

7SR210 Non-Directional Relay

7SR220 Directional Relay

Performance Specification

(Software Version 2435H85008R7a-7a) (7SR210)

(Software Version 2435H85009R7a-7a) (7SR220)

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Document Release History

This document is issue **2011/08**. The list of revisions up to and including this issue is:

2011/05	First issue.
2011/08	Typographical revisions and added data.

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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 Current	Nominal
Frequency	Nominal
Ambient temperature	20 °C

1.1.3 Dimensions

Parameter		Value
Width	E6 case	155.5 mm
	E8 case	207.5 mm
Height		177 mm
Depth behind panel, including clearance for: -		
	Wiring	241.5 mm
	Fibre Optic	261.5 mm
	Ethernet enclosure	286.5 mm
Depth below Ethernet variant for cables		75 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.

1.1.4 Weights

Parameter		Value
Net weight	7SR2102, E6 case	3.3 kg
	7SR2103, E8 case	4.6 kg
	7SR2104, E8 case	4.8 kg
	7SR2202, E6 case	4.8 kg
	7SR2203, E8 case	4.9 kg
	7SR2204, E8 case	5.0 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 V DC	24 to 290 V DC

1.2.1.1 Burden

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

1.2.1.2 Operational Features

Attribute	Value	Comments
0% Dip Withstand Period	100 ms	
Dip Immunity Acquisition Period	5 minutes	Typical time after switch on to attain claimed immunity to dips
NOTE: -		
Dips in supply that fall below the minimum voltage for a period greater than the 0% Dip Withstand Period, will invoke a relay reset.		
During conditions of auxiliary input voltage variations which are not described ⁽¹⁾ in section 1.4.3.1, the relay may enter a safety protection mode where a power supply shutdown occurs. This condition is designed to protect the power supply from damage as well as prevent internal relay faults from developing into dangerous situations.		
Once the relay has entered this safety mode, it may be necessary to reduce the auxiliary input voltage to zero volts for up to 30 seconds before re-application of the auxiliary supply will cause the relay to power up and operate normally.		
(1) Using fuses as on/off switches or allowing batteries to run at very low cell voltages for extended periods and then attempting to re-charge them are examples of such auxiliary supply conditions.		

1.2.2 AC Current

Nominal		Measuring Range
I_n	1, 5 A Phase and earth	80 x I_n
f_n	50 Hz, 60 Hz	47 Hz to 62 Hz

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

1.2.2.1 Burden

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

1.2.2.2 Thermal Withstand

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

1.2.3 AC Voltage

Nominal		Operating Range
V_n	63.5 V, 110 V	270 V
f_n	50 Hz, 60 Hz	47 Hz to 62 Hz

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		5 A AC or DC
Make and carry (L/R ≤ 40 ms and V ≤ 300 V)	for 0.5 s	20 A AC or DC
	for 0.2 s	30 A 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 ≤ 10 ms
Contact Operate / Release Time		7 ms / 3 ms
Minimum number of operations		1000 at maximum load
Minimum recommended load		0.5 W at minimum of 10 mA or 5 V

