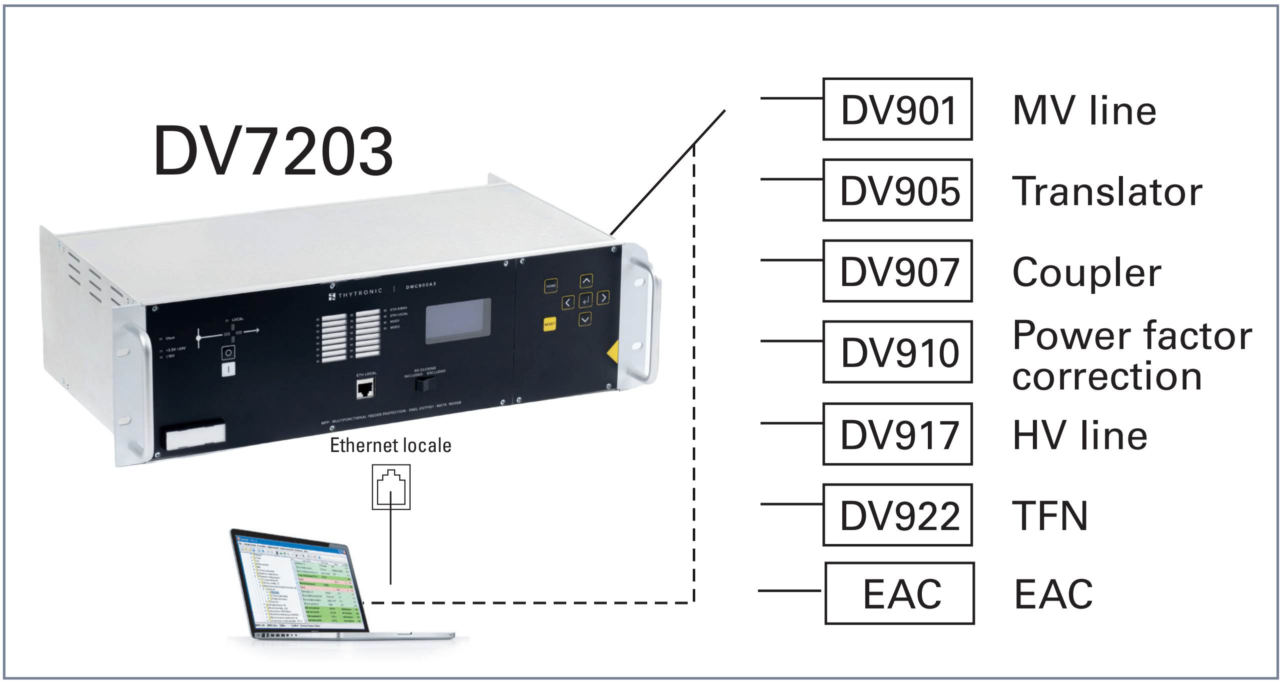
DMC3S

MULTIFUNCTIONAL PROTECTION
AND CONTROL PANEL FOR PRIMARY
SUBSTATIONS

MANUAL



SUMMARY

1 GENERAL INFORMATION

— Preface

Protection and control panels can be installed to the risers of the MV section and HV user line of primary substations supplied by ENEL Distribuzione S.p.A.
The devices can also be installed to MV nodes and primary substations operated with neutral to ground or very low neutral resistance in foreign countries in which ENEL has operations.
To supplement the protection functions, the system includes the following functions: breaker failure (BF), CT monitoring (74CT), VT monitoring (74VT), trip circuit monitoring (74TCS), Synchrocheck relay, EAC (Equilibratore Automatico di Carico) [ALB frequency (Automatic Load Balancer)] protection, programmable logic controller (PLC) and automatic reclosing (79).
The system can be calibrated, programmed and its logs and values read with a PC running the Thy-Setter software, or via Ethernet; all the above operations are also available via the front panel keypad (MMI).

2 DESCRIPTION

— Main Characteristics

- Three phase with definite 1A or 5A nominal current selectable via software.
- One residual current input with 1A or 5A nominal current selectable via software.
- Three phase with nominal voltage programmable in the range 50...130 V (U_R=100V) and one residual input with nominal voltage programmable in the range 50...130 V (U_{ER} = 100V).
- Backlight LCD graphic display.
- Multicolour indicator LED on the front panel, freely programmable.
- Logical inputs on input board (IN1-1...IN1-6), freely programmable.
- Logical inputs on input board (INC-1...INC-5).
- Output relays (KS1-1...KS1-6) independently programmable, for protection functions, self-test and control functions, and outputs with solid state relays.
- One rear port for communication with remote communications and control systems via Ethernet, running the IEC 61850 protocol.
- Two rear ports for communication with remote I/O modules via Ethernet, running the MODBUS TCP/IP® and IEC61850 protocols.
- One front panel Ethernet port, for local communications, running the MODBUS TCP/IP® protocol.
- Calendar clock with buffer.
- Nominal frequency 50 or 60 Hz, programmable via software.

The major operational characteristics are:
- Measurement of the effective value of the fundamental component of the currents and voltages using DFT (Discrete Fourier Transform).
- The directional current function employs a special operating criterion based on a voltage memory algorithm: this enables the relay to operate properly even in case of three-phase dead short when the line voltage goes almost to zero.
- Logging of recent malfunctions (SFR) and events (SER).
- Logging of oscilloscope readings (DFR) in the COMTRADE format.
- All settings and logged data (faults, events, couinters, oscilloscope) are saved to non-volatile memory and are thus available even in case of auxiliary voltage failure
- Option to update the firmware.

— Protection Functions

- 27CC(80.s) Direct undervoltage
- 32P Directional active overpower
- 46 Negative sequence overcurrent
- 50/51 Phase overcurrent
- 50N/51N Residual overcurrent
- 51N(E) Neutral overcurrent
- 51N(Eme) Residual emergency overcurrent
- 51(SQL) Neutral unbalance overcurrent
- 59 Overvoltage
- 59N Residual overvoltage
- 59N(Eme) Residual emergency overvoltage
- 67 Phase directional overcurrent
- 67N Ground directional overcurrent

— Control Functions

- 25 Synchrocheck relay
- 79 Automatic reclosing
- 74CT Phase CT monitoring
- 74VT Line VT monitoring

3 TECHNICAL CHARACTERISTICS

3.1 GENERAL INFORMATION

— Mechanical characteristics

Installation	Rack 19" 3U
Dimensions (H x W x D)	133 x 483 x 344
Terminals	Screw clamps
Maximum wire cross section	4 mm^2
Weight	4.7 kg

— Electromagnetic compatibility (EMC)

Standard	EN 61000-6-2
Part 6-2: Generic standards - Immunity for industrial environments	
Standard	EN 61000-6-4
Part 6-4: Generic standards - Emissions for industrial environments	
Standard	EN 61000-4-2, EN 61000-4-2/A1, EN 61000-4-2/A2
Electrostatic discharge immunity test	
Standard	EN 61000-4-3
Radiofrequency electromagnetic field immunity test	
Standard	EN 61000-4-4
Electrical fast transient immunity test	
Standard	EN 61000-4-5
Pulse immunity test	
Standard	EN 61000-4-6, EN 61000-4-6/A1
Immunity to conducted disturbances induced by radiofrequency fields	
Standard	EN 61000-4-8, EN 61000-4-8/A1
mains frequency magnetic field immunity test	
Standard	EN 61000-4-10, EN 61000-4-10/A1
Damped oscillatory magnetic field immunity test	
Standard	EN 61000-4-11
Immunity test for voltage dips, brief interruptions and voltage variations	
Standard	EN 61000-4-12
Oscillatory wave immunity test	
Standard	EN 61000-4-16, EN 61000-4-16/A1
Immunity test for conducted common mode disturbances in the frequency range 0 to 150 kHz	
Standard	EN 61000-4-29
Immunity test for voltage dips, brief interruptions and voltage variations on DC power ports	
Standard	EN 55011, 55011/A1, 55011/A2
Industrial, scientific and medical radiofrequency equipment (ISM) - Radiodisturbance characteristics - Limits and measurement methods	
Standard	EN 50160
Characteristics of public electrical power grid voltage	

— Disturbance immunity tests

Enclosure door

Standard	IEC 61000-4-2 EN 60255-22-2
Electrostatic discharge (Level 4)	
• Contact discharge	8 kV
• Air discharge	15 kV
Standard	IEC 61000-4-3 EN 61000-4-3
Radiofrequency electromagnetic fields (Level 3)	
• 80...3000 MHz AM 80%	10 V/m
• 900...1980 MHz MHz Pulse modulated	10 V/m
Standard	IEC 61000-4-8 EN 61000-4-8
Magnetic field 50 Hz (Level 5)	
• 50 Hz continuous	100 A/m
• 50 Hz 1 s	1 kA/m
Standard	IEC 61000-4-10 EN 61000-4-10
Damped oscillatory wave (Level 5)	
• Damped oscillatory wave 0.1 MHz	100 A/m
• Damped oscillatory wave 1 MHz	100 A/m

Ground port

Standard	IEC61000-4-4 EN 60255-22-4
Fast transients 5/50 ns (Level 4)	
• Fast transients	4 kV
Standard	IEC 61000-4-6 EN 61000-4-6
Conducted electromagnetic fields (Level 3)	
• 0.15...80 MHz AM 80% 1kHz	10 V

Signal port

Standard	IEC61000-4-4 EN 61000-4-4
Fast transients 5/50 ns (Level 4)	
Fast transients	2 kV
Standard	IEC 61000-4-6
Conducted electromagnetic fields (Level 3)	
• 0.15...80 MHz AM 80% 1kHz	10 V
Standard	EC 61000-4-18 EN 60255-22-1
Damped oscillatory wave (Level 3)	
• 0.1 MHz and 1 MHz common mode	2.5 kV
• 0.1 MHz and 1 MHz differential mode	1.0 kV
Standard	EC 61000-4-12 EN 60255-22-1
Damped oscillatory wave (Level 3)	
• Ring wave common mode	2.0 kV
• Ring wave differential mode	1.0 kV
Standard	IEC 61000-4-16
Mains frequency voltages (Level 3-4)	
• $16^{2/3}$ continuous	100 V
• $16^{2/3}$ 1s	300 V
• 50 Hz continuous	100 V
• 50 Hz 1 s	300 V
• 0.015...150 kHz	10-1-1-10 V

DC power input and output port

Standard	IEC61000-4-4 EN 60255-22-4
Fast transients 5/50 ns (Level 4)	
Fast transients	2 kV, 4kV
Standards	
Standard	IEC 61000-4-5
High energy pulses (Level 4)	
• U_{aux} (line-ground)	4 kV
• U_{aux} (line-line)	2 kV
Standard	IEC 61000-4-6 EN 61000-4-6
Conducted electromagnetic fields (Level 3)	
• 0.15...80 MHz AM 80% 1kHz	10 V
Standard	EC 61000-4-12 EN 60255-22-1
Damped oscillatory wave (Level 3)	
• 0.1 MHz common mode	2.0 kV
• 0.1 MHz differential mode	1.0 kV
Standard	IEC 61000-4-16
Mains frequency voltages (Level 3-4)	
• $16^{2/3}$ continuous	100 V
• $16^{2/3}$ 1s	300 V
• 50 Hz continuous	100 V
• 50 Hz 1 s	300 V
• 0.015...150 kHz	10-1-1-10 V
Standard	IEC 61000-4-17
Ripple on DC auxiliary power circuit	
DC auxiliary power supply	
• Variation	10%
Standard	IEC 61000-4-29
Voltage dips, short interruptions and voltage variations on DC input power port immunity tests	
• Voltage dip duration with UT=40%	100 ms
• Short interruption duration with UT=0%	50 ms
• Voltage variation duration with Un=80...120%	10 s

