SIPROTEC Compact 7SJ80 Overcurrent Time Protection

V4.6

Technical Data

Extract from manual E50417-G1140-C343-A4, chapter 4

Energy Automation

SIEMENS

Note

For safety purposes, please note instructions and warnings in the Preface.

Disclaimer of Liability

We have checked the contents of this manual against the hardware and software described. However, deviations from the description cannot be completely ruled out, so that no liability can be accepted for any errors or omissions contained in the information given.

The information given in this document is reviewed regularly and any necessary corrections will be included in subsequent editions. We appreciate any suggested improvements.

We reserve the right to make technical improvements without notice.

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Order no.: E50417-G1140-C343-A4

Preface

Purpose of this Manual

This manual describes the functions, operation, installation, and commissioning of 7SJ80 devices. In particular, one will find:

- Information regarding the configuration of the scope of the device and a description of the device functions and settings → Chapter 2;
- Instructions for Installation and Commissioning → Chapter 3;
- Compilation of the Technical Data → Chapter 4;
- As well as a compilation of the most significant data for advanced users → Appendix A.

General information with regard to design, configuration, and operation of SIPROTEC 4 devices are set out in the SIPROTEC 4 System Description /1/.

Target Audience

Protection engineers, commissioning engineers, personnel concerned with adjustment, checking, and service of selective protective equipment, automatic and control facilities, and personnel of electrical facilities and power plants.

Applicability of this Manual

This manual is valid for: SIPROTEC 4 7SJ80 Multifunctional Protection Device ; Firmware Version V4.6

Indication of 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 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage Directive 2006/95 EC). This conformity is proved by tests conducted by Siemens AG in accordance with the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for EMC directive, and with the standard EN 60255-27 for the low-voltage directive. The device has been designed and produced for industrial use. The product conforms with the international standards of the series IEC 60255 and the German standard VDE 0435.

Additional Standards

IEEE C37.90 (see Chapter 4 "Technical Data")
This product is UL-certfied with the values as stated in the Technical Data.
file E194016

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Additional Support

Should further information on the System SIPROTEC 4 be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the local Siemens representative.

Our Customer Support Center provides a 24-hour service.

Telephone: +49 (180) 524-7000

Fax: +49 (180) 524-2471

e-mail: support.energy@siemens.com

Training Courses

Enquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG

Siemens Power Academy TD

Humboldt Street 59

90459 Nuremberg

Telephone: +49 (911) 433-7005

Fax: +49 (911) 433-7929

Internet: www.siemens.com/power-academy-td

Technical Data 4

This chapter provides the technical data of the device SIPROTEC 7SJ80 and its individual functions, including the limit values that may not be exceeded under any circumstances. The electrical and functional data for the maximum functional scope are followed by the mechanical specifications with dimensioned drawings.

4.1 General Device Data

4.1.1 Analog Inputs

Current Inputs

Nominal Frequency	f_N	50 Hz or 60 Hz	(adjustable)
Frequency working range (independent of the nominal frequency)		25 Hz to 79 Hz	
Nominal current	I_{Nom}	1 A or 5 A	
Ground current, sensitive	I_{Ns}	≤ 1,6· I_{Nom} linear range [1)]	
Burden per phase and ground path - at I_{Nom} = 1 A - at I_{Nom} = 5 A - for sensitive ground fault detection at 1 A		 ≤ 0.05 VA ≤ 0.3 VA ≤ 0.05 VA	
Load capacity current path - thermal (rms) - dynamic (peak value)		 500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half-cycle)	
Load capacity input for sensitive ground fault detection I_{Ns} [1)]			
- thermal (rms) - dynamic (peak value)		300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half-cycle)	

[1)] only in models with input for sensitive ground fault detection (see ordering data in Appendix A.1)

Voltage inputs

Nominal voltage		34 V – 225 V (adjustable) for connection of phase-to-ground voltages 34 V – 200 V (adjustable) for connection of phase-to-phase voltages
Measuring Range		0 V to 200 V
Burden	at 100 V	approx. 0.005 VA
Overload capacity in the voltage path		
– thermal (rms)		230 V continuous

4.1.2 Auxiliary Voltage

DC Voltage

Voltage supply via an integrated converter		
Nominal auxiliary DC voltage V_{Aux}–	24 V to 48 V	60 V to 250 V
Permissible voltage ranges	19 V to 60 V	48 V to 300 V
Overvoltage category, IEC 60255-27	III	
AC ripple voltage peak to peak, IEC 60255-11	15 % of auxiliary voltage	

Power input	Quiescent	Energized
7SJ80	approx. 5 W	approx. 12 W
Bridging time for failure/short-circuit, IEC 60255–11	≥ 50 ms at V ≥ 110 V	
	≥ 10 ms at V < 110 V	

AC Voltage

Voltage supply via an integrated converter		
Nominal auxiliary AC voltage V_H	115 V	230 V
Permissible voltage ranges	92 V to 132 V	184 V to 265 V
Overvoltage category, IEC 60255-27	III	

Power input (at 115 V / 230 V)	Quiescent	Energized
7SJ80	approx. 5 VA	approx. 12 VA
Bridging time for failure/short-circuit	≥ 10 ms at V = 115 V / 230 V	

4.1.3 Binary Inputs and Outputs

Binary Inputs

Variant	Quantity	
7SJ801/803	3 (configurable)	
7SJ802/804	7 (configurable)	
Nominal direct voltage range	24 V to 250 V	
Current input, energized (independent of the control voltage)	Approx. 0,4 mA	
Pickup time Response time of BO, triggered from BI	Approx. 3 ms Approx. 9 ms	
Dropout time Response time of BO, triggered from BI	Approx. 4 ms Approx. 5 ms	
Secured switching thresholds	(adjustable)	
for nominal voltages	24 V to 125 V	V high > 19 V V low < 10 V
for nominal voltages	110 V to 250 V	V high > 88 V V low < 44 V
for nominal voltages	220 V and 250 V	V high > 176 V V low < 88 V
Maximum permissible voltage	300 V	
Input interference suppression	220 Vdc across 220nF at a recovery time between two switching operations ≥ 60 ms	

Output Relay

Signal/command Relay, Alarm Relay		
Quantity and data	depending on the order variant (allocatable)	
Order variant	NO contact *)	NO/NC selectable *)
7SJ801/803	3	2 (+ 1 life contact not allocatable)
7SJ802/804	6	2 (+ 1 life contact not allocatable)
Switching Capability MAKE	1000 W / 1000 VA	
Switching capability BREAK	40 W or 30 VA at L/R ≤ 40 ms	
Switching voltage AC and DC	250 V	
Admissible current per contact (continuous)	5 A	
Permissible current per contact (close and hold)	30 A for 1 s (NO contact)	
Interference supporession capacitor at the relay outputs 2.2 nF, 250 V, ceramic	Frequency	Impedance
	50 Hz	$1{,}4 \cdot 10^6\ \Omega \pm 20\ \%$
	60 Hz	$1{,}2 \cdot 10^6\ \Omega \pm 20\ \%$

4.1.4 Communication Interfaces

Operator Interface

Terminal	Front side, non-isolated, USB type B socket for connecting a personal computer Operation from DIGSI V4.82 via USB 2.0 full speed
Operation	With DIGSI
Transmission speed	up to 12 Mbit/s max.
Bridgeable distance	5 m

Port A

Ethernet electrical for DIGSI	Operation	With DIGSI
	Terminal	Front case bottom, mounting location "A", RJ45 socket 100BaseT in acc. with IEEE802.3 LED yellow: 10/100 Mbit/s (on/off) LED green: connection/no connection (on/off)
	Test voltage	500 V; 50 Hz
	Transmission speed	10/100 Mbit/s
	Bridgeable distance	20 m (66 ft)

Port B

IEC 60870-5-103 single		
	RS232/RS485/FO depending on the order variant	Isolated interface for data transfer to a control center
RS232		
	Terminal	Back case bottom, mounting location "B", 9-pin DSUB socket
	Test voltage	500 V; 50 Hz
	Transmission speed	min. 1 200 Bd, max. 115 000 Bd; factory setting 9 600 Bd
	Bridgeable distance	15 m
RS485		
	Terminal	Back case bottom, mounting location "B", 9-pin DSUB socket
	Test voltage	500 V; 50 Hz
	Transmission speed	min. 1 200 Bd, max. 115 000 Bd; factory setting 9 600 Bd
	Bridgeable distance	max. 1 km

Fiber optic cable (FO)		
	FO connector type	ST connector
	Terminal	Back case bottom, mounting location "B"
	Optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825-1/-2	When using glass fiber 50/125 µm or glass fiber 62.5/125 µm
	Permissible optical signal attenuation	max. 8 dB, with glass fiber 62.5/125 µm
	Bridgeable distance	max. 1.5 km
	Character idle state	Configurable; factory setting „Light off“
IEC 60870-5-103 redundant RS485		
	Isolated interface for data transfer to a control center	
	Terminal	Back case bottom, mounting location "B", RJ45 socket
	Test voltage	500 V; 50 Hz
	Transmission speed	min. 2,400 Bd, max. 57,600 Bd; factory setting 19,200 Bd
	Bridgeable distance	max. 1 km
Profibus RS485 (DP)		
	Terminal	Back case bottom, mounting location "B", 9-pin DSUB socket
	Test voltage	500 V; 50 Hz
	Transmission speed	Up to 1.5 MBd
	Bridgeable distance	1 000 m (3 300 ft) at ≤ 93.75 kBd 500 m (1 600 ft) at ≤ 187.5 kBd 200 m (660 ft) at ≤ 1.5 MBd
Profibus FO (DP)		
	FO connector type	ST connector Double ring
	Terminal	Back case bottom, mounting location "B"
	Transmission speed	Up to 1.5 MBd
	Recommended:	> 500 kBd with normal casing
	Optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825-1/-2	When using glass fiber 50/125 µm or glass fiber 62.5/125 µm
	Permissible optical signal attenuation	max. 8 dB, with glass fiber 62.5/125 µm
	Bridgeable distance	max. 2 km
DNP3.0 /MODBUS RS485		
	Terminal	Back case bottom, mounting location "B", 9-pin DSUB socket
	Test voltage	500 V; 50 Hz
	Transmission speed	Up to 19.200 Baud
	Bridgeable distance	max. 1 km

DNP3.0 /MODBUS FO		
	FO connector type	ST connector transmitter/receiver
	Terminal	Back case bottom, mounting location "B"
	Transmission speed	Up to 19 200 Baud
	Optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825-1/-2	When using glass fiber 50/125 μm or glass fiber 62.5/125 μm
	Permissible optical signal attenuation	max. 8 dB, with glass fiber 62.5/125 μm
	Bridgeable distance	max. 1.5 km
Ethernet electrical (EN 100) for IEC61850 and DIGSI		
	Terminal	Back case bottom, mounting location "B", 2 x RJ45 socket 100BaseT in acc. with IEEE802.3
	Test voltage (with regard to the socket)	500 V; 50 Hz
	Transmission speed	100 MBit/s
	Bridgeable distance	20 m
Ethernet optical (EN 100) for IEC61850 and DIGSI		
	Terminal	Back case bottom, mounting location "B", LC connector 100BaseF in acc. with IEEE802.3
	Transmission speed	100 MBit/s
	Optical wavelength	1300 nm
	Bridgeable distance	max. 2 km (1.24 mi)

4.1.5 Electrical Tests

Standards

Standards:	IEC 60255 IEEE Std C37.90, see individual functions VDE 0435 for more standards see also individual functions

Insulation test

Standards:	IEC 60255-27 and IEC 60870-2-1
Voltage test (routine test) of all circuits except auxiliary voltage, binary inputs and communication ports	2.5 kV, 50 Hz
Voltage test (routine test) of auxiliary voltage and binary inputs	DC: 3.5 kV
Voltage test (routine test) of isolated communication ports only (A and B)	500 V, 50 Hz
Impulse voltage test (type test) of all process circuits (except for communication ports) against the internal electronics	6 kV (peak value); 1.2/50 μs; 0.5 J; 3 positive and 3 negative impulses at intervals of 1 s
Impulse voltage test (type test) of all process circuits against each other (except for communication ports) and against the PE terminal of class III	5 kV (peak value); 1.2/50 μs; 0.5 J; 3 positive and 3 negative impulses at intervals of 1 s

EMC Tests for Immunity (Type Tests)

Standards:		IEC 60255-6 and -22, (product standards) IEC/EN 61000-6-2 VDE 0435 For more standards see also individual functions
1 MHz test, Class III IEC 60255-22-1, IEC 61000-4-18, IEEE C37.90.1		2.5 kV (Peak); 1 MHz; τ = 15 μs; 400 Surges per s; Test duration 2 s; R_i = 200 Ω
Electrostatic discharge, Class IV IEC 60255-22-2, IEC 61000-4-2		8 kV contact discharge; 15 kV air discharge, both polarities; 150 pF; R_i = 330 Ω
Radio frequency electromagnetic field, amplitude-modulated, Class III IEC 60255-22-3, IEC 61000-4-3		10 V/m; 80 MHz to 2.7 GHz; 80 % AM; 1 kHz
Fast transient bursts, Class IV IEC 60255-22-4, IEC 61000-4-4, IEEE C37.90.1		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), Installation Class III IEC 60255-22-5, IEC 61000-4-5		Impulse: 1.2/50 μs
	Auxiliary voltage	common mode: 4 kV; 12 Ω; 9 μF Diff. mode:1 kV; 2 Ω; 18 μF
	Measuring inputs, binary inputs and relay outputs	common mode: 4 kV; 42 Ω; 0,5 μF Diff. mode: 1 kV; 42 Ω; 0,5 μF
HF on lines, amplitude-modulated, Class III IEC 60255-22-6, IEC 61000-4-6		10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field IEC 61000-4-8, Class IV;		30 A/m continuous; 300 A/m for 3 s;
Radiated Electromagnetic Interference IEEE Std C37.90.2		20 V/m; 80 MHz to 1 GHz; 80 % AM; 1 kHz
Damped oscillations IEC 61000-4-18		2.5 kV (peak value); 100 kHz; 40 pulses per s; Test Duration 2 s; Ri = 200 Ω

EMC Test for Noise Emission (Type Test)

Standard:	IEC/EN 61000-6-4
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 11	150 kHz to 30 MHz Limit Class A
Interference field strength IEC-CISPR 11	30 MHz to 1000 MHz Limit Class A
Harmonic currents on the network lead at AC 230 V IEC 61000-3-2	Device is to be assigned Class D (applies only to devices with > 50 VA power consumption)
Voltage fluctuations and flicker on the network lead at AC 230 V IEC 61000-3-3	Limit values are kept

4.1.6 Mechanical Stress Tests

Vibration and Shock Stress during Stationary Operation

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class II; IEC 60068-2-6	Sinusoidal 10 Hz to 60 Hz: ± 0,075 mm amplitude; 60 Hz to 150 Hz: 1g acceleration frequency sweep rate 1 octave/min 20 cycles in 3 orthogonal axes.
Shock IEC 60255-21-2, Class I; IEC 60068-2-27	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 II; IEC 60068-3-3	Sinusoidal 1 Hz to 8 Hz: ±7.5 mm amplitude (horizontal axis) 1 Hz to 8 Hz: ±3.5 mm amplitude (vertical axis) 8 Hz to 35 Hz: 2 g acceleration (horizontal axis) 8 Hz to 35 Hz: 1 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

Vibration and Shock Stress during Transport

Standards:	IEC 60255-21 and IEC 60068
Oscillation 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 orthogonal 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)

4.1.7 Climatic Stress Tests

Temperatures

Standards:	IEC 60255-6
Type test (in acc. with IEC 60068-2-1 and -2, Test Bd for 16 h)	–25 °C to +85 °C or –13 °F to +185 °F
Permissible temporary operating temperature (tested for 96 h)	–20 °C to +70 °C or –4 °F to +158 °F (clearness of the display may be impaired from +55 °C or +131 °F)
Recommended for permanent operation (in acc. with IEC 60255-6)	–5 °C to +55 °C or +23 °F to +131 °F
Limit temperatures for storage	–25 °C to +55 °C or –13 °F to +131 °F
Limit temperatures for transport	–25 °C to +70 °C or –13 °F to +158 °F
Storage and transport with factory packaging	

Humidity

Permissible humidity	Mean value per year ≤ 75 % relative humidity; on 56 days of the year up to 93 % relative humidity; condensation must be avoided!
Siemens recommends that all devices be installed such that they are not exposed to direct sunlight, nor subject to large fluctuations in temperature that may cause condensation to occur.	

4.1.8 Service Conditions

The protective device is designed for use in an industrial environment and an electrical utility environment. Proper installation procedures should be followed to ensure electromagnetic compatibility (EMC).

In addition, the following is recommended:

- All contacts and relays that operate in the same cubicle, cabinet, or relay panel as the numerical protective device should, as a rule, be equipped with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables should be shielded with a conductive shield grounded at both ends. For substations with lower operating voltages, no special measures are normally required.
- Do not withdraw or insert individual modules or boards while the protective device is energized. In withdrawn condition, some components are electrostatically endangered; during handling the ESD standards (for **E**lectrostatic **S**ensitive **D**evices) must be observed. They are not endangered when inserted into the case.

