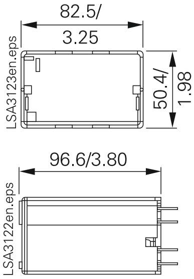


Fig. 15/45
7TS16, 7PA30 three-phase

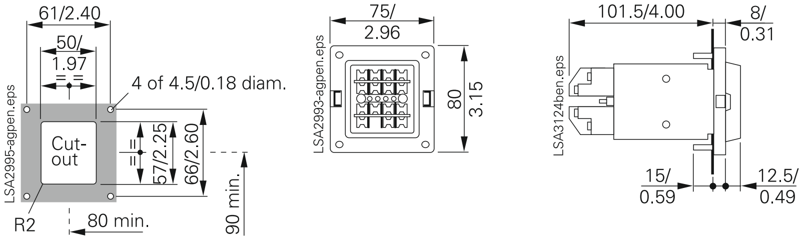


Fig. 15/46
Flush mounting socket 7XP9011-2
for 7PA27 auxiliary relay

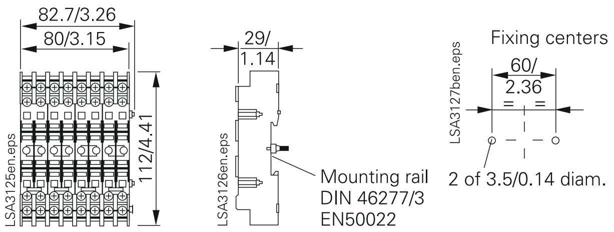


Fig. **15/47**
Surface mounting socket 7XP9012
7PA22, 7PA26 auxiliary relays
7TS16 indication relay
7PA30 three-phase trip circuit supervision

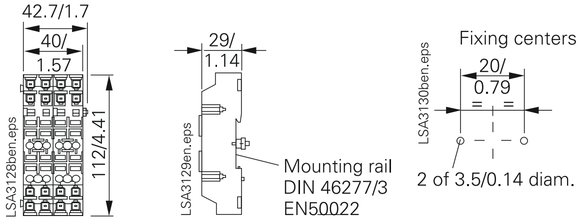


Fig. 15/48
Surface mounting socket 7XP9013
for 7PA23/27 auxiliary relay
7PA30 single-phase trip circuit supervision