— Climate tests

Standard	IEN 60068-2-1
Environmental tests: Part 2-1: Tests - Test A: Cold	
Standard	IEN 60068-2-2
Environmental tests: Part 2-2: Tests - Test B: Dry heat	
Standard	IEN 60068-2-14
Environmental tests: Part 2: Tests - Test N: Temperature change	
Standard	IEN 60068-2-33
Environmental tests: Part 2: Tests - Temperature change test guidelines	
Standard	IEN 60068-2-78
Environmental tests: Test Cab: Damp heat, stationary regime	
Standard	IEN 60068-3-1
Environmental tests: Part 3: Basic information. Section 1: Cold and dry heat tests	
Standard	IEN 60068-3-4

Environmental tests: Part 3-4: Supporting documentation and guidelines. Damp heat tests

— Mechanical tests

Standard EN 60255-21-1 EN 60255-21-2 RMEC01
Vibration, impact, shock and seismic resistance tests for measurement relays and protection equipment
• EN 60255-21-1 Vibration tests (sinusoidal) Class 1
• EN 60255-21-2 Impact and shock tests Class 1

— Insulation test

Standard EN 60255-5
Coordination of the isolation of measurement relays and protection equipment
Test at 50Hz (1 min):
• Auxiliary circuit 2 kV
• Input circuits 2 kV
• Output circuits 2 kV
• Output circuits (between open contacts) 1 kV
• Communication ports 1 kV
Isolation resistance >100 MΩ

Standard EN 60255-5
Pulse resistance voltage test
Pulse test (1.2/50 µs):
• Auxiliary circuit 5 kV
• Input circuits 5 kV
• Output circuits 5 kV
• Output circuits (between open contacts) 5 kV

Standard EN 61010-1
Insulation test for electrical measurement, control and laboratory equipment
Pollution degree 3
Reference voltage 250 V
Reference category IV

Standard EN 60204-1
Safety of machinery - Electrical equipment of machines. Part 1: General rules

— Reference specifications

Structural and functional requisites for the Multifunctional Protection and Control Panel for Primary Substations (DV7203) ENEL DMI 9 00016

Protection and control device for HV/MV substation – Multifunctional feeder protection (MFP) GSTP101_01

Protection and control device for HV/MV substation – Communication profile (according to IEC 61850) for the MFP GSTP103_01

Cyber security requirements for protection and control devices GSTP901_01

Electrical Diagrams for Protection and control device for HV / MV substation – Multifunctional Feeder Protection MFP GSTX101_01

— ENEL general standards and tables

Standard IEC61850-x
Communications networks and system for automation of electrical systems
Standard IEE 802.x
Standards relating to the Ethernet port
ENEL unification table DV25
Spring loaded clamps
ENEL unification table DV29
Terminals
ENEL unification table DV1000 rev .01
Data communications, electrical and functional characteristics
ENEL unification table DV801A
Connectors (34 pole)

— Certifications

CE conformity
• EMC Directive 2014/30/EC
• Low Voltage Directive 2014/35/EC

— Environmental Condition

Ambient temperature -10...+55 °C
Storage temperature -20...+70 °C
Relative humidity ≤95 %
Atmospheric pressure 860...1060 kPa

3.2 INPUT CIRCUITS

— Auxiliary circuit power U_{aux}

Voltage	
• Nominal value (range)	110 V-
• Operating range	77...143 V- (± 30%)
• Maximum inrush current	10 A, 10 ms
• Ripple	10%
• Max power draw (3 relays excited and MMI active)	10 W
• Overload (1 s)	2 V_n
• Insensitivity to micro-interruptions Vaux 0V	50 ms
• Cooling	Natural ventilation

— Amperometric phase inputs

Nominal phase current of relay I_n	1A or 5A, set by softwarePermanent
overload	25 A
Thermal overload (1s)	250 A
Dynamic overload (0.01s)	800 A
Power draw (per phase)	≤ 0.003 VA with I_n=1 A
Power draw (per phase)	≤ 0.07 VA with I_n=5 A

— Residual current amperometric inlet

Nominal residual current of relay I_{En}	1A or 5A, set by softwarePermanent
overload	25 A
Thermal overload (1 s)	500 A
Dynamic overload (0.01 s)	800 A
Power draw	≤ 0.003 VA with I_{En}=1 A
	≤ 0.07 VA with I_{En}=5 A

— Voltmetric inputs

Nominal phase-to-phase voltage of relay U_n	50...130 V (U_R = 100 V)
Nominal phase voltage of relay $E_n = U_n / \sqrt{3}$	-
Permanent overload	1.3 U_n
Thermal overload (1 s)	2 U_n
Power draw (per phase with U_R = 100 V)	≤ 0.2 VA

— Residual voltage / Vsync voltage voltmetric input

Nominal residual voltage of relay U_{En}	50...130 V (U_{ER} = 100 V)
Permanent overload	1.3 U_{En}
Thermal overload (1 s)	2 U_{En}
Power draw (U_{ER} = 100 V)	≤ 0.2 VA

— Digital inputs

Number of inputs:	
• Input board (IN1-1...IN1-6)	6
• Control board (INC1...INC-5)	5
• External module DMRIS01 (DMRIS01-1, DMRIS01-12)	12
• External module DMRIS02 (DMRIS02-1, DMRIS02-12)	12
Type of circuit	optocoupler
Operational range	as Uaux
Minimum activation voltage	82.5 V
Reset voltage	66 V
Maximum current draw with excited input	3 mA
Timers associated with the logical inputs	
• Acquisition delay OFF/ON (IN1-1 t_{ON}, INx-x t_{ON})	0.00...100.0 s
• Acquisition delay ON/OFF (IN1-1 t_{OFF}, INx-x t_{OFF})	0.00...100.0 s
Logic	POSITIVE/NEGATIVE

3.3 OUTPUT CIRCUITS

— Final electromechanical relays

Number	6
Type of contact (KS1-1...KS1-6)	closing (SPST-NO, type A)
Nominal current	5 A
Nominal voltage / maximum switchable voltage	250 V~/400 V~
Closing power (MAKE)	1000 W/VA
Minimum switchable load	300 mW (5 V/ 5 mA)
Mechanical service life	10^6
Electrical service life	10^5
Interrupting capacity:	
• DC (L/R = 40 ms)	0.2 A
• AC (λ = 0.4)	1250 VA
Minimum pulse duration	0....500 ms (step 5 ms)

— Final solid state relays

Number	4
Contact type:	
• 52CH, 52AP, Trip MV	closing (SPST-NO, type A)
• 80S NC	closing (SPST-NC, type B)
• 80S NO	closing (SPST-NC, type A)
Nominal current	10 A
Nominal voltage	110 V-
Interrupting capacity, DC (L/R = 40 ms)	4 A

3.4 MMI

Display	Backlight LCD graphic 128x64 px
LEDs	
Number	20
• Ethernet, 61850 (green)	1
• Ethernet, local (green)	1
• Ethernet, remote module 1 (green)	1
• Ethernet, remote module 2 (green)	1
• Programmable (red-green-yellow)	16
Breaker position cross indicator	LED
Keypad	7 buttons
Breaker control buttons	AP - CH
Reclosing selector	Rocker switch

3.5 COMMUNICATIONS CIRCUITS

— Local port

Ethernet	10/100 Base TX
• Protocol	ModBus®TCP/IP
• Connection	RJ45

— Connection 61850

Ethernet	100 Base FX
• Connection	LC - Fibre optic 1300 nm
• Protocol	ModBus®TCP/IP, IEC51850

— Remote module connection

Number	2
Ethernet	100 Base FX
• Connection	LC - Fibre optic 1300 nm
• Protocol	ModBus®TCP/IP, IEC61850

3.6 PROTECTION AND CONTROL FUNCTIONS

Protection Functions	Thresholds	Operating time	Shrink time trip
27CC (80.S)	UCC<	DEFINITE	NO
32P	P1>	DEFINITE	NO
	P2>	DEFINITE	NO
46	I2>	DEFINITE/INVERSE	YES
	I2>>	DEFINITE/INVERSE	YES
50/51	I>	DEFINITE/INVERSE	YES
	I>>	DEFINITE/INVERSE	YES
	I>>>	DEFINITE	YES
	I>>>>	DEFINITE/INVERSE	YES
50N/51N	IE>	DEFINITE/INVERSE	YES
	IE>>	DEFINITE	YES
	IE>>>	DEFINITE	YES
51N(E)	INe>	DEFINITE/INVERSE	YES
	INe>>	DEFINITE	YES
51N(Eme)	IEeme>	DEFINITE/INVERSE	YES
51(SQL)	ISQL>	DEFINITE/INVERSE	YES
59	U>	DEFINITE/INVERSE	NO
	U>>	DEFINITE	NO
59N	UE>	DEFINITE/INVERSE	NO
	UE>>	DEFINITE	NO
59N(Eme)	UEeme>	DEFINITE/INVERSE	NO
67	IPD>	DEFINITE/INVERSE	YES
	IPD>>	DEFINITE/INVERSE	YES
	IPD>>>	DEFINITE	YES
	IPD>>>>	DEFINITE/INVERSE	YES
67N	IED>	DEFINITE/INVERSE	YES
	IED>>a	DEFINITE/INVERSE	YES
	IED>>b	DEFINITE	YES
	IED>>>	DEFINITE	YES
	67N.Sb	DEFINITE	YES
	IED>>>>	DEFINITE	NO
	IED>>>>>	DEFINITE	NO
Control Functions			
25			
79	RR		
	RR+L		
	RM1		
	RM2		
	RM3		
74VT			
74CT			
FSL	FSL1	Logical selectivity	
	FSL2	Logical selectivity	

3.6 NOMINAL VALUES

Clamp voltage value UE or V2	U_E or V_2
Phase correction V1-V2	0...360 °
Voltage value for synchrocheck V1	$U_{L1}/U_{L2}/U_{L3}$
Nominal relay frequency (f_n)	50, 60 Hz
Nominal phase current I_{L1}, I_{L2}, I_{L3} of relay (I_n)	1 A or 5 A
Nominal phase current I_{SQL}- I_{Ne}, I_{L3} of relay - I_n	1 A or 5 A
Primary CT nominal current of phase - I_{np}	1 A...10 kA
	1...499 A (step 1 A)
	500...4990 A (step 10 A)
	5000...10000 A (step 100 A)
Nominal residual current of relay - I_{En}	1 A or 5 A
Primary CT residual nominal current - I_{np}	1 A...10 kA
	1...499 A (step 1 A)
	500...4990 A (step 10 A)
	5000...10000 A (step 100 A)
Nominal phase-to-phase voltage of relay - U_n	50...130 V (step 1 V)
Nominal phase-to-phase voltage of relay V2 - U_{n2}	50...130 V (step 1 V)
Nominal phase voltage of relay - E_n	$E_n = U_n / \sqrt{3}$
Nominal residual voltage of relay with direct measurement - U_{En}	50...130 V (step 1 V)
Nominal residual voltage of relay with calculated residual voltage - U_{ECN}	$U_{ECN} = U_n \cdot \sqrt{3} = E_n \cdot 3$
Nominal active power of relay - $P_n = \sqrt{3} \cdot U_n \cdot I_n = 3 \cdot E_n \cdot I_n$	-
Nominal reactive power of relay - $Q_n = \sqrt{3} \cdot U_n \cdot I_n = 3 \cdot E_n \cdot I_n$	-
Nominal apparent power of relay - $S_n = \sqrt{3} \cdot U_n \cdot I_n = 3 \cdot E_n \cdot I_n$	-
Nominal primary phase-to-phase VT line voltage - U_{np}	50 V...500 kV
	50...499 V (step 1 V)
	500...4990 V (step 10 V)
	5000...49900 V (step 100 V)
	50000...500000 V (step 1000 V)
Nominal primary phase-to-phase VT residual voltage $\cdot\sqrt{3}$ - U_{Enp}	50 V...500 kV
	50...499 V (step 1 V)
	500...4990 V (step 10 V)
	5000...49900 V (step 100 V)
	50000...500000 V (step 1000 V)
Nominal primary phase-to-phase V2 side VT voltage - U_{n2p}	50 V...500 kV
	50...499 V (step 1 V)
	500...4990 V (step 10 V)
	5000...49900 V (step 100 V)
	50000...500000 V (step 1000 V)

