7SR242 Duobias

Multi-Function 2-Winding Transformer Protection Relay

Document Release History

This document is issue **2010/06**. The list of revisions up to and including this issue is:

2010/06	Additional Comms modules option of (RS485 + IRIG-B) and (RS232 + IRIG-B) and typographical revisions
2010/02	Document reformat due to rebrand
2010/02	Third issue. Software revision 2662H80001 R4c-3
2008/07	Second issue. Software revision 2662H80001R3d-2c.
2008/05	First issue

Software Revision History

2010/02	2662H80001 R4c-3	Revisions to: VT ratio settings, 87BD 1st bias slope limit setting increments, CB fail function, LED CONFIG menu, DATA STORAGE menu. Added: Open circuit detection (46BC), CONTROL MODE menu, Close circuit supervision (74CCS), Measured earth fault undercurrent (37G), Pulsed output contacts.
2008/07	2662H80001R3d-2c.	Demand metering. Optional DNP3.0 data comms.
2008/05	2662H80001R3-2b	First Release

Contents

List of Figures

Section 1: Common Functions

1.1 General

1.1.1 CE Conformity

CE This product is CE compliant to relevant EU directives.

1.1.2 Reference

This product complies with IEC 60255-3, IEC 60255-6 and IEC 60255-12.

1.1.2.1 Accuracy Reference Conditions

This product has been tested under the following conditions, unless specifically stated otherwise.

Parameter	**Value**
Auxiliary supply	Nominal
AC Voltage	Nominal
AC Current	Nominal
Frequency	Nominal
Ambient temperature	20 °C

1.1.3 Dimensions and Weights

1.1.3.1 Dimensions

Parameter		**Value**
Width	7SR2422, E8 case	207.5 mm
	7SR2423, E10 case	260 mm
Height		177 mm
Depth behind panel (including clearance for wiring and fibre)		241.5 mm
Projection (from front of panel)		31 mm

See appropriate case outline and panel drilling drawing, as specified in Diagrams and Parameters document, for complete dimensional specifications.

1.1.3.2 Weights

Parameter		**Value**
Net weight	7SR2422, E8 case	5.2 kg
	7SR2423, E10 case	6.8 kg

NB: If supplied with communication interface devices please add an additional 0.165 kg

1.2 Energising Quantities

1.2.1 Auxiliary Power Supply

Nominal		**Operating Range**
V_{AUX}	30, 48, 110, 220 VDC	24 to 290 VDC

1.2.1.1 Burden

Attribute		**Value**
30V DC	Quiescent (typical)	6.0 W
	Quiescent (back light)	7.0 W
48V DC	Quiescent (typical)	5.5W
	Quiescent (back light)	6.5W
110V DC	Quiescent (typical)	6.5W
	Quiescent (back light)	7.5W
220V DC	Quiescent (typical)	7.5W
	Quiescent (back light)	8.5W

1.2.2 AC Current

Nominal		**Measuring Range**
In	1, 5 A Phase and earth	80 x *In*
fn	50, 60Hz	47 to 62Hz

Note. 1 A and 5 A nominal inputs are user selectable on each model.

1.2.2.1 Burden

Attribute	**Value - Phase and Earth**	
	1A	**5A**
AC Burden	≤ 0.1 VA	≤ 0.3 VA

1.2.2.2 Thermal Withstand

Overload Period	**Overload Current**	
	Phase and Earth	
	1A	**5A**
Continuous	3.0 *xIn*	
10 minutes	3.5 *xIn*	
5 minutes	4.0 *xIn*	
3 minutes	5.0 *xIn*	
2 minutes	6.0 *xIn*	
3 seconds	57.7A	202A
2 seconds	70.7A	247A
1 second	100A	350A
1 cycle	700A	2500A

1.2.3 AC Voltage

Nominal		Operating Range
Vn	40 to 160 V	Up to 270 V
fn	50, 60Hz	47 to 62Hz

1.2.3.1 Burden

Attribute	Value
AC Burden	≤ 0.1 VA at 110 V

1.2.4 Binary (Digital) Outputs

Contact rating to IEC 60255-0-2

Attribute		Value
Carry continuously		5A AC or DC
Make and carry (L/R ≤ 40 ms and V ≤ 300 V)	for 0.5 s	20A AC or DC
	for 0.2 s	30A AC or DC
Break (≤ 5 A and ≤ 300 V)	AC resistive	1250 VA
	AC inductive	250 VA at p.f. ≤ 0.4
	DC resistive	75 W
	DC inductive	30 W at L/R ≤ 40ms 50 W at L/R ≤ 10ms
Contact Operate / Release Time		7ms / 3ms
Minimum number of operations		1000 at maximum load
Minimum recommended load		0.5 W at minimum of 10mA or 5V