Dimension drawings in mm / inch

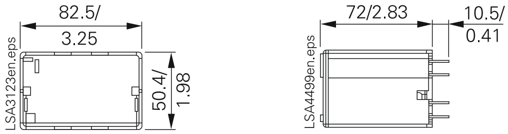


Fig. 15/49
7PA26 auxiliary relay

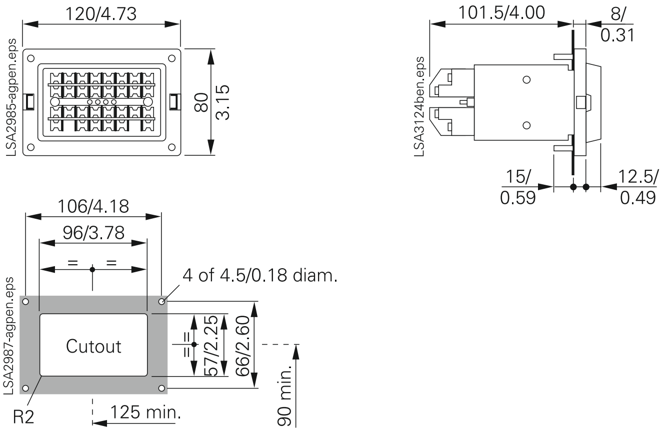


Fig. 15/50
Flush-mounting socket 7XP9010-3 for 7PA26

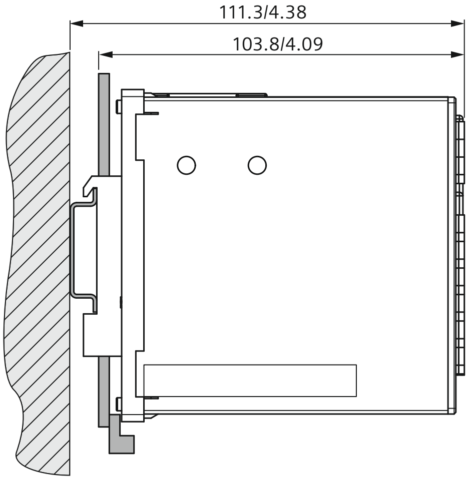
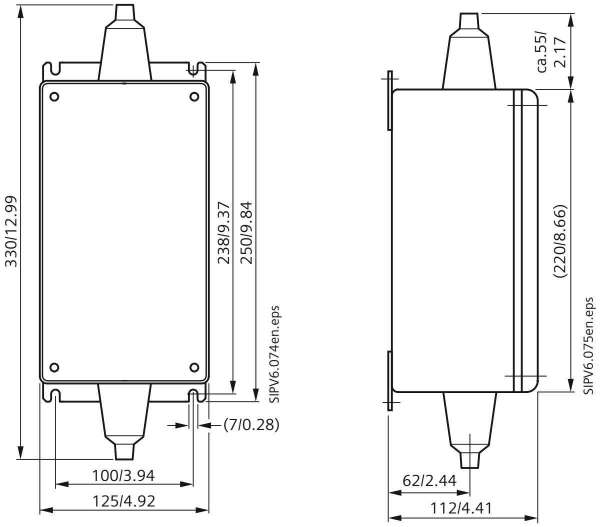


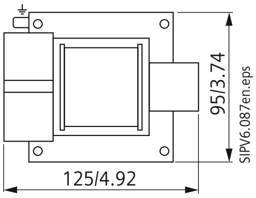
Fig. 15/51
7XV5673 *I*/O-Unit



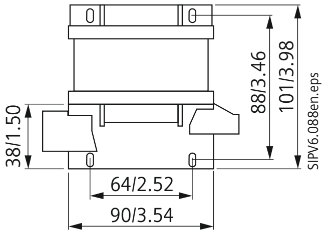
Top view

Side view

Fig. 15/52 7XR9513 isolating transformer

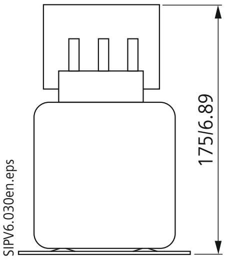


Side view

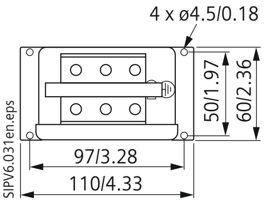


Top view

Fig. 15/53 7XR9515 isolating transformer



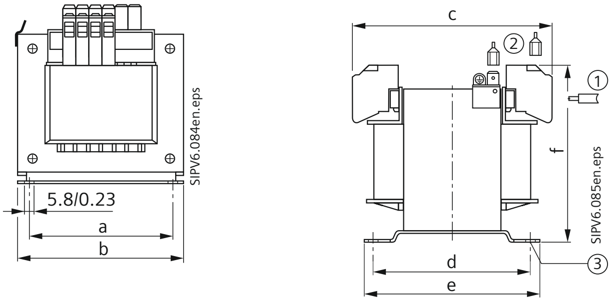
Side view



Top view

Fig. 15/54 7XR9516 isolating transformer

Dimension drawings in mm / inch



Type	a	b*)	c*)	d	e*)	f*)
4AM5065 4AM5070	84/3.31	99/3.90	106/4.17	86.5/3.4	104.5/4.11	105/4.13
4AM5170	84/3.31	99/3.90	120/4.72	86.5/3.41	104.5/4.11	105/4.13
4AM5272	90/3.54	123/4.84	116/4.57	85/3.35	103/4.06	123/4.84