3.7 PROTECTION FUNCTIONS

— Direct undervoltage - 27CC (80.s)

Threshold U_{CC}<

Definite time

First definite time threshold (U_{cc}<$_{def}$)	0.60...1.00 U_{ncc} (step 0.01 U_{ncc})
Operating time ($t_{Ucc<def}$)	0.00...10.00 s (step 0.01 s)

— Maximum directional active power 32P

Threshold P1>

Parameters

Tripping direction (P_1>$_{DIR}$)	P Forward/P Reverse/P Forward/Reverse
Reset delay ($t_{P1>RES}$)	0.00...100.0 s
	0.00...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)

Definite time

First definite time threshold ($P1$>$_{def}$)	0.80...1.20 P_n (step 0.01 P_n)
Operating time ($t_{P1>def}$)	0.05...1000 s
	0.05...99.9 s (step 0.01 s)
	10.0...99.9 s (step 0.1 s)
	100...1000 s (step 1 s)
Back-up time ($t_{rP1>def}$)	0.05...0.50 s (step 0.01 s)

Threshold P2>

Parameters

Tripping direction (P_2>$_{DIR}$)	P Forward/P Reverse/P Forward/Reverse
Reset delay ($t_{P2>RES}$)	0.00...100.0 s
	0.00...9.99 s (step 0.01 s)
	10.0...99.9 s (step 0.1 s)

Definite time

Second definite time threshold ($P2$>$_{def}$)	0.80...1.20 P_n (step 0.01 P_n)
Operating time ($t_{P2>>def}$)	0.05...1000 s
	0.05...99.9 s (step 0.01 s)
	10.0...99.9 s (step 0.1 s)
	100...1000 s (step 1 s)
Back-up time ($t_{rP2>def}$)	0.05...0.50 s (step 0.01 s)

— Negative sequence overcurrent - 46

Threshold I_2>

	Type of characteristic I_2> (I_{2}>$_{Curve}$)	DEFINITE, IEC/BS A, B, B-LI, C,
	Reset delay (t_2>$_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	First definite time threshold (I_2>$_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Operating time (t_2>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink time trip (t_{cI2}>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time (tt_{atcI2}>$_{def}$)	1...60 s (step 1 s)
Inverse time [1]		
	First inverse time threshold (I_2>$_{inv}$)	0.050...20.0 I_n 0.050...0.999 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
	Operating time (t_2>$_{inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

Threshold I_2>>

	Reset delay (t_2>>$_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	Second definite time threshold (I_2>>$_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Operating time (t_2>>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink time trip (t_{cI2}>>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time (t_{atcI2}>>$_{def}$)	1...60 s (step 1 s)
Inverse time		
	Second inverse time threshold (I_2>$_{inv}$)	0.050...20.0 I_n 0.050...0.999 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
	Operating time (t_2>$_{inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

Note 1 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_2\text{>}_{inv} / [(I_2/I_2\text{>}_{inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_2\text{>}_{inv} / [(I_2/I_2\text{>}_{inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_2\text{>}_{inv} / [(I_2/I_2\text{>}_{inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_2\text{>}_{inv} / [(I_2/I_2\text{>}_{inv})^2 - 1]$
t: *operating time*
t_2>$_{inv}$: *operating time regulation*
I_2>$_{inv}$: *trip threshold regulation*
I_2: *measured current*
Asymptotic reference value: 1.1 I_2>$_{inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \le I_2/I_2\text{>}_{inv} \le 20$
With regulation I_2>$_{inv}$ greater than 2.5 I_n*, the upper limit of the measurement range is* 30 I_n

— Overcurrent - 50/51

Threshold I>

	Type of characteristic $I>$ ($I>_{Curve}$)	DEFINITE, IEC/BS A, B, B-LI, C
	Reset delay $I>$ ($t>_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	First definite time threshold ($I>_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Operating time ($t>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink time trip ($t_{cl}>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time ($t_{atcl}>_{def}$)	1...60 s (step 1 s)
Inverse time[1]		
	First inverse time threshold ($I>_{inv}$)	0.050...20.00 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
	Operating time ($t>_{inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

Threshold I>>

	Type of characteristic ($I>>_{Curve}$)	DEFINITE, IEC/BS A, B, B-LI, C
	Reset delay ($t>>_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	Second definite time threshold ($I>>_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Operating time ($t>>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink time trip ($t_{cl}>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time ($t_{atcl}>_{def}$)	1...60 s (step 1 s)
Inverse time		
	Second inverse time threshold ($I>_{inv}$)	0.050...20.00 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
	Operating time ($t>>_{inv}$)	0.02...10.00 s (step 0.01 s)

Threshold I>>>

	Reset delay $I>>>$ ($t>>>_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	Third definite time threshold ($I>>>_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)

Note 1

Inverse time curve IEC 255-3/BS142 (type A or SIT): $t = 0.14 \cdot t>_{inv} / [(I/I>_{inv})^{0.02} - 1]$

Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t>_{inv} / [(I/I>_{inv}) - 1]$

Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t>_{inv} / [(I/I>_{inv}) - 1]$

Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t>_{inv} / [(I/I>_{inv})^2 - 1]$

t: *operating time, minimum operating time:* 0.1 s

$t>_{inv}$: *operating time regulation*

$I>_{inv}$: *trip threshold regulation*

I: *measured current*

Asymptotic reference value: 1.1 $I>_{inv}$

Dynamic: $1.1 \le I/I>_{inv} \le 20$, *with regulation* $I>_{inv}$ *greater than* 2.5 I_n, *the upper limit of the measurement range is* 30 I_n

	Operating time ($t>>>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink time trip ($t_{cI}>>>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time ($t_{atcI}>>>_{def}$)	1...60 s (step 1 s)
Threshold I>>>>		
	Type of characteristic ($I>>>>_{Curve}$)	DEFINITE, IEC/BS A, B, B-LI, C
	Reset delay ($t>>>>_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	Second definite time threshold ($I>>>>_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Operating time ($t>>>>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink time trip ($t_{cI}>>>>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time ($t_{atcI}>>>>_{def}$)	1...60 s (step 1 s)
Inverse time		
	Second inverse time threshold ($I>>>>_{inv}$)	0.050...20.00 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
	Operating time ($t>>>>_{inv}$)	0.02...10.00 s (step 0.01 s)

— Residual overcurrent - 50N/51N

Threshold IE>		
	Type of characteristic ($I_{E>Curve}$)	DEFINITE, IEC/BS A, B, B-LI, C
	Reset delay ($t_{E>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	First definite time threshold ($I_{E>def}$)	0.005...25.0 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...9.99 I_{En} (step 0.01 I_{En}) 10.0...25.0 I_{En} (step 0.1 I_{En}
	Operating time ($t_{E>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink time trip ($t_{cIE>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time ($t_{atcIE>def}$)	1...60 s (step 1 s)
Inverse time[1]		
	First inverse time threshold ($I_{E>inv}$)	0.005...2.00 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...2.00 I_{En} (step 0.01 I_{En})
	Operating time ($t_{E>inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

Note1 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_{E>inv} / [(I_E/I_{E>inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_{E>inv} / [(I_E/I_{E>inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_{E>inv} / [(I_E/I_{E>inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{E>inv} / [(I_E/I_{E>inv})^2 - 1]$
t: *operating time*
$t_{E>inv}$: *operating time regulation*
$I_{E>inv}$: *trip threshold regulation*
I_E: *measured residual current*
Asymptotic reference value: 1.1 $I_{E>inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \le I_E/I_{E>inv} \le 20$ *With regulation* $I_{E>inv}$ *greater than* 0.5 I_{En}, *the upper limit of the measurement range is* 10 I_{En}

Threshold IE>>

Reset delay ($t_{E>>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time	
Second definite time threshold ($I_{E>>def}$)	0.005...25.0 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...9.99 I_{En} (step 0.01 I_{En}) 10.0...25.0 I_{En} (step 0.1 I_{En}
Operating time ($t_{E>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink time trip ($t_{cIE>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink activation time ($t_{atcIE>>def}$)	1...60 s (step 1 s)

Threshold IE>>>

Reset delay ($t_{E>>>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time	
Third definite time threshold ($I_{E>>>def}$)	0.005...25.0 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...9.99 I_{En} (step 0.01 I_{En}) 10.0...25.0 I_{En} (step 0.1 I_{En}
Operating time ($t_{E>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink time trip ($t_{cIE>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink activation time ($t_{atcIE>>def}$)	1...60 s (step 1 s)

— Neutral overcurrent - 51N(E)

Threshold INe>

Type of characteristic ($I_{Ne>Curve}$)	DEFINITE, IEC/BS A, B, B-LI, C
Reset delay ($t_{Ne>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time	
First definite time threshold ($I_{Ne>def}$)	0.005...25.0 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...9.99 I_{En} (step 0.01 I_{En}) 10.0...25.0 I_{En} (step 0.1 I_{En}
Operating time ($t_{Ne>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink time trip ($t_{cINe>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink activation time ($t_{atcINe>>def}$)	1...60 s (step 1 s)
Inverse time[1]	
First inverse time threshold ($I_{Ne>inv}$)	0.005...2.00 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...2.00 I_{En} (step 0.01 I_{En})

Note1 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_{Ne>inv} / [(I_{Ne}/I_{Ne>inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_{Ne>inv} / [(I_{Ne}/I_{Ne>inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_{Ne>inv} / [(I_{Ne}/I_{Ne>inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{Ne>inv} / [(I_{Ne}/I_{Ne>inv})^2 - 1]$
t: *operating time*
$t_{Ne>inv}$: *operating time regulation*
$I_{Ne>inv}$: *trip threshold regulation*
I_{Ne}: *measured residual current*
Asymptotic reference value: 1.1 $I_{ENe>inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \le I_{Ne}/I_{Ne>inv} \le 20$;
With regulation $I_{Ne>inv}$ *greater than* 0.5 I_{En}, *the upper limit of the measurement range is* 10 I_{En}

Operating time ($t_{Ne>inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)
Threshold INe>>	
Reset delay ($t_{Ne>>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time	
Second definite time threshold ($I_{Ne>>def}$)	0.005...25.0 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...9.99 I_{En} (step 0.01 I_{En}) 10.0...25.0 I_{En} (step 0.1 I_{En}
Operating time ($t_{E>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink time trip ($t_{cNe>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink activation time ($t_{atcINe>>def}$)	1...60 s (step 1 s)

— Residual emergency overcurrent - 51N(Eme)

Threshold INe>	
Type of characteristic ($I_{Eeme>Curve}$)	DEFINITE, IEC/BS A, B, B-LI, C
Reset delay ($t_{Eeme>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time	
First definite time threshold ($I_{Eeme>def}$)	0.005...25.0 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...9.99 I_{En} (step 0.01 I_{En}) 10.0...25.0 I_{En} (step 0.1 I_{En}
Operating time ($t_{Eeme>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink time trip ($t_{cIEeme>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink activation time ($t_{atcIEeme>def}$)	1...60 s (step 1 s)
Inverse time[1]	
First inverse time threshold ($I_{Eeme>inv}$)	0.005...2.00 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...2.00 I_{En} (step 0.01 I_{En})
Operating time ($t_{Eeme>inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

Note1 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv})^2 - 1]$
t: *operating time*
$t_{Eeme>inv}$: *operating time regulation*
$I_{Eeme>inv}$: *trip threshold regulation*
I_E: *measured residual current*
Asymptotic reference value: 1.1 $I_{Eeme>inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \leq I_E/I_{Eeme>inv} \leq 20$
With regulation $I_{Eeme>inv}$ *greater than* 0.5 I_{En}*, the upper limit of the measurement range is* 10 I_{En}