1.2.5 Binary (Digital) Inputs

Nominal		Operating Range
V_{BI}	19 VDC	17 to 290 VDC
	88 VDC	74 to 290 VDC

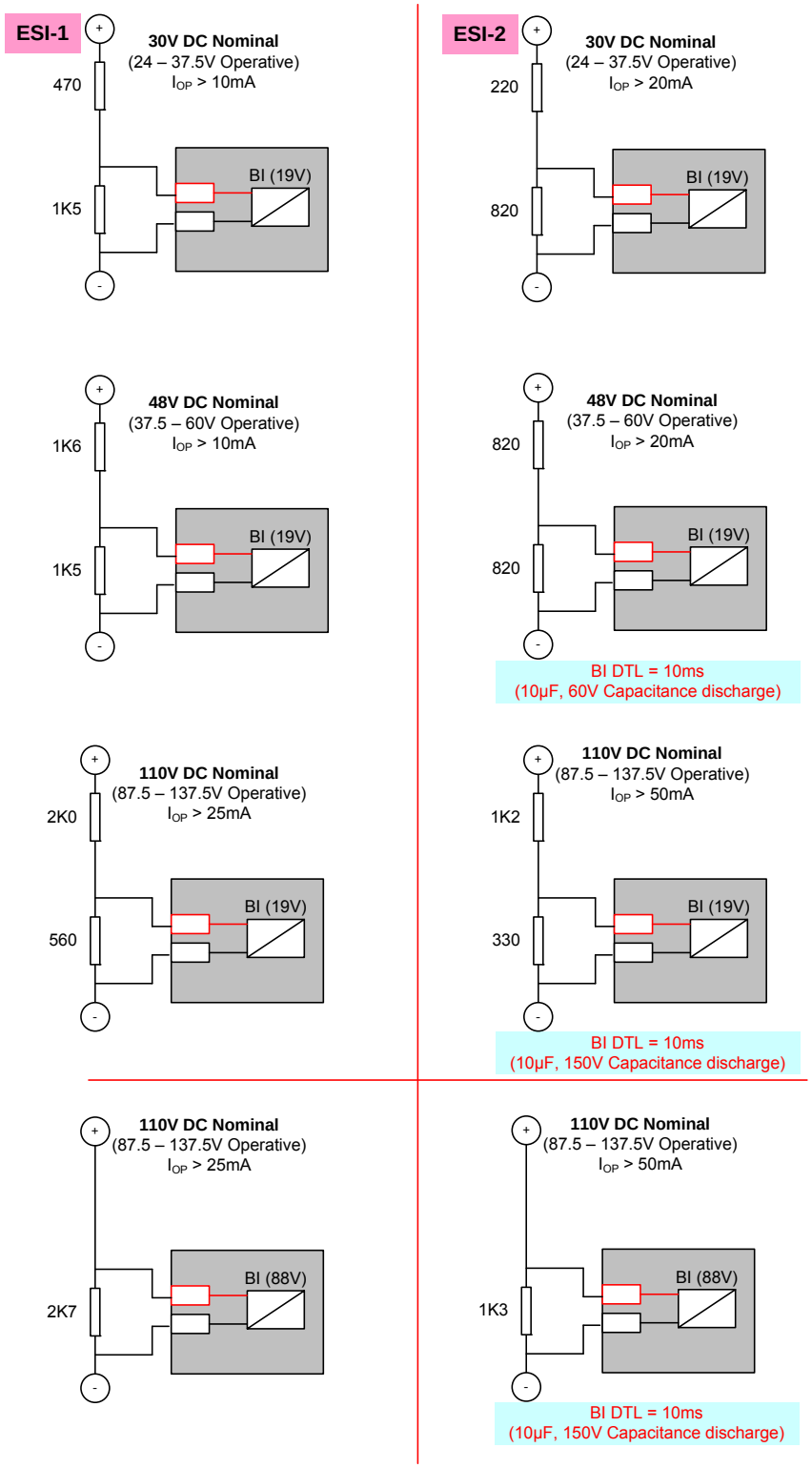
1.2.5.1 Performance

Attribute		Value
Maximum DC current for operation	V_{BI} = 19 V	1.5mA
	V_{BI} = 88 V	1.5mA
Reset/Operate voltage ratio		≥ 90 %
Response time		< 7ms
Response time when programmed to energise an output relay contact (i.e. includes output relay operation)		< 20ms

The binary inputs have a low minimum operate current and may be set for high speed operation. Where a binary input is both used to influence a control function (e.g. provide a tripping function) and it is considered to be susceptible to mal-operation due to capacitive currents, the external circuitry can be modified to provide immunity to such disturbances.

To comply with EATS 48-4, classes ESI 1 and ESI 2, external components / BI pick-up delays are required as shown in fig. 1-1.

To achieve immunity from AC interference, a BI pick-up delay of typically one-cycle can be applied.



Resistor power ratings:

30V DC Nominal	>3W
48V DC Nominal	>3W
110V DC Nominal	>10W (ESI- 1)
110V DC Nominal	>20W (ESI-2)

Resistors must be wired with crimped connections as they may run hot

Figure 1-1: Binary Input Configurations Providing Compliance with EATS 48-4 Classes ESI 1 and ESI 2

1.3 Functional Performance

1.3.1 Instrumentation

	Instrument Value	Reference	Typical accuracy
I	Current	$I \geq 0.1$ x*In*	± 1 % *In*
V	Voltage	$V \geq 0.8$ x*Vn*	± 1 % *Vn*

1.3.2 USB Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	USB-Type B

1.3.3 Fibre optic Data Communication Interface

Attribute	Value
Physical layer	Fibre-optic
Connectors	ST™ (BFOC/2.5)
Recommended fibre	62.5/125 μm glass fibre with ST connector
Launch power (into recommended fibre)	-16 dBm
Receiver sensitivity	-24 dBm

1.3.4 RS485 Data Communication Interface (Standard Rear Port)

Attribute	Value
Physical layer	Electrical
Connectors	4mm Ring Crimp

1.3.5 RS485 Data Communication Interface (Optional Rear Mounted Port)

Attribute	Value
Physical layer	Electrical
Connectors	4-way Plug

1.3.6 RS232 Data Communication Interface (Optional Rear Mounted Port)

Attribute	Value
Physical layer	Electrical
Connectors	9-way D-plug

1.3.7 Real Time Clock

1.3.7.1 Internal Clock

The specification below applies only while no external synchronisation signal (e.g. IRIG-B, IEC 60870-5-103) is being received.

Attribute	**Value**
Accuracy (-10 to +55^{o}C)	± 3.5 ppm

1.3.7.2 IRIG-B

Attribute	**Value**
Connector	BNC
Signal Type	IRIG-B 120, 122 or 123
Applied signal level	minimum 3 V, maximum 6 V, peak-to-peak
Signal : carrier ratio	≥ 3

1.4 Environmental Performance

1.4.1 General

1.4.1.1 Temperature

IEC 60068-2-1/2

Type	Level
Operating range	-10 °C to +55 °C
Storage range	-25 °C to +70 °C

1.4.1.2 Humidity

IEC 60068-2-3

Type	Level
Operational test	56 days at 40 °C and 93 % relative humidity

1.4.1.3 Transient Overvoltage

IEC 60255-5

Type	Level
Between all terminals and earth, or between any two independent circuits	5.0 kV, 1.2/50 μs 0.5j

1.4.1.4 Insulation

IEC 60255-5

Type	Level
Between any terminal and earth	2.0 kV AC RMS for 1 min
Between independent circuits	
Across normally open contacts	1.0 kV AC RMS for 1 min