4.1.9 Design

Case	7XP20
Dimensions	see dimensional drawings, Section 4.22

Device	Case	Size	Weight
7SJ80**-*B	for panel surface mounting	$^{1}/_{6}$	4.5 kg (9.9 lb)
7SJ80**-*E	for panel flush mounting	$^{1}/_{6}$	4 kg (8.8 lb)

Protection type acc. to IEC 60529	
For equipment in the surface-mounting case	IP 50
For equipment in flush mounting case	Front IP 51 Rear IP 50
for operator protection	IP 2x for current terminal IP 1x for voltage terminal
Degree of pollution, IEC 60255-27	2

4.1.10 UL-certification conditions

Qutput Relais	DC 24 V	5 A General Purpose
	DC 48 V	0,8 A General Purpose
	DC 240 V	0,1 A General Purpose
	AC 240 V	5 A General Purpose
	AC 120 V	1/3 hp
	AC 250 V	1/2 hp
	B300, R300	
Voltage Inputs	Input voltage range	300 V
Battery	Servicing of the circuitry involving the batteries and replacement of the lithium batteries shall be done by a trained technician. Replace Battery with VARTA or Panasonic Cat. Nos. CR 1/2 AA or BR 1/2 AA only. Use of another Battery may present a risk of fire or explosion. See manual for safety instructions. Caution: The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C (212°F) or incinerate. Dispose of used battery promptly. Keep away from children.	
Climatic Stress	Surrounding air temperature	tsurr: max. 70 °C (158 °F), normal operation
Design	Field Wires of Control Circuits shall be separated from other circuits with respect to the end use requirements!	
	Type 1 if mounted into a door or front cover of an enclosure.	

4.2 Definite-Time Overcurrent Protection 50(N)

Operating Modes

Three-phase	Standard
Two-phase	Phases A and C

Measuring Method

All elements	First harmonic, r.m.s. value (true RMS)
51Ns-3	Additional instantaneous values

Setting Ranges / Increments

Pickup current 50–1, 50–2 (phases)	for I_{Nom} = 1 A	0.10 A to 35.00 A or ∞ (disabled)	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 175.00 A or ∞ (disabled)	
Pickup current 50–3 (phases)	for I_{Nom} = 1 A	1.0 A to 35.00 A or ∞ (disabled)	
	for I_{Nom} = 5 A	5.0 A to 175.00 A or ∞ (disabled)	
Pickup Current 50N–1, 50N–2 (ground)	for I_{Nom} = 1 A	0.05 A to 35.00 A or ∞ (disabled)	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 175.00 A or ∞ (disabled)	
Pickup Current 50N–3 (ground)	for I_{Nom} = 1 A	0.25 A to 35.00 A or ∞ (disabled)	
	for I_{Nom} = 5 A	1.25 A to 175.00 A or ∞ (disabled)	
Time delays T		0.00 s to 60.00 s or ∞ (disabled)	Increments 0.01 s
Dropout time delays 50 T DROP-OUT, 50N T DROP-OUT		0.00 s to 60.00 s	Increments 0.01 s

Times

Pickup times (without inrush restraint, with restraint + 1 period)	
First harmonic, rms value - for 2 x setting value - for 10 x setting value Instantaneous value - for 2 x setting value - for 10 x setting value	 approx. 30 ms Approx. 20 ms approx. 16 ms approx. 16 ms
Dropout Times First harmonic, rms value Instantaneous value	 approx. 30 ms approx. 40 ms

Dropout Ratio

Dropout ratio for - first harmonic, rms value - instantaneous value	 approx. 0,95 for $I/I_{Nom} \geq 0.3$ approx. 0,90 for $I/I_{Nom} \geq 0.3$

Tolerances

Pickup times	3 % of setting value or 15 mA at I_{Nom} = 1 A or 75 mA at I_{Nom} = 5 A
Time delays T	1 % or 10 ms

Influencing Variables for Pickup and Dropout

Auxiliary DC voltage in range $0.8 \le V_{Aux}/V_{AuxNom} \le 1.15$	1 %
Temperature in range –5 °C (41 °F) $\le \Theta_{amb} \le$ 55 °C (131 °F)	0.5 %/10 K
Frequency in range of 50 Hz to 70 Hz	
Frequency in range $0.95 \le f/f_{Nom} \le 1.05$	1 %
Frequency outside range $0.95 \le f/f_{Nom} \le 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic at instantaneous value of 50-3/50N-3 elements	 1 % 1 % Increased tolerances
Transient overreaction for τ > 100 ms (with full displacement)	<5 %

4.3 Inverse-Time Overcurrent Protection 51(N)

Operating Modes

Three-phase	Standard
Two-phase	Phases A and C

Measuring Technique

All elements	First harmonic, rms value (true rms)

Setting Ranges / Increments

Pickup currents 51 (phases)	for I_{Nom} = 1 A	0.10 A to 4.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 20.00 A	
Pickup currents 51N (ground)	for I_{Nom} = 1 A	0.05 A to 4.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 20.00 A	
Time multiplier T for 51, 51N for IEC characteristics		0.05 s to 3.20 s or ∞ (disabled)	Increments 0.01 s
Time multiplier T for 51, 51N for ANSI characteristics		0.50 s to 15.00 s or ∞ (disabled)	Increments 0.01 s

Trip Time Curves acc. to IEC

Acc. to IEC 60255-3 or BS 142, Section 3.5.2 (see also Figures 4-1 and 4-2)

INVERSE (Type A)

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

VERY INVERSE (Type B)

$$t = \frac{13.5}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$

EXTREMELY INV. (Type C)

$$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p \quad [s]$$

LONG INVERSE (Type B)

$$t = \frac{120}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$

Where:
- t Trip time in seconds
- T_p Setting Value of the Time Multiplier
- I Fault Current
- I_p Setting Value of the Pickup Current

The tripping times for $I/I_p \geq 20$ are identical with those for $I/I_p = 20$

For zero sequence current, read 3I0p instead of I_p and T_{3I0p} instead of T_p; for ground fault, read I_{Ep} instead of I_p and T_{IEp} instead of T_p

Pickup threshold	approx. 1.10 · I_p

Dropout Time Characteristics with Disk Emulation acc. to IEC

Acc. to IEC 60255-3 or BS 142, Section 3.5.2 (see also Figures 4-1 and 4-2)	
INVERSE (Type A)	$t_{Reset} = \frac{9.7}{1-(I/I_p)^2} \cdot T_p$ [s]
VERY INV. (Type B)	$t_{Reset} = \frac{43.2}{1-(I/I_p)^2} \cdot T_p$ [s]
EXTREMELY INV. (Type C)	$t_{Reset} = \frac{58.2}{1-(I/I_p)^2} \cdot T_p$ [s]
LONG INVERSE (Type B)	$t_{Reset} = \frac{80}{1-(I/I_p)^2} \cdot T_p$ [s] Where: t_{Reset} Reset Time T_p Setting Value of the Time Multiplier I Fault Current I_p Setting Value of the Pickup Current
The dropout time curves apply to $(I/Ip) \leq 0.90$	
For zero sequence current, read 3I0p instead of I_p and T_{3I0p} instead of T_p; for ground fault, read I_{Ep} instead of I_p and T_{IEp} instead of T_p	

Dropout Setting

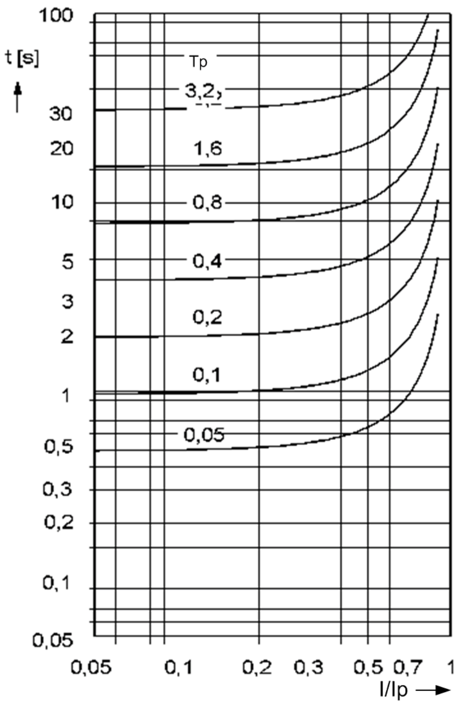
IEC without Disk Emulation	approx. 1.05 · setting value I_p for $I_p/I_N \geq 0.3$, this corresponds to approx. 0.95 · pickup value
IEC with Disk Emulation	approx. 0.90 · I_p setting value

Tolerances

Pickup/dropout thresholds I_p, I_{Ep}	3 % of setting value or 15 mA for I_{Nom} = 1 A, or 75 mA for I_{Nom} = 5 A
Trip time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value +2 % current tolerance, or 30 ms
Dropout time for $I/Ip \leq 0.90$	5 % of reference (calculated) value +2 % current tolerance, or 30 ms

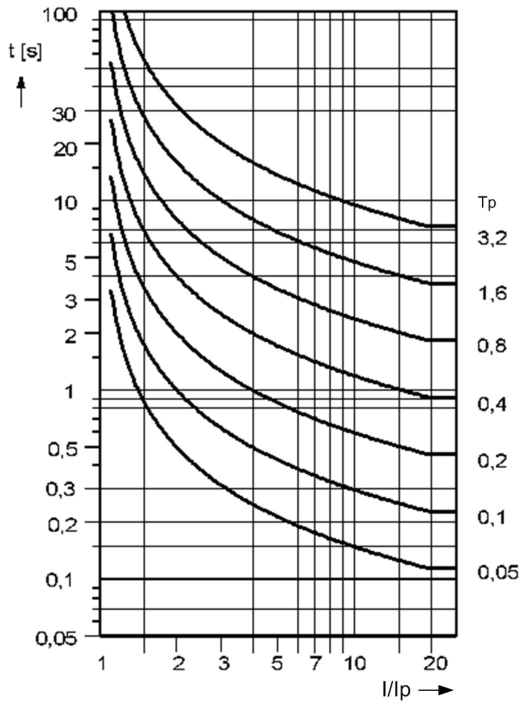
Influencing Variables for Pickup and Dropout

Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in range 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in range of 50 Hz to 70 Hz	
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Transient overreaction during fundamental harmonic measuring procedure for τ > 100 ms (with full displacement)	<5 %



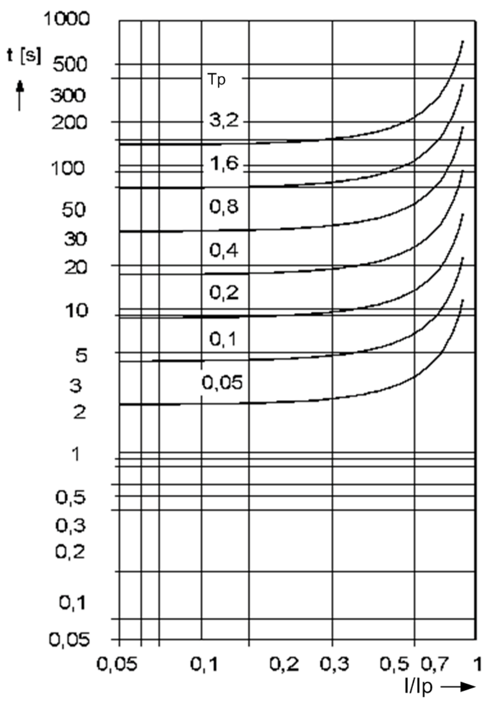
Dropout normal inverse: Type A

$$t = \frac{9.7}{1 - (I / I_p)^2} \cdot T_p \;[s]$$



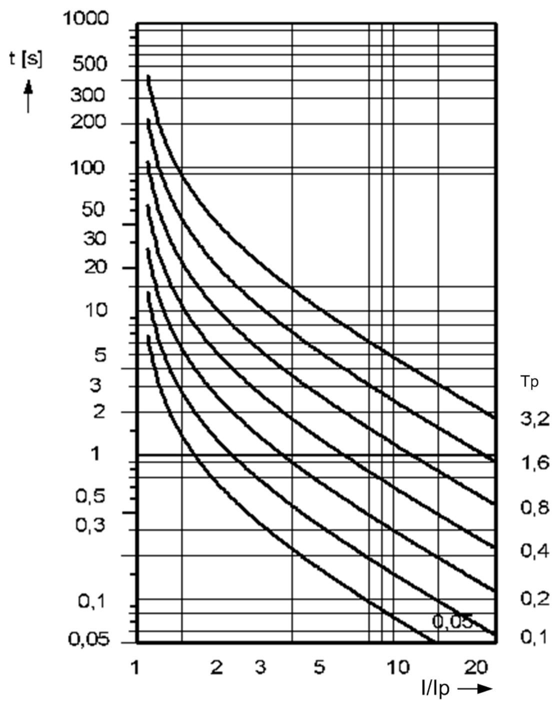
Normal Inverse: Type A

$$t = \frac{0,14}{(I / I_p)^{0.02} - 1} \cdot T_p \;[s]$$



Reset Very Inverse: Type B

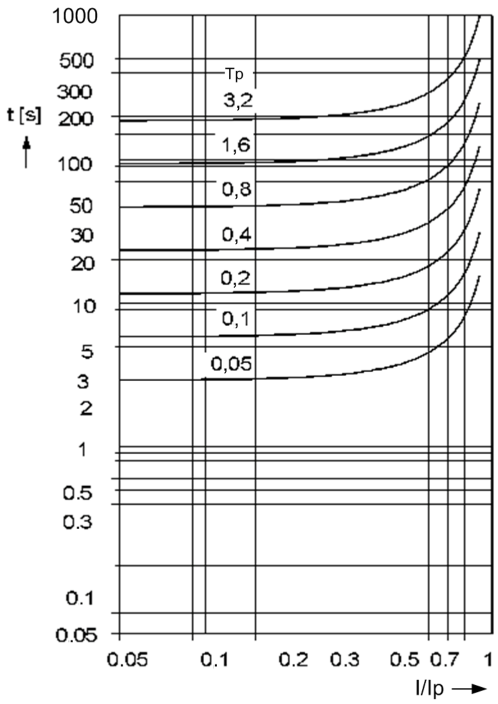
$$t = \frac{43.2}{1 - (I / I_p)^2} \cdot T_p \;[s]$$



VERY INVERSE: Type B

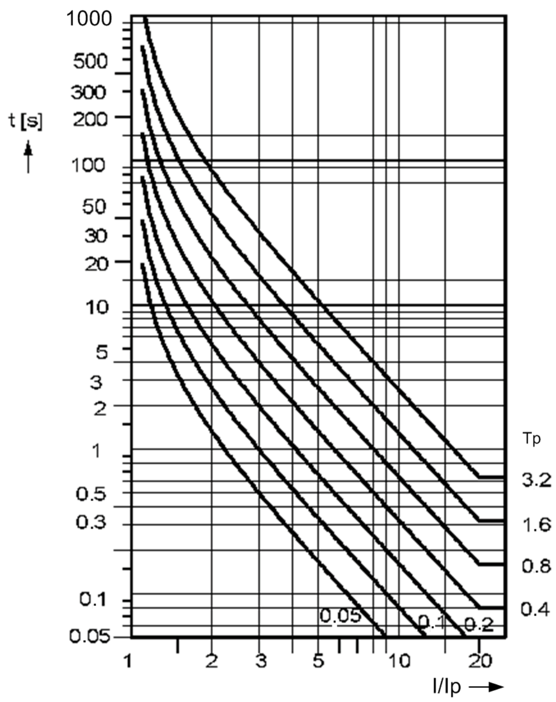
$$t = \frac{13.5}{(I / I_p)^1 - 1} \cdot T_p \;[s]$$