— Neutral current unbalance - 51(SQL)

Threshold I_{SQL}>

		Type of characteristic (I_{SQL}>Curve)	DEFINITE, IEC/BS A, B, B-LI, C
		Reset delay I> ($t_{>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
	Definite time		
		First definite time threshold ($I_{SQL>def}$)	0.005...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
		Operating time ($t_{SQL>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
		Shrink time trip ($t_{cISQL>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
		Shrink activation time ($t_{atcISQL>def}$)	1...60 s (step 1 s)
	Inverse time[1]		
		First inverse time threshold ($I_{SQL>inv}$)	0.005...2.00 I_n 0.005...0.995 I_n (step 0.005 I_n) 1.00...2.00 I_n (step 0.01 I_n)
		Operating time ($t_{SQL>inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

— Overvoltage - 59

Common configurations:

		Type of voltage measurement for 59 - phase-to-phase/phase (Utype59)[2]	U_{ph-ph}/U_{ph-n}
		Operating logic 59 (*Logic*59)	AND/OR
Threshold U>			
		Type of characteristic U> ($U_{>Curve}$)	DEFINITE/INVERSE
	Definite time		
		First 59 definite time threshold ($U_{>def}$)	0.500...1.500 U_n (step 0.001 U_n)
		Operating time $U_{>def}$ ($t_{U>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Inverse time[3]		
		First 59 inverse time threshold ($U_{>inv}$)	0.500...1.500 U_n (step 0.001 U_n)
		Operating time ($t_{U>inv}$)	0.10...100.0 s 0.10...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Threshold U>>			
	Definite time		
		Second definite time threshold ($U_{>>def}$)	0.500...1.500 U_n (step 0.001 U_n)
		Operating time ($t_{U>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)

Note 2

Inverse time curve IEC 255-3/BS142 (type A or SIT):	$t = 0.14 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT):	$t = 13.5 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI):	$t = 120 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT):	$t = 80 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv})^2 - 1]$

t: operating time, minimum operating time: 0.1 s
$t_{SQL>inv}$: *operating time regulation*
$I_{SQL>inv}$: *trip threshold regulation*
I_{SQL}: *measured current*
Asymptotic reference value: 1.1 $I_{SQL>inv}$
Dynamic: $1.1 \le I_{SQL}/I_{SQL>inv} \le 20$, *with regulation* $I_{SQL>inv}$ *greater than* 2.5 I_{SQLn}, *the upper limit of the measurement range is* 30 I_{SQLn}

Note 2 With U_{ph-ph} set on the MMI, all thresholds are expressed in p.u. U_n, With U_{ph-n} set on the MMI, all thresholds are expressed in p.u. E_n

Note 3 The general formula for inverse time curves is: $t = (0.5 \cdot t_{U>inv}) / [(U/U_{>inv}) - 1]$
t = operating time (in seconds)
$t_{U>inv}$ *= operating time regulation (in seconds), U = measured voltage*
$U_{>inv}$ *= trip threshold regulation*

— Residual overvoltage - 59N

Common configurations:

Type of residual voltage measurement for 59N- direct/calculated ($3Vo_{Type59N}$) U_E / U_{EC}

Threshold U_E>

Type of characteristic (U_E>Curve)	DEFINITE/INVERSE[1]
Reset delay ($t_{UE>RES}$)	0.00...100.0 s
	0.00...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)

Definite time

First definite time threshold ($U_{E>def}$)	0.001...1.000 U_{En} (step 0.001 U_{En})
Operating time ($t_{UE>def}$)	0.05...1000 s
	0.05...9.99 s (step 0.01 s)
	10.0...99.9 s (step 0.1 s)
	100...1000 s (step 1 s)

Inverse time

First 59N inverse time threshold ($U_{E>inv}$)	0.001...1.000 U_{En} (step 0.001 U_{En})
Operating time $_v$ ($t_{UE>inv}$)	0.10...100.0 s
	0.10...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)

Threshold U_E>>

Reset delay ($t_{UE>>RES}$)	0.00...100.0 s
	0.00...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)

Definite time

Second definite time threshold ($U_{E>>def}$)	0.01...0.70 U_{En} (step 0.01 U_{En})
Operating time ($t_{UE>>def}$)	0.05...1000 s
	0.05...9.99 s (step 0.01 s)
	10.0...99.9 s (step 0.1 s)
	100...1000 s (step 1 s)

— Residual emergency overcurrent - 59N(eme)

Common configurations:

Type of residual voltage measurement for 59N- direct/calculated ($3Vo_{Type59N}$) U_E / U_{EC}

Threshold U_{Eeme}>

Type of characteristic (U_{Eeme}>Curve)	INVERSE/DEFINITE[2]
Reset delay $t_{UEeme>RES}$)	0.00...100.0 s
	0.00...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)

Definite time

First definite time threshold ($U_{Eeme>def}$)	0.001...1.000 U_{En} (step 0.001 U_{En})
Operating time ($t_{UEeme>def}$)	0.05...1000 s
	0.05...9.99 s (step 0.01 s)
	10.0...99.9 s (step 0.1 s)
	100...1000 s (step 1 s)

Inverse time

First inverse time threshold ($U_{Eeme>inv}$)	0.001...1.000 U_{En} (step 0.001 U_{En})
Operating time ($t_{UEeme>inv}$)	0.10...100.0 s
	0.10...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)

Note 1 The general formula for inverse time curves is: $t = (0.5 \cdot t_{UE>inv}) / [(U_E/U_{E>inv}) - 1]$
t = operating time (in seconds)
$t_{UE>inv}$ = operating time regulation (in seconds)
U_E = residual voltage (measured directly or calculated according to the measurement type configuration)
$U_{E>inv}$ = trip threshold regulation

Note 2 The general formula for inverse time curves is: $t = (0.5 \cdot t_{UEeme>inv}) / [(U_E/U_{Eeme>inv}) - 1]$
t = operating time (in seconds)
$t_{UE>inv}$ = operating time regulation (in seconds)
U_E = residual voltage (measured directly or calculated according to the measurement type configuration)
$U_{E>inv}$ = trip threshold regulation

— Maximum directional current - 67

Common configurations:

	Operating mode 67 (*Mode67*)	*I*/*I*·*cos*
	Operating logic 67 (*Logic*67)	1/3 / 2/3
Threshold $I_{PD}>$		
	Type of characteristic ($I_{PD}>$Curve)	DEFINITE, IEC/BS A, B, C, B-LI
	Reset delay ($t_{PD>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	First definite time threshold ($I_{PD>def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Characteristic angle (*Theta*$_{PD>def}$)	0...359° (step 1°)
	Operating time ($t_{PD>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Back-up time ($t_{rPD>def}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip ($t_{clPD>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time ($t_{atclPD>def}$)	1...60 s (step 1 s)
Inverse time[1]		
	First inverse time threshold ($I_{PD>inv}$)	0.050...20.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
	Characteristic angle (*Theta*$_{PD>inv}$)	0...359° (step 1°)
	Operating time ($t_{PD>inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)
Threshold $I_{PD}>>$		
	Type of characteristic ($I_{PD}>>$Curve)	DEFINITE, IEC/BS A, B, C, B-LI
	Reset delay ($t_{PD>>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	Second definite time threshold ($I_{PD>>def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Characteristic angle (*Theta*$_{PD>>def}$)	0...359° (step 1°)
	Operating time ($t_{PD>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Back-up time ($t_{rPD>>def}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip ($t_{clSQL>>def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time ($t_{atclPD>>def}$)	1...60 s (step 1 s)

Note1 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_{PD>inv} / [(I/I_{PD>inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_{>inv} / [(I/I_{PD>inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_{>inv} / [(I/I_{PD>inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{PD>inv} / [(I/I_{PD>inv})^2 - 1]$
t: *operating time*
$t_{PD>inv}$: *operating time regulation*
$I_{PD>inv}$: *trip threshold regulation*
I_{PD}: *measured current*
Asymptotic reference value: 1.1 $I_{PD>inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \leq I/I_{PD>inv} \leq 20$
With regulation $I_{PD>inv}$ *greater than* 2.5 I_n, *the upper limit of the measurement range is* 30 I_n

Inverse time[1]		
	Second inverse time threshold (I_{PD}>>$_{inv}$)	0.050...20.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
	Characteristic angle ($Theta_{PD}$>>$_{inv}$)	0...359° (step 1°)
	Operating time (t_{PD}>>$_{inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)
Threshold I_{PD}>>>		
	Reset delay I_{PD}>>> (t_{PD}>>>$_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	Third definite time threshold (I_{PD}>>>$_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Characteristic angle ($Theta_{PD}$>>>$_{def}$)	0...359° (step 1°)
	Operating time (t_{PD}>>>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Back-up time (t_{rPD}>>>$_{def}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip (t_{cIPD}>>>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time (t_{atcIPD}>>>$_{def}$)	1...60 s (step 1 s)
Threshold I_{PD}>>>>		
	Type of characteristic (I_{PD}>>>>Curve)	DEFINITE, IEC/BS A, B, C, B-LI
	Reset delay I_{PD}>>>> (t_{PD}>>>>$_{RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
Definite time		
	Fourth definite time threshold (I_{PD}>>$_{def}$)	0.050...25.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
	Characteristic angle ($Theta_{PD}$>>>>$_{def}$)	0...359° (step 1°)
	Operating time (t_{PD}>>>>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Back-up time (t_{rPD}>>>>$_{def}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip (t_{cIPD}>>>>$_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
	Shrink activation time (t_{atcIPD}>>>>$_{def}$)	1...60 s (step 1 s)

Note1 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_{PD>inv} / [(I/I_{PD>inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_{>inv} / [(I/I_{PD>inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_{>inv} / [(I/I_{PD>inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{PD>inv} / [(I/I_{PD>inv})^2 - 1]$
t: *operating time*
$t_{PD>inv}$: *operating time regulation*
$I_{PD>inv}$: *trip threshold regulation*
I_{PD}: *measured current*
Asymptotic reference value: 1.1 $I_{PD>inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \le I/I_{PD>inv} \le 20$
With regulation $I_{PD>inv}$ *greater than* 2.5 I_n*, the upper limit of the measurement range is* 30 I_n

Inverse time[1]

Fourth inverse time threshold ($I_{PD}>>>>_{inv}$)	0.050...20.0 I_n 0.050...0.995 I_n (step 0.005 I_n) 1.00...20.00 I_n (step 0.01 I_n)
Characteristic angle ($Theta_{PD}>>>>_{inv}$)	0...359° (step 1°)
Operating time ($t_{PD}>>>>_{inv}$)	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

— Ground directional overcurrent - 67N

Common configurations:

Operating mode 67N (*Mode67N*)	*I*/*I*·*cos*
Type of residual voltage measurement for 67N - direct/calculated (*3VoType67N*)	U_E / U_{EC}
67N threshold multiplier for insensitivity zone (*M*)	1.5...10.0 (step 0.1)

Threshold $I_{ED}>$

Type of characteristic ($I_{ED}>$Curve)	DEFINITE, IEC/BS A, B, C, B-LI
Reset delay ($t_{ED>RES}$)	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)

Definite time

First definite time threshold ($I_{ED}>_{def}$ - $U_{ED}>_{def}$)	
Residual current operating time	0.005...25.0 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...9.99 I_{En} (step 0.01 I_{En}) 10.0...25.0 I_{En} (step 0.1 I_{En})
Residual current trip value	0.001...1.000 U_{En} (step 0.001 U_{En})
Characteristic angle	0...359° (step 1°)
Operating half-sector	1...180° (step 1°)
Operating time ($t_{ED}>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Back-up time ($t_{rED}>_{def}$)	0.05...0.50 s (step 0.01 s)
Shrink time trip ($t_{cIED}>_{def}$)	0.05...1000 s 0.05...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...1000 s (step 1 s)
Shrink activation time ($t_{atcIED}>_{def}$)	1...60 s (step 1 s)