1.4.1.5 IP Ratings

Type	Level
Installed with cover on	IP 50
Installed with cover removed	IP 30

1.4.2 Emissions

IEC 60255-25

1.4.2.1 Radiated Radio Frequency

Type	Limits at 10 m, Quasi-peak
30 to 230 MHz	40 dB(μV/m)
230 to 10000 MHz	47 dB(μV/m)

1.4.2.2 Conducted Radio Frequency

Type	Limits	
	Quasi-peak	Average
0.15 to 0.5 MHz	79 dB(μV)	66 dB(μV)
0.5 to 30 MHz	73 dB(μV)	60 dB(μV)

1.4.3 Immunity

1.4.3.1 Auxiliary DC Supply Variation

Quantity	Value
Allowable superimposed ac component	≤ 12% of DC voltage
Allowable breaks/dips in supply (collapse to zero from nominal voltage)	≤ 20ms

1.4.3.2 High Frequency Disturbance

IEC 60255-22-1 Class III

Type	Level	Variation
Common (longitudinal) mode	2.5 kV	≤ 5 %
Series (transverse) mode	1.0 kV	

1.4.3.3 Electrostatic Discharge

IEC 60255-22-2 Class IV

Type	Level	Variation
Contact discharge	8.0 kV	≤ 5 %

1.4.3.4 Radiated Immunity

IEC 60255-22-3 Class III

Type	Level	Variation
80 MHz to 1000 MHz	10 V/m	≤ 5 %

1.4.3.5 Fast Transients

IEC 60255-22-4 Class IV

Type	Level	Variation
5/50 ns 2.5 kHz repetitive	4kV	≤ 5 %

1.4.3.6 Surge Immunity

IEC 60255-22-5

Type	Level	Variation
Between all terminals and earth	4.0 kV	≤ 10 %
Between Line to Line	2.0 kV	

1.4.3.7 Conducted Radio Frequency Interference

IEC 60255-22-6

Type	Level	Variation
0.15 to 80 MHz	10 V	≤ 5 %

1.4.3.8 Magnetic Field with Power Frequency

IEC 6100-4-8 Level 5

100A/m, (0.126mT) continuous	50Hz
1000A/m, (1.26mT) for 3s	

1.4.4 Mechanical

1.4.4.1 Vibration (Sinusoidal)

IEC 60255-21-1 Class I

Type	Level	Variation
Vibration response	0.5 gn	≤ 5 %
Vibration endurance	1.0 gn	

1.4.4.2 Shock and Bump

IEC 60255-21-2 Class I

Type	Level	Variation
Shock response	5 gn, 11 ms	≤ 5 %
Shock withstand	15 gn, 11 ms	
Bump test	10 gn, 16 ms	

1.4.4.3 Seismic

IEC 60255-21-3 Class I

Type	Level	Variation
Seismic response	1 gn	≤ 5 %

1.4.4.4 Mechanical Classification

Type	Level
Durability	> 10^6 operations

Section 2: Protection Functions

2.1 24 Over Fluxing

2.1.1 Reference (24DT)

	Parameter	Value
V/f_s	Setting	0.10, 0.11… 2.0 x Nominal Voltage / Nominal Frequency
Hyst	Hysteresis setting	0, 0.1… 80.0%
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.1.2 Operate and Reset Level (24DT)

	Attribute		Value
V/f_{op}	Operate level		100% x V/f_s, ± 2 % or ± 0.02
	Reset level		≥ 95% of V/f_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %

2.1.3 Operate and Reset Time (24DT)

	Attribute	Value
t_{basic}	Element basic operate time	0.9 to 1.1 x V/f_s: 400 ms ± 200ms
		0.9 to 2.0 x V/f_s: 320 ms ± 200ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 200ms
	Repeatability	± 1 %
	Disengaging time	< 250ms

2.1.4 Reference (24IT)

	Parameter	Value
t_{reset}	Reset setting	0, 1… 1000 s

2.1.5 Operate and Reset Level (24IT)

	Attribute		Value
V/f_{op}	Operate level		100% x V/f_s, ± 2 % or ± 0.02
	Reset level		≥ 95% of V/f_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %

2.1.6 Operate and Reset Time (24IT)

	Attribute	**Value**
t_{basic}	Element basic operate time	500ms ± 300ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 2s
	Repeatability	± 1 %
	Disengaging time	< 250ms

2.2 27/59 Under/Over Voltage

2.2.1 Reference

	Parameter	Value
V_s	Setting	5, 5.5…200V
hyst	Hysteresis setting	0, 0.1… 80.0%
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.2.2 Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		100 % *Vs*, ± 1 % or ±0.25V
	Reset level	Overvoltage	= (100 % - *hyst*) *x* $V_{op,}$ ± 1 %
		Undervoltage	= (100 % + *hyst*) *x* $V_{op,}$ ± 1 %
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.2.3 Operate and Reset Time

	Attribute		Value
t_{basicE}	Element basic operate time	Overvoltage	0 to 1.1 x *Vs*: 73 ms ± 10ms
			0 to 2.0 x*Vs*: 63 ms ± 10ms
		Undervoltage	1.1 to 0.5 x*Vs*: 58 ms ± 10ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability		± 1 % or ± 10ms
	Disengaging time		< 80 ms

2.3 37,37G Undercurrent

2.3.1 Reference

	Parameter	Value
Is	37-n Setting	0.05, 0.10…5.0 *xIn*
t_d	37-n Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s
Is	37-n U/I Guard Setting	0.05, 0.10…5.0 *xIn*

	Parameter	Value
Is	37G-n Setting	0.05, 0.10…5.0 *xIn*
t_d	37G-n Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.3.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≤ 105 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.3.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.1 to 0.5 x*Is*: 35 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability	± 1 % or ± 10ms
	Overshoot time	< 40 ms
	Disengaging time	< 60 ms

2.4 46BC Open Circuit

2.4.1 Reference

	Parameter	Value
I_{set}	NPS to PPS ratio	20,21…100%
t_f	Delay setting	0.03,04,20.0,20.1,100,101,1000,1010…..14400 s
Is	46BC-n U/I Guard Setting	0.05, 0.10…5.0 *xIn*

2.4.2 Operate and Reset Level

	Attribute		Value
I_{curr}	Operate level: NPS to PPS ratio		100 % I_{set} ± 5 %
	Reset level		90 % I_{curr} , ± 5 %
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz harmonics to f_{cutoff}	≤ 5 %