1.2.5 Binary (Digital) Inputs

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

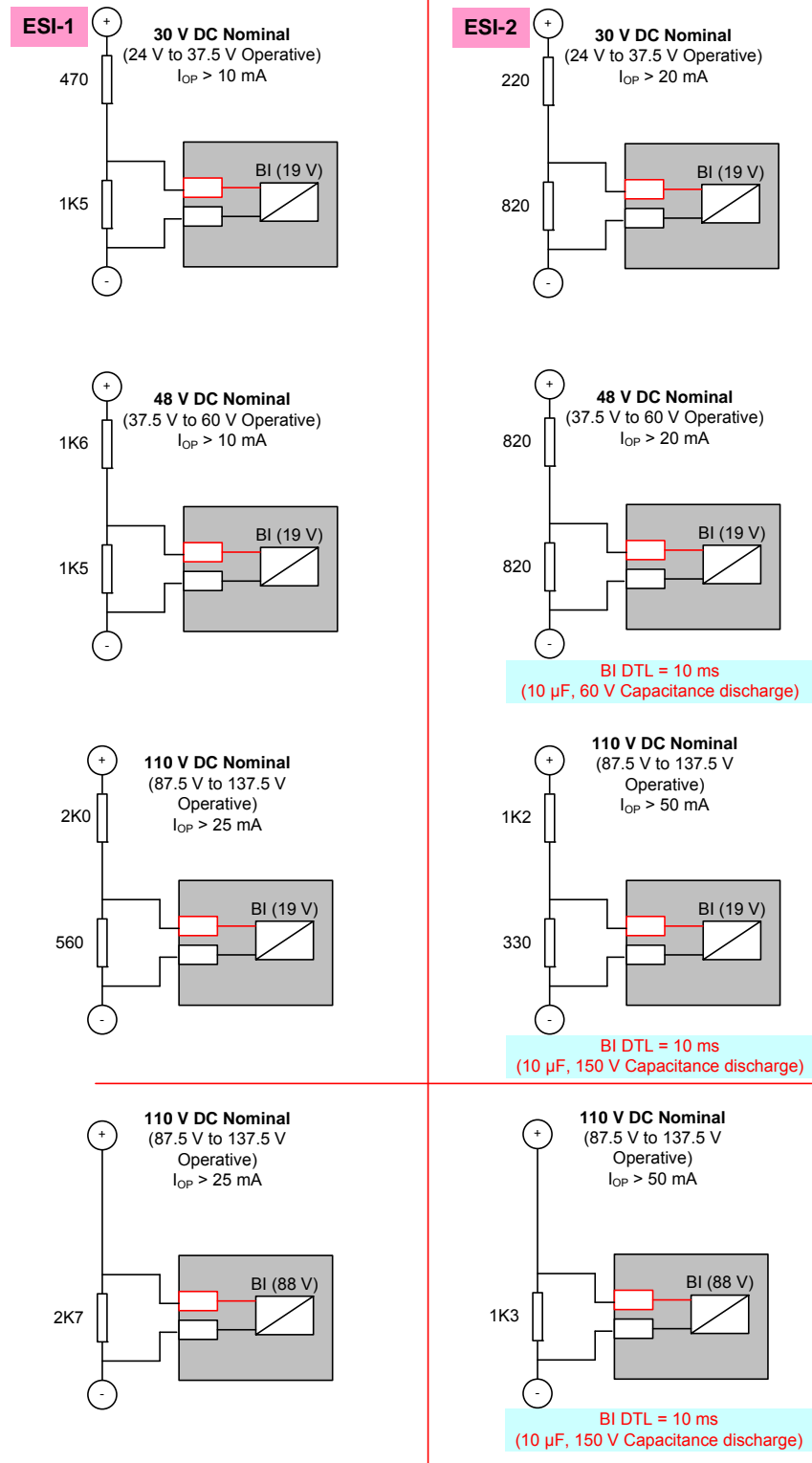
1.2.5.1 Performance

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

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: 30 V DC Nominal >3 W
 48 V DC Nominal >3 W
 110 V DC Nominal >10 W (ESI-1)
 110 V DC Nominal >20 W (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	$I \geq 0.1 \times I_n$	$\pm 1 \% I_n$
V	Voltage	$V \geq 0.8 \times V_n$	$\pm 1 \% V_n$
	Power, real and apparent	$V = V_n, I \geq 0.1 \times I_n, pf \geq 0.8$	$\pm 3 \% P_n$, where $P_n = V_n \times I_n$
pf	Power factor	$V = V_n, I \geq 0.1 \times I_n, pf \geq 0.8$	± 0.05

1.3.2 USB Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	USB-Type B

1.3.3 Fibre Optic Serial Data Communication Interface (Optional Rear Mounted Port)

Attribute	Value
Physical layer	Fibre-optic
Connectors	ST TM (BFOC/2.5)
Recommended fibre	62.5/125 μ m glass fibre with ST connector
Optical Wavelength	820 nm
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	4 mm 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 Fibre Optic Ethernet Data Communication Interface (IEC 61850 Option)

Attribute	Value
Physical layer	Fibre-optic
Connectors	Duplex LC 100BaseF in acc. With IEEE802.3
Recommended fibre	62.5/125 μ m glass fibre with Duplex-LC connector
Transmission Speed	100 MBits/s
Optical Wavelength	1300 nm
Bridgeable distance	2 km

1.3.8 Electrical Ethernet Data Communication Interface (IEC 61850 Option)

Attribute	Value
Physical layer	Electrical
Connectors	RJ45 100BaseF in acc. With IEEE802.3
Transmission Speed	100 MBits/s
Test Voltage (with regard to socket)	500 VAC 50 Hz
Bridgeable distance	20 m

1.3.9 Real Time Clock

1.3.9.1 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 °C to + 55 °C)	\pm 100 ppm

1.3.9.2 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

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 95 % 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 μ s 0.5j

1.4.1.4 Insulation

IEC 60255-5

Type	Level
Between any terminal and earth	2.5 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 from front of relay
Installed with cover removed	IP 30 from front of relay

1.4.2 Emissions

IEC 60255-25

1.4.2.1 Radiated Radio Frequency

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

1.4.2.2 Conducted Radio Frequency

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

1.4.3 Immunity

1.4.3.1 Auxiliary DC Supply Variation

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

1.4.3.2 High Frequency Disturbance

IEC 60255-22-1 Class III

Type	Level	Variation
Common (longitudinal) mode	2.5 kV	$\leq 5\%$
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	$\leq 5\%$

1.4.3.4 Radiated Immunity

IEC 60255-22-3 Class III

Type	Level	Variation
80 MHz to 1000 MHz	10 V/m	$\leq 5\%$

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
Between all terminals and earth	4.0 kV
Between Line to Line*	2.0 kV

* Note: 45 ms pick-up delay for DTL applied to binary inputs

1.4.3.7 Conducted Radio Frequency Interference

IEC 60255-22-6

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

1.4.3.8 Magnetic Field with Power Frequency

IEC 61000-4-8 level 5

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

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 27/59 Phase Under/Over Voltage

2.1.2 Reference

	Parameter	Value
V_s	Setting	5, 5.5...199.5, 200 V
$hyst$	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

2.1.3 Operate and Reset Level

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

2.1.4 Operate and Reset Time

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

2.2 27/59 Vx Under/Over Voltage

2.2.1 Reference

	Parameter	Value
V_s	Setting	5, 5.5...199.5, 200 V
V_s <i>Guard</i>	Guard Setting	1, 1.5, ...199.5, 200 V
<i>hyst</i>	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 % V_s , ± 1 % or ± 0.25 V
	Reset level	Overtage = $(100 \% - hyst) \times V_{op}$, ± 1 % or ± 0.25 V
		Undervoltage = $(100 \% + hyst) \times V_{op}$, ± 1 % or ± 0.25 V
	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	Overtage
		0 to 1.1 x V_s : 73 ms ± 10 ms
		0 to 2.0 x V_s : 63 ms ± 10 ms
	Undervoltage	1.1 to 0.5 x V_s : 58 ms ± 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Disengaging time	< 80 ms

2.3 37 Undercurrent

2.3.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.10...5.0 $\times I_n$
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s
I_s	37-n U/I Guard Setting	0.05, 0.10...5.0 $\times I_n$

2.3.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\% I_n$
	Reset level	$\leq 105\% I_{op}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C $\leq 5\%$
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$ $\leq 5\%$

2.3.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.1 to 0.5 $\times I_s$: 35 ms, $\pm 10\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 60\text{ ms}$

2.4 37G & 37SEF Undercurrent

2.4.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.10...5.0 $\times I_n$
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.4.2 Operate and Reset Level

	Attribute	Value	
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\% I_n$	
	Reset level	$\leq 105\% I_{op}$ or $I_{op} \pm 0.1\% I_n$	
	Repeatability	$\pm 1\%$	
	Variation	-10 °C to +55 °C	$\leq 5\%$
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$	$\leq 5\%$