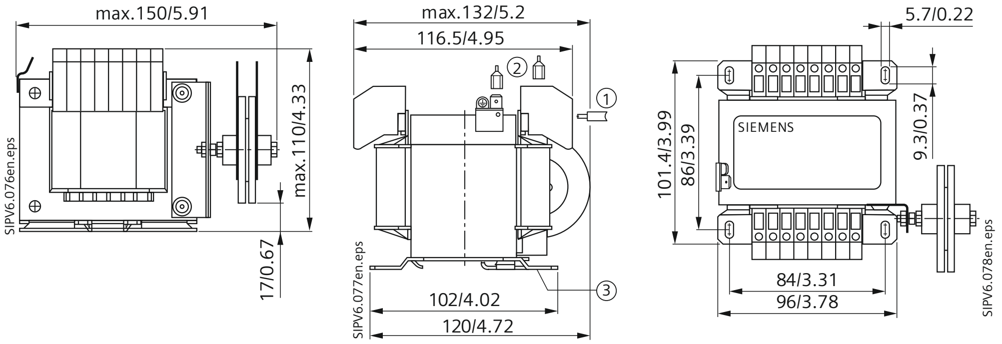
*) max. dimension

SIPV6.086en.eps

Front view

Side view

Fig. 15/55
4AM50, 4AM5170, 4AM52 auxiliary current transformer without varistor



1 Terminal 8WA9200 Siemens
Cross-section:
Single-wire 0.5 mm^2 to 6 mm^2
Fine-wire 0.5 mm^2 to 4 mm^2
Current rating: 21 A
Number of terminals depending on design

2 Flat connector DIN46244-A6.3-0.8

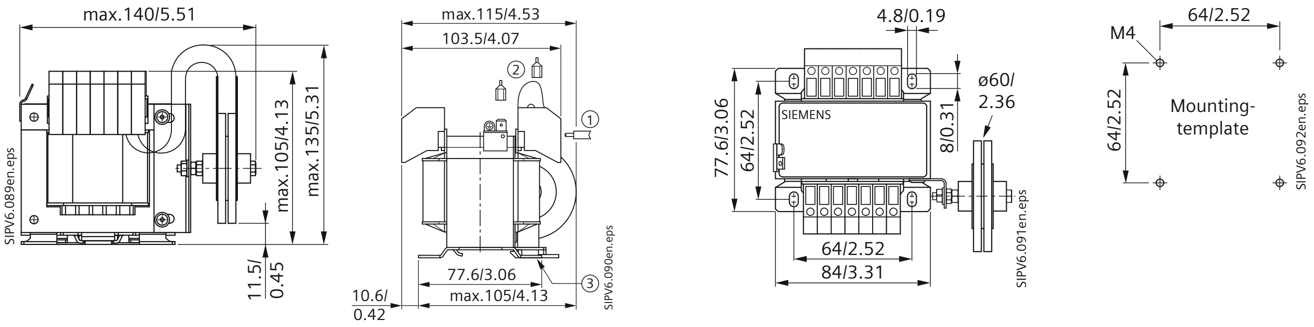
3 Fixing racket for DIN rail mounting

Front view

Side view

Top view

Fig. 15/56
4AM5120 auxiliary current transformer with varistor



Front view

Side view

Top view

Fig. 15/57
4AM auxiliary current transformer

Assignment for products

Products applied until now	Function	Recommended new products
7PA10	Auxiliary relay	7PA26/27
7PA20	Lockout relay	7PA22/23
7PA21	Trip circuit monitoring	7PA30
7RP72	Frequency relay	7RW600
7SD24	Line differential relay	7SD600
7SD510/511	Line differential relay via FO	7SD610
7SD512	Line differential relay via FO	7SD5
7SA500	Distance protection	7SA6, 7SA522
7SA501	Distance protection	7SA6, 7SA522
7SA502	Distance protection	7SA6, 7SA522
7SA510	Distance protection	7SA6, 7SA522
7SA511	Distance protection	7SA6, 7SA522
7SA513	Distance protection	7SA6, 7SA522
7SJ41	Overcurrent relay	7SJ45
7SJ50	Overcurrent relay	7SJ600/602/80
7SJ510	Overcurrent relay	7SJ61
7SJ511	Overcurrent relay	7SJ61
7SJ512	Overcurrent relay	7SJ62
7SJ531	Overcurrent relay	7SJ63
7SK52	Motor protection	7SK80 See SIP 3.01 SIPROTEC Compact Catalog E50001-K4403-A011-A1-7600
7SN71	Transient earth fault relay	7SN600
7UT512	Transformer differential relay	7UT612
7UT513	Transformer differential relay	7UT613/7UT63
7UM51	Machine protection	7UM61/62
7TS15	Annuciation relay	7TS16
7SS51	Busbar protection	7SS52
7SS13	Busbar protection	7SS60
7VH80/83, 7VH60	High-impedance diff. protection	7SR23 Reyrolle See www.siemens.com/siprotec
7SV50	BF relay	7SV600
7SV512	Breaker failure relay	7VK61
7VK512	Auto-reclosure und synchronism check relay	7VK61
7XV72	Test switch	7XV75
7XS50	DIGSI operating program	7XS54