	Attribute		Value
I_{op}	Operate level: 46BC-n U/I Guard Setting		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≤ 105 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.4.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Basic operate time	1x In to 0 A	40 ms
	Operate time		t_f + t_{basic}, ± 1 % or ± *20ms*
	Repeatability		± 1 % or ± *20ms*
	Variation	f_{nom} - 3 Hz to f_{nom} + 2 Hz harmonics to f_{cutoff}	≤ 5 %

2.5 46NPS Negative Phase Sequence Overcurrent

2.5.1 Reference (46DT)

	Parameter	Value
I_s	Setting	0.05, 0.06... 4.0x*In*
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.5.2 Operate and Reset Level (46DT)

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.5.3 Operate and Reset Time (46DT)

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x*Is*: 40 ms, ± 10ms
		0 to 5 xIs: 30 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability	± 1 % or ± 10ms
	Overshoot time	<40 ms
	Disengaging time	< 60 ms

2.5.4 Reference (46IT)

	Parameter	Value
char	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting	0.025, 0.050 … 1.6
I_s	Setting	0.05, 0.06… 2.5x*In*
t_d	Delay setting	0, 0.01… 20 s
t_{res}	Reset setting	ANSI DECAYING, 0, 1… 60 s

2.5.5 Operate and Reset Level (46IT)

	Attribute		Value
I_{op}	Operate level		105 % *Is*, ± 4 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.5.6 Operate and Reset Time (46IT)

	Attribute		Value
	Starter operate time (≥ 2*xIs*)		35 ms, ± 10ms
t_{op}	Operate time	*char* = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5 % absolute or ± 50 ms, for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5 % absolute or ± 50 ms, for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
		char = DTL	t_d, ± 1 % or ± 20ms
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{Is}\right]^{2} - 1} \times Tm$, ± 5 % absolute or ± 50 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		t_{res}	t_{res}, ± 1 % or ± 20ms
	Repeatability		± 1 % or ± 20ms
	Overshoot time		< 40 ms
	Disengaging time		< 60 ms

2.6 49 Thermal Overload

2.6.1 Reference

	Parameter	Value
Is	Overload setting	0.10, 0.11… 3 *xIn*
τ	Time constant setting	1, 1.5… 1000 min

2.6.2 Operate and Reset Level

	Attribute		Value
I_{ol}	Overload level		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≥ 95 % I_{ol}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.6.3 Operate and Reset Time

	Attribute	Value	
t_{op}	Overload trip operate time	$t = \tau \times \ln\left\{\frac{I^2 - I_p^2}{I^2 - (k \times I_B)^2}\right\}$ where I_P = prior current	, ± 5 % absolute or ± 100ms,
	Repeatability	± 100ms	

Figure 2-1 shows the thermal curves for various time constants.

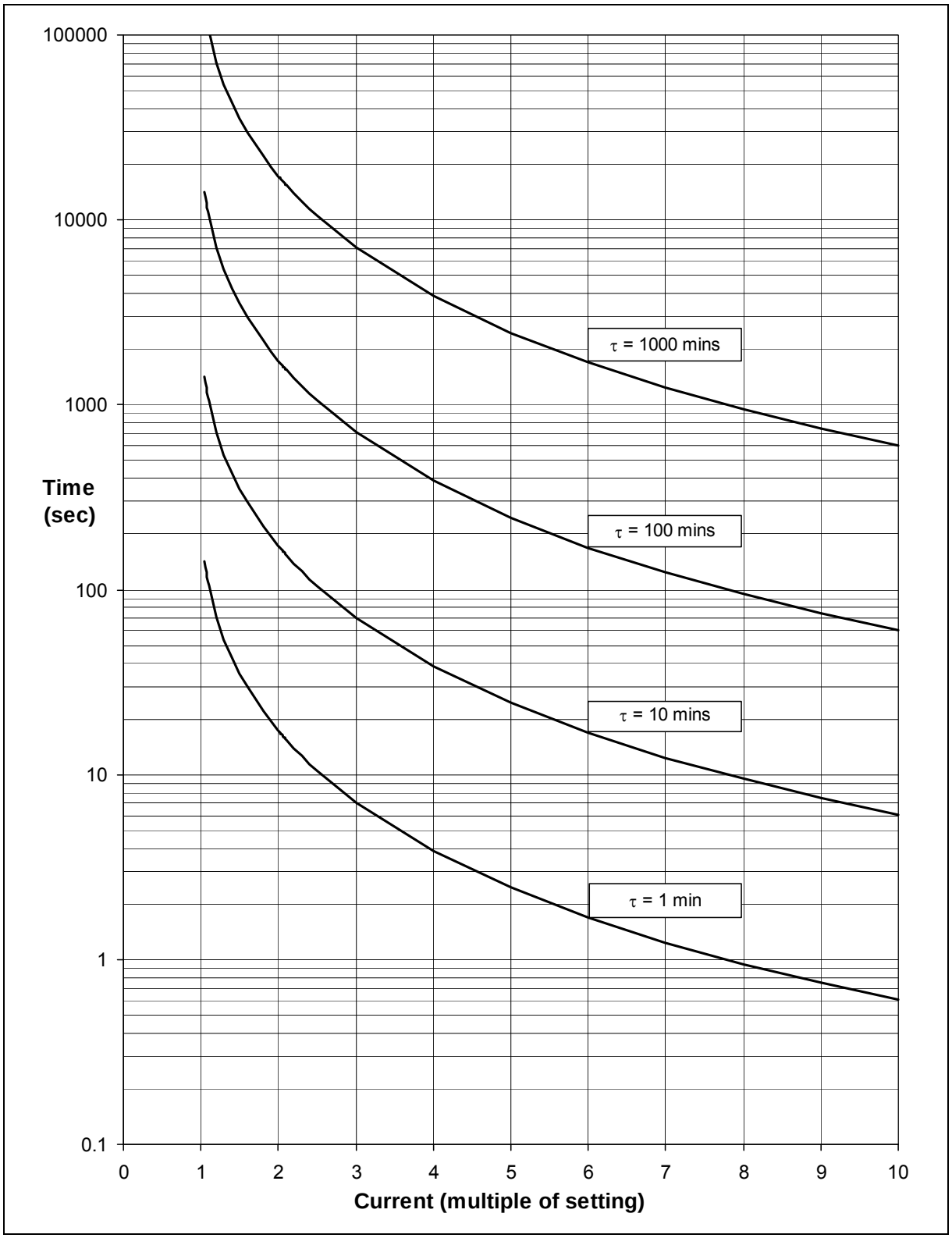


Figure 2-1 Thermal Overload Protection Curves

2.7 50 instantaneous overcurrent

2.7.1 Reference

	Parameter	Value
Is	Setting	0.05, 0.10… 25, 25.5… 50 x*In*
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.7.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.7.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x*Is*: 35 ms, ± 10ms
		0 to 5 x*Is*: 25 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability	± 1 % or ± 10ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.8 50N instantaneous Derived Earth Fault