2.4.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.1 to 0.5 $\times I_s$: 35 ms, $\pm 10\text{ ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 60\text{ ms}$

2.5 46NPS Negative Phase Sequence Overcurrent

2.5.1 Reference (46DT)

	Parameter	Value
I_s	Setting	0.05, 0.06... $4.0 \times I_n$
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 % I_s , $\pm 5\%$ or $\pm 1\% I_n$
	Reset level	$\geq 95\% I_{op}$
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.5.3 Operate and Reset Time (46DT)

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x/s: 40 ms, $\pm 10\text{ ms}$
		0 to 5 x/s: 30 ms, $\pm 10\text{ ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ ms}$
	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
T_m	Time Multiplier setting	0.025, 0.050 ... 1.6
I_s	Setting	0.05, 0.06... $2.5 \times I_n$
I	Applied Current (for operate time) IDMTL	2 to 20 x I_s
t_d	Delay setting	0, 0.01... 20 s
t_{res}	Reset setting	ANSI DECAYING, 0, 1... 60 s

Operate and Reset Level (46IT)

	Attribute	Value
I_{op}	Operate level	105 % I_s , ± 4 % or ± 1 % I_n
	Reset level	(100%-Hyst.) $\times V_{op} \pm 1$ % or ± 0.25 V
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz

2.5.5 Operate and Reset Time (46IT)

	Attribute	Value
	Starter operate time ($\geq 2 \times I_s$)	35 ms, ± 10 ms
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times T_m, \pm 5 \text{ % absolute or } \pm 50 \text{ ms,}$ for char = IEC-NI : $K = 0.14, \alpha = 0.02$ IEC-VI : $K = 13.5, \alpha = 1.0$ IEC-EI : $K = 80.0, \alpha = 2.0$ IEC-LTI : $K = 120.0, \alpha = 1.0$
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times T_m, \pm 5 \text{ % absolute or } \pm 50 \text{ ms,}$ 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	$t_d, \pm 1$ % or ± 20 ms
	Reset time	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times T_m, \pm 5 \text{ % absolute or } \pm 50 \text{ ms,}$ for char = ANSI-MI : $R = 4.85$ ANSI-VI : $R = 21.6$ ANSI-EI : $R = 29.1$
	t_{res}	$t_{res}, \pm 1$ % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Overshoot time	< 40 ms
	Disengaging time	< 60 ms

2.6 47 Negative Phase Sequence Voltage

2.6.1 Reference (47)

	Parameter	Value
V_s	Setting	1, 1.5... 90 V
<i>Hyst.</i>	Hysteresis	0, 0.1... 80 %
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.6.2 Operate and Reset Level (47)

	Attribute	Value
V_{op}	Operate level	100 % V_s , ± 2 % or ± 0.5 V
	Reset level	$(100 \% - \text{Hyst.}) \times V_{op} \pm 1\%$ or ± 0.25 V
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz
		≤ 5 %
		≤ 5 %

2.6.3 Operate and Reset Time (47)

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x V_s , 80 ms, ± 20 ms
		0 to 10 x V_s , 55 ms, ± 20 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, ± 2 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Overshoot time	< 40 ms
	Disengaging time	< 60 ms

2.7 49 Thermal Overload

2.7.1 Reference

	Parameter	Value
I_s	Overload setting	0.10, 0.11... 3 $x I_n$
τ	Time constant setting	1, 1.5... 1000 min

2.7.2 Operate and Reset Level

	Attribute	Value
I_{ol}	Overload level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{ol}
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz
		$\leq 5\%$
		$\leq 5\%$

2.7.3 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
		$\pm 5\%$ absolute or ± 100 ms, (For I_s range 0.3 $x I_n$ to 3 $x I_n$)
	Repeatability	± 100 ms