Figure 4-1 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to IEC



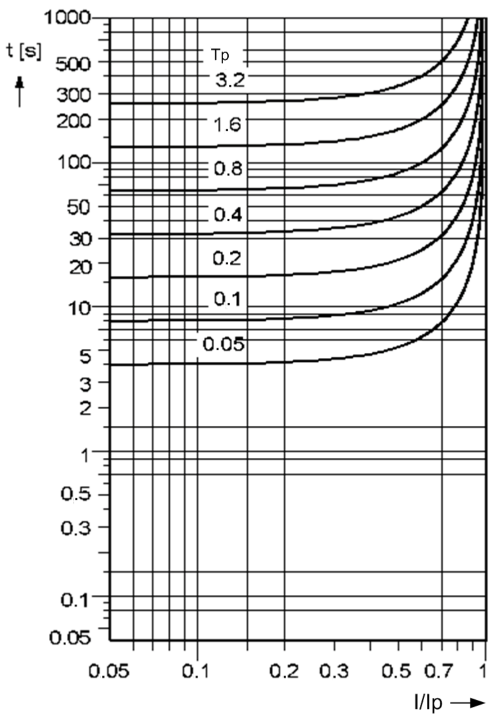
Reset Extremely Inverse:
Type C

$$t = \frac{58.2}{1-(I/I_p)^2} \cdot T_p \ [s]$$



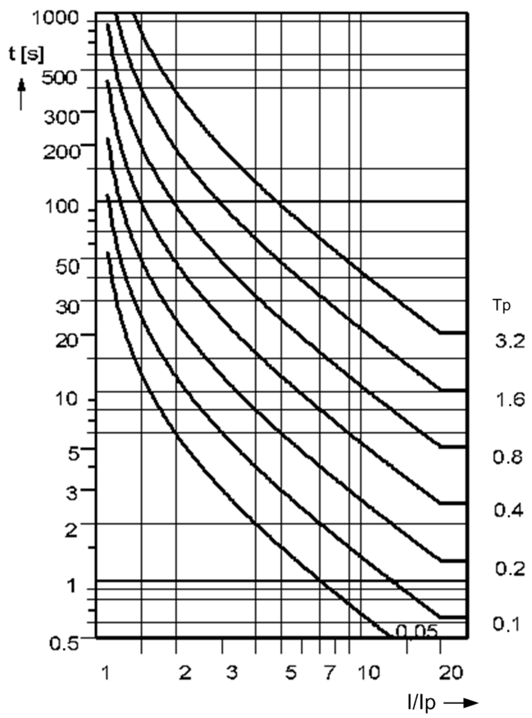
Extremely Inverse:
Type C

$$t = \frac{80}{(I/I_p)^2-1} \cdot T_p \ [s]$$



Reset long inverse:
Type B

$$t = \frac{80}{1-(I/I_p)^2} \cdot T_p \ [s]$$



Long time Inverse:
Type B

$$t = \frac{120}{(I/I_p)^1-1} \cdot T_p \ [s]$$

Figure 4-2 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to IEC

Trip Time Curves acc. to ANSI

Acc. to ANSI/IEEE (see also Figures 4-3 to 4-6)	
INVERSE	$t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966\right) \cdot D \quad [s]$
SHORT INVERSE	$t = \left(\frac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393\right) \cdot D \quad [s]$
LONG INVERSE	$t = \left(\frac{5.6143}{(I/I_p) - 1} + 2.18592\right) \cdot D \quad [s]$
MODERATELY INV.	$t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228\right) \cdot D \quad [s]$
VERY INVERSE	$t = \left(\frac{3.922}{(I/I_p)^{2} - 1} + 0.0982\right) \cdot D \quad [s]$
EXTREMELY INV.	$t = \left(\frac{5.64}{(I/I_p)^{2} - 1} + 0.02434\right) \cdot D \quad [s]$
DEFINITE INV.	$t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359\right) \cdot D \quad [s]$
	Where: t Trip Time D Setting Value of the Time Multiplier I Fault Current I_p Setting Value of the Pickup Current
The tripping times for $I/I_p \geq 20$ are identical with those for $I/I_p = 20$.	
For zero sequence current read 3I0p instead of I_p and T_{3I0p} instead of T_p; for ground fault read I_{Ep} instead of I_p and T_{IEp} instead of T_p	
Pickup Threshold	approx. 1.10 · I_p

Dropout Time Characteristics with Disk Emulation acc. to ANSI/IEEE

Acc. to ANSI/IEEE (see also Figures 4-3 to 4-6)	
INVERSE	$t_{Reset} = \left(\frac{8.8}{1-(I/I_p)^{2.0938}}\right) \cdot D \quad [s]$
SHORT INVERSE	$t_{Reset} = \left(\frac{0.831}{1-(I/I_p)^{1.2969}}\right) \cdot D \quad [s]$
LONG INVERSE	$t_{Reset} = \left(\frac{12.9}{1-(I/I_p)^{1}}\right) \cdot D \quad [s]$
MODERATELY INV.	$t_{Reset} = \left(\frac{0.97}{1-(I/I_p)^{2}}\right) \cdot D \quad [s]$
VERY INVERSE	$t_{Reset} = \left(\frac{4.32}{1-(I/I_p)^{2}}\right) \cdot D \quad [s]$
EXTREMELY INV.	$t_{Reset} = \left(\frac{5.82}{1-(I/I_p)^{2}}\right) \cdot D \quad [s]$
DEFINITE INV.	$t_{Reset} = \left(\frac{1.03940}{1-(I/I_p)^{1.5625}}\right) \cdot D \quad [s]$
for $0.5 < (I/I_p) \le 0.90$	Where: t_{Reset} Reset time D Setting value of the multiplier I Fault Current I_p Setting value of the pickup current
The dropout time curves apply to $(I/Ip) \le 0.90$	
For zero sequence current read 3I0p instead of I_p and T_{3I0p} instead of T_p; for ground fault read I_{Ep} instead of I_p and T_{IEp} instead of T_p	

Dropout Setting

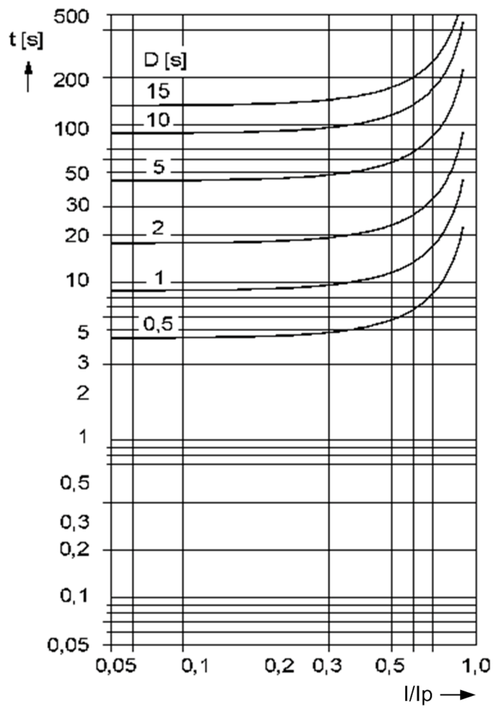
ANSI without Disk Emulation	approx. 1.05 · setting value I_p for $I_p/I_N \ge 0.3$; this corresponds to approx. 0.95 · pickup value
ANSI with Disk Emulation	approx. 0.90 · I_p setting value

Tolerances

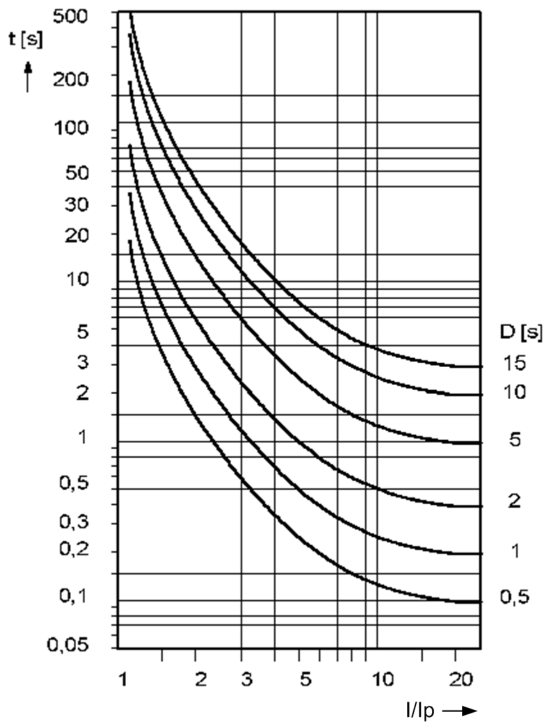
Pickup/dropout thresholds I_p, I_{Ep}	3 % of setting value or 15 mA for I_N = 1 A, or 75 mA for I_N = 5 A
Trip time for $2 \le I/I_p \le 20$	5 % of reference (calculated) value +2 % current tolerance, or 30 ms
Dropout time for $I/Ip \le 0.90$	5 % of reference (calculated) value +2 % current tolerance, or 30 ms

Influencing Variables for Pickup and Dropout

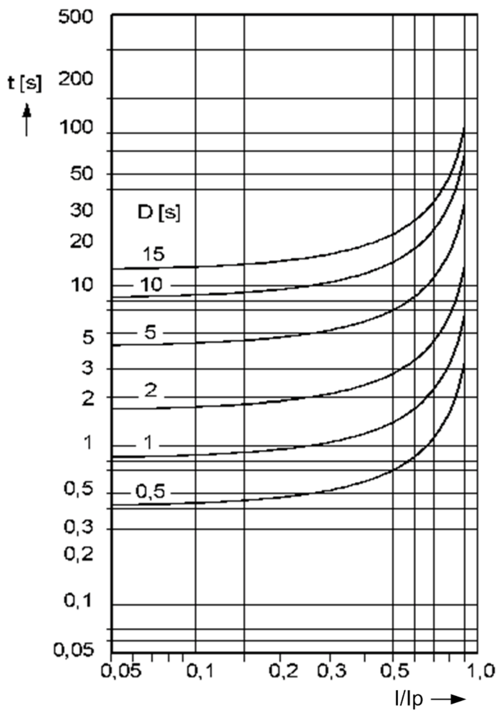
Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in range 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in range of 50 Hz to 70 Hz	
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1% 1%
Transient overreaction during fundamental harmonic measuring procedure for τ > 100 ms (with full displacement)	<5 %



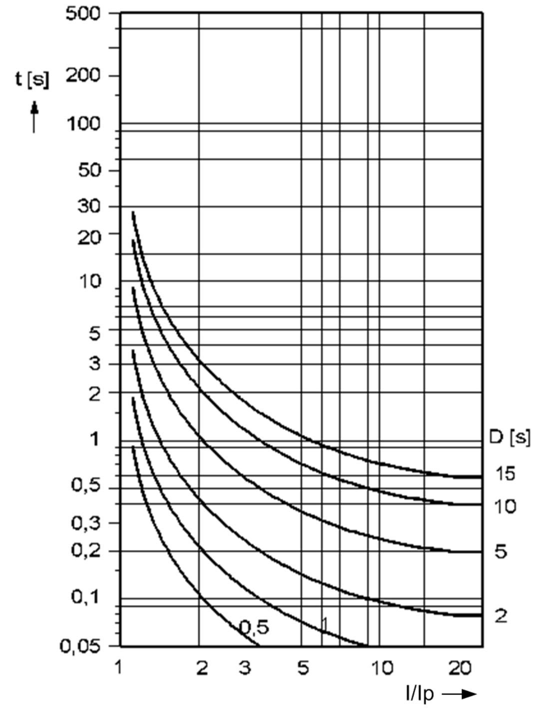
RESET INVERSE $t = \frac{8.8}{1-(I/I_p)^{2.0938}} \cdot D \ [s]$



INVERSE $t = \left(\frac{8.9341}{(I/I_p)^{2.0938}-1} + 0.17966\right) \cdot D \ [s]$

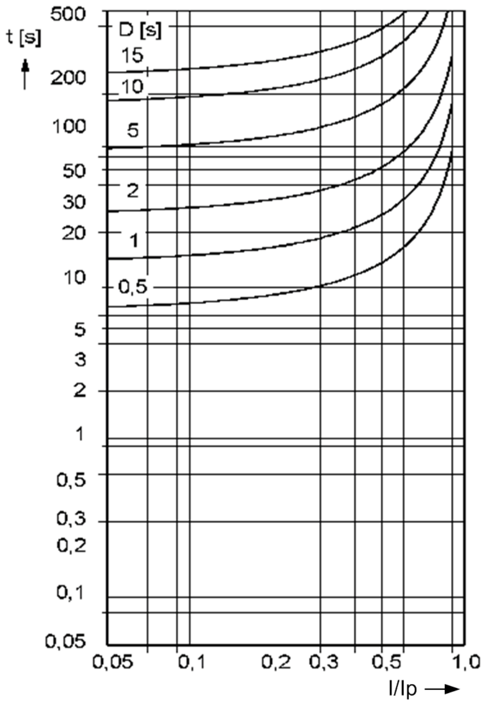


RESET SHORT INVERSE $t = \frac{0.831}{1-(I/I_p)^{1.2969}} \cdot D \ [s]$

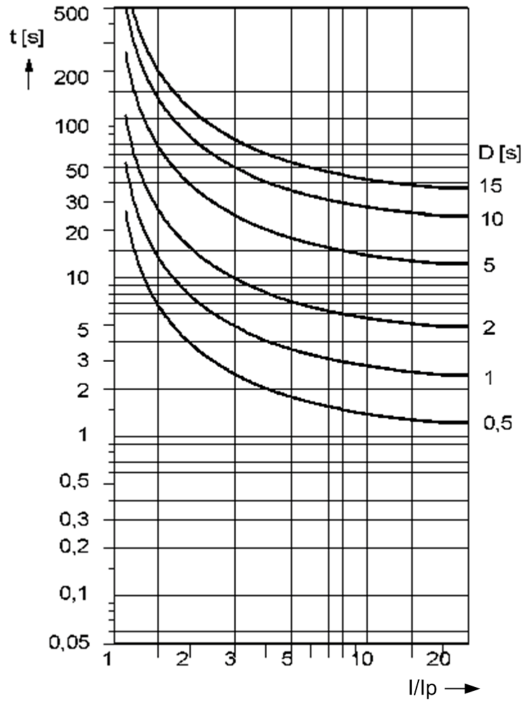


SHORT INVERSE $t = \left(\frac{0.2663}{(I/I_p)^{1.2969}-1} + 0.03393\right) \cdot D \ [s]$

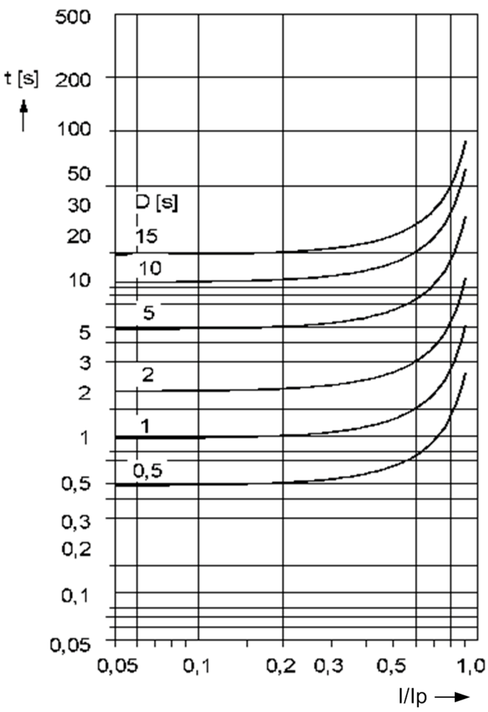
Figure 4-3 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to ANSI/IEEE



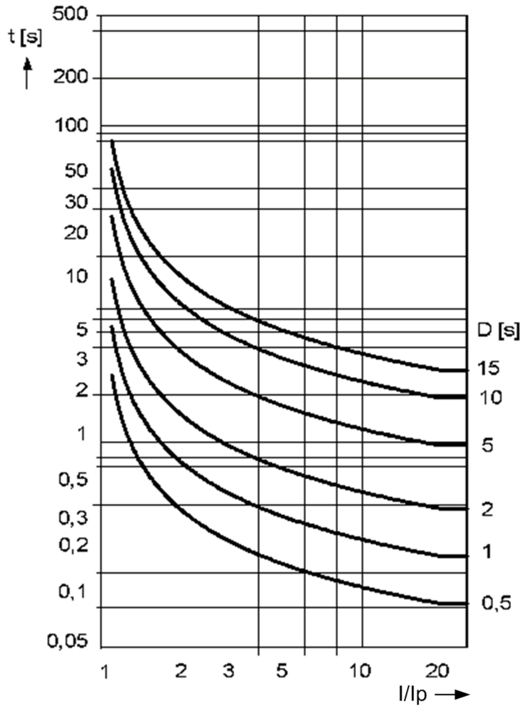
RESET LONG INVERSE $t = \left(\frac{12.9}{1-(I/I_p)^1}\right) \cdot D \;[s]$



LONG INVERSE $t = \left(\frac{5.6143}{(I/I_p)-1} + 2.18592\right) \cdot D \;[s]$

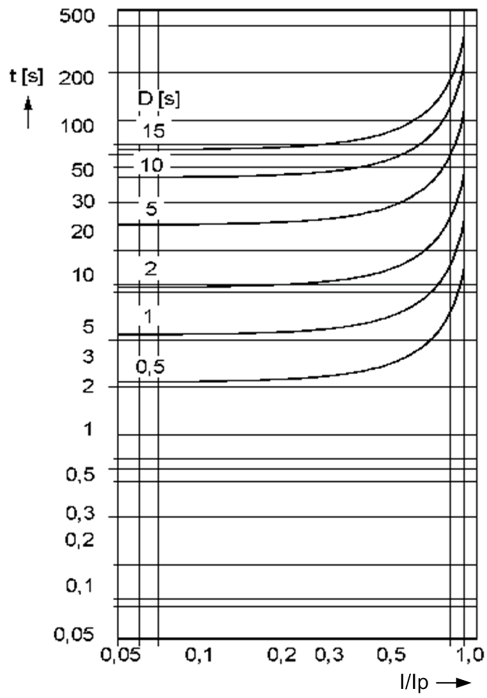


RESET MODERATELY INVERSE $t = \left(\frac{0.97}{1-(I/I_p)^2}\right) \cdot D \;[s]$