2.8.1 Reference

	Parameter	Value
Is	Setting	0.05, 0.10… 25, 25.5… 50 x*In*
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.8.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.8.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x*Is*: 35 ms, ± 10ms
		0 to 5 x*Is*: 30 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability	± 1 % or ± 10ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.9 50G Instantaneous Measured Earth Fault

2.9.1 Reference

	Parameter	Value
Is	Setting	0.005…25.0 x*In*
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.9.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.9.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x*Is*: 35 ms, ± 10ms
		0 to 5 x*Is*: 25 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability	± 1 % or ± 10ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.10 51 Time Delayed Overcurrent

2.10.1 Reference

	Parameter	**Value**
Is	Setting	0.05, 0.1… 2.5 *xIn*
char	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting	0.025, 0.05… 1.6
t_d	Delay setting	0, 0.01… 20 s
t_{res}	Reset setting	ANSI DECAYING, 0, 1… 60 s

2.10.2 Operate and Reset Level

	Attribute		**Value**
I_{op}	Operate level		105 % *Is*, ± 4 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.10.3 Operate and Reset Time

	Attribute		Value
	Starter operate time (≥ 2*xIs*)		20 ms, ± 20ms
t_{op}	Operate time	*char* = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5 % absolute or ± 30 ms, for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5 % absolute or ± 30 ms, for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
		char = DTL	t_d, ± 1 % or ± 20ms
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{Is}\right]^{2} - 1} \times Tm$, ± 5 % absolute or ± 30 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		t_{res}	t_{res}, ± 1 % or ± 20ms
	Repeatability		± 1 % or ± 20ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

Figure 2-2 shows the operate times for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2-3 and figure 2.4 show the ANSI operate and reset curves. These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

2.11 51N Time Delayed Derived Earth Fault

2.11.1 Reference

	Parameter	**Value**
Is	Setting	0.05, 0.1… 2.5 *xIn*
char	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting	0.025, 0.05… 1.6
t_d	Delay setting	0, 0.01… 20 s
t_{res}	Reset setting	ANSI DECAYING, 0, 1… 60 s

2.11.2 Operate and Reset Level

	Attribute		**Value**
I_{op}	Operate level		105 % *Is*, ± 4 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.11.3 Operate and Reset Time

	Attribute		Value
	Starter operate time (≥ 2*xIs*)		20 ms, ± 20ms
t_{op}	Operate time	*char* = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5 % absolute or ± 30 ms, for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5 % absolute or ± 30 ms, for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
		char = DTL	t_d, ± 1 % or ± 20ms
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{Is}\right]^{2} - 1} \times Tm$, ± 5 % absolute or ± 30 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		t_{res}	t_{res}, ± 1 % or ± 20ms
	Repeatability		± 1 % or ± 20ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

Figure 2-2 shows the operate times for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2-3 and figure 2.4 show the ANSI operate and reset curves. These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

2.12 51G Time Delayed Measured Earth Fault

2.12.1 Reference

	Parameter		Value
Is	Setting		0.005, 0.10… 1.0 *xIn*
Char	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting		0.025, 0.05… 1.6
t_d	Delay setting (DTL)		0, 0.01… 20 s
t_{res}	Reset setting		ANSI DECAYING, 0, 1… 60 s
I	Applied current (for operate time)	IDMTL	2 to 20 x*Is*
		DTL	5 x*Is*

2.12.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % *Is*, ± 4 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.12.3 Operate and Reset Time

	Attribute		Value
	Starter operate time (≥ 2*xIs*)		20 ms, ± 20ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5 % absolute or ± 30 ms, for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5 % absolute or ± 30 ms, for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
		char = DTL	t_d, ± 1 % or ± 20ms
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{Is}\right]^{2} - 1} \times Tm$, ± 5 % absolute or ± 30 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		t_{res}	t_{res}, ± 1 % or ± 20ms
	Repeatability		± 1 % or ± 20ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

Figure 2-2 shows the operate times for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2-3 and figure 2.4 show the ANSI operate and reset curves. These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