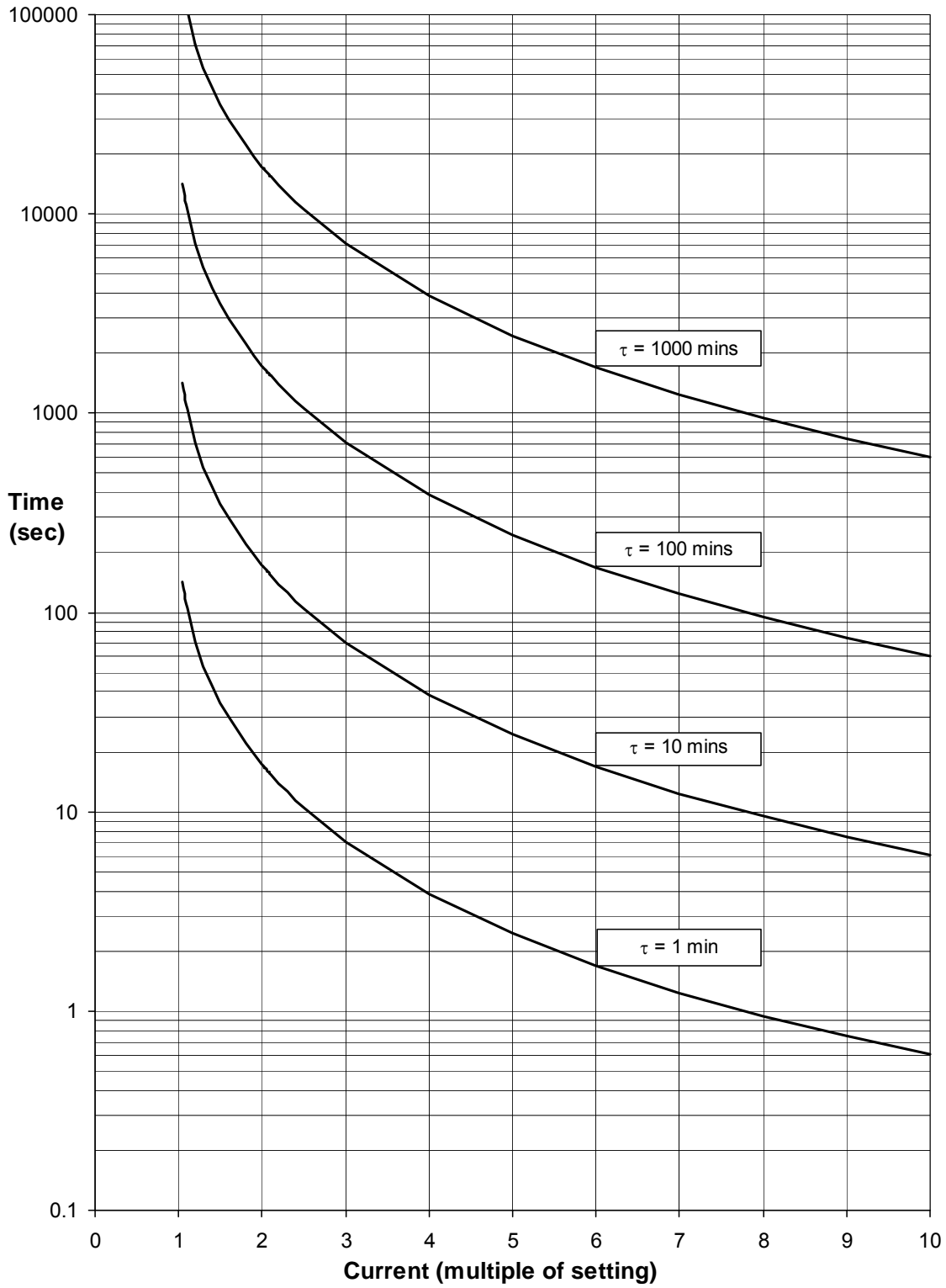


Figure 2-1 Thermal Overload Protection Curves

2.8 50 Instantaneous Overcurrent

2.8.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06... 25, 25.5... 50 $\times I_n$
i	Applied Current (for operate time)	2 to 5 $\times I_s$
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 % I_s , $\pm 5\%$ or $\pm 1\% I_n$
	Reset level	$\geq 95\% I_{op}$
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.8.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 $\times I_s$: 35 ms, $\pm 10\text{ ms}$
		0 to 5 $\times I_s$: 25 ms, $\pm 10\text{ ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.9 50G Instantaneous Measured Earth Fault

2.9.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.006... 25 xIn
i	Applied Current (for operate time)	2 to 5 x Is
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 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Transient overreach (X/R ≤ 100)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.9.3 Operate and Reset Time

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

2.10 50N instantaneous Derived Earth Fault

2.10.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06... 25, 25.5... 50 $\times I_n$
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.10.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\% I_n$
	Reset level	$\geq 95\% I_{op}$
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.10.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 $\times I_s$: 35 ms, $\pm 10\text{ ms}$
		0 to 5 $\times I_s$: 25 ms, $\pm 10\text{ ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.11 50SEF Instantaneous Sensitive Earth Fault

2.11.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.006... 5.0 xIn
t_d	Delay setting	0.00 , 0.01... 20.0, 20.1 .. 100.0, 101....1000, 1010 ... 10000 , 10100 ... 14400
I	Applied current (for operate time)	5 xIs

2.11.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ In
	Reset level	95 % $I_{op} \pm 5\%$ or $\pm 0.1\%$ In
	Repeatability	$\pm 1\%$
	Transient overreach (X/R ≤ 100)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$ harmonics to f_{cutoff}
		$\leq 5\%$
		$\leq 5\%$

2.11.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 xIs: 35 ms, $\pm 10\text{ ms}$
		0 to 5 xIs: 25 ms, $\pm 10\text{ ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$
	Variation	$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$

2.12 51 Time Delayed Overcurrent

2.12.1 Reference

	Parameter		Value
I_s	Setting		0.05, 0.06... 2.5 $x I_n$
$char$	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
T_m	Time Multiplier setting		0.025, 0.05... 1.6
t_d	Delay setting		0, 0.01... 20 s
t_{res}	Reset setting		ANSI DECAIVING, 0, 1... 60 s
I	Applied Current (for operate time)	IDMTL	2 to 20 $x I_s$
		DTL	5 $x I_s$

2.12.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_s , ± 4 % or ± 1 % I_n
	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 ($\geq 2 \times I_s$)		20 ms, ± 20 ms
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5 \% \text{ absolute or } \pm 30 \text{ ms,}$ for char = IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5 \% \text{ absolute or } \pm 30 \text{ ms,}$ 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	$t_d, \pm 1 \% \text{ or } \pm 20$ ms
Reset time	ANSI DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5 \% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
	t_{res}	$t_{res}, \pm 1 \% \text{ or } \pm 20$ ms
Repeatability		$\pm 1 \% \text{ or } \pm 20$ ms
Overshoot time		< 40 ms
Disengaging time		< 50 ms

Fig. 2.2 shows the operate times for the four IEC IDMTL curves with a time multiplier of 1.

Figs 2.3 and 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.