Order No. Index

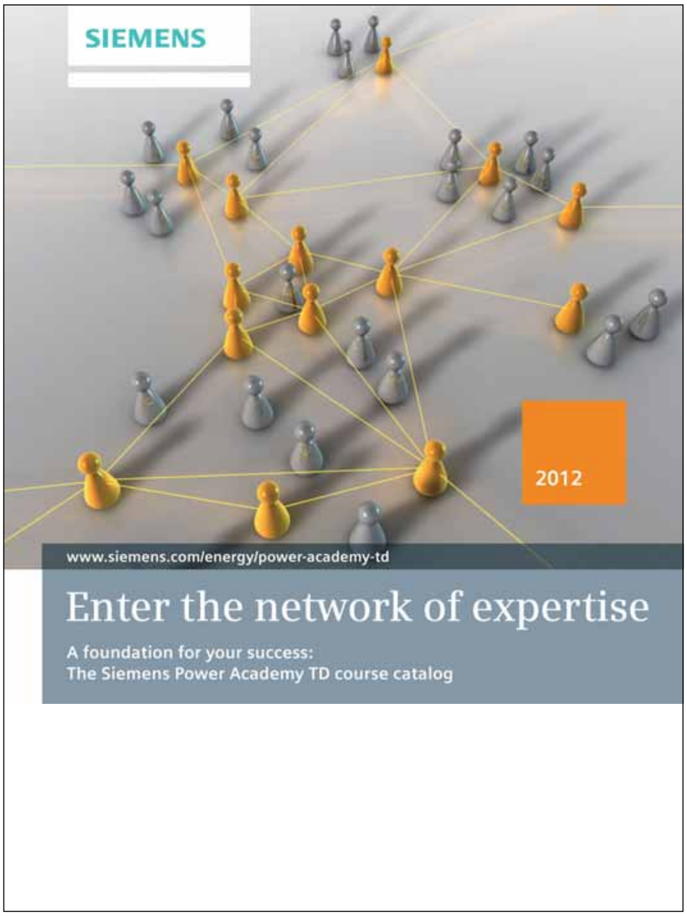
Order No. Index

Training

Equipment reliability and availability are essential for all owners and users. At the same time, maintenance costs need to be kept to a minimum. The liberalization of energy markets presents new challenges to all; maintaining and enhancing competitive strength are among today's most important business goals. Investment in technical plants and human resources enables these goals to be realized. Innovations in the technical field confront the users with the need of establishing, maintaining and extending their qualification and know-how. Our training programs are tailored to meet your specific needs. With our know-how, we can help you to keep ahead.

Our training centers offer training programs comprising an extensive range of courses covering all the important aspects of numerical protective relaying. Choosing our courses will simplify your planning and ensure you of high-quality professional instruction at a reasonable cost. It is also possible to arrange training on your own premises thereby reducing costs for group participation. We will jointly plan a complete training program that matches your business goals and your particular working context.

Each course and the corresponding training documents are available in many languages. On the Internet at www.siemens.com/power-academy you will find our complete training program with details of contents, dates, costs and contacts.



SIEMENS

2012

www.siemens.com/energy/power-academy-td

Enter the network of expertise

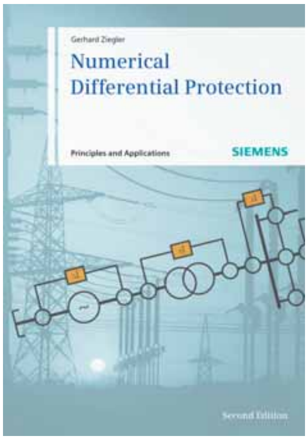
A foundation for your success:
The Siemens Power Academy TD course catalog

SIPV6_113.tif

Books and publications

Books on protection

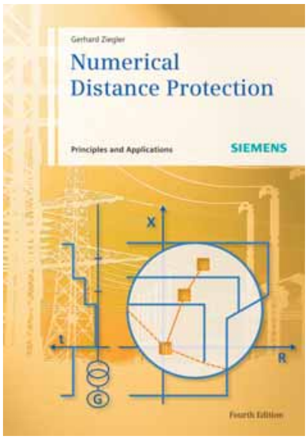
A textbook and standard work in one, these books cover all topics, which have to be paid attention to for planning, designing, configuring and applying differential and distance protection systems. The books are aimed at students and engineers who wish to familiarize themselves with the subject of differential/distance substation protection, as well as the experienced user, entering the area of numerical differential/distance protection. Furthermore, they serve as a reference guide for solving application problems.