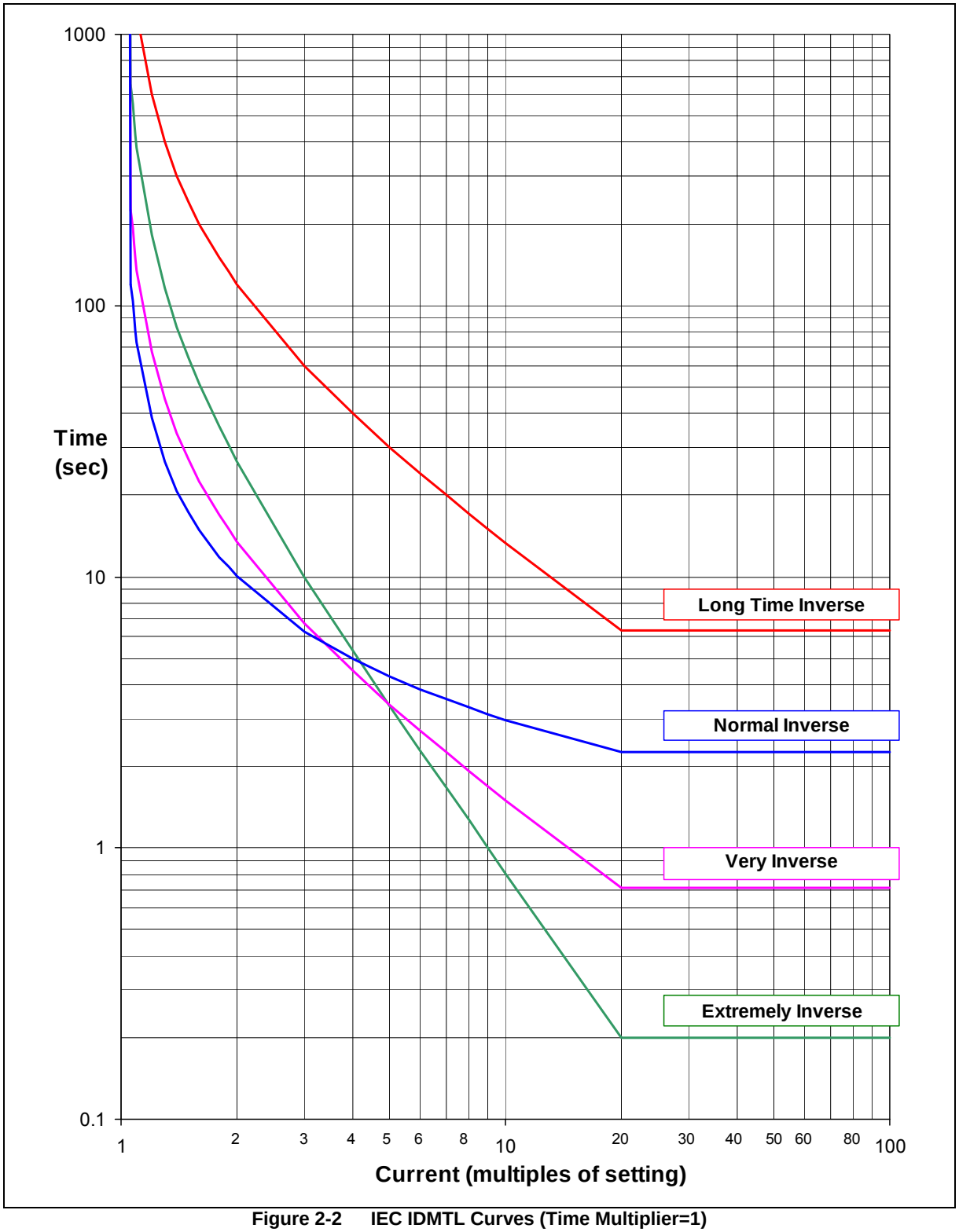


Figure 2-2 IEC IDMTL Curves (Time Multiplier=1)

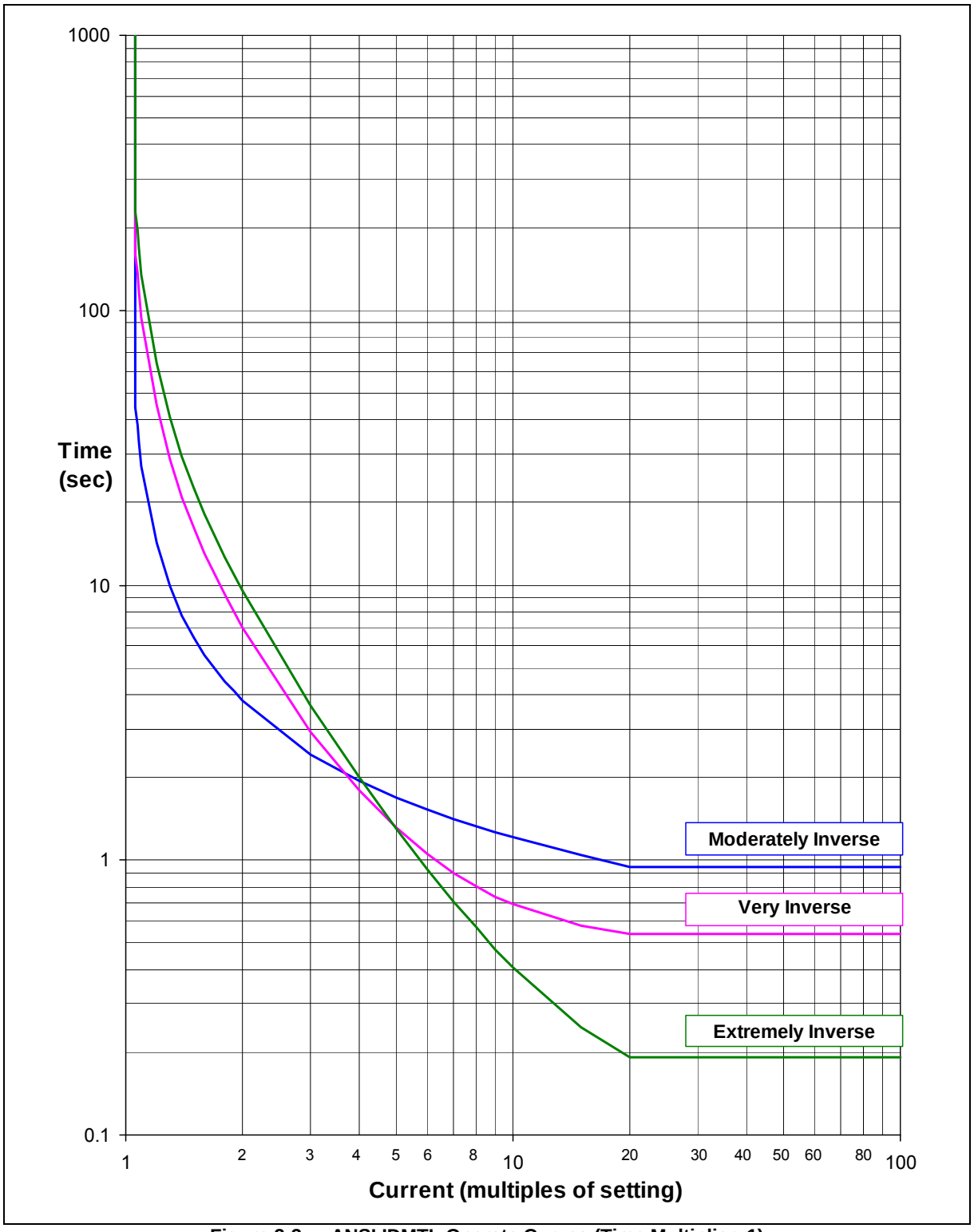


Figure 2-3 ANSI IDMTL Operate Curves (Time Multiplier=1)