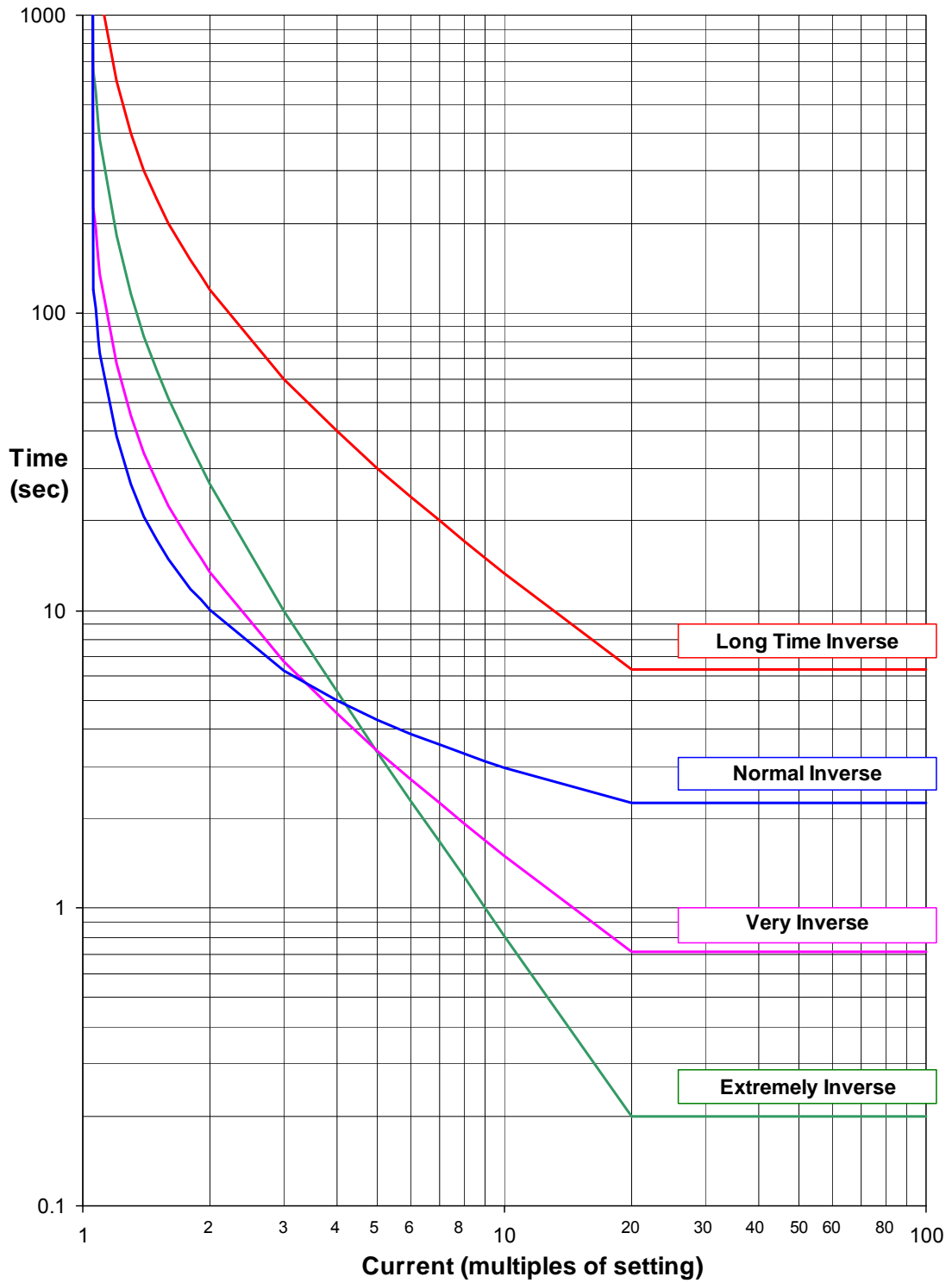


Figure 2-2 IEC IDMTL Curves (Time Multiplier = 1)

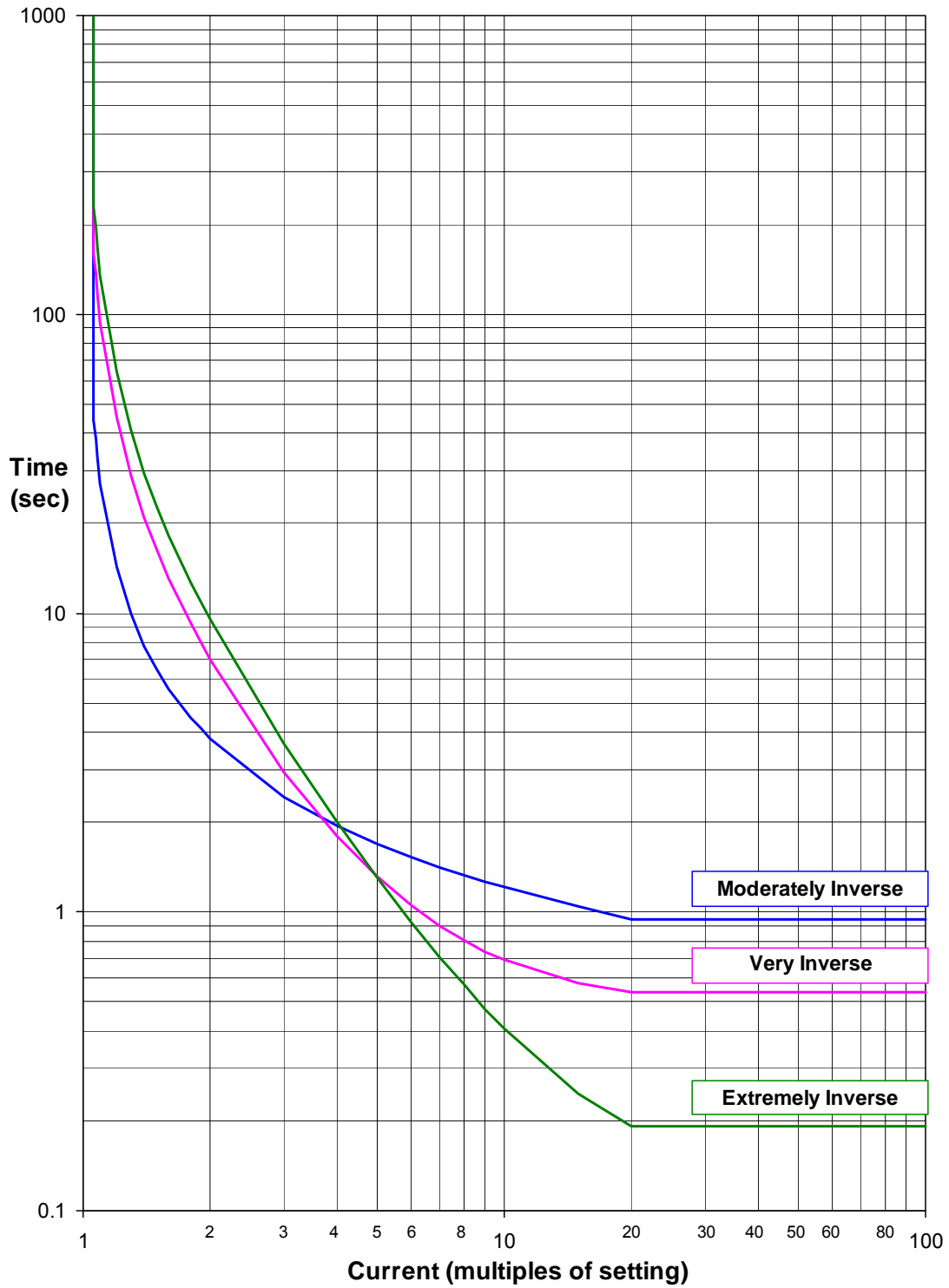


Figure 2-3 ANSI IDMTL Operate Curves (Time Multiplier = 1)