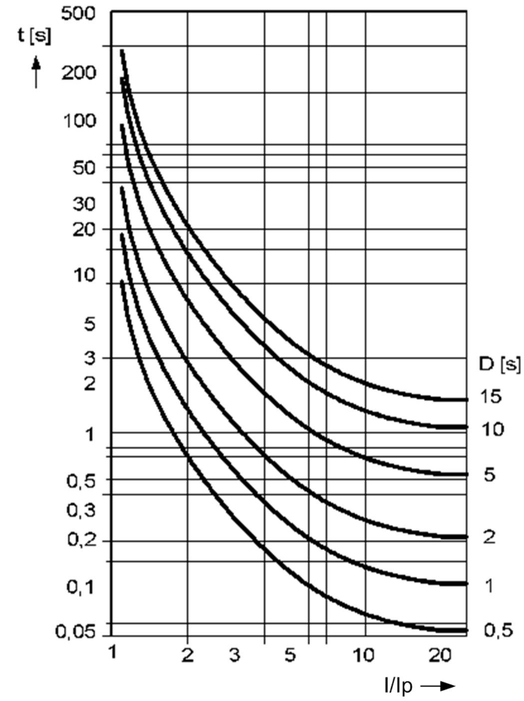


MODERATELY INVERSE $t = \left(\frac{0.0103}{(I/I_p)^{0.02}-1} + 0.0228\right) \cdot D \;[s]$

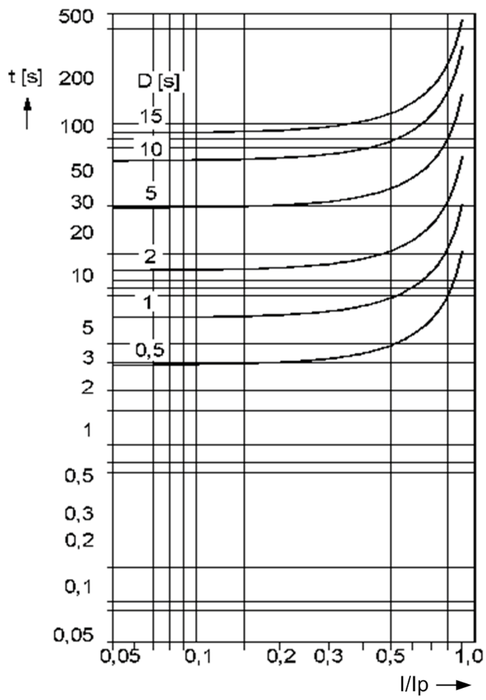
Figure 4-4 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to ANSI/IEEE



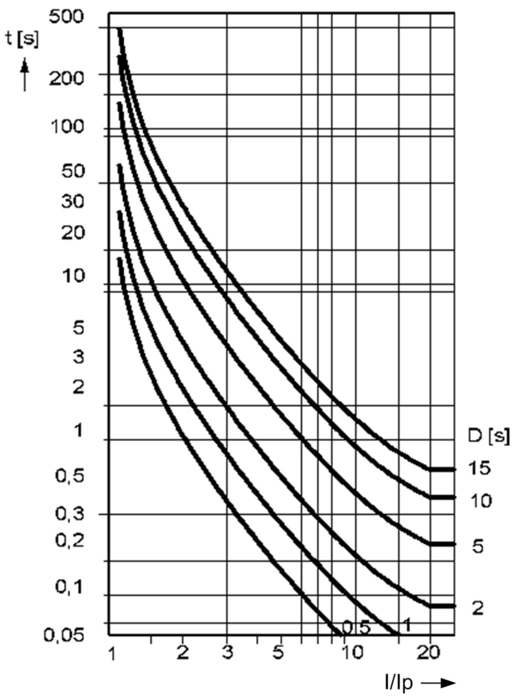
RESET VERY INVERSE $t = \left(\frac{4.32}{1-(I/I_p)^2}\right)\cdot D\ \ [s]$



VERY INVERSE: $t = \left(\frac{3.922}{(I/I_p)^2-1}+0.0982\right)\cdot D\ \ [s]$

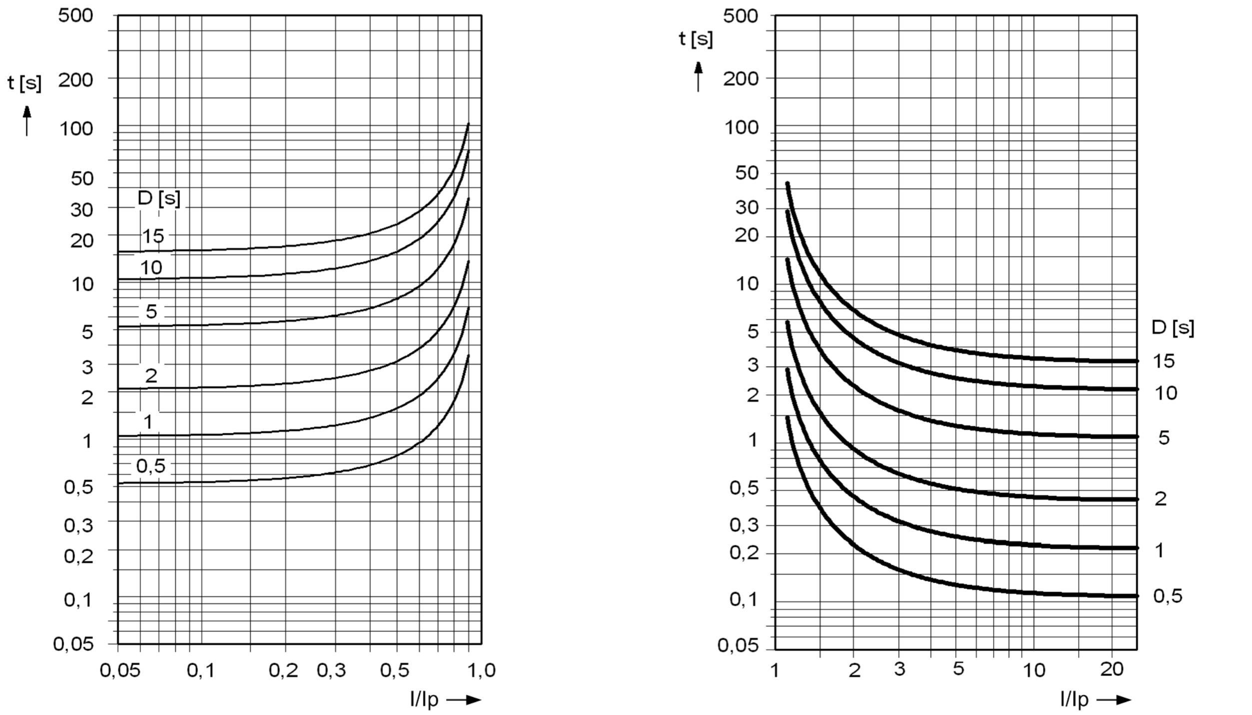


RESET EXTREMELY INVERSE $t = \left(\frac{5.82}{1-(I/I_p)^2}\right)\cdot D\ \ [s]$



EXTREMELY INVERSE $t = \left(\frac{5.64}{(I/I_p)^2-1}+0.02434\right)\cdot D\ \ [s]$

Figure 4-5 Dropout time and trip time curves of the inverse time overcurrent protection, acc. to ANSI/IEEE



RESET DEFINITE INVERSE

$$t = \left(\frac{1.0394}{1-(I/I_p)^{1.5625}}\right) \cdot D \ [s]$$

DEFINITE INVERSE

$$t = \left(\frac{0.4797}{(I/I_p)^{1.5625}-1} + 0.21359\right) \cdot D \ [s]$$

Note:
For earth fault read IEP instead of Ip and DIEp instead of DIp.

Figure 4-6 Dropout time and trip time curve of the inverse time overcurrent protection, acc. to ANSI/IEEE

4.4 Directional Time Overcurrent Protection 67, 67N

Time Overcurrent Elements

The same specifications and characteristics apply as for non-directional time overcurrent protection (see previous Sections).

Determination of Direction

Moreover, the following data apply to direction determination:

For Phase Faults

Type	With cross-polarized voltages; with voltage memory (memory depth 2 seconds) for measuring voltages which are too small
Forward range	$V_{ref,rot}$ ± 86°
Rotation of the reference voltage $V_{ref,rot}$	-180° to +180° Increments 1°
Dropout difference	3°
Directional sensitivity	Unlimited for single- and two-phase faults For three-phase faults, dynamically unlimited, steady-state approx. 7V phase-to-phase

For Ground Faults

Polarization	with zero sequence quantities $3V_0$, $3I_0$
Forward range	$V_{ref,rot}$ ± 86°
Rotation of the reference voltage $V_{ref,rot}$	-180° to +180° Increments 1°
Dropout difference	3°
Directional sensitivity	$V_N \approx 2.5$ V displacement voltage, measured $3V_0 \approx 5$ V displacement voltage, calculated

Polarization	with negative sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot}$ ± 86°
Rotation of the reference voltage $V_{ref,rot}$	-180° to +180° Increments 1°
Dropout difference	3°
Directional sensitivity	$3V_2 \approx 5$ V negative sequence voltage $3I_2 \approx 45$ mA negative sequence current with I_{Nom} = 1 A $3I_2 \approx 225$ mA negative sequence current with I_{Nom} = 5 A

Times

Pickup times (without inrush restraint, with restraint + 1 period)	
50-1, 50-2, 50N-1, 50N-2 - for 2 x setting value - for 10 x setting value	 approx. 45 ms approx. 40 ms
Dropout Times 50-1, 50-2, 50N-1, 50N-2	 approx. 40 ms

Tolerances

Angle faults for phase and ground faults	±3° electrical

Influencing Variables

Frequency Influence – With no memory voltage	 approx 1° in range 25 Hz to 50 Hz

4.5 Inrush Restraint

Controlled Functions

Overcurrent elements	50-1, 50N-1, 51, 51N, 67-1, 67N-1

Setting Ranges / Increments

Stabilization factor I_{2f}/I	10 % to 45 %	Increments 1 %

Functional Limits

Lower function limit phases	for I_{Nom} = 1 A	at least one phase current (50 Hz and 100 Hz) ≥ 50 mA	
	for I_{Nom} = 5 A	at least one phase current (50 Hz and 100 Hz) ≥ 125 mA	
Lower function limit ground	for I_{Nom} = 1 A	Ground current (50 Hz and 100 Hz) ≥ 50 mA	
	for I_{Nom} = 5 A	Ground current (50 Hz and 100 Hz) ≥ 125 mA	
Upper function limit, configurable	for I_{Nom} = 1 A	0.30 A to 25.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	1.50 A to 125.00 A	Increments 0.01 A

Cross-blocking

Cross-blocking I_A, I_B, I_C	ON/OFF

4.6 Dynamic Cold Load Pickup

Timed Changeover of Settings

Controlled functions	Directional and non-directional time overcurrent protection (separated acc. to phases and Ground)
Initiation criteria	Current Criteria "BkrClosed I MIN"
	Interrogation of the circuit breaker position
	Automatic reclosing function ready
	Binary input
Time control	3 time elements ($T_{CB\ Open.}$, T_{Active}, T_{Stop})
Current control	Current threshold "BkrClosed I MIN" (reset on current falling below threshold: monitoring with timer)

Setting Ranges / Increments

Current Control	for I_{Nom} = 1 A	0.04 A to 1.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.20 A to 5.00 A	
Time Until Changeover To Dynamic Settings $T_{CB\ OPEN}$		0 s to 21600 s (= 6 h)	Increments 1 s
Period Dynamic Settings are Effective After a Reclosure T_{Active}		1 s to 21600 s (= 6 h)	Increments 1 s
Fast Reset Time T_{Stop}		1 s to 600 s (= 10 min) or ∞ (fast reset inactive)	Increments 1 s
Dynamic Settings of Pickup Currents and Time Delays or Time Multipliers		Adjustable within the same ranges and with the same increments as the directional and non-directional time overcurrent protection	

4.7 Single-phase Overcurrent Protection

Current Elements

High-set current elements	50-2	0.001 A to 1.6 A or ∞ (element disabled) for I_{Nom} = 1 A 0.005 A to 8 A or ∞ (element disabled) for I_{Nom} = 5 A	Increments 0.001 A
	T_{50-2}	0.00 s to 60.00 s or ∞ (no trip)	Increments 0.01 s
Definite time current element	50-1	0.001 A to 1.6 A or ∞ (element disabled) for I_{Nom} = 1 A 0.005 A to 8 A or ∞ (element disabled) for I_{Nom} = 5 A	Increments 0.001 A
	T_{50-1}	0.00 s to 60.00 s or ∞ (no trip)	Increments 0.01 s

Operating Times

Pickup/Dropout Times		
Frequency Pickup Time	50 Hz	60 Hz
minimum	14 ms	13 ms
maximum	≤ 35 ms	≤ 35 ms
Dropout time approx.	25 ms	22 ms

Dropout Ratios

Current Elements	approx. 0.95 for $I/I_{Nom} \geq 0.5$

Tolerances

Currents	5 % of setting value or 1 mA
Times	1 % of setting value or 10 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$	1 %
Temperature in range –5 °C (41 °F) ≤ Θ_{amb} ≤ 55 °C (131 °F)	0.5 %/10 K
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.8 Voltage Protection 27, 59

Setting Ranges / Increments

Undervoltages 27-1, 27-2			
Measured quantity used With three-phase connection:		- Positive sequence system of the voltages - Smallest phase-to-phase voltage - Smallest phase-to-Ground voltage	
Measured quantity used with single-phase connection		Connected single-phase Phase-to-Ground voltage	
Connection of phase-to-Ground voltages: - Evaluation of phase-to-Ground voltages - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system		 10 V to 120 V 10 V to 210 V 10 V to 210 V	 Increments 1 V Increments 1 V Increments 1 V
Connection of phase-to-phase voltages		10 V to 120 V	Increments 1 V
Connection: Single-phase		10 V to 120 V	Increments 1 V
Dropout ratio r for 27-1, 27-2 [1]		1.01 to 3.00	Increments 0.01
Dropout threshold for (r· 27-1) or (r· 27-2)		max. 130 V for phase-to-phase voltage max. 225 V for phase-to-Ground voltage Minimum hysteresis 0.6 V	
Time delays T 27-1, T 27-2		0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s
Current criterion "BkrClosed I MIN"	for I_{Nom} = 1 A	0.04 A to 1.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.20 A to 5.00 A	
Overvoltages 59-1, 59-2			
Measured quantity used With three-phase connection:		- Positive sequence system of the voltages - Negative sequence system of the voltages - Largest phase-to-phase voltage - Largest phase-to-Ground voltage	
Measured quantity used with single-phase connection		Connected single-phase Phase-to-Ground voltage	
Connection of phase-to-Ground voltages: - Evaluation of phase-to-Ground voltages - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system - Evaluation of negative sequence system		 20 V to 150 V 20 V to 260 V 20 V to 150 V 2 V to 150 V	 Increments 1 V Increments 1 V Increments 1 V Increments 1 V
Connection of phase-to-phase voltages: - Evaluation of phase-to-phase voltages - Evaluation of positive sequence system - Evaluation of negative sequence system		 20 V to 150 V 20 V to 150 V 2 V to 150 V	 Increments 1 V Increments 1 V Increments 1 V
Connection: Single-phase		20 V to 150 V	Increments 1 V
Dropout ratio r for 27-1, 27-2 [1]		0.90 to 0.99	Increments 0.01 V
Dropout threshold for (r· 59-1) or (r· 59-2)		max. 150 V for phase-to-phase voltage max. 260 V for phase-to-Ground voltage Minimum hysteresis 0.6 V	
Time delay T 59-1, T 59-2		0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s

[1] $r = V_{dropout}/V_{pickup}$

Times

Pickup Times	
- Undervoltage 27-1, 27-2, 27-1 V_1, 27-2 V_1 - Overvoltage 59-1, 59-2 - Overvoltage 59-1 V_1, 59-2 V_1, 59-1 V_2 , 59-2 V_2	Approx. 50 ms Approx. 50 ms Approx. 60 ms
Dropout Times	
- Undervoltage 27-1, 27-2, 27-1 V_1, 27-2 V_1 - Overvoltage 59-1, 59-2 - Overvoltage 59-1 V_1, 59-2 V_1, 59-1 V_2 , 59-2 V_2	Approx. 50 ms Approx. 50 ms Approx. 60 ms

Tolerances

Pickup Voltage Limits	3 % of setting value or 1 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Auxiliary DC voltage in range $0.8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$	1 %
Temperature in range –5 °C (41 °F) ≤ Θ_{amb} ≤ 55 °C (131 °F)	0.5 %/10 K
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.9 Negative Sequence Protection 46-1, 46-2

Setting Ranges / Increments

Unbalanced load tripping element 46-1,46-2	for I_{Nom} = 1 A	0.10 A to 3.00 A or ∞ (disabled)	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 15.00 A or ∞ (disabled)	
Delay Times 46-1, 46-2		0.00 s to 60.00 s or ∞ (disabled)	Increments 0.01 s
Dropout Delay Times 46 T DROP-OUT		0.00 s to 60.00 s	Increments 0.01 s

Functional Limit

Functional Limit	for I_{Nom} = 1 A	all phase currents ≤ 10 A
	for I_{Nom} = 5 A	all phase currents ≤ 50 A

Times

Pickup Times Dropout Times	Approx. 35 ms Approx. 35 ms

Dropout Ratio

Characteristic 46-1, 46-2	Approx. 0.95 for $I_2/I_{Nom} \geq 0.3$

Tolerances

Pickup values 46-1, 46-2	3 % of setting value or 15 mA for I_{Nom} = 1 A, or 75 mA for I_{Nom} = 5 A
Time Delays	1 % or 10 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$	1 %
Temperature in range –5 °C (41 °F) ≤ Θ_{amb} ≤ 55 °C (131 °F)	0.5 %/10 K
Frequency in range of 50 Hz to 70 Hz	
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Transient overreaction for τ > 100 ms (with full displacement)	<5 %

4.10 Negative Sequence Protection 46-TOC

Setting Ranges / Increments

Pickup value 46-TOC (I_{2p})	for I_{Nom} = 1 A	0.10 A to 2.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 10.00 A	
Time Multiplier T_{I2p} (IEC)		0.05 s to 3.20 s or ∞ (disabled)	Increments 0.01 s
Time Multiplier D_{I2p} (ANSI)		0.50 s to 15.00 s or ∞ (disabled)	Increments 0.01 s

Functional Limit

Functional Limit	for I_{Nom} = 1 A	all phase currents ≤ 10 A
	for I_{Nom} = 5 A	all phase currents ≤ 50 A

Trip Time Curves acc. to IEC

See also Figure 4-7

INVERSE

$$t_{TRIP} = \frac{0.14}{(I_2/I_{2p})^{0.02} - 1} \cdot T_{I2p} \quad [s]$$

VERY INVERSE

$$t_{TRIP} = \frac{13.5}{(I_2/I_{2p})^{1} - 1} \cdot T_{I2p} \quad [s]$$

EXTREMELY INV.

$$t_{TRIP} = \frac{80}{(I_2/I_{2p})^{2} - 1} \cdot T_{I2p} \quad [s]$$

Where:

t_{TRIP} Trip Time

T_{I2p} Setting Value of the Time Multiplier

I_2 Negative Sequence Current

I_{2p} Setting Value of the Pickup Current

The trip times for $I_2/I_{2p} \geq 20$ are identical to those for $I_2/I_{2p} = 20$.