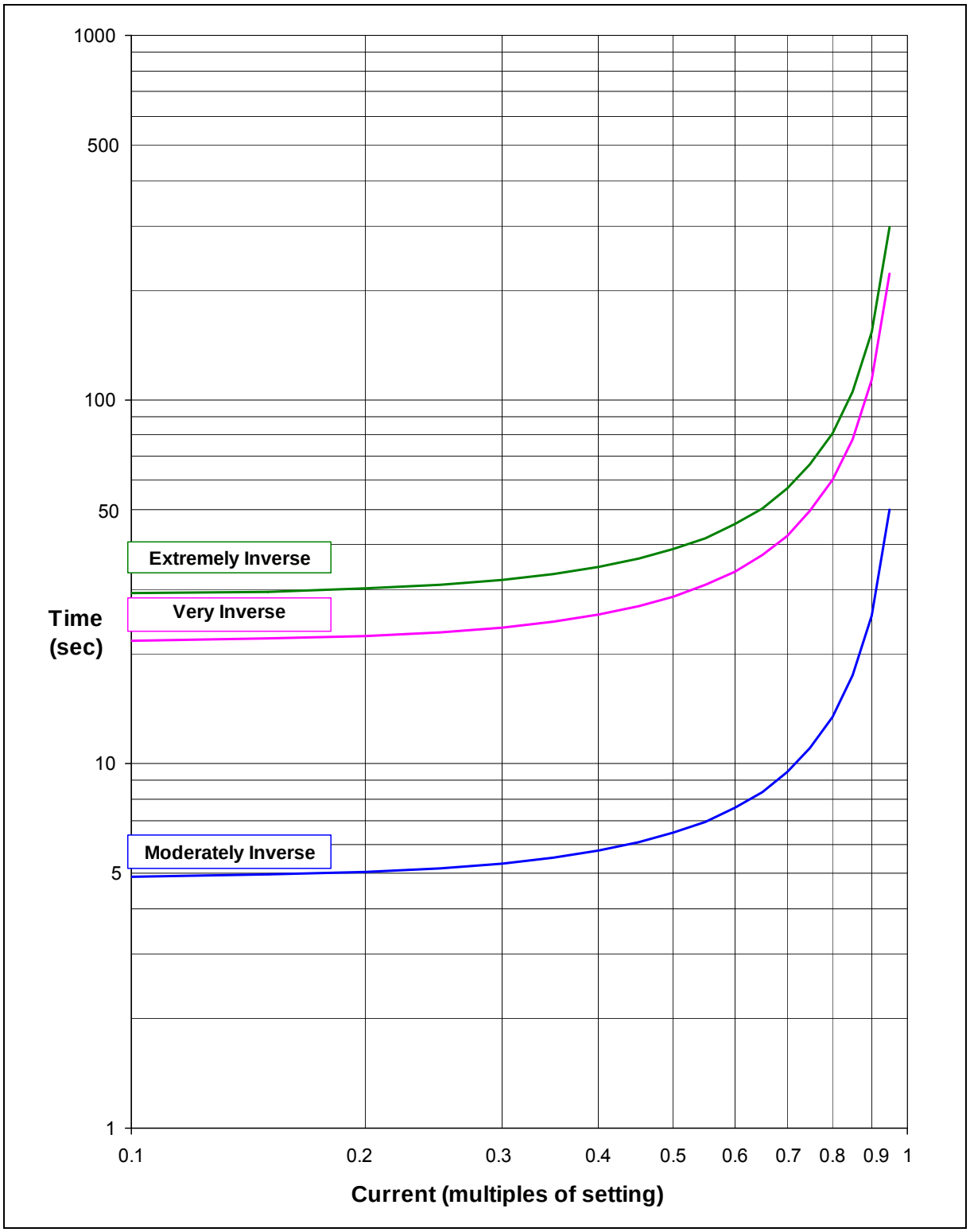


Figure 2-4 ANSI Reset Curves (Time Multiplier=1)

2.13 59N Neutral Voltage Displacement

2.13.1 Reference (59NDT)

	Parameter	Value
V_s	Setting	1, 1.5… 100V
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.13.2 Operate and Reset Level (59NDT)

	Attribute		Value
V_{op}	Operate level		100 % *Vs*, ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.13.3 Operate and Reset Time (59NDT)

	Attribute	Value
t_{basic}	Element basic operate time	0V to 1.5 *xVs*, 76 ms, ± 20ms
		0V to 10 *xVs*, 63 ms, ± 20ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 20ms
	Repeatability	± 1 % or ± 20ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.13.4 Reference (59NIT)

	Parameter	Value
M	Multiplier setting	0.1, 0.2… 10, 10.5… 140
Vs	Setting	1, 1.5… 100V
t_d	Delay setting	0, 0.01… 20 s
t_{res}	Reset setting	0, 1…60 s

2.13.5 Operate and Reset Level (59NIT)

	Attribute		Value
V_{op}	Operate level		105 % *Vs*, ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.13.6 Operate and Reset Time (59NIT)

	Attribute		**Value**
t_{basic}	Starter operate time (≥ 2*xVs*)		65 ms, ± 20ms
t_{op}	Operate time	char = IDMTL	$t_{op} = \frac{M}{\left[\frac{3V0}{Vs}\right] - 1}$, ± 5 % or ± 65 ms
		char = DTL	t_d, ± 1 % or ± 40ms
	Reset Time	char = IDMTL	t_{res}, ± 5 % or ± 65ms
		char = DTL	t_{res}, ± 1 % or ± 40ms
	Repeatability		± 1 % or ± 20ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

2.14 64H Restricted Earth Fault Protection

2.14.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.010… 0.95 x*In*
t_d	Delay setting	0.00, 0.01… 20.0, 20.1… 100.0, 101….1000, 1010 … 10000 , 10100 … 14400 s