Inverse time[2]

First inverse time threshold ($I_{ED}>_{inv}$ - $U_{ED}>_{inv}$)	
Residual current operating time	0.005...20.00 I_{En} 0.005...0.995 I_{En} (step 0.005 I_{En}) 1.00...20.00 I_{En} (step 0.01 I_{En})
Residual current trip value	0.001...1.000 U_{En} (step 0.001 U_{En})
Characteristic angle	0...359° (step 1°)
Operating half-sector	1...180° (step 1°)

Note1 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_{PD}>_{inv} / [(I/I_{PD}>_{inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t>_{inv} / [(I/I_{PD}>_{inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t>_{inv} / [(I/I_{PD}>_{inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{PD}>_{inv} / [(I/I_{PD}>_{inv})^2 - 1]$
t: operating time
$t_{PD}>_{inv}$: *operating time regulation*
$I_{PD}>_{inv}$: *trip threshold regulation*
I_{PD}: *measured current*
Asymptotic reference value: 1.1 $I_{PD}>_{inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \leq I/I_{PD}>_{inv} \leq 20$
With regulation $I_{PD}>_{inv}$ *greater than* 2.5 I_n, *the upper limit of the measurement range is* 30 I_n

Note2 *Inverse time curve IEC 255-3/BS142 (type A or SIT):* $t = 0.14 \cdot t_{ED}>_{inv} / [(I_E/I_{ED}>_{inv})^{0.02} - 1]$
Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_{ED}>_{inv} / [(I_E/I_{ED}>_{inv}) - 1]$
Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_{ED}>_{inv} / [(I_E/I_{ED}>_{inv}) - 1]$
Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{ED}>_{inv} / [(I_E/I_{ED}>_{inv})^2 - 1]$
t: operating time
$t_{ED}>_{inv}$: *operating time regulation*
$I_{ED}>_{inv}$: *trip threshold regulation*
I_E: *measured residual current*
Asymptotic reference value: 1.1 $I_{ED}>_{inv}$
Minimum operating time: 0.1 s
Dynamic: $1.1 \leq I_E/I_{ED}>_{inv} \leq 20$
With regulation $I_{ED}>_{inv}$ *greater than* 0.5 I_{En}, *the upper limit of the measurement range is* 10 I_{En}

	Operating time ($t_{ED>inv}$)	0.02...60.0 s
		0.02...9.99 s (step 0.01 s)
		10.0...60.0 s (step 0.1 s)
Threshold I_{ED}>>a		
	Type of characteristic ($I_{ED>>a}$Curve)	DEFINITE,
		IEC/BS A, B, C, B-LI
	Reset delay ($t_{ED>>aRES}$)	0.00...100.0 s
		0.00...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
Definite time		
	Second definite time threshold ($I_{ED>>adef}$ - $U_{ED>>adef}$)	
	Residual current operating time	0.005...25.0 I_{En}
		0.005...0.995 I_{En} (step 0.005 I_{En})
		1.00...9.99 I_{En} (step 0.01 I_{En})
		10.0...25.0 I_{En} (step 0.1 I_{En})
	Residual current trip value	0.001...1.000 U_{En} (step 0.001 U_{En})
	Characteristic angle	0...359° (step 1°)
	Operating half-sector	1...180° (step 1°)
	Operating time ($t_{ED>>adef}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Back-up time ($t_{rED>>adef}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip ($t_{cIED>>adef}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Shrink time operating time ($t_{atcIED>>adef}$)	1...60 s (step 1 s)
Inverse time[1]		
	Second inverse time threshold ($I_{ED>>ainv}$ - $U_{ED>>ainv}$)	
	Residual current operating time	0.005...20.00 I_{En}
		0.005...0.995 I_{En} (step 0.005 I_{En})
		1.00...20.00 I_{En} (step 0.01 I_{En})
	Residual current trip value	0.001...1.000 U_{En} (step 0.001 U_{En})
	Characteristic angle	0...359° (step 1°)
	Operating half-sector	1...180° (step 1°)
	Operating time ($t_{ED>>ainv}$)	0.02...60.0 s
		0.02...9.99 s (step 0.01 s)
		10.0...60.0 s (step 0.1 s)
Threshold I_{ED}>>b		
	Reset delay ($t_{ED>>bRES}$)	0.00...100.0 s
		0.00...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
Definite time		
	Third definite time threshold ($I_{ED>>bdef}$ - $U_{ED>>bdef}$)	
	Residual current operating time	0.005...25.0 I_{En}
		0.005...0.995 I_{En} (step 0.005 I_{En})
		1.00...9.99 I_{En} (step 0.01 I_{En})
		10.0...25.0 I_{En} (step 0.1 I_{En})
	Residual current trip value	0.001...1.000 U_{En} (step 0.001 U_{En})
	Characteristic angle	0...359° (step 1°)
	Operating half-sector	1...180° (step 1°)
	Operating time ($t_{ED>>bdef}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Back-up time ($t_{rED>>bdef}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip ($t_{cIED>>bdef}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Shrink time operating time ($t_{atcIED>>bdef}$)	1...60 s (step 1 s)

Note1 Inverse time curve IEC 255-3/BS142 (type A or SIT): $t = 0.14 \cdot t_{ED>>inv} / [(I_E/I_{ED>>inv})^{0.02} - 1]$

Very inverse time curve IEC 255-3/BS142 (type B or VIT): $t = 13.5 \cdot t_{ED>>inv} / [(I_E/I_{ED>>inv}) - 1]$

Long inverse time curve (IEC 255-3/BS B LTI): $t = 120 \cdot t_{ED>>inv} / [(I_E/I_{ED>>inv}) - 1]$

Extremely inverse time curve IEC 255-3/BS142 (type C or EIT): $t = 80 \cdot t_{ED>>inv} / [(I_E/I_{ED>>inv})^2 - 1]$

t: operating time

$t_{ED>>inv}$: operating time regulation

$I_{ED>>inv}$: trip threshold regulation

I_E: measured residual current

Asymptotic reference value: 1.1 $I_{ED>>inv}$

Minimum operating time: 0.1 s

Dynamic: $1.1 \leq I_E/I_{ED>>inv} \leq 20$

With regulation $I_{ED>>inv}$ greater than 0.5 I_{En}, *the upper limit of the measurement range is* 10 I_{En}

Threshold I_{ED}>>>		
	Reset delay ($t_{ED>>>RES}$)	0.00...100.0 s
		0.00...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
Definite time		
	Fourth definite time threshold ($I_{ED>>>def}$ - $U_{ED>>>def}$)	
	Residual current operating time	0.005...25.0 I_{En}
		0.005...0.995 I_{En} (step 0.005 I_{En})
		1.00...9.99 I_{En} (step 0.01 I_{En})
		10.0...25.0 I_{En} (step 0.1 I_{En})
	Residual current trip value	0.001...1.000 U_{En} (step 0.001 U_{En})
	Characteristic angle	0...359° (step 1°)
	Operating half-sector	1...180° (step 1°)
	Operating time ($t_{ED>>>def}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Back-up time ($t_{rED>>>def}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip ($t_{cIED>>>def}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Shrink activation time ($t_{atcIED>>>def}$)	1...60 s (step 1 s)
Threshold 67N.Sb		
	Reset delay ($t_{ED>>>>RES}$)	0.00...100.0 s
		0.00...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
Definite time		
	Fifth 67N definite time threshold ($I_{ED}Sb_{def}$ - $U_{ED}Sb_{def}$)	
	Residual current operating time	0.005...25.0 I_{En}
		0.005...0.995 I_{En} (step 0.005 I_{En})
		1.00...9.99 I_{En} (step 0.01 I_{En})
		10.0...25.0 I_{En} (step 0.1 I_{En})
	Residual current trip value	0.001...1.000 U_{En} (step 0.001 U_{En})
	Characteristic angle	0...359° (step 1°)
	Operating half-sector	1...180° (step 1°)
	Operating time ($t_{EDSbdef}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Back-up time ($t_{rED}Sb_{def}$)	0.05...0.50 s (step 0.01 s)
	Shrink time trip ($t_{cIED}Sb_{def}$)	0.05...1000 s
		0.05...9.99 s (step 0.01 s)
		10.0...99.9 s (step 0.1 s)
		100...1000 s (step 1 s)
	Shrink activation time ($t_{atcIED}Sb_{def}$)	1...60 s (step 1 s)
Threshold I_{ED}>>>> (Intermittent faults)		
	Residual current trip value	0.040...1.500 U_{En} (step 0.001 U_{En})
	59N startup drop-out delay ($t_{ED>>>>RRI59N}$)	0.05...100.0 s
		0.05...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
	67N startup drop-out delay ($t_{ED>>>>RRI67N}$)	0.05...100.0 s
		0.05...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
	Operating time ($t_{ED>>>def}$)	0.50...60.0 s
		0.50...9.99 s (step 0.01 s)
		10.0...60.0 s (step 0.1 s)
	Maximum fault time for disable ($t_{ED>>>>Inb}$)	0.50...2.00 s (step 0.01 s)
	Disable hold time ($t_{ED>>>>1s}$)	0.50...2.00 s (step 0.01 s)
Threshold I_{ED}>>>> (Evolving faults)		
	Control threshold U_E> (I_{ED}>>>>>-U_E>)	0.040...1.500 U_{En} (step 0.001 U_{En})
	59N startup drop-out delay ($t_{ED>>>>>RRIC}$)	0.05...100.0 s
		0.05...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
	Observation activation delay ($t_{ED>>>>>RAO}$)	0.05...100.0 s
		0.05...9.99 s (step 0.01 s)
		10.0...100.0 s (step 0.1 s)
	Observation time ($t_{ED>>>>>o}$)	0.50...2.00 s (step 0.01 s)

— EAC (Equilibratore Automatico di Carico) [ALB frequency (Automatic Load Balancer)]

Block thresholds

Minimum voltage Ueac<def	0.05 ...1.40 En (step 0.05 En)
Operating time tUeac<	0.05 ...9.99 s (step 0.01 s)
	10.0 .. 99.9 s (step 0.1 s)
	100 ...1000 s (step 1 s)
Maximum voltage Ueac>def	0.05 ...1.40 En (step 0.05 En)
Operating time tUeac>	0.05 ...9.99 s (step 0.01 s)
	10.0 .. 99.9 s (step 0.1 s)
	100 ...1000 s (step 1 s)
Maximum unbalance ULS>def	0.05 ...1.00 Um (step 0.05 Um)
Reset delay tULS>RES	0.00 ...9.99 s (step 0.01 s)
	10.0 .. 100.0 s (step 0.1 s)
Operating time tULS>	0.05 ...9.99 s (step 0.01 s)
	10.0 .. 99.9 s (step 0.1 s)
	100 ...1000 s (step 1 s)
Maximum frequency difference UG>def	10 ...200 mHz (step 1 mHz)
Reset delay tUG>RES	0.00 ...9.99 s (step 0.01 s)
	10.0 .. 100.0 s (step 0.1 s)
Operating time tUG>	0.05 ...9.99 s (step 0.01 s)
	10.0 .. 99.9 s (step 0.1 s)
	100 ...1000 s (step 1 s)
Maximum active return power P->	-1.00 ...-0.01 Pn (step 0.01 Pn)
Reset delay tP->RES	0.00 ...9.99 s (step 0.01 s)
	10.0 .. 100.0 s (step 0.1 s)
Operating time tP->	0.05 ...9.99 s (step 0.01 s)
	10.0 .. 99.9 s (step 0.1 s)
	100 ...1000 s (step 1 s)
Maximum variation in consecutive periods UDT>	50 ...7000 us (step 10 us)