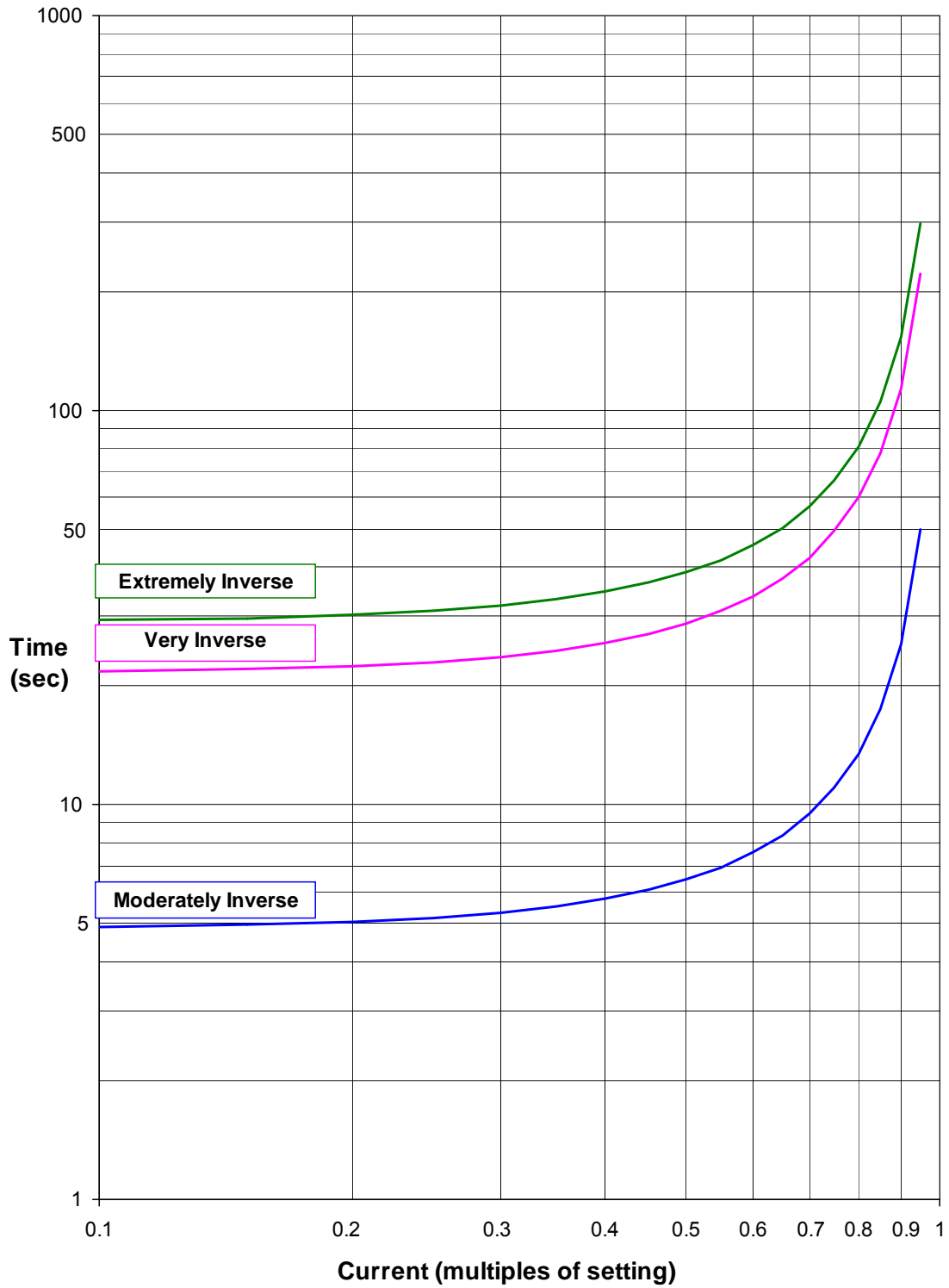


Figure 2-4 ANSI IDMTL Operate Curves (Time Multiplier = 1)

2.13 51G Time Delayed Measured Earth Fault

2.13.1 Reference

	Parameter	Value	
I_s	Setting	0.005, 0.006... 1.0 $\times I_n$	
$Char$	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL	
T_m	Time Multiplier setting	0.025, 0.05... 1.6	
t_d	Delay setting (DTL)	0, 0.01... 20 s	
t_{res}	Reset setting	ANSI DECAING, 0, 1... 60 s	
I	Applied current (for operate time)	IDMTL	2 to 20 $\times I_s$
		DTL	5 $\times I_s$

2.13.2 Operate and Reset Level

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

2.13.3 Operate and Reset Time

Attribute		Value
Starter operate time ($\geq 2 \times I_s$)		20 ms, ± 20 ms
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ 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	$t_d, \pm 1\% \text{ or } \pm 20 \text{ ms}$
Reset time	ANSI DECAIVING	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
	t_{res}	$t_{res}, \pm 1\% \text{ or } \pm 20 \text{ ms}$
Repeatability		$\pm 1\% \text{ or } \pm 20 \text{ ms}$
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.

Figures 2-3 and 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.