Pickup Threshold	Approx. $1.10 \cdot I_{2p}$

Trip Time Curves acc. to ANSI

It can be selected one of the represented trip time characteristic curves in the figures 4-8 and 4-9 each on the right side of the figure.	
INVERSE	$t_{TRIP} = \left(\frac{8.9341}{(I_2/I_{2p})^{2.0938} - 1} + 0.17966\right) \cdot D_{I2p} \quad [s]$
MODERATELY INVERSE	$t_{TRIP} = \left(\frac{0.0103}{(I_2/I_{2p})^{0.02} - 1} + 0.0228\right) \cdot D_{I2p} \quad [s]$
VERY INVERSE	$t_{TRIP} = \left(\frac{3.922}{(I_2/I_{2p})^{2} - 1} + 0.0982\right) \cdot D_{I2p} \quad [s]$
EXTREMELY INV.	$t_{TRIP} = \left(\frac{5.64}{(I_2/I_{2p})^{2} - 1} + 0.02434\right) \cdot D_{I2p} \quad [s]$
	Where: t_{TRIP} Trip Time D_{I2p} Setting Value of the Time Multiplier I_2 Negative Sequence Currents I_{2p} Setting Value of the Pickup Current
The trip times for $I_2/I_{2p} \geq 20$ are identical to those for $I_2/I_{2p} = 20$.	
Pickup Threshold	Approx. $1.10 \cdot I_{2p}$

Tolerances

Pickup threshold I_{2p}	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA at I_{Nom} = 5 A
Time for $2 \leq I/I_{2p} \leq 20$	5 % of reference (calculated) value +2 % current tolerance, or 30 ms

Dropout Time Curves with Disk Emulation acc. to ANSI

Representation of the possible dropout time curves, see figure 4-8 and 4-9 each on the left side of the figure

INVERSE	$t_{Reset} = \left(\frac{8.8}{1-(I_2/I_{2p})^{2.0938}}\right) \cdot D_{I2p}$	[s]
MODERATELY INV.	$t_{Reset} = \left(\frac{0.97}{1-(I_2/I_{2p})^{2}}\right) \cdot D_{I2p}$	[s]
VERY INVERSE	$t_{Reset} = \left(\frac{4.32}{1-(I_2/I_{2p})^{2}}\right) \cdot D_{I2p}$	[s]
EXTREMELY INV.	$t_{Reset} = \left(\frac{5.82}{1-(I_2/I_{2p})^{2}}\right) \cdot D_{I2p}$	[s]
	Where: t_{Reset} Reset Time D_{I2p} Setting Value of the Time Multiplier I_2 Negative Sequence Current I_{2p} Setting Value of the Pickup Current	
The dropout time constants apply to $(I_2/I_{2p}) \leq 0.90$		

Dropout Value

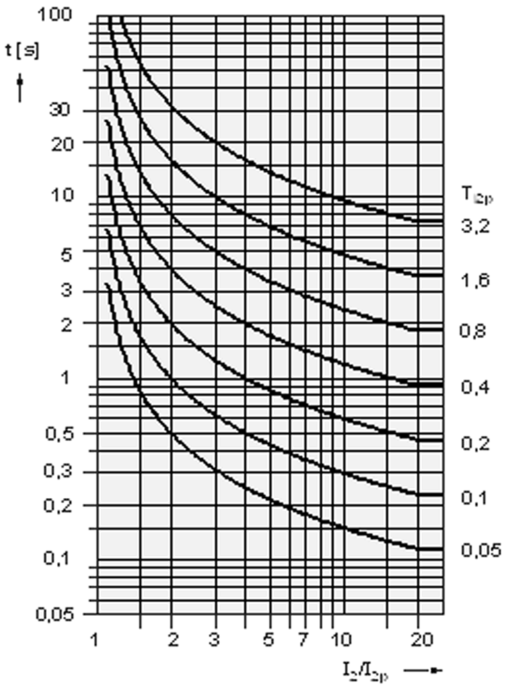
IEC and ANSI (without Disk Emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup thresholdI_2
ANSI with Disk Emulation	Approx. 0.90 · I_{2p} setting value

Tolerances

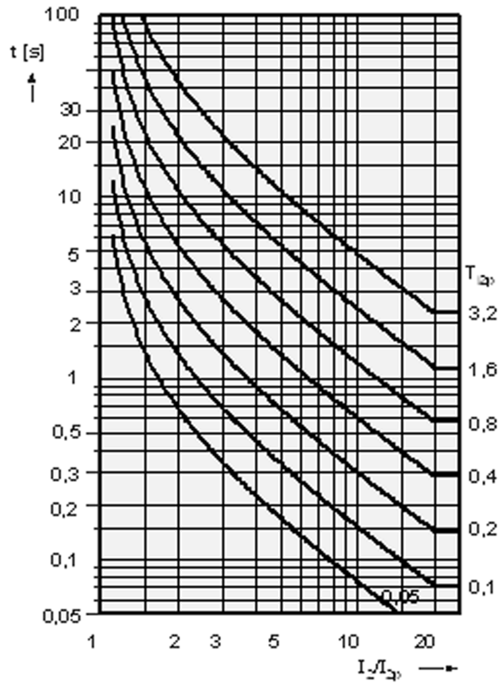
Dropout value I_{2p}	3 % of setting value or 15 mA for I_{Nom} = 1 A or 75 mA for I_{Nom} = 5 A
Time for $I_2/I_{2p} \leq 0.90$	5 % of reference (calculated) value +2 % current tolerance, or 30 ms

Influencing Variables for Pickup Values

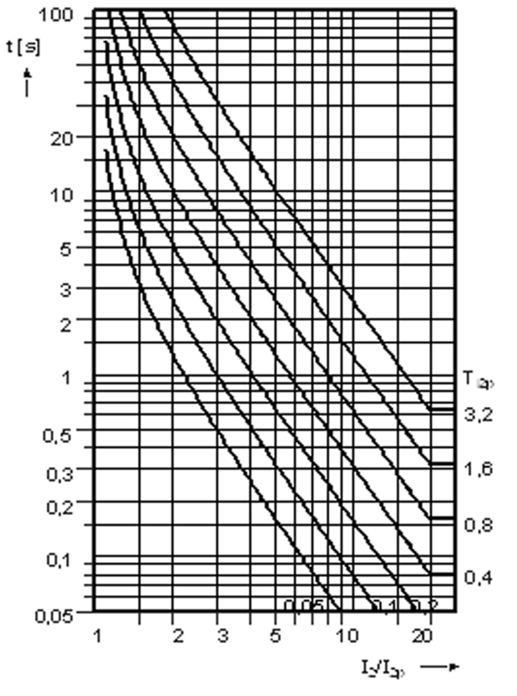
Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in range 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Frequency in range of 50 Hz to 70 Hz	
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Transient overreaction for τ > 100 ms (with full displacement)	<5 %



IEC INVERSE: $t = \frac{0,14}{(I_2/I_{2p})^{0,02} - 1} \cdot T_{I2p}$ [s]



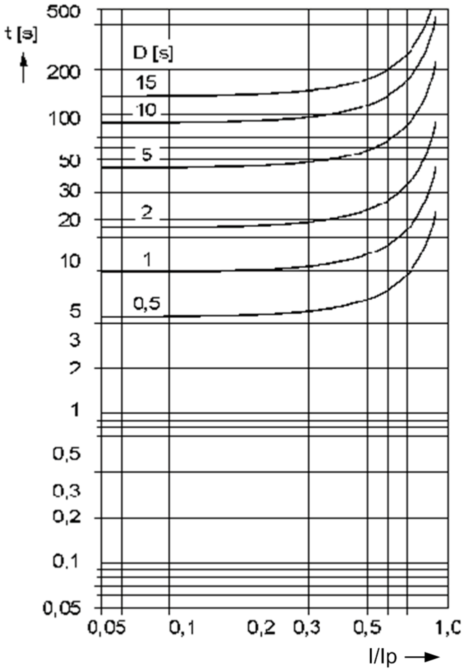
IEC VERY INVERSE: $t = \frac{13,5}{(I_2/I_{2p})^{1} - 1} \cdot T_{I2p}$ [s]



IEC EXTREMELY INVERSE: $t = \frac{80}{(I_2/I_{2p})^{2} - 1} \cdot T_{I2p}$ [s]

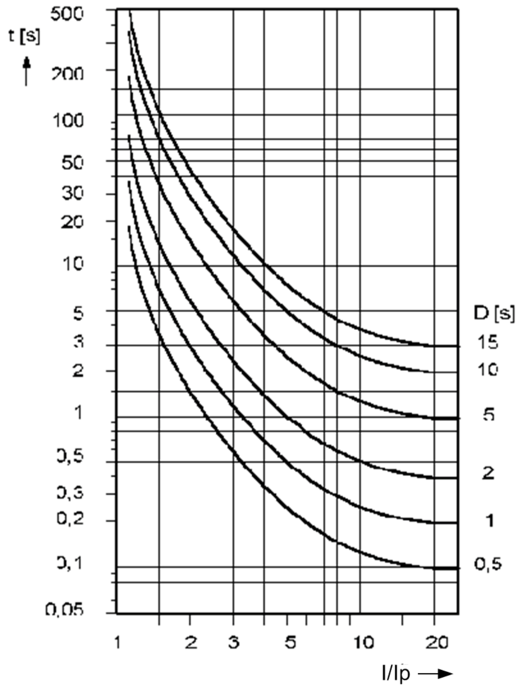
t	Tripping Time
T_{I2p}	Setting Value of the Time Factor
I_2	Inverse current
I_{2p}	Pickup current of unbalanced load protection

Figure 4-7 Trip time characteristics of the inverse time negative sequence element 46-TOC, acc. to IEC



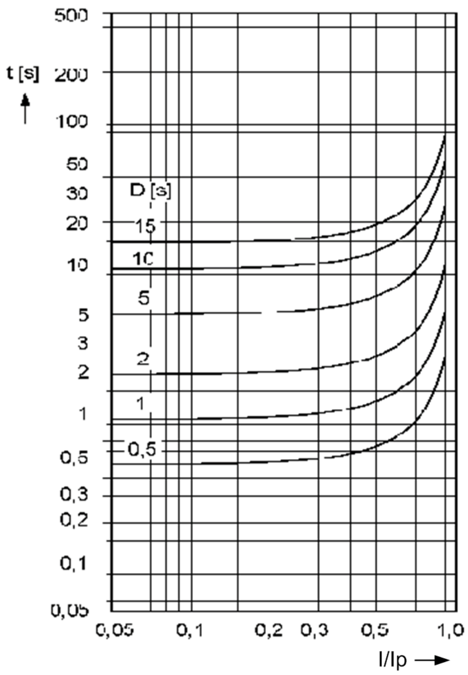
RESET INVERSE

$$t = \left(\frac{8.8}{1-(I_2/I_{2p})^{2.0938}}\right)\cdot D\ [s]$$



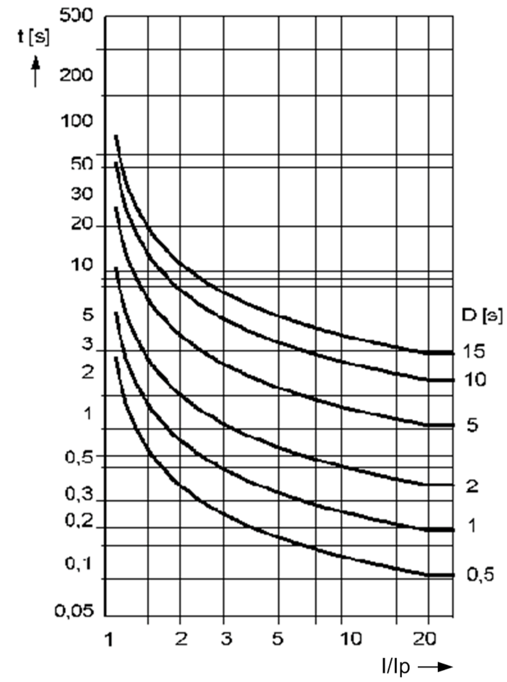
INVERSE

$$t = \left(\frac{8.9341}{(I_2/I_{2p})^{2.0938}-1}+0.17966\right)\cdot D\ [s]$$



RESET MODERATELY INVERSE

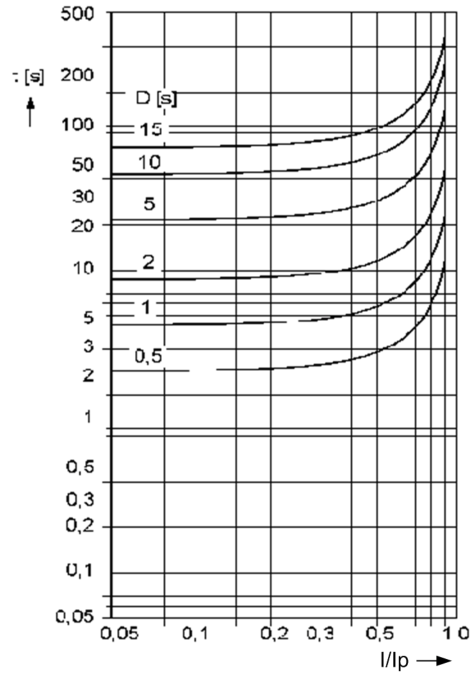
$$t = \left(\frac{0.97}{1-(I_2/I_{2p})^{2}}\right)\cdot D\ [s]$$



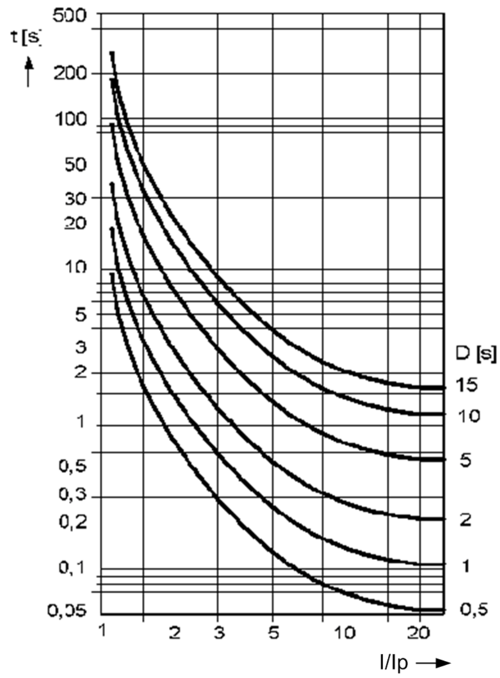
MODERATELY INVERSE

$$t = \left(\frac{0.0103}{(I_2/I_{2p})^{0.02}-1}+0.0228\right)\cdot D\ [s]$$

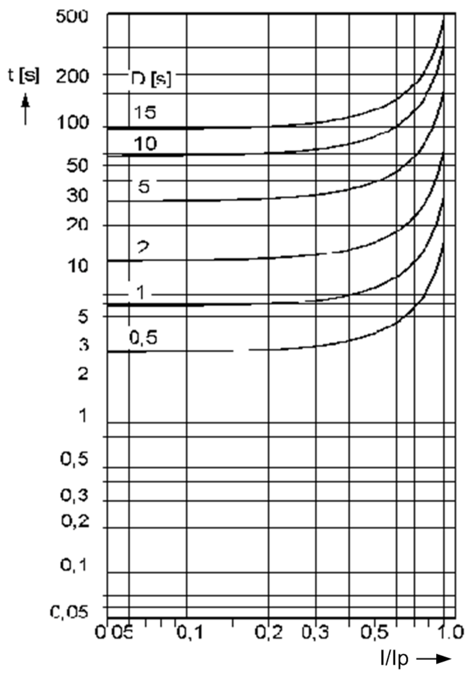
Figure 4-8 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI



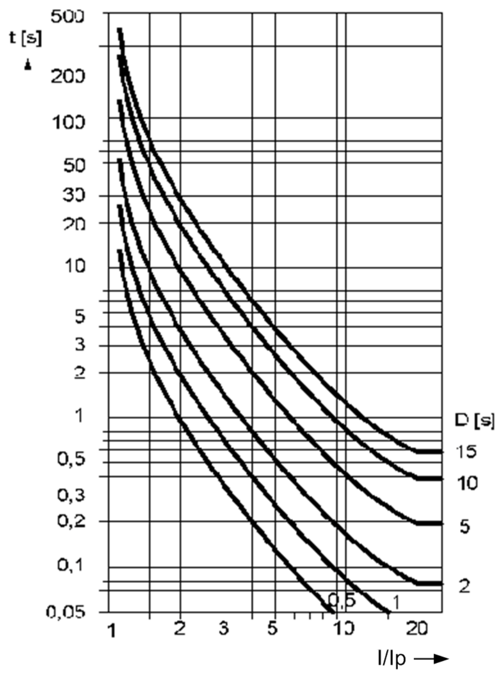
RESET VERY INVERSE $t = \left(\frac{4.32}{1-(I_2/I_{2p})^2}\right)\cdot D\ [s]$



VERY INVERSE: $t = \left(\frac{3.922}{(I_2/I_{2p})^2-1}+0.0982\right)\cdot D\ [s]$



RESET EXTREMELY INVERSE $t = \left(\frac{5.82}{1-(I_2/I_{2p})^2}\right)\cdot D\ [s]$



EXTREMELY INVERSE $t = \left(\frac{5.64}{(I_2/I_{2p})^2-1}+0.02434\right)\cdot D\ [s]$

Figure 4-9 Dropout time and trip time characteristics of the inverse time unbalanced load stage, acc. to ANSI

4.11 Frequency Protection 81 O/U

Setting Ranges / Increments

Number of frequency elements	4; each can be set to f> or f<	
Pickup values f> or f< for f_{Nom} = 50 Hz	40.00 Hz to 60.00 Hz	Increments 0.01 Hz
Pickup values f> or f< for f_{Nom} = 60 Hz	50.00 Hz to 70.00 Hz	Increments 0.01 Hz
Dropout threshold = |pickup threshold - dropout threshold|	0.02 Hz to 1.00 Hz	Increments 0.01 Hz
Time delays T	0.00 s to 100.00 s or ∞ (disabled)	Increments 0.01 s
Undervoltage blocking with three-phase connection: Positive sequence component V_1 with single-phase connection (connection type "Vph-n, Vsyn"): single-phase Phase-to-ground voltage	10 V to 150 V	Increments 1 V

Times

Pickup times f>, f<	approx. 100 ms at f_{Nom} = 50 Hz approx. 80 ms at f_{Nom} = 60 Hz
Dropout times f>, f<	approx. 100 ms at f_{Nom} = 50 Hz approx. 80 ms at f_{Nom} = 60 Hz

Dropout Difference

Δf = I pickup value - dropout value I	0.02 Hz to 1 Hz

Dropout Ratio

Dropout Ratio for Undervoltage Blocking	approx. 1.05

Tolerances

Pickup frequencies 81/O or 81U Undervoltage blocking Time delays 81/O or 81/U	15 mHz (with $V = V_{nom}$, $f = f_{Nom} \pm 5$ Hz) 3 % of setting value or 1 V 1 % of setting value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq V_{PS}/V_{PSNom} \leq 1.15$	1 %
Temperature in range 23.00 °F (-5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.12 Thermal Overload Protection 49

Setting ranges / increments

Factor k according to IEC 60255-8		0.10 to 4.00	Increments 0.01
Time constant τ_{th}		1.0 min to 999.9 min	Increments 0.1 min
Current alarm element I_{Alarm}	for I_{Nom} = 1 A	0.10 A to 4.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.50 A to 20.00 A	
Extension with machine at rest kτ factor		1.0 to 10.0 relative to the time constant for the machine running	Increments 0.1
Dropout time (emergency start) $T_{Emergency}$		10 s to 15000 s	Increments 1 s

Trip Characteristic

Trip Characteristic Curve for $(I/k \cdot I_{Nom}) \leq 8$

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

Where:

t	Trip Time in minutes
τ_{th}	Heating-up Time Constant
I	Actual Load Current
I_{pre}	Preload Current
k	Setting Factor per IEC 60255-8
I_{Nom}	Nominal Current of the Protected Object

Dropout Ratios

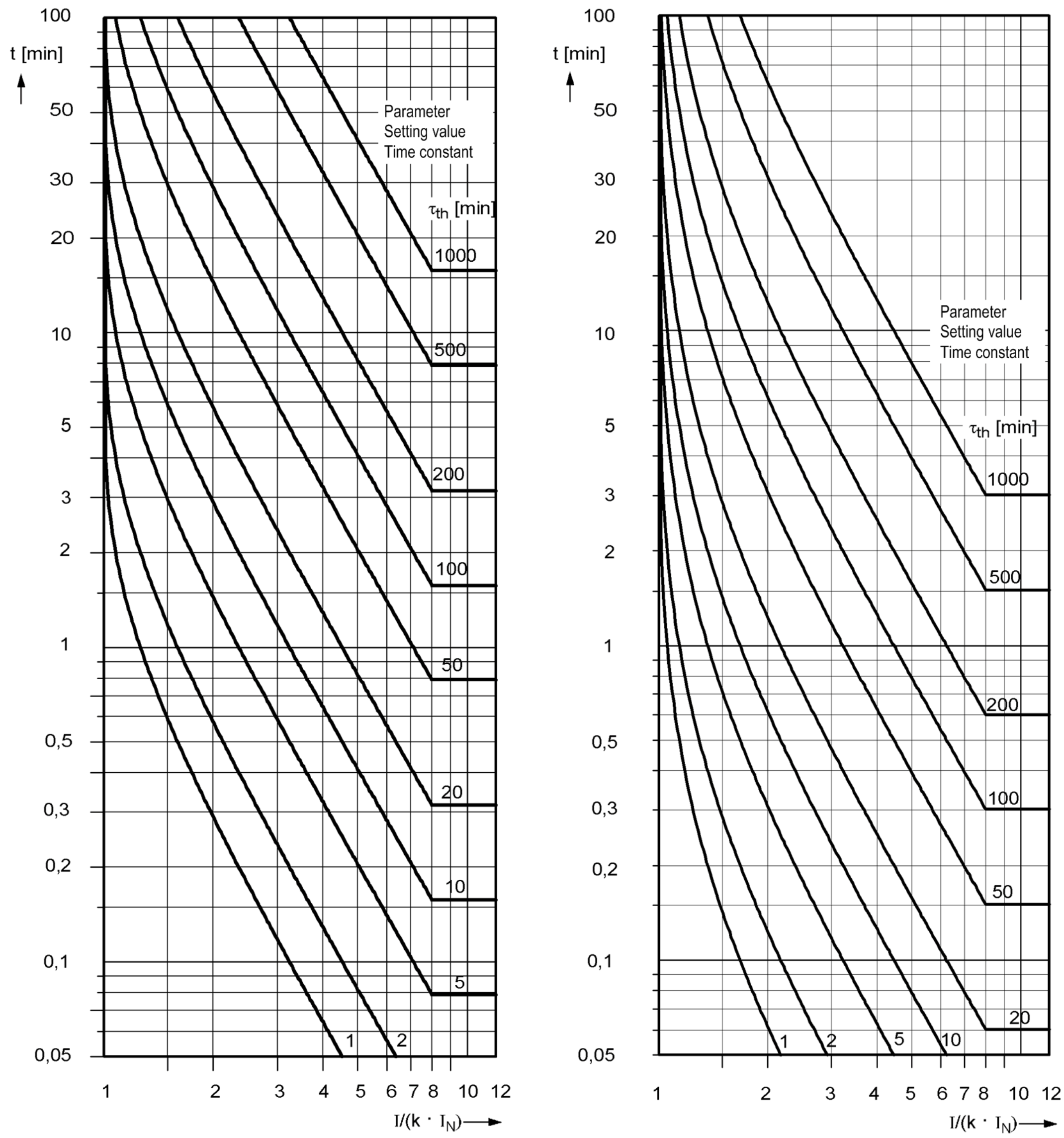
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97

Tolerances

Referring to $k \cdot I_{Nom}$	3 % or 15 mA for I_{Nom} = 1 A, or 75 mA for I_{Nom} = 5 A, 2 % class according to IEC 60255-8
Referring to trip time	3 % or 1 s for $I/(k \cdot I_{Nom}) > 1.25$; 3 % class according to IEC 60255-8

Influencing Variables Referring to $k \cdot I_{Nom}$

Auxiliary DC voltage in range $0,8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$	1 %
Temperature in range –5 °C (41 °F) ≤ Θ_{amb} ≤ 55 °C (131 °F)	0.5 %/10 K
Frequency in range of 50 Hz to 70 Hz	
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances



without pre-load:

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \text{ [min]}$$

with 90 % pre-load:

$$t = \tau_{th} \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \text{ [min]}$$

Figure 4-10 Trip time curves for the thermal overload protection (49)

4.13 Ground Fault Protection 64, 67N(s), 50N(s), 51N(s)

Displacement Voltage Element For all Types of Ground Faults

Displacement voltage, measured	V0 > 1.8 V to 200.0 V	Increments 0.1 V
Displacement voltage, calculated	$3V_0$ > 10.0 V to 225.0 V	Increments 0.1 V
Pickup delay T-DELAY Pickup	0.04 s to 320.00 s or ∞	Increments 0.01 s
Additional tripping delay 64-1 DELAY	0.10 s to 40000.00 s or ∞ (disabled)	Increments 0.01 s
Operating time	approx. 50 ms	
Dropout value	0.95 or (pickup value – 0.6 V)	
Measurement tolerance V0 > (measured) 3V0 > (calculated)	 3 % of setting value or 0.3 V 3 % of setting value or 3 V	
Operating time tolerances	1 % of setting value or 10 ms	

Phase Detection for Ground Faults on an Ungrounded System

Measuring Principle	Voltage measurement (phase-Ground)	
$V_{PHASE\ MIN}$ (Ground Fault Phase)	10 V to 100 V	Increments 1V
$V_{PHASE\ MAX}$ (Healthy Phase)	10 V to 100 V	Increments 1V
Measurement Tolerance acc. to VDE 0435, Part 303	3 % of setting value or 1 V	

Ground Fault Pickup for All Types of Ground Faults (Definite Time Characteristic)

Pickup current 50Ns-2 PICKUP, 50Ns-1 PICKUP for sensitive 1 A transformer for sensitive 5 A transformer for normal 1 A transformer for normal 5 A transformer	 0.001 A to 1.600 A 0.005 A to 8.000 A 0.05 A to 35.00 A 0.25 A to 175.00 A	 Increments 0.001 A Increments 0.005 A Increments 0.01 A Increments 0.05 A
Time delay 50Ns-2 DELAY, 50Ns-1 DELAY	0.00 s to 320.00 s or ∞ (disabled)	Increments 0.01 s
Dropout time delay 50Ns T DROP-OUT	0.00 s to 60.00 s	Increments 0.01 s
Operating time	≤ 50 ms (non-directional) ≤ 50 ms (directional)	
Dropout ratio	approx. 0.95 for 50Ns > 50 mA	
Measurement tolerance sensitive non-sensitive	 3 % of setting value or 1 mA for I_{Nom} = 1 A, or 5 mA for I_{Nom} = 5 A for setting values < 10 mA approx. 20 % 3 % of setting value or 15 mA for I_{Nom} = 1 A, or 75 mA for I_{Nom} = 5 A	
Operating time tolerance	1 % of setting value or 10 ms	

Ground Fault Pickup for All Types of Ground Faults (Inverse Time Characteristic)

User-defined characteristic (defined by a maximum of 20 value pairs of current and time delay in direction measurement method "cos phi and sin phi")		
Pickup current 51Ns for sensitive 1 A transformer for sensitive 5 A transformer for normal 1 A transformer for normal 5-A transformer	 0.001 A to 1.400 A 0.005 A to 7.000 A 0.05 A to 4.00 A 0.25 A to 20.00 A	 Increments 0.001 A Increments 0.005 A Increments 0.01 A Increments 0.05 A
Time multiplier T_{51Ns}	0.10 s to 4.00 s or ∞ (disabled)	Increments 0.01 s
Pickup threshold	Approx. $1.10 \cdot I_{51Ns}$	
Dropout ratio	Approx. $1.05 \cdot I_{51Ns}$ for I_{51Ns} > 50 mA	
Measurement tolerance sensitive non-sensitive	 3 % of setting value or 1 mA for I_{Nom} = 1 A, or 5 mA for I_{Nom} = 5 A for setting values < 10 mA approx. 20 % 3 % of setting value or 15 mA for I_{Nom} = 1 A, or 75 mA for I_{Nom} = 5 A	
Operating time tolerance in linear range	7 % of reference (calculated) value for $2 \leq I/I_{51Ns} \leq 20$ + 2 % current tolerance, or 70 ms	

Influencing Variables

Auxiliary DC voltage in range $0{,}8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$	1 %
Temperature in range –5 °C (41 °F) ≤ Θ_{amb} ≤ 55 °C (131 °F)	0.5 %/10 K
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %
Note: When using the sensitive transformer, the linear range of the measuring input for sensitive ground fault detection is from 0.001 A to 1.6 A or 0.005 A to 8.0 A, depending on parameter 205 CT SECONDARY. The function is however still preserved for larger currents.	

Direction Determination for all Types of Ground Fault with cos φ / sin φ Measurement

Direction measurement	- I_N and V_N measured - $3I_0$ and $3V_0$ calculated	
Measuring principle	Active/reactive power measurement	
Measuring release RELEASE DIRECT. (current component perpendicular (90º) to directional limit line) for sensitive 1 A transformer for sensitive 5 A transformer for normal 1 A transformer for normal 5-A transformer	0.001 A to 1.600 A 0.005 A to 8.000 A 0.05 A to 35.00 A 0.25 A to 175.00 A	Increments 0.001 A Increments 0.005 A Increments 0.01 A Increments 0.05 A
Dropout ratio	Approx. 0.80	
Measurement method	cos φ and sin φ	
Directional limit line PHI CORRECTION	-45.0° to +45.0°	Increments 0.1°
Dropout delay RESET DELAY	1 s to 60 s	Increments 1 s

Direction Determination for all Types of Ground Fault with V0 φ / I0 φ Measurement

Direction measurement	- I_N and V_N measured - $3I_0$ and $3V_0$ calculated	
Measuring principle	U0 / I0 phase angle measurement	
50Ns-1 element		
Minimum voltage 50Ns-1 Vmin V0 measured 3V0 calculated	 0.4 V to 50 V 10 V to 90 V	 Increments 0.1 V Increments 1 V
Phase angle 50Ns-1 Phi	- 180° to 180°	Increments 1°
Delta phase angle 50Ns-1 DeltaPhi	0° to 180°	Increments 1°
50Ns-2 element		
Minimum voltage 50Ns-2 Vmin V0 measured 3V0 calculated	 0.4 V to 50 V 10 V to 90 V	 Increments 0.1 V Increments 1 V
Phase angle 50Ns-2 Phi	- 180° to 180°	Increments 1°
Delta phase angle 50Ns-2 DeltaPhi	0° to 180°	Increments 1°

Angle Correction

Angle correction for cable converter in two operating points F1/I1 and F2/I2:		
Angle correction F1, F2 (for resonant-grounded system)	0.0° to 5.0°	Increments 0.1°
Current values I1, I2 for angle correction for sensitive 1 A transformer for sensitive 5 A transformer for normal 1 A transformer for normal 5 A transformer	 0.001 A to 1.600 A 0.005 A to 8.000 A 0.05 A to 35.00 A 0.25 A to 175.00 A	 Increments 0.001 A Increments 0.005 A Increments 0.01 A Increments 0.05 A
Measurement tolerance sensitive non-sensitive	 3 % of setting value or 1 mA for I_{Nom} = 1 A, or 5 mA for I_{Nom} = 5 A for setting values < 10 mA approx. 20 % 3 % of setting value or 15 mA for I_{Nom} = 1 A, or 75 mA for I_{Nom} = 5 A	
Angle tolerance	3°	
Note: Due to the high sensitivity, the linear range of the measuring input I_{Nom} with integrated sensitive input transformer is from 0.001 · I_{Nom} to 1.6 · I_{Nom}. For currents greater than 1.6 · I_{Nom}, correct direction determination can no longer be guaranteed.		