Calculated means of f and df

Number of mean frequency semi-periods	1 ... 32 (step 1)
Number of first scale df/dt calculation semi-periods (0.1÷0.9 Hz/s)	0 ... 20 (step 1)
Number of second scale df/dt calculation semi-periods (1÷4.9 Hz/s)	0 ... 20 (step 1)
Number of third scale df/dt calculation semi-periods (5÷10 Hz/s)	0 ... 20 (step 1)
Number of first scale df/dt calculation means (0.1÷0.9 Hz/s)	Means (1, 2, 4, 8, 10, 12, 14, 16, 18, 20)
Number of second scale df/dt calculation means (1÷4.9 Hz/s)	Means (1, 2, 4, 8, 10, 12, 14, 16, 18, 20)
Number of third scale df/dt calculation means (5÷10 Hz/s)	Means (1, 2, 4, 8, 10, 12, 14, 16, 18, 20)

Threshold EAC1

Type f>/f<1a	Maximum/Minimum
Threshold f>/f<1a	45.00 ... 55.00 Hz (step 0.01 Hz)
Operating time tf>/f<1a	0.00 ... 60.00 s (step 0.01 s)
Type f>/f<1b	Maximum/Minimum
Threshold f>/f<1b	45.00 ... 55.00 Hz (step 0.01 Hz)
Operating time tf>/f<1b	0.00 ... 60.00 s (step 0.01 s)
Threshold df>1	0.1 ... 10.00 Hz/s (step 0.1 Hz/s)
Operating time tdf>1	0.00 ... 60.00 s (step 0.01 s)

Threshold EAC2

Type f>/f<2a	Maximum/Minimum
Threshold f>/f<2a	45.00 ... 55.00 Hz (step 0.01 Hz)
Operating time tf>/f<2a	0.00 ... 60.00 s (step 0.01 s)
Type f>/f<2b	Maximum/Minimum
Threshold f>/f<2b	45.00 ... 55.00 Hz (step 0.01 Hz)
Operating time tf>/f<2b	0.00 ... 60.00 s (step 0.01 s)
Threshold df>2	0.1 ... 10.00 Hz/s (step 0.1 Hz/s)
Operating time tdf>2	0.00 ... 60.00 s (step 0.01 s)

— Second harmonic restraint - 2ndh-REST

Second harmonic restraint threshold (I_{2ndh}>)	10...50 % (step 1 %)
Reset delay ($t_{2ndh>RES}$)	0...100.0 s
	0.00...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)

3.8 CONTROL FUNCTIONS

— Synchrocheck relay - 25

Common configurations:

Minimum stabilisation time (t_{STAB})	0.10...10.00 s (step 0.01 s)
Breaker closing time ($t_{CB-CLOSE}$)	0.02...0.20 s (step 0.01 s)
Synchronisation timeout ($timeout_{-SYNC}$)	1...20 min (step 1 min)
Synchronisation emission delay (t_{SYNC})	0.00...60.0 s 0.00...9.99 (step 0.01 s) 1.0...60.0 (step 0.1 s)
Upper voltage limit threshold ($V_{max-SYNC}$)	0.50...1.50 E_n-U_{n2} (step 0.01 E_n)
Lower voltage limit threshold ($V_{min-SYNC}$)	0.20...1.50 U_n/E_n/U_{n2} (step 0.01 E_n)
Permitted frequency range for V1, V2 (f_{RANGE})	f_n ±0.5...3.0 Hz (step 0.01 Hz)
Frequency measurement repeatability ($Rof>_{-SYNC}$)	0.00...0.60 Hz (step 0.05 Hz)

Parameters:

Synchronism/asynchronism threshold (df_{-GRID})	0.01...0.10 Hz (step 0.01 Hz)
Frequency difference with f1>f2 ($df_{12-SYNC}$)	0.02...1.00 Hz (step 0.01 Hz)
Frequency difference with f2>f1 ($df_{21-SYNC}$)	0.02...1.00 Hz (step 0.01 Hz)
Voltage difference with V1>V2 ($dV_{12-SYNC}$)	0.01...0.40 U_n/E_n-U_{n2} (step 0.01 V)
Voltage difference with V2>V1 ($dV_{21-SYNC}$)	0.01...0.40 U_n/E_n-U_{n2} (step 0.01 V)
Phase difference with V2 in advance of V1 ($dp_{12-SYNC}$)	1...60 °(step 1 degree)
Phase difference with V2 behind V1 ($dp_{21-SYNC}$)	1...60 °(resolution 0.01 V)
No voltage threshold V1 ($V_{1<-SYNC}$)	0.05...0.60 E_n (step 0.01 V)
No voltage threshold V2 ($V_{2<-SYNC}$)	0.05...0.60 E_n (step 0.01 V)
Minimum no voltage time V1 ($t_{V1<SYNC}$)	0.00...10.00 s (step 0.01 s)
Minimum no voltage time V2 ($t_{V2<SYNC}$)	0.00...10.00 s (step 0.01 s)

— VT monitoring - 74TV

Maximum negative sequence voltage threshold for 74VT ($U_{2VT>}$)	0.05...0.50 E_n (step 0.01 V)
Negative sequence overcurrent threshold for 74VT ($I_{2VT>}$)	0.05...0.50 I_n (step 0.01 I_n)
Minimum phase voltage threshold for 74VT ($U_{VT<}$)	0.05...0.50 E_n (step 0.01 V)
Minimum current variation threshold for 74VT ($D_{IVT<}$)	0.05...0.50 I_n (step 0.01 I_n)
Minimum current disable threshold for 74VT ($I_{VT<}$)	0.100...25.0 I_n 0.100...0.999 I_n (step 0.001 I_n) 1.00...9.99 I_n (step 0.01 I_n) 10.0...25.0 I_n (step 0.1 I_n)
Alarm delay (t_{VT-AL})	0.0...10.0 s (step 0.1 s)

— CT Monitoring - 74CT

Threshold *74CT* ($S<$)	0.10...0.95 (step 0.01)
Maximum current threshold 74CT (I_*)	0.10...1.00 I_n (step 0.01 I_n)
Operating time $S<$ ($t_{S<}$)	0.03...200 s 0.03...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...200 s (step 1 s)

— Breaker failure - BF

Phase current threshold for BF ($I_{BF>}$)	0.05...1.00 I_n (step 0.01 I_n)
Residual current threshold for BF ($I_{EBF>}$)	0.01...2.00 I_n (step 0.01 I_{En})
Operating time (t_{BF})	0.06...10.00 s (step 0.01 s)

— Breaker coils control monitoring

Pulse duration CH	2 ÷ 5 ms (step 1 ms)
Pulse duration AP	2 ÷ 5 ms (step 1 ms)

— Opening command breaker diagnostics

Opening counter threshold (*N.Open*)	0...10000 (step 1)
Command under load counter threshold (*N.MnvLoad*)	0...10000 (step 1)
No load command counter threshold (*N.MnvLoad*)	0...10000 (step 1)
Command under load current threshold (*MnvLoad>*)	0.00...1.00 I_n (step 0.01 I_n)
Interrupted current sum threshold (*SumI*)	0...5000 I_n (step 1 I_n)
Opening time for calculation ΣI^2t (t_{break})	0.05...1.00 s (step 0.01 s)
Interrupted I^2t sum threshold (*SumI^2t*)	0...5000 $I_n^2 \cdot s$ (step 1 $I_n^2 \cdot s$)
Maximum admitted opening time ($t_{break>}$)	0.05...0.50 s (step 0.01 s)

— Closing command breaker diagnostics

Closing counter threshold (*N.Close*)	0...10000 (step 1)
Maximum admitted closing time ($t_{close>}$)	0.05...0.50 s (step 0.01 s)

— Automatic reclosing - 79

Reclosing program (*79 Mode*)	Rapid/Rapid+Slow
Number of memorised reclosings (*N.DAR*)	0...5 (step 1)
Rapid wait (t_{rdt})	0.10...1.00 s (step 0.01 s)
Slow wait (t_{sdt})	1...200 s (step 1 s)
Phase trip neutralisation time (t_{rf})	1...200 s (step 1 s)
Ground trip neutralisation time (t_{rt})	1...200 s (step 1 s)
Rapid closing discrimination time (t_{dr})	0...10 s (step 1 s)
Slow closing discrimination time (t_{dl})	0...10 s (step 1 s)
Memorized closing discrimination time (t_{dm})	0...10 s (step 1 s)
Intentional closing discrimination time (t_{d})	1...10 s (step 1 s)

3.9 MEASUREMENTS

— Precision (type tests)

VALUE	Reference value	Tolerance	Reference value	Tolerance
Measured phase current	≥ 20 mA	1%	< 20 mA	1% ± 2 mA
Reconstructed phase current	≥ 20 mA	1%	< 20 mA	1% ± 2 mA
Measured residual current	≥ 20 mA	1%	< 20 mA	1% ± 2 mA
Calculated residual current	≥ 20 mA	1%	< 20 mA	1% ± 2 mA
Phase voltage	≥ 1 V	1%	< 1 V	1% ± 50 mV
Measured residual voltage	≥ 1 V	1%	< 1 V	1% ± 50 mV
Calculated residual voltage	≥ 1 V	1%	< 1 V	1% ± 50 mV
Power	≥ 20 mA and ≥ 1 V	1%	< 20 mA or < 1 V	2.5 %
Frequency	0.02 Un	5 mHz	1 U_n	3 mHz
Angles (protection 67)	≥ 20 mA and ≥ 1 V	0.5°	< 20 mA or < 1 V	1°
Angles (protection 67N)	≥ 0.005 I_{En} and 0.01 U_{En}	0.5°	< 0.005 I_{En} and 0.01 U_{En}	1°
Startup and operating time	1.2 x threshold regulation 1.5% ± 5 ms			

— Measurements

Direct

Frequency	(f)
RMS fundamental phase currents	(I_{L1}, I_{L2}, I_{L3})
RMS fundamental phase voltages	(U_{L1}, U_{L2}, U_{L3})
RMS fundamental residual current	(I_E)
RMS fundamental residual voltage	(U_E)
RMS fundamental unbalance current	(I_{SQL})
RMS fundamental neutral current	(I_{Ne})

Auxiliary voltage

Auxiliary voltage	(U_{aux})

Breaker coils current

Breaker coils current	(I_{CBcoil})

Calculated

Phase-to-phase voltages	(U_{12}, U_{23}, U_{31})
Calculated residual voltage	(U_{EC})
Reconstructed L2 phase current	(I_{L2C})
Maximum current between I_{L1}-I_{L2}-I_{L3}	(I_{Lmax})
Minimum current between I_{L1}-I_{L2}-I_{L3}	(I_{Lmin})
Mean current between I_{L1}-I_{L2}-I_{L3}	(I_L)
Maximum voltage between U_{L1}-U_{L2}-U_{L3}	(U_{Lmax})
Mean voltage between U_{L1}-U_{L2}-U_{L3}	(U_L)
Maximum voltage between U_{12}-U_{23}-U_{31}	(U_{max})
Mean voltage between U_{12}-U_{23}-U_{31}	(U)

Phase shift

Phase shift of I_{L1} relative to U_{L1}	(*PhiL1*)
Phase shift of I_{L2} relative to U_{L2}	(*PhiL2*)
Phase shift of I_{L3} relative to U_{L3}	(*PhiL3*)
Phase shift of I_{L1} relative to U_{23}	(*Alpha1*)
Phase shift of I_{L2} relative to U_{31}	(*Alpha2*)
Phase shift of I_{L3} relative to U_{12}	(*Alpha3*)
Phase shift of U_E relative to I_E	(*PhiE*)
Phase shift of U_{EC} relative to I_E	(*PhiEC*)

Sequences

Direct sequence current	(I_1)
Inverse sequence current	(I_2)
Direct sequence current with reconstructed IL2	(I_{1C})
Inverse sequence current with reconstructed IL2	(I_{2C})
Direct sequence voltage	(U_1)
Inverse sequence voltage	(U_2)