2.14 51N Time Delayed Derived Earth Fault

2.14.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06... 2.5 $x I_n$
$char$	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
T_m	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

2.14.2 Operate and Reset Level

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

2.14.3 Operate and Reset Time

Attribute		Value
Starter operate time ($\geq 2 \times I_s$)		20 ms, ± 20 ms
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ 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	$t_d, \pm 1\% \text{ or } \pm 20 \text{ ms}$
Reset time	ANSI DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
	t_{res}	$t_{res}, \pm 1\% \text{ or } \pm 20 \text{ ms}$
Repeatability		$\pm 1\% \text{ or } \pm 20 \text{ ms}$
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.

Figures 2-3 and 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.

2.15 51SEF Time Delayed Sensitive Earth Fault

2.15.1 Reference

	Parameter	Value	
I_s	Setting	0.005, 0.006...1 xIn	
$char$	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL	
T_m	Time multiplier	1.0	
t_d	Delay setting	0.00...20.00 s	
t_{res}	Reset setting	DECAYING, 0, 1...60 s	
I	Applied current (for operate time)	IDMTL	2 to 20 x/s
		DTL	5 x/s

2.15.2 Operate and Reset Level

	Attribute	Value	
I_{op}	Operate level	105 % I_s , ± 4 % or ± 1 % I_n	
	Reset level	≥ 95 % $I_{op} \pm 4$ % or ± 1 % I_n	
	Repeatability	± 1 %	
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz harmonics to f_{cutoff}	≤ 5 %

2.15.3 Operate and Reset Time

Attribute		Value
Starter operate time		20 ms, ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI $t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		char = ANSI-MI, ANSI-VI, ANSI-EI, $t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ 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	$t_d, \pm 1\%$ or $\pm t_{cycle}$
Reset time	char = ANSI and t_{res} = DECAYING $t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1	
	$t_{res} \neq$ DECAYING	$t_{res}, \pm 1\%$ or ± 20 ms
Repeatability		$\pm 1\%$ or ± 20 ms
Overshoot time		< 40 ms
Disengaging time		< 50 ms
Variation	$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz harmonics to f_{cutoff}	$\leq 5\%$

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

Figures 2-3 and 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.

2.16 51V Voltage Controlled Overcurrent (Ph-Ph)

2.16.1 Reference

	Parameter	Value
V_s	Setting	5, 5.5...199.5, 200 V
m	Multiplier	0.25, 0.3...0.95, 1
I_s	Setting	1 xIn

2.16.2 Operate and Reset Level

	Attribute	Value
V_{op}	Operate level	100 % V_s , $\pm 1\%$ or ± 0.25 V
	Reset level	$\leq 105\% V_{op}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz harmonics to f_{cutoff}
		$\leq 5\%$
		$\leq 5\%$

Operate and Reset Time

As per Phase Fault Shaped Characteristic Element (ANSI 51).

Where Pickup Level = I_s for Voltage > V_s

Pickup Level = ($I_s \times m$) for Voltage < V_s

2.17 59N Neutral Voltage Displacement

2.17.1 Reference (59NDT)

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

2.17.2 Operate and Reset Level (59NDT)

	Attribute	Value
V_{op}	Operate level	100 % V_s , $\pm 2\%$ or ± 0.5 V
	Reset level	$\geq 95\%$ V_{op} or ± 0.25 V
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz
		$\leq 5\%$
		$\leq 5\%$

2.17.3 Operate and Reset Time (59NDT)

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

2.17.4 Reference (59NIT)

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

2.17.5 Operate and Reset Level (59NIT)

	Attribute	Value
V_{op}	Operate level	105 % V_s , $\pm 2\%$ or $\pm 0.5\text{ V}$
	Reset level	$\geq 95\%$ V_{op} or $\pm 0.25\text{ V}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$

2.17.6 Operate and Reset Time (59NIT)

	Attribute	Value
t_{basic}	Starter operate time ($\geq 2 \times V_s$)	65 ms, $\pm 20\text{ ms}$
t_{op}	Operate time	char = IDMTL
		$t_{op} = \frac{M}{\left[\frac{3V_0}{V_s}\right] - 1}$, $\pm 5\%$ or $\pm 65\text{ ms}$
		char = DTL
		t_d , $\pm 1\%$ or $\pm 40\text{ ms}$
	Reset Time	char = IDMTL
		t_{res} , $\pm 5\%$ or $\pm 65\text{ ms}$
		char = DTL
		t_{res} , $\pm 1\%$ or $\pm 40\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 20\text{ ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.18 64H Restricted Earth Fault Protection

2.18.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.006... 0.95 xI_n
t_d	Delay setting	0.00, 0.01... 20.0, 20.1... 100.0, 101....1000, 1010 ... 10000 , 10100 ... 14400 s

2.18.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\% xI_n$
	Reset level	95 % I_{op} , $\pm 5\%$ or $\pm 0.1\% xI_n$
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.18.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 xI_s , 40 ms, $\pm 10\text{ ms}$
		0 to 5 xI_s , 30 ms, $\pm 10\text{ ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.19 67/67N Directional Overcurrent & Earth Fault

2.19.1 Reference

	Parameter	Value
θ_s	Angle setting	-95...+95 °
I	Applied current	I_n
V	Applied voltage	110 V phase-phase (63.5 V phase-earth)

2.19.2 Operate Angle

	Attribute	Value	
CA	Characteristic angle (I with respect to V)	$\theta_s, \pm 5^\circ$	
	Operating angle	forward	$CA - 85^\circ \pm 5^\circ$ to $CA + 85^\circ \pm 5^\circ$
		reverse	$(CA - 180^\circ) - 85^\circ \pm 5^\circ$ to $(CA - 180^\circ) + 85^\circ \pm 5^\circ$
	Variation in characteristic angle	10°C to +55°C	$\pm 5^\circ$
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz	$\pm 5^\circ$

2.19.3 Operate Threshold

	Attribute	Value	
	Minimum levels for operation	I (p/f)	$> 5\% I_n$
		I (e/f)	$> 10\% I_n$
		V (p/f)	> 1 V
		V (e/f)	> 1 V

2.19.4 Operate and Reset Time

	Attribute	Value
	Operate time	typically $32 < 40$ ms at characteristic angle
	Reset time	typically < 65 ms at characteristic angle