SIPV6_114.tif

Siemens Order No.
A19100-L531-B107-X-7600

ISBN 978-3-89578-351-7



SIPV6_115.tif

Siemens Order No.
A19100-L531-B972-X-7600

ISBN 978-3-89578-318-0

Motor Protection and IEC Standard Application Brochures for SIPROTEC Protection Relays

On 76 pages the "Motor protection brochure" describes the principles of asynchronous and synchronous motors, gives an overview of relay protection functions for motors and details on protection of low-, medium- and high-power motors.

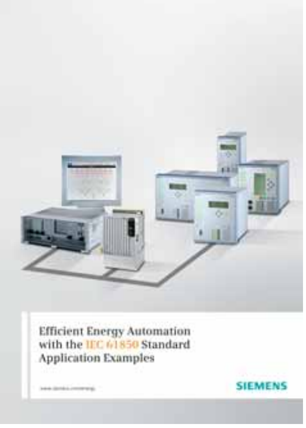
If you wish to know more about efficient energy automation in accordance with the IEC 61850 standard, then our "IEC 61850 brochure" is the right source to turn to.

Topics covered comprise, among others, switchgear interlocking with IEC 61850 GOOSE, reverse interlocking, innovative solutions for substation control with IEC 61850.

Please contact your Siemens representative for free copies by indicating the Order No.

LSP2892.tif

Order No.
E50001-K4454-A101-A1-7600



LSP2893.tif

Order No.
E50001-K4455-A101-A2-7600

Multimedia CD ROMs/DVDs

Useful information on selection and application for the SIPROTEC protection relays is provided for the user.

The following subject matters are available on one DVD:

- SIPROTEC relay features
- SIPROTEC application hints
- Communication based on IEC 61850
- DIGSI Software operating program
- SIGRA Software evaluation of fault records

Computer-based interactive training: Study, practice, check your knowledge

Ask your Siemens representative for the CDs/DVDs free of charge.

List of available multimedia CD ROMs/DVDs	
Title	Order No.
SIPROTEC 4 Tutorial	E50001-U310-D21-X-7100

LSP2894.tif

Legal notice

Indication of conformity

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compability (EMC Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2006/95/EC).

This conformity has been proved by tests performed according to the Council Directive in accordance with the generic standards EN 61000-6-2 and EN 61000-6-4 (for EMC directive) and with the standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standard of IEC 60255 and the German standard VDE 0435.

Disclaimer of liability

This document has been subjected to rigorous technical review before being published. It is revised at regular intervals, and any modifications and amendments are included in the subsequent issues. The content of this document has been compiled for information purposes only. Although Siemens AG has made best efforts to keep the document as precise and up-to-date as possible, Siemens AG shall not assume any liability for defects and damage which result through use of the information contained herein.

This content does not form part of a contract or of business relations; nor does it change these. All obligations of Siemens AG are stated in the relevant contractual agreements.

Siemens AG reservers the right to revise this document from time to time.

Document version: 06

Release status: 12.2011

Copyright

Copyright © Siemens AG 2012. All rights reserved.

The disclosure, duplication, distribution and editing of this document, or utilization and communication of the content are not permitted, unless authorized in writing. All rights, including rights created by patent grant or registration of a utility model or a design, are reserved.

Registered trademarks

SIPROTEC and DIGSI are registered trademarks of Siemens AG. Any unauthorized use is illegal. All other designations in this document can be trademarks whose use by third parties for their own purposes can infringe the rights of the owner.

Published by and copyright © 2012:
Siemens AG
Infrastructure & Cities Sector
Smart Grid Division
Humboldtstr. 59
90459 Nuremberg, Germany

Siemens AG
Infrastructure & Cities Sector
Smart Grid Division
Energy Automation
Humboldtstr. 59
90459 Nuremberg, Germany
www.siemens.com/protection

Printed on elementary chlorine-free bleached paper.

For more information, please contact
our Customer Support Center.
Tel.: +49 180 524 84 37
Fax: +49 180 524 24 71
(Charges depending on provider)
E-mail: support.ic@siemens.com

Order No.: E50001-K4400-A101-A6-7600
Printed in Germany
Dispo 06200, c4bs 7442
KG 12.11 1.0 878 EN
3600/35522 WÜ