Power

Total active power	(P)
Total reactive power	(Q)
Total apparent power	(S)
Power factor	(*cosPhi*)
Phase active power	(P_{L1}, P_{L2}, P_{L3})
Phase reactive power	(Q_{L1}, Q_{L2}, Q_{L3})
Phase power factor	(*CosPhiL1, CosPhiL2, CosPhiL3*)

Total harmonic distortion

Total harmonic distortion of L3 current	(I_{L3-THD})
Total harmonic distortion of L3 voltage	(U_{L3-THD})

Second harmonic

Phase current second harmonic	(I_{L1-2nd}, I_{L2-2nd}, I_{L3-2nd})
Maximum percentage ratio of second harmonic of phase currents/fundamental component	(I_{L1-2nd}/I_{L1}, I_{L2-2nd}/I_{L1}, I_{L3-2nd}/I_{L1})

Third harmonic

Phase current third harmonic	(I_{L1-3rd}, I_{L2-3rd}, I_{L3-3rd})
Residual current third harmonic	(I_{E-3rd})
Residual voltage third harmonic	(U_{E-3rd})

Fourth harmonic

Phase current fourth harmonic	(I_{L1-4th}, I_{L2-4th}, I_{L3-4th})

Fifth harmonic

Phase current fifth harmonic	(I_{L1-5th}, I_{L2-5th}, I_{L3-5th})

Sinchro check (25)

Voltage V1	(V_1)
Voltage V2	(V_2)
Frequency V1	(fV_1)
Frequency V2	(fV_2)
Voltage differential V1 V2	(*DV*)
Frequency differential V1 V2	(*Df*)
Phase shift of V2 relative to V1	(*Phi V1V2*)

Averaged phase currents

Fixed mean phase current	(I_{L1FIX}, I_{L2FIX}, I_{L3FIX})
Mobile mean phase current	(I_{L1ROL}, I_{L2ROL}, I_{L3ROL})
Phase overcurrent	(I_{L1MAX}, I_{L2MAX}, I_{L3MAX})
Minimum phase current	(I_{L1MIN}, I_{L2MIN}, I_{L3MIN})

Averaged phase-to-phase voltages

Fixed mean phase-to-phase voltages	(U_{12FIX}, U_{23FIX}, U_{31FIX})
Mobile mean phase-to-phase voltages	(U_{12ROL}, U_{23ROL}, U_{31ROL})
Maximum phase-to-phase voltages	(U_{12MAX}, U_{23MAX}, U_{31MAX})
Minimum phase-to-phase voltages	(U_{12MIN}, U_{23MIN}, U_{31MIN})

Average total harmonic distortion

Fixed mean total harmonic distortion of L3 current	($THDI_{L3FIX}$)
Fixed mean total harmonic distortion of L3 voltage	($THDU_{L3FIX}$)
Mobile mean total harmonic distortion of L3 current	($THDI_{L3ROL}$)
Mobile mean total harmonic distortion of L3 voltage	($THDU_{L3ROL}$)
Maximum total harmonic distortion of L3 current	($THDI_{L3MAX}$)
Maximum total harmonic distortion of L3 voltage	($THDU_{L3MAX}$)
Minimum total harmonic distortion of L3 current	($THDI_{L3MIN}$)
Minimum total harmonic distortion of L3 voltage	($THDU_{L3MIN}$)

Averaged powers

Fixed mean active power	(P_{FIX})
Fixed mean reactive power	(Q_{FIX})
Mobile mean active power	(P_{ROL})
Mobile mean reactive power	(Q_{ROL})
Maximum active power	(P_{MAX})
Maximum reactive power	(Q_{MAX})
Minimum active power	(P_{MIN})
Minimum reactive power	(Q_{MIN})

Averaged to 10 s

10 s mean of phase currents	(I_{L1IST}, I_{L2IST}, I_{L3IST})
10 s mean of reconstructed L2 phase current	(I_{L2CIST})
10 s mean of phase-to-phase voltages	(U_{12IST}, U_{23IST}, U_{31IST})
10 s mean of active power	(P_{IST})
10 s mean of reactive power	(Q_{IST})
!0 s mean of total harmonic distortion of L3 current	($THDI_{L3IST}$)
!0 s mean of total harmonic distortion of L3 voltage	($THDU_{L3IST}$)

4 FUNCTIONAL CHARACTERISTICS

4.1 CONFIGURABILITY

The DMC3S multifunctional panel features a modular construction with removable boards.
The panel can be customised for a variety of types of riser; the type of riser can be selected in the **Set\Base** menu.
The firmware selected on the panel defines the measured values of amperometric channel C2, while the measurements on voltmetric channel V4 must be selected from UE and V2 in the **Set\Base** menu.

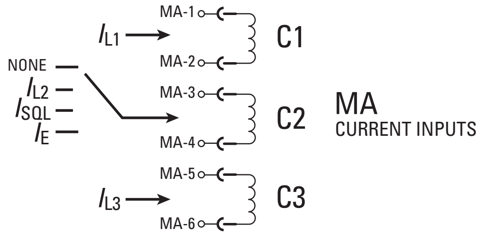
Measurement channels

Channel	Type of channel	Measurement
V1	Analogue voltage measurement channel	Phase voltage U_{L1}
V2	Analogue voltage measurement channel	Phase voltage U_{L2}
V3	Analogue voltage measurement channel	Phase voltage U_{L3}
V4	Analogue voltage measurement channel	Phase voltage U_E / V_{sync}
C1	Analogue current measurement channel	Phase current I_{L1}
C2	Analogue current measurement channel	Phase current I_{L2} / I_{SQL} / I_E
C3	Analogue current measurement channel	Phase current I_{L3}
C4	Analogue current measurement channel	Residual current I_E

Channel C2

Correspondence to panel A2	Type of riser	Assignment of channel C2
901	MV line stall	Measurement I_{L2}
910	Capacitor stall	Measurement I_{SQL}
922	TFN stall	Second measurement channel I_E
907	Coupler stall	No measurement (I_{L2}) [1]
905	Transfer bar	No measurement (I_{L2}) [1]
917	User HV line stall	No measurement (I_{L2}) [1]

Note 1 The system assigns the measurement to I_{L2} even when the input is not connected



Depending on the assignment of channel C2, the measurement and protection functions are given in the table:

Measurement functions of channel C2

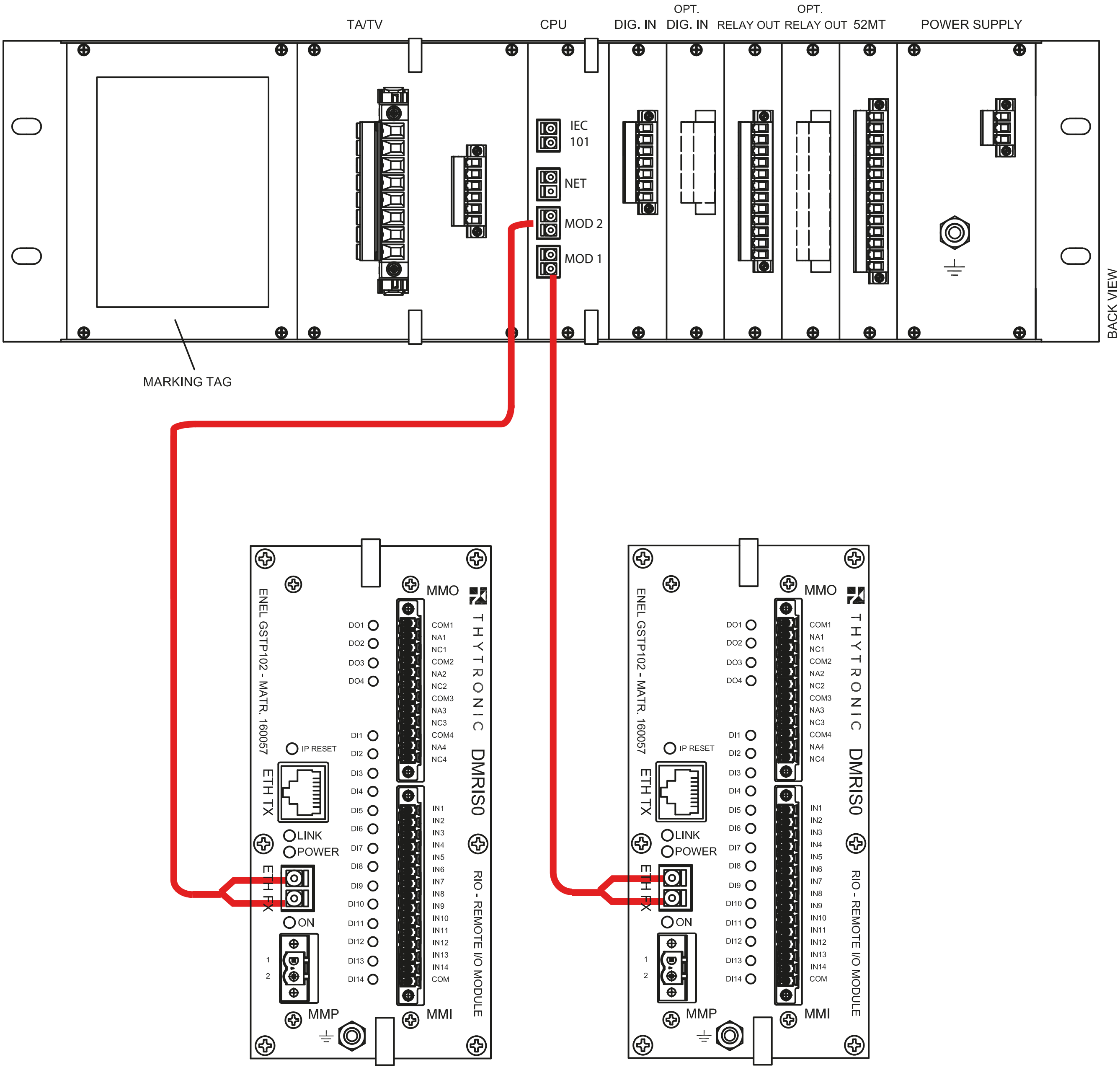
Measurement assigned to C2	Measurement and protection functions	Correspondence to panel A2
None	32P (U_{L1}; U_{L2}; U_{L3}; I_{L1}; I_{L3}) 51 (I_{L1}; I_{L3}) 67 (U_{12}; U_{23}; U_{31}; I_{L1}; I_{L3}; -I_E) 46 (not used) 51SQL (not active)	905 - 907 - 917
I_{L2}	32P (U_{L1}; U_{L2}; U_{L3}; I_{L1}; I_{L2}; I_{L3}) 51 (I_{L1}; I_{L2}; I_{L3}) 67 (U_{12}; U_{23}; U_{31}; I_{L1}; I_{L2}; I_{L3}) 46 (U_{L1}; U_{L2}; U_{L3}; I_{L1}; I_{L2}; I_{L3}) 51SQL (not active)	901
I_{SQL}	32P (U_{L1}; U_{L2}; U_{L3}; I_{L1}; I_{L3}) 51 (I_{L1}; I_{L3}) 67 (U_{12}; U_{23}; U_{31}; I_{L1}; I_{L3}; -I_E) 46 (not used) 51SQL	910
Second measurement channel I_E(51N)	32P (U_{L1}; U_{L2}; U_{L3}; I_{L1}; I_{L3}) 51 (I_{L1}; I_{L3}) 67 (U_{12}; U_{23}; U_{31}; I_{L1}; I_{L3}; -I_E) 46 (not used)	922

4.2 ADDITIONAL EXTERNAL MODULES

An external I/O module is available to increase the number of final output relays and digital inputs.

The DMRIS0 module includes:
- 2 final relay with transfer contact
- 12 digital inputs with common contact
- one RS232 serial port for setting the IP address

The electrical specifications (auxiliary power, specifications of digital inputs and output relays) are identical to those of the I/O circuits on board the panel.
Connection to the DMC3S panel is via fibre optics with LC connectors.
One or two DMRIS0 modules can be connected.