2.14.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ±1% *xIn*
	Reset level		95 % I_{op}, ± 5 % or ±0.1% *xIn*
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.14.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x*Is*, 40 ms, ± 10ms
		0 to 5 xIs, 30 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1% or ± 10ms
	Repeatability	± 1% or ± 10ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.15 81Under/Over Frequency

2.15.1 Reference

	Parameter	Value
F_s	Setting	40, 40.01… 69.99 Hz
Hyst	Hysteresis setting	0, 0.1… 80%
td	Delay setting	0.00, 0.01… 20.0, 20.1… 100.0, 101.…1000, 1010 … 10000 , 10100 … 14400 s

2.15.2 Operate and Reset Level

	Attribute		Value
F_{op}	Operate level		100 % F_s, ± 10mHz
	Reset level	overfrequency	(100 % - *hyst*) $xF_{op,}$ ± 10mHz
		underfrequency	(100 % + *hyst*) $xF_{op,}$ ± 10mHz
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %

2.15.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time (for ROCOF between 0.1 and 5.0 Hz/sec)	overfrequency	Typically < 110ms
			Maximum < 150ms
		underfrequency	Typically < 110ms
			Maximum < 150ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability		± 1 % or ± 10ms
	Disengaging time		< 100 ms

2.16 87 Biased Differential

2.16.1 Reference

	Parameter	Value
ICT	Multiplier	1.00x
I_{init}	Initial Setting	0.1, 0.15… 2 xIn
I_{B1}	1st Bias Slope setting	0.1, 0.15… 0.7 x
I_{B1L}	1st Bias Slope Limit	1, 2… 20 xIn
I_{B2}	2nd Bias Slope setting	1, 1.05… 2 x
I_{B2T}	2nd Bias Slope Type setting	Line, Curve
ts	Delay setting	0, 0.005… 1s

2.16.2 Operate and Reset Level

	Attribute		Value
I_{OP}	Operate level 2nd Bias Slope Type = Line		$I_{OPERATE} > I_{87\,INITIAL\,SETTING}$ and $I_{OPERATE} > M_1 \times I_{RESTRAIN}$ and $I_{OPERATE} > M_2 \times I_{RESTRAIN}$ (for $I_{RESTRAIN} > B$) Where $I_{OPERATE} = \lvert I_1 + I_2 \rvert$ $I_{RESTRAIN} = \frac{\lvert I_1 \rvert + \lvert I_2 \rvert}{2}$ B = 87BD 1st Bias slope limit M_1 = 87BD 1st Bias slope M_2 = 87BD 2nd Bias slope
	Operate level 2nd Bias Slope Type = Curve		$I_{OPERATE} > I_{87\,INITIAL\,SETTING}$ and $I_{OPERATE} > M_1 \times I_{RESTRAIN}$ and $I_{OPERATE} > \sqrt{\frac{I_{RESTRAIN}^2 - K^2}{2}}$ (for $I_{RESTRAIN} > B$) Where $K^2 = B^2 - 2M_1^2B^2$
	87BD Initial Setting		± 5% of setting or ± 0.01In
	87BD Bias Slope		± 10% of bias slope setting
	Reset level		≥ 90% of I_{OP}
	Repeatability		± 2%
	Transient overreach		≤ 5%
	Variation	-10 °C to +55 °C	
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	

2.16.3 Operate Time

	Attribute	Value
t_{basic}	Element basic operate time (Inrush Action: Enabled)	0 to 3 x I_{OP}, 35 ms, ± 10ms
		0 to 10 x I_{OP}, 30 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1% or ± 10ms

2.17 87HS High-Set Differential

2.17.1 Reference

	Parameter	Value
ICT	Multiplier	1.00x
Is	Setting	1, 2 … 30 xIn
ts	Delay setting	0, 0.005… 1s

2.17.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		± 5% of setting or ± 0.01In
	Reset level		≥ 95% of I_{OP}
	Repeatability		± 2%
	Transient overreach		≤ 5%
	Variation	-10 °C to +55 °C	
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	

2.17.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 3 x I_{OP}, 30 ms, ± 10ms
		0 to 5 x I_{OP}, 25 ms, ± 10ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1% or ± 10ms

Section 3: Supervision Functions

3.1 50BF Circuit Breaker Fail

3.1.1 Reference

	Parameter	Value
Is	Setting: 50BF-n	0.050, 0.055… 2.0 x*In*
Is	Setting: 50BF-n-I4	0.005, 0.010… 2.0 x*In*
t_{CBF1}	Stage 1 Delay setting	0, 5… 60000ms
t_{CBF2}	Stage 2 Delay setting	0, 5… 60000ms

3.1.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% *In*
I_{reset}	Reset level		<100 % I_{op}, ± 5 % or ± 1% *In*
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

3.1.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	< 20ms
t_{op}	Stage 1	t_{CBF1}, ± 1 % or ± 20ms
	Stage 2	t_{CBF2}, ± 1 % or ± 20ms
	Repeatability	± 1 % or ± 20ms
	Overshoot	< 2 x 20ms
	Disengaging time	< 20ms

3.2 74TCS/CCS Trip/Close Circuit Supervision

3.2.1 Reference

	Parameter	Value
t_d	Delay setting	0, 0.02…60 s

3.2.2 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		30ms ± 10ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability		± 1 % or ± 10ms
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

3.3 81HBL2 Inrush Detector

3.3.1 Reference

	Parameter	Value
I	Setting (Ratio of 2nd Harmonic current to Fundamental component current)	0.10, 0.11... 0.5

3.3.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *I*, ± 4 % or ± 1% *In*
	Reset level		100 % I_{op}, ± 4 % or ± 1% *In*
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

3.3.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	Will pick-up before operation of any protection element due to magnetic inrush
	Reset Time	Will operation until drop-off of any protection element due to magnetic inrush

3.4 81HBL5 Overfluxing Detector

3.4.1 Reference

	Parameter	Value
I	Setting (Ratio of 5th Harmonic current to Fundamental component current)	0.10, 0.11... 0.5

3.4.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *I*, ± 4 % or ± 1% *In*
	Reset level		100 % I_{op}, ± 4 % or ± 1% *In*
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

3.4.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	Will pick-up before operation of any protection element due to overfluxing
	Reset Time	Will operation until drop-off of any protection element due to overfluxing