2.20 81 Under/Over Frequency

2.20.1 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

2.20.2 Operate and Reset Level

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

2.20.3 Operate and Reset Time

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

Section 3: Supervision Functions

3.1 46BC & 46BC U/C Broken Conductor

3.1.1 Reference

	Parameter	Value
	Setting (NPS to PPS ratio)	20...100 %
	U/C Guard setting	0.05, 0.1 ... 4.95, 5
t_f	Delay setting	0.02...1000 s

3.1.2 Operate and Reset Level

	Attribute	Value
I_{curr}	Operate level	100 % $I_{set} \pm 5 \%$
	Reset level	90 % $I_{curr} \pm 5 \%$
	Repeatability	$\pm 1 \%$
	Variation	- 10 °C to + 55 °C $\leq 5 \%$
		$f_{nom} - 3 \text{ Hz}$ to $f_{nom} + 2 \text{ Hz}$ harmonics to f_{cutoff} $\leq 5 \%$

3.1.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Basic operate time 1x In to 0 A	40 ms
	Operate time	$t_f + t_{basic} \pm 1 \%$ or $\pm 20 \text{ ms}$
	Repeatability	$\pm 1 \%$ or $\pm 20 \text{ ms}$
	Variation	$f_{nom} - 3 \text{ Hz}$ to $f_{nom} + 2 \text{ Hz}$ harmonics to f_{cutoff} $\leq 5 \%$

3.2 50BF & 50BF-I4 Circuit Breaker Fail

3.2.1 Reference

	Parameter	Value
I_s	50BF Setting	0.050, 0.055... 2.0 x I_n
I_s	50BF-I4 Setting	0.005, 0.01... 2.0 x I_n
t_{CBF1}	Stage 1 Delay setting	20, 25... 60000ms
t_{CBF2}	Stage 2 Delay setting	20, 25... 60000ms

3.2.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\% I_n$
I_{reset}	Reset level	$< 100\% I_{op}$, $\pm 5\%$ or $\pm 1\% I_n$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

3.2.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	$< 20\text{ ms}$
t_{op}	Stage 1	t_{CBF1} , $\pm 1\%$ or $\pm 20\text{ ms}$
	Stage 2	t_{CBF2} , $\pm 1\%$ or $\pm 20\text{ ms}$
	Repeatability	$\pm 1\%$ or $\pm 20\text{ ms}$
	Overshoot	$< 2 \times 20\text{ ms}$
	Disengaging time	$< 30\text{ ms}$

3.3 60CTS & CTS-I Current Transformer Supervision

3.3.1 Reference

	Parameter	Value
I_{thresh}	Current Threshold	0.05, 0.1... 1 x/n
V_{thresh}	Voltage Threshold	7, 8... 110V
t_d	Delay setting	0.03, 0.04...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s
$CTS-I$ I_{thresh}	Current Threshold	0.05, 0.1... 2 x/n

3.3.2 Current & Voltage Threshold

	Attribute	Value
I_{op}	CT failed current level	100 % I_{thresh} , $\pm 5\%$ or $\pm 1\%$ In
	Reset level	90 % I_{op} , $\pm 5\%$ or $\pm 1\%$ In
V_{op}	CT failed voltage level	100 % V_{thresh} , $\pm 2\%$ or ± 0.5 V
	Reset level	110 % V_{op} , $\pm 2\%$ or ± 0.5 V
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz harmonics to f_{cutoff}
		$\leq 5\%$
		$\leq 5\%$

3.3.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Basic operate time	30 ms \pm 20ms
	Operate time	t_{basic} , $\pm 1\%$ or ± 20 ms
	Repeatability	$\pm 1\%$ or ± 20 ms

3.4 60VTS Voltage Transformer Supervision

3.4.1 Reference

	Parameter	Value
V_{nps}	Vnps Level	7, 8 ... 110 V
I_{nps}	Inps Level	0.05, 0.1 ... 1 x In
I_{pps}	Ipps Load Level	0.05, 0.1 ... 1 x In
I_{Fpps}	Ipps Fault Level	0.05, 0.1 ... 20 x In
V_{pps}	Vpps Level	1, 2 ... 110 V
t_d	60VTS Delay	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

3.4.2 Operate and Reset Level

	Attribute	Value
V_{NPSop}	Voltage NPS operate level	100 % V_{nps} , $\pm 5\%$ V_n
	Voltage NPS reset level	90 % V_{NPSop} , $\pm 5\%$ V_n
V_{PPSop}	Voltage PPS operate level	100 % V_{pps} , $\pm 5\%$ V_n
	Voltage PPS reset level	110 % V_{PPSop} , $\pm 5\%$ V_n
I_{NPSblk}	Current NPS operate level	100 % I_{nps} , $\pm 5\%$ xI_n
	Current NPS reset level	90 % I_{NPSblk} , $\pm 5\%$ xI_n
I_{PPSblk}	Current PPS operate level	100 % I_{Fpps} , $\pm 5\%$ xI_n
	Current PPS reset level	90 % I_{PPSblk} , $\pm 5\%$ xI_n
$I_{PPSload}$	Current PPS operate level	100 % I_{pps} , $\pm 5\%$ xI_n
	Current PPS reset level	90 % $I_{PPSload}$, $\pm 5\%$ xI_n
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

3.4.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Basic operate time	0V to 2 x Vs	32 ms \pm 10 ms
	Operate time		t_{basic} , \pm 1 % or \pm 10 ms
	Repeatability		\pm 1 % or \pm 10 ms

3.5 74TCS Trip Circuit Supervision

3.5.1 Reference

	Parameter	Value
t_d	Delay setting	0, 0.02...60 s

3.5.2 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	25 ms \pm 20 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or ± 10 ms
	Repeatability	$\pm 1\%$ or ± 10 ms
	Variation	- 10 °C to + 55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz
		$\leq 5\%$
		$\leq 5\%$

3.6 81HBL2 Inrush Detector

3.6.1 Reference

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

3.6.2 Operate and Reset Level

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

3.6.3 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