4.14 Automatic Reclosing System 79

Number of reclosures	0 to 9 (separately for phase and ground) Cycles 1 to 4 can be adjusted individually	
The following protection functions initiate the 79 AR (no 79 start / 79 start / 79 blocked)	50-1, 50-2, 50-3, 51, 67-1, 67-2, 67-TOC, 50N-1, 50N-2, 50N-3, 51N, 67N-1, 67N-2, 67N-TOC, sensitive ground fault detection, unbalanced load, binary input	
Blocking of 79 AR by	Pickup of protection functions for which 79 AR blocking is set (see above)	
	Three-phase pickup (optional)	
	Binary input	
	Last trip command after the reclosing cycle is complete (unsuccessful reclosing)	
	Trip command from the breaker failure protection	
	Opening of the circuit breaker without 79 AR start	
	External CLOSE Command	
	Breaker failure monitoring	
Dead times T_{Dead} (separately for phase and ground and individually for cycles 1 to 4)	0.01 s to 320.00 s	Increments 0.01 s
Extension of dead time	Using binary input with time monitoring	
Blocking duration for manual CLOSE detection $T_{Blk\ Manual\ Close}$	0.50 s to 320.00 s or ∞	Increments 0.01 s
Blocking duration after reclosing $T_{Blk\ Time}$	0.50 s to 320.00 s	Increments 0.01 s
Blocking duration after dynamic blocking $T_{Blk\ Dyn}$	0.01 s to 320.00 s	Increments 0.01 s
Start signal monitoring time $T_{Start\ Monitor}$	0.01 s to 320.00 s or ∞	Increments 0.01 s
Circuit breaker monitoring time $T_{CB\ Monitor}$	0.10 s to 320.00 s	Increments 0.01 s
Maximum dead time extension $T_{Dead\ Exten}$	0.50 s to 320.00 s or ∞	Increments 0.01 s
Start delay of dead time	Using binary input with time monitoring	
Max. start delay of dead time $T_{Dead\ Delay}$	0.0 s to 1800.0 s or ∞	Increments 1.0 s
Operating time T_{Operat}	0.01 s to 320.00 s or ∞	Increments 0.01 s
The following protection functions can be influenced by the automatic reclosing function individually for cycles 1 to 4 (setting value T=T/ instantaneous T=0/ blocked T=infinite):	50-1, 50-2, 50-3, 51, 67-1, 67-2, 67-TOC, 50N-1, 50N-2, 50N-3, 51N, 67N-1, 67N-2, 67N-TOC	
Additional functions	Final trip Circuit breaker monitoring by evaluating the auxiliary contacts Synchronous closing (optionally with integrated or external synchrocheck)	

4.15 Fault Locator

Units of Distance Measurement		in Ω primary and secondary in km or miles line length or in % of line length [1]	
Trigger		trip command, Dropout of an Element, or External command via binary input	
Reactance Setting (secondary)	for I_{Nom} = 1 A	0.0050 to 9.5000 Ω/km	Increments 0.0001
		0.0050 to 15.0000 Ω/mile	Increments 0.0001
	for I_{Nom} = 5 A	0.0010 to 1.9000 Ω/km	Increments 0.0001
		0.0010 to 3.0000 Ω/mile	Increments 0.0001
For the remaining parameters refer to the Power System Data 2.			
When configuring mixed lines, the reactance value must be set for each line section (A1 to A3).			
Measurement Tolerance acc. to VDE 0435, Part 303 for Sinusoidal Measurement Quantities		2.5% fault location (without intermediate infeed) 30° ≤ φ_K ≤ 90° and V_K/V_{Nom} ≥ 0.1 and I_K/I_{Nom} ≥ 1.0	

[1] Homogeneous lines or correctly configured line sections are assumed when the fault distance is given in km, miles or %.

4.16 Breaker Failure Protection 50BF

Setting Ranges / Increments

Pickup threshold 50-1 BF	for I_{Nom} = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 100.00 A	
Pickup threshold 50N-1 BF	for I_{Nom} = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_{Nom} = 5 A	0.25 A to 100.00 A	
Time delay 50 BF trip timer		0.06 s to 60.00 s or ∞	Increments 0.01 s

Times

Pickup times - for internal start - for external start Dropout time Dropout ratio 50-1, 50N-1	 Included in time delay Included in time delay approx. 25 ms [1)] = 0.95 (minimum hysteresis between Pickup and dropout ≥ 32.5 mA)

Tolerances

Pickup threshold 50-1 BF, 50N-1 BF	3 % of setting value, or 15 mA for I_{Nom} = 1 A or 75 mA for I_{Nom} = 5 A
Time delay 50 BF trip timer	1 % or 20 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \le V_{Aux}/V_{AuxNom} \le 1.15$	1 %
Temperature in range –5 °C (41 °F) ≤ Θ_{amb} ≤ 55 °C (131 °F)	0.5 %/10 K
Frequency in range $0.95 \le f/f_{Nom} \le 1.05$	1 %
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

[1)] A further delay for the current may be caused by compensation in the secondary CT circuit.

4.17 Flexible Protection Functions

Measured Values / Modes of Operation

Three-phase	I, $3I_0$, $I1$, $I2$, $I2/I1$, V, $3V_0$, V1, V2, P forward, P reverse, Q forward, Q reverse, cosφ
Single-phase	I, I_N, I_{Ns},I_{N2}, V, V_N,V_x, P forward, P reverse, Q forward, Q reverse, cosφ
Without fixed phase reference	f, df/dt, binary input
Measurement method for I, V	Fundamental, r.m.s. value (true RMS), positive sequence system, negative sequence system, zero sequence system
Pickup on	exceeding threshold value or falling below threshold value

Setting Ranges / Increments

Pickup thresholds:			
Current I, I_1, I_2, $3I_0$, I_N	for I_N = 1 A	0.05 A to 40.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 200.00 A	
Relationship I_2/I_1		15 % to 100 %	Increments 1%
Sensitive ground current I_{Ns}		0.001 A to 1.500 A	Increments 0.001 A
Voltage V, V_1, V_2, $3V_0$		2.0 V to 260.0 V	Increments 0.1 V
Displacement voltage V_N		2.0 V to 200.0 V	Increments 0.1 V
Power P, Q	for I_N = 1 A	2.0 W to 10000 W	Increment 0.1 W
	for I_N = 5 A	10 W to 50000 W	
Power factor cosφ		-0.99 to +0.99	Increments 0.01
Frequency	for f_{Nom} = 50 Hz for f_{Nom} = 60 Hz	40.0 Hz to 60.0 Hz 50.0 Hz to 70.0 Hz	Increments 0.01 Hz Increments 0.01 Hz
Frequency change df/dt		0.10 Hz/s to 20.00 Hz/s	Increments 0.01 Hz/s
Dropout ratio > element		1.01 to 3.00	Increments 0.01
Dropout ratio < element		0.70 to 0.99	Increments 0.01
Dropout difference f		0.02 Hz to 1.00 Hz	Increments 0.01 Hz
Pickup delay (standard)		0.00 s to 60.00 s	Increments 0.01 s
Pickup delay for I_2/I_1		0.00 s to 28800.00 s	Increments 0.01 s
Command delay time		0.00 s to 3600.00 s	Increments 0.01 s
Dropout delay		0.00 s to 60.00 s	Increments 0.01 s

Function Limits

Power measurement three-phase	for I_{Nom} = 1 A	Positive sequence system current > 0.03 A
	for I_{Nom} = 5 A	Positive sequence system current > 0.15 A
Power measurement single-phase	for I_{Nom} = 1 A	Phase current > 0.03 A
	for I_{Nom} = 5 A	Phase current > 0.15 A
Relationship I_2/I_1 measurement	for I_{Nom} = 1 A	Positive or negative sequence system current > 0.1 A
	for I_{Nom} = 5 A	Positive or negative sequence system current > 0.5 A

Times

Pickup times:	
Current, voltage (phase quantities) for 2 times the setting value for 10 times the setting value	 approx. 30 ms approx. 20 ms
Current, voltage (symmetrical components) for 2 times the setting value for 10 times the setting value	 approx. 40 ms approx. 30 ms
Power typical maximum (small signals and threshold values)	 approx. 120 ms approx. 350 ms
Power factor	300 to 600 ms
Frequency	approx. 100 ms
Frequency change for 1.25 times the setting value	approx. 220 ms
Binary input	approx. 20 ms
Dropout times:	
Current, voltage (phase quantities)	< 20 ms
Current, voltage (symmetrical components)	< 30 ms
Power typical maximum	 < 50 ms < 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Frequency change	< 200 ms
Binary input	< 10 ms

Tolerances

Pickup thresholds:		
Current	for I_{Nom} = 1 A	3% of setting value or 15 mA
	for I_{Nom} = 5 A	3% of setting value or 75 mA
Current (symmetrical components)	for I_{Nom} = 1 A	4% of setting value or 20 mA
	for I_{Nom} = 5 A	4% of setting value or 100 mA
Current (I_2/I_1)		4% of setting value
Voltage		3% of setting value or 0.2 V
Voltage (symmetrical components)		4% of setting value or 0.2 V
Power	for I_{Nom} = 1 A	3% of setting value or 0.5 W (for nominal values)
	for I_{Nom} = 5 A	3% of setting value or 2.5 W (for nominal values)
Power factor		3°
Frequency		15 mHz
Frequency change		5% of setting value or 0.05 Hz/s
Times		1% of setting value or 10 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \leq V_{Aux}/V_{AuxNom} \leq 1.15$	1 %
Temperature in range –5 °C (41 °F) $\leq \Theta_{amb} \leq$ 55 °C (131 °F)	0.5 %/10 K
Frequency in range $0.95 \leq f/f_{Nom} \leq 1.05$	1 %
Frequency outside range $0.95 \leq f/f_{Nom} \leq 1.05$	Increased tolerances
Harmonics - up to 10 % 3rd harmonic - up to 10 % 5th harmonic	 1 % 1 %

4.18 Synchrocheck 25

Modes of Operation

- Synchrocheck

Additional Release Conditions

- Live bus / dead line, - Dead bus / live line, - Dead bus and dead line - Bypassing

Voltages

Maximum operating voltage V_{max}	20 V to 140 V (phase-to-phase)	Increments 1 V
Minimum operating voltage V_{min}	20 V to 125 V (phase-to-phase)	Increments 1 V
V< for dead line V> for live line	1 V to 60 V (phase-to-phase) 20 V to 140 V (phase-to-phase)	Increments 1 V Increments 1 V
Primary transformer rated voltage V2N	0.10 kV to 800.00 kV	Increments 0.01 kV
Tolerances	2 % of pickup value or 2 V	
Dropout Ratios	approx. 0.9 (V>) or 1.1 (V<)	

Permissible Differences

Voltage differences V2>V1; V2<V1 Tolerance	0.5 V to 50.0 V (phase-to-phase) 1 V	Increments 0.1 V
Frequency difference f2>f1; f2<f1 Tolerance	0.01 Hz to 2.00 Hz 30 mHz	Increments 0.01 Hz
Angle differences $\alpha 2 > \alpha 1$; $\alpha 2 < \alpha 1$	2° to 80°	Increments 1°
Tolerance	2°	
Max. angle error	5° for $\Delta f \leq 1$ Hz 10° for $\Delta f \leq 1$ Hz	

Matching

Vector group matching via angle	0° to 360°	Increments 1°
Different voltage transformer V1/V2	0.50 to 2.00	Increments 0.01

Times

Minimum Measuring Time	approx. 80 ms	
Maximum Duration $T_{SYN\ DURATION}$	0.01 s to 1200.00 s or ∞ (disabled)	Increments 0.01 s
Monitoring Time $T_{SUP\ VOLTAGE}$	0.00 s to 60.00 s	Increments 0.01 s
Tolerance of all times	1 % of setting value or 10 ms	

Measured Values of the Synchrocheck Function

Reference voltage V1 - Range - Tolerance [1)]	in kV primary, in V secondary or in % of V_{Nom} 10 % to 120 % of V_{Nom} ≤ 1 % of measured value, or 0.5 % of V_{Nom}
Voltage to be synchronized V2 - Range - Tolerance [1)]	in kV primary, in V secondary or in % of V_{Nom} 10 % to 120 % of V_{Nom} ≤ 1 % of measured value, or 0.5 % of V_{Nom}
Frequency of the voltage V1 - Range - Tolerance [1)]	f1 in Hz 25 Hz ≤ f ≤ 70 Hz 20 mHz
Frequency of the voltage V2 - Range - Tolerance [1)]	f2 in Hz 25 Hz ≤ f ≤ 70 Hz 20 mHz
Voltage difference V2-V1 - Range - Tolerance [1)]	in kV primary, in V secondary or in % of V_{Nom} 10 % to 120 % of V_{Nom} ≤ 1 % of measured value, or 0.5 % of V_{Nom}
Frequency difference f2-f1 - Range - Tolerance [1)]	in mHz f_{Nom} ± 3 Hz 30 mHz
Angle difference $\alpha 2 - \alpha 1$ - Range - Tolerance [1)]	in ° 0 to 180° 1°

[1)] at nominal frequency

4.19 User-defined Functions (CFC)

Function Modules and Possible Assignments to Task Levels

Function Module	Explanation	Task Level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
ABSVALUE	Magnitude Calculation	X	—	—	—
ADD	Addition	X	X	X	X
ALARM	Alarm clock	X	X	X	X
AND	AND - Gate	X	X	X	X
FLASH	Blink block	X	X	X	X
BOOL_TO_CO	Boolean to Control (conversion)	—	X	X	—
BOOL_TO_DI	Boolean to Double Point (conversion)	—	X	X	X
BOOL_TO_IC	Bool to Internal SI, Conversion	—	X	X	X
BUILD_DI	Create Double Point Annunciation	—	X	X	X
CMD_CANCEL	Command cancelled	X	X	X	X
CMD_CHAIN	Switching Sequence	—	X	X	—
CMD_INF	Command Information	—	—	—	X
COMPARE	Metered value comparison	X	X	X	X
CONNECT	Connection	—	X	X	X
COUNTER	Counter	X	X	X	X
DI_GET_STATUS	Decode double point indication	X	X	X	X
DI_SET_STATUS	Generate double point indication with status	X	X	X	X
D_FF	D- Flipflop	—	X	X	X
D_FF_MEMO	Status Memory for Restart	X	X	X	X
DI_TO_BOOL	Double Point to Boolean (conversion)	—	X	X	X
DINT_TO_REAL	Adaptor	X	X	X	X
DIST_DECODE	Conversion double point indication with status to four single indications with status	X	X	X	X
DIV	Division	X	X	X	X
DM_DECODE	Decode Double Point	X	X	X	X
DYN_OR	Dynamic OR	X	X	X	X
INT_TO_REAL	Conversion	X	X	X	X
LIVE_ZERO	Live-zero, non-linear Curve	X	—	—	—
LONG_TIMER	Timer (max.1193h)	X	X	X	X
LOOP	Feedback Loop	X	X	—	X
LOWER_SETPOINT	Lower Limit	X	—	—	—

Function Module	Explanation	Task Level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
MUL	Multiplication	X	X	X	X
MV_GET_STATUS	Decode status of a value	X	X	X	X
MV_SET_STATUS	Set status of a value	X	X	X	X
NAND	NAND - Gate	X	X	X	X
NEG	Negator	X	X	X	X
NOR	NOR - Gate	X	X	X	X
OR	OR - Gate	X	X	X	X
REAL_TO_DINT	Adaptor	X	X	X	X
REAL_TO_INT	Conversion	X	X	X	X
REAL_TO_UINT	Conversion	X	X	X	X
RISE_DETECT	Rise detector	X	X	X	X
RS_FF	RS- Flipflop	—	X	X	X
RS_FF_MEMO	RS- Flipflop with state memory	—	X	X	X
SQUARE_ROOT	Root Extractor	X	X	X	X
SR_FF	SR- Flipflop	—	X	X	X
SR_FF_MEMO	SR- Flipflop with state memory	—	X	X	X
ST_AND	AND gate with status	X	X	X	X
ST_NOT	Inverter with status	X	X	X	X
ST_OR	OR gate with status	X	X	X	X
SUB	Substraction	X	X	X	X
TIMER	Timer	—	X	X	—
TIMER_SHORT	Simple timer	—	X	X	—
UINT_TO_REAL	Conversion	X	X	X	X
UPPER_SETPOINT	Upper Limit	X	—	—	—
X_OR	XOR - Gate	X	X	X	X
ZERO_POINT	Zero Supression	X	—	—	—

General Limits

Description	Limit	Comment
Maximum number of all CFC charts considering all task levels	32	If the limit is exceeded, the device rejects the parameter set with an error message, restores the last valid parameter set and restarts using that parameter set.
Maximum number of all CFC charts considering one task level	16	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of all CFC inputs considering all charts	400	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of reset-resistant flipflops D_FF_MEMO	350	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

Device-specific Limits

Description	Limit	Comment
Maximum number of synchronous changes of chart inputs per task level	165	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of chart outputs per task level	150	

Additional Limits

Additional limits [1)] for the following CFC blocks:		
Task Level	**Maximum Number of Modules in the Task Levels**	
	TIMER[2) 3)]	TIMER_SHORT[2) 3)]
MW_BEARB	—	—
PLC1_BEARB	15	30
PLC_BEARB		
SFS_BEARB	—	—

1) When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

2) The following condition applies for the maximum number of timers: (2 · number of TIMER + number of TIMER_SHORT) < 30. TIMER and TIMER_SHORT hence share the available timer resources within the frame of this inequation. The limit does not apply to the LONG_TIMER.

3) The time values for the blocks TIMER and TIMER_SHORT must not be selected shorter than the time resolution of the device of 10 ms, as the blocks will not then start with the starting pulse.

Maximum Number of TICKS in the Task Levels

Task level	Limit in TICKS [1)]
MW_BEARB (measured value processing)	10000
PLC1_BEARB (slow PLC processing)	2000
PLC_BEARB (fast PLC processing)	400
SFS_BEARB (interlocking)	10000

1) When the sum of TICKS of all blocks exceeds the limits mentioned before, an error message is output in the CFC.

Processing Times in TICKS Required by the Individual Elements

Individual Element		Number of TICKS
Block, basic requirement		5
Each input more than 3 inputs for generic modules		1
Connection to an input signal		6
Connection to an output signal		7
Additional for each chart		1
Arithmetic	ABS_VALUE	5
	ADD	26
	SUB	26
	MUL	26
	DIV	54
	SQUARE_ROOT	83
Basic logic	AND	5
	CONNECT	4
	DYN_OR	6
	NAND	5
	NEG	4
	NOR	5
	OR	5
	RISE_DETECT	4
	X_OR	5
Information status	SI_GET_STATUS	5
	CV_GET_STATUS	5
	DI_GET_STATUS	5
	MV_GET_STATUS	5
	SI_SET_STATUS	5
	DI_SET_STATUS	5
	MV_SET_STATUS	5
	ST_AND	5
	ST_OR	5
	ST_NOT	5
Memory	D_FF	5
	D_FF_MEMO	6
	RS_FF	4
	RS_FF_MEMO	4
	SR_FF	4
	SR_FF_MEMO	4
Control commands	BOOL_TO_CO	5
	BOOL_TO_IC	5
	CMD_INF	4
	CMD_CHAIN	34
	CMD_CANCEL	3
	LOOP	8

Individual Element		Number of TICKS
Type converter	BOOL_TO_DI	5
	BUILD_DI	5
	DI_TO_BOOL	5
	DM_DECODE	8
	DINT_TO_REAL	5
	DIST_DECODE	8
	UINT_TO_REAL	5
	REAL_TO_DINT	10
	REAL_TO_UINT	10
Comparison	COMPARE	12
	LOWER_SETPOINT	5
	UPPER_SETPOINT	5
	LIVE_ZERO	5
	ZERO_POINT	5
Metered value	COUNTER	6
Time and clock pulse	TIMER	5
	TIMER_LONG	5
	TIMER_SHORT	8
	ALARM	21
	FLASH	11

Configurable in Matrix

In addition to the defined preassignments, indications and measured values can be freely configured to buffers, preconfigurations can be removed.

4.20 Additional Functions

Operational Measured Values

Currents I_A; I_B; I_C Positive sequence component I_1 Negative sequence component I_2 I_N or 3I0	in A (kA) primary and in A secondary or in % of I_{Nom}
Range Tolerance [1)]	10 % to 150 % I_{Nom} 1.5 % of measured value, or 1 % I_{Nom} and between 151 % and 200 % I_{Nom} 3 % of measured value
Voltages (phase-to-ground) V_{A-N}, V_{B-N}, V_{C-N} Voltages (phase-to-phase) V_{A-B}, V_{B-C}, V_{C-A}, V_{SYN} V_N, V_{ph-N}, V_x or V_0 Positive sequence component V_1 Negative sequence component V_2	in kV primary, in V secondary or in % of V_{Nom}
Range Tolerance [1)]	10 % to 120 % of V_{Nom} 1.5 % of measured value, or 0.5 % of V_{Nom}
S, apparent power	in kVAR (MVAR or GVAR) primary and in % of S_{Nom}
Range Tolerance [1)]	0 % to 120 % of S_{Nom} 1.5 % 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 Tolerance [1)]	0 % to 120 % of S_{Nom} 2 % of S_{Nom} for V/V_{Nom} and I/I_{Nom} = 50 to 120% and $\mid \cos\varphi \mid$ = 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 % of S_{Nom}
Range Tolerance [1)]	0 % to 120 % of S_{Nom} 2 % of S_{Nom} for V/V_{Nom} and I/I_{Nom} = 50 to 120% and $\mid \sin\varphi \mid$ = 0.707 to 1 with $S_{Nom} = \sqrt{3} \cdot V_{Nom} \cdot I_{Nom}$
cos φ, power factor[2)]	total and phase-segregated
Range Tolerance [1)]	-1 to +1 2 % for $\mid \cos\varphi \mid \geq 0.707$
Angle φ_A; φ_B; φ_C,	in degrees (°)
Range Tolerance [1)]	0 to 180° 0,5°
Frequency f	in Hz
Range Tolerance [1)]	f_N ± 5 Hz 20 mHz
Temperature overload protection Θ / Θ_{Trip}	in %
Range Tolerance [1)]	0 % to 400 % 5 % class accuracy in acc. with IEC 60255-8
Currents of sensitive ground fault detection (total, active, and reactive current) I_{Ns}, $I_{Ns\ active}$; $I_{Ns\ reactive}$	in A (kA) primary and in mA secondary

Range Tolerance [1]	0 mA to 1600 mA or 0 A to 8 A for I_{Nom} = 5 A 3 % of measured value or 1 mA
Synchrocheck function	see section (Synchrocheck)

[1] at nominal frequency

[2] Displaying of cos φ as of I/I_{Nom} and V/V_{Nom} greater than 10%

Long-Term Averages

Time Window	5, 15, 30 or 60 minutes
Frequency of Updates	adjustable
Long-Term Averages	
of Currents of Real Power of Reactive Power of Apparent Power	I_{Admd}; I_{Bdmd}; I_{Cdmd}; I_{1dmd} in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAr (kVAr, MVAr) S_{dmd} in VAr (kVAr, MVAr)

Min / Max Report

Storage 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 ∞)
Manual Reset	Using binary input Using keypad Via communication
Min/Max Values for Current	I_A; I_B; I_C; I_1 (positive sequence component)
Min/Max Values for Voltages	V_{A-N}; V_{B-N}; V_{C-N}; V_1 (Positive Sequence Component); V_{A-B}; V_{B-C}; V_{C-A}
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_{Admd}; I_{Bdmd}; I_{Cdmd}; I_1 (positive sequence component); S_{dmd}; P_{dmd}; Q_{dmd}

Fuse Failure Monitor

Setting range of the displacement voltage 3U0 above which voltage failure is detected	10 - 100 V
Setting range of the ground current above which no voltage failure is assumed	0.1 - 1 A for I_{Bdmd} = 1 A 0.5 - 5A for I_{Bdmd} = 5A
Setting range of the pickup threshold I> above which no voltage failure is assumed	0.1 - 35 A for I_{Bdmd} = 1 A 0.5 - 175 A for I_{Bdmd} = 5A
Measuring voltage monitoring	depends on the MLFB and configuration with measured and calculated values V_N and I_N

Broken-wire Monitoring of Voltage Transformer Circuits

suited for single-, two- or three-pole broken-wire detection of voltage transformer circuits; only for connection of phase-Ground voltages

Local Measured Value Monitoring

Current asymmetry	I_{max}/I_{min} > symmetry factor, for I > I_{limit}
Voltage asymmetry	V_{max}/V_{min} > symmetry factor, for V > V_{limit}
Current sum	$\| i_A + i_B + i_C + k_I \cdot i_N \|$ > limit value, with $k_I = \frac{\text{Ignd-CT PRIM} / \text{Ignd-CT SEC}}{\text{CT PRIMARY} / \text{CT SECONDARY}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)

Fault Event Recording

Recording of indications of the last 8 power system faults
Recording of indications of the last 3 power system ground faults

Time Allocation

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

Fault Recording

maximum of 8 fault records saved; memory maintained by buffer battery in the case of auxiliary voltage failure	
Recording time	5 s per fault record, in total up to 18 s at 50 Hz (max. 15 s at 60 Hz)
Intervals at 50 Hz Intervals at 60 Hz	1 instantaneous value each per 1.0 ms 1 instantaneous value each per 0.83 ms

Energy Counter

Meter Values for Energy Wp, Wq (real and reactive energy)	in kWh (MWh or GWh) and in kVARh (MVARh or GVARh)
Range Tolerance [1]	28 bit or 0 to 2 68 435 455 decimal for IEC 60870-5-103 (VDEW protocol) 31 bit or 0 to 2 147 483 647 decimal for other protocols (other than VDEW) ≤ 2 % for I > 0.1 I_{Nom}, V > 0.1 V_{Nom} and $\| \cos \varphi \| \geq 0.707$

[1] At nominal frequency

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
Accumulated Interrupted Current (segregated according to pole)	Up to 4 digits

Operating Hours Counter

Display Range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (element 50-1, BkrClosed I MIN)

Circuit Breaker Monitoring

Calculation method	on r.m.s. value basis: ΣI, ΣI^x, 2P; on instantaneous value basis: I^2t
Measured value acquisition/processing	phase-selective
Evaluation	one limit value each per subfunction
Saved number of statistical values	up to 13 decimal places

Trip Circuit Monitoring

With one or two binary inputs.

Commissioning Aids

- Phase rotation test - Operational measured values - Circuit breaker test by means of control function - Creation of a test fault report - Creation of messages

Clock

Time synchronization		Binary input Communication
Modes of operation for time tracking		
No.	Mode of operation	Explanations
1	Internal	Internal synchronization using RTC (presetting)
2	IEC 60870-5-103	External synchronization using port B (IEC 60870-5-103)
3	Pulse via binary input	External synchronization with pulse via binary input
4	Field bus (DNP, Modbus, VDEW Redundant)	External synchronization using field bus
5	NTP (IEC 61850)	External synchronization using port B (IEC 61850)

Group Switchover of the Function Parameters

Number of available setting groups	4 (parameter group A, B, C and D)
Switchover can be performed via	the keypad on the device DIGSI using the operator interface protocol using port B binary input

IEC 61850 GOOSE (Inter-Relay Communication)

The GOOSE communication service of IEC 61850 is qualified for switchgear interlocking. Since the transmission time of GOOSE messages depends on both the number of IEC 61850 clients and the relay's pickup condition, GOOSE is not generally qualified for protection-relevant applications. The protective application is to be checked with regard to the required transmission time and cleared with the manufacturer.

4.21 Breaker Control

Number of Controlled Switching Devices	Depends on the number of binary inputs and outputs available
Interlocking	Freely programmable interlocking
Messages	Feedback messages; closed, open, intermediate position
Control Commands	Single command / double command
Switching Command to Circuit Breaker	1-, 1½ - and 2-pole
Programmable Logic Controller	PLC logic, graphic input tool
Local Control	Control via menu control assignment of function keys
Remote Control	Using Communication Interfaces Using a substation automation and control system (e.g. SICAM) Using DIGSI (e.g. via Modem)

4.22 Dimensions

4.22.1 Panel Flush and Cubicle Mounting (Housing Size 1/6)

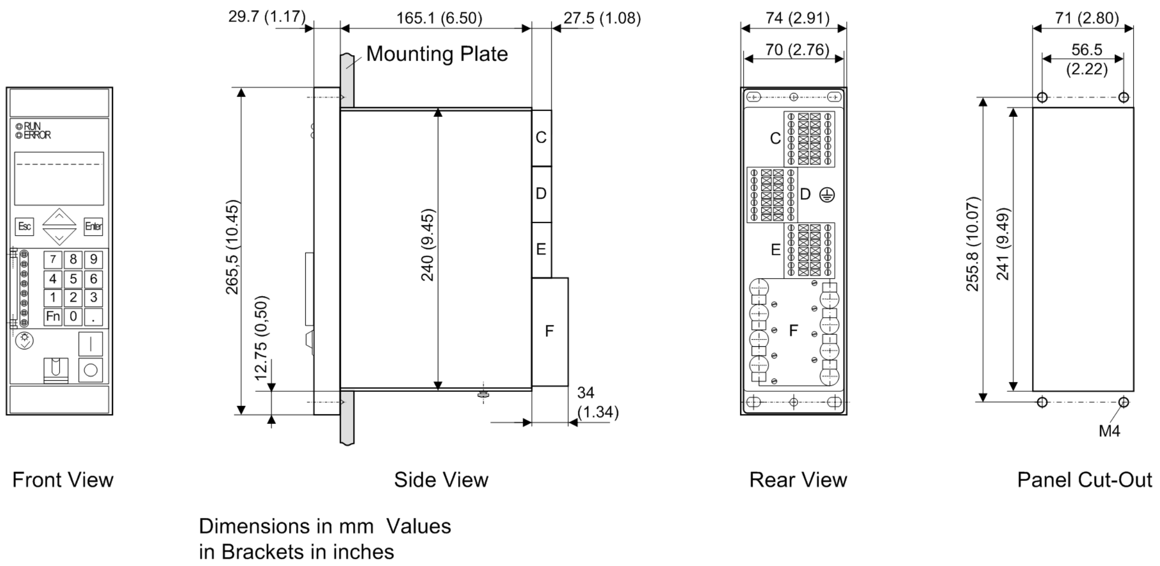


Figure 4-11 Dimensional drawing of a 7SJ80 for panel flush or cubicle mounting (housing size $^1/_6$)

Note: An angle strip set (contains upper and lower mounting brackets) (Order-No. C73165-A63-D200-1) is necessary to install the device in a rack. Using the Ethernet interface it might be necessary to rework the lower mounting bracket.

Please consider enough space for the cabling of the communication modules at the bottom of the relay or below the relay.

4.22.2 Panel Surface Mounting (Housing Size 1/6)

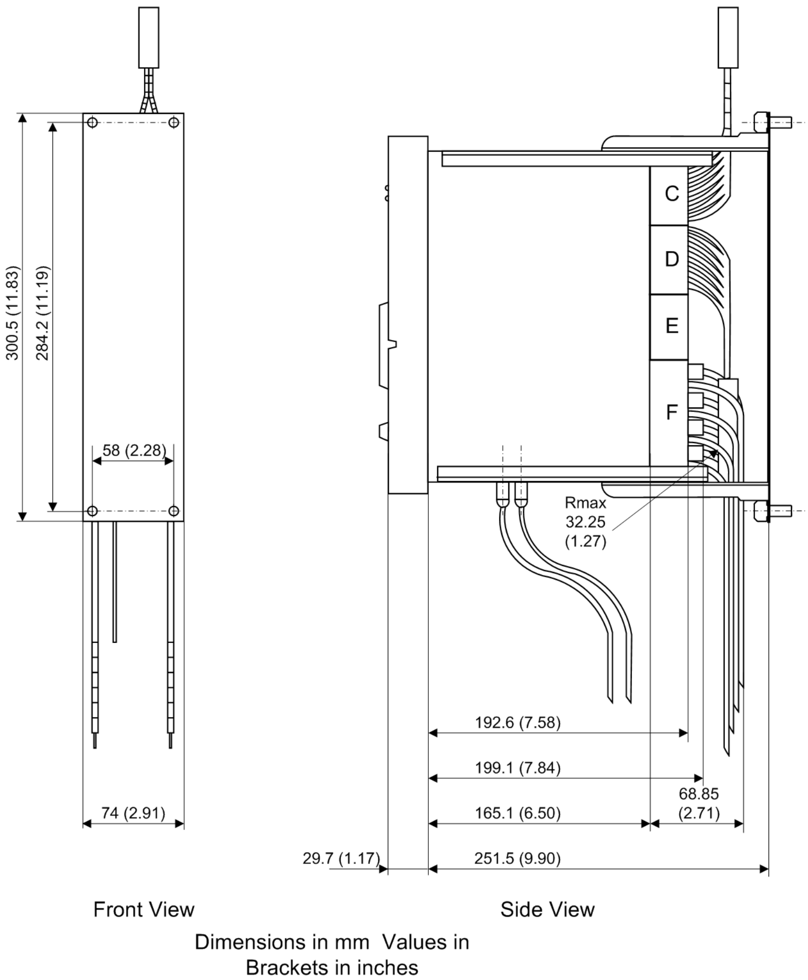


Figure 4-12 Dimensional drawing of a 7SJ80 for panel surface mounting (housing size $^1/_6$)

4.22.3 Bottom view

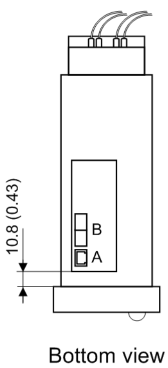


Figure 4-13 Bottom view of a 7SJ80 (housing size $^1/_6$)

4.22.4 Varistor

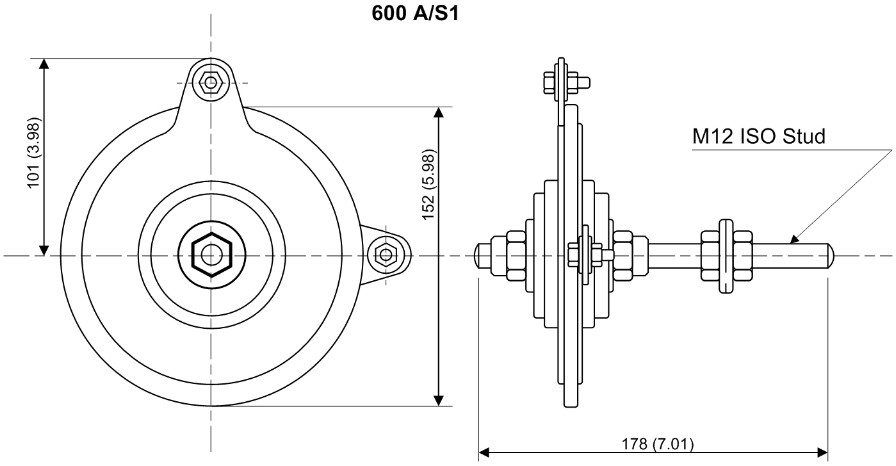


Figure 4-14 Dimensional drawing of the varistor for voltage limiting in high-impedance differential protection

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