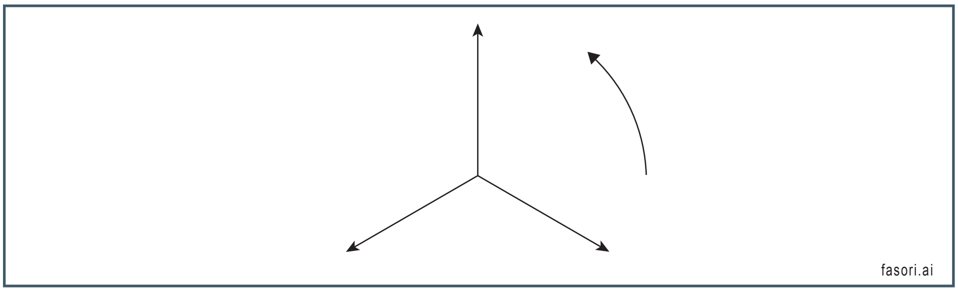


4.3 DESCRIPTION OF OPERATION

— Measurement conventions

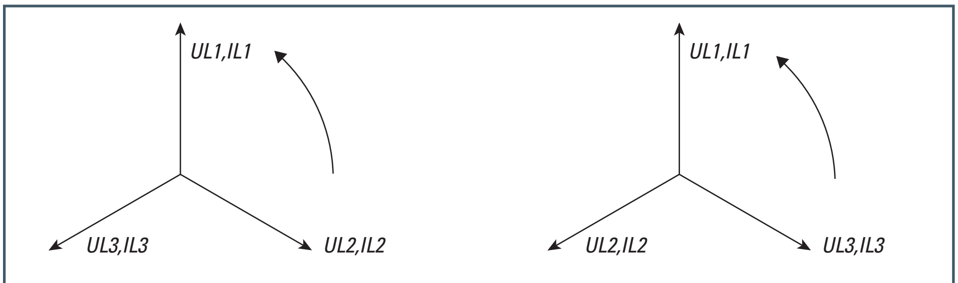
Phasor direction of rotation

The conventional direction of rotation assumed for the voltage and current phasors is counterclockwise.

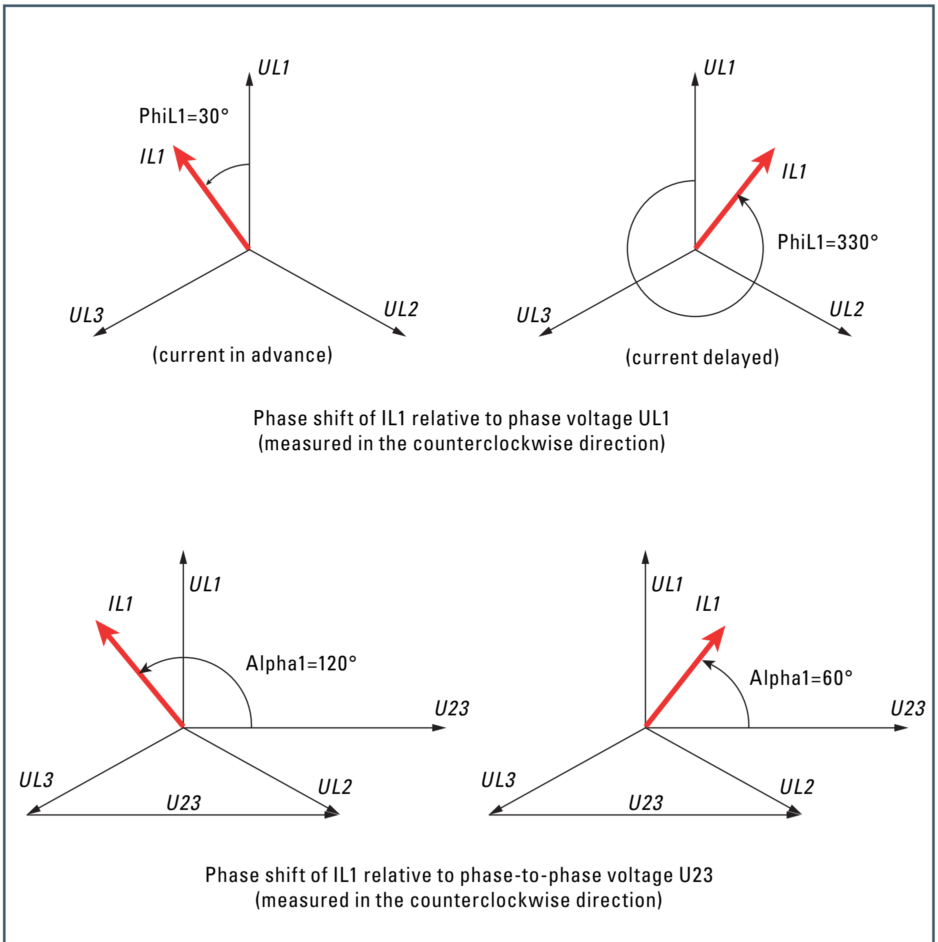


Cyclic phase sequence

For a set of three voltage or current phasors rotating counterclockwise, one conventionally assumes a direct cycle if the three phases follow the sequence L1, L2, L3, and an inverse cycle when the sequence is L1, L3, L2.



Sign conventional for phase shifts[1]



Phase shifts

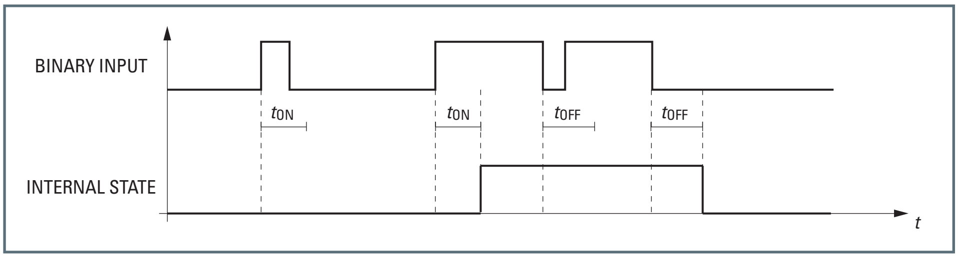
Note 1 *The phase shift regulation and display ranges are 0°... 359°*

— Logical inputs

The input module has 6 inputs, with 5 inputs on the Control module.
The no-voltage inputs must be controlled by applying an external voltage (usually the auxiliary power voltage).
Refer to the insertion diagrams for the hookup scheme.
Each input has the following configurable parameters:

- Logic: DIRECT (active when the input is powered), or INVERSE (active without voltage to the input).
- Trip delay (IN1-1 tON, IN1-2 tON... IN1-6 tON) and drop-out delay (IN1-1 tOFF, IN1-2 tOFF... IN1-6 tON).
- Mapping functions to the input module inputs (IN1-1...IN1-6).[1]

The Trip and Deactivation timer settings provide for inserting a programmable delay on input signal transitions; in particular, the positive transition is considered valid only if the input remains stably active for at least the programmed delay t_{ON}; in the same way, for negative transitions, the input must remain inactive for at least the programmed delay t_{OFF}.



Each logical input on the input board (IN1-1...IN1-6) can be mapped to one of the default functions listed below. The parameters can be set in the menu **Set \ Input board inputs.**

FUNCTIONS	Logical inputs					
	IN1-1	IN1-2	IN1-3	IN1-4	IN1-5	IN1-6
Signal reset	■	■	■	■	■	■
Reset counters	■	■	■	■	■	■
Reset CB Monitor (resets the breaker monitoring data)	■	■	■	■	■	■
52a (auxiliary contact acquisition)	■	■	■	■	■	■
52b (auxiliary contact acquisition)	■	■	■	■	■	■
Breaker open	■	■	■	■	■	■
Breaker close	■	■	■	■	■	■
Logical block	■	■	■	■	■	■
Remote trip	■	■	■	■	■	■
Remote control	■	■	■	■	■	■
Return voltage with CB open	■	■	■	■	■	■
Trip time contraction	■	■	■	■	■	■

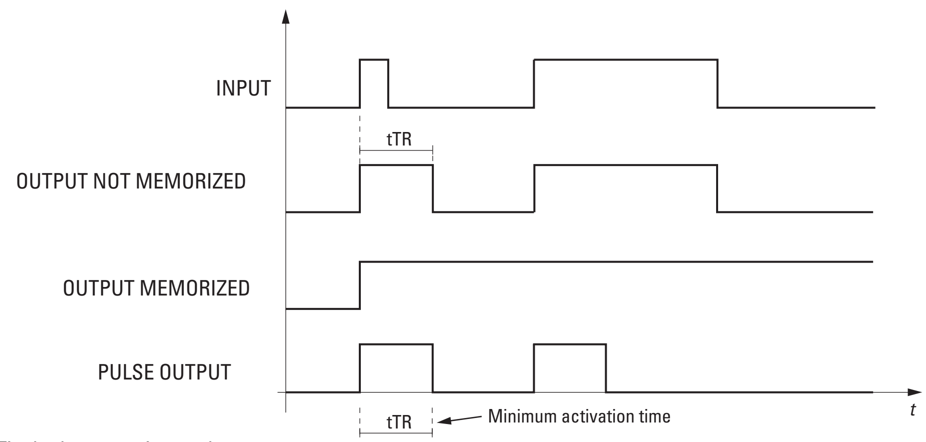
Each logical input on the external DMRIS0 board (DMRIS01-1...DMRIS01-12 and DMRIS02-1...DMRIS02-12) can be mapped to one of the default functions listed below..

FUNCTIONS	Logical inputs				
	DMRIS01-1	DMRIS01-2	DMRIS01-x	DMRIS02-1	DMRIS02-x
SZTT position closed (89ccX)	■	■	■	■	■
SZTT position open (89ccX)	■	■	■	■	■
52 inserted	■	■	■	■	■
52 selected	■	■	■	■	■
63G Alarm	■	■	■	■	■
63G Trip	■	■	■	■	■
No voltage to MV breaker (80S)	■	■	■	■	■
Spring load breaker trip (6L)	■	■	■	■	■
CH-port for (BLP) block	■	■	■	■	■
Springs unloaded (X33)	■	■	■	■	■

Note1 The control board function mappings are not programmable

— Output relays

The following are available:
• 6 electromechanical relays (KS1-1...KS1-1...6),
• 4 solid state relays
Each final relay is independently programmable with operating mode normally excited or de-excited (*EXCITED/DE-EXCITED LOGIC*) and non-memorised, pulse or memorized operating mode (*NON-MEMORISED/PULSE/MEMORIZED OPERATING MODE*).
A programmable timer is available for each final relay, which sets the minimum pulse duration of the relay itself. The parameters can be set in the menu **Set \ Relays.**



Final relay operating modes

Programming and configuration area available at any time, even with the relay in service, independently for each relay.
Detailed information:
• If a final relay is set to normally de-excited, it remains in standby at input values corresponding to no trip
• If a final relay is set to normally excited, it remains in operation when powered and at input values corresponding to no trip
• If the relay is set to automatic reset (*Operating mode NON-MEMORIZED*), it switches to standby when the anomalous condition of the input value ceases. A timer can be set for each final relay to set the minimum hold time when the relay is actuated (Minimum operating time)
• If manual reset is set (*Operating mode MEMORIZED*), the final relay remains actuated until the RESET button is pressed or the respective command is sent via software (ThySetter of comms bus)
• If set to pulse mode (*Operating mode PULSE*), the final relay switches to standby after a programmable delay (Minimum operating time) regardless of the condition of the input values

Output relays KS1-1...KS1-6 can be assigned independently in the menu for the individual; protection functions, as shown in the matrix described below (Tripping Matrix).[1][2]

Each relay on the external DMRIS0 board (DMRIS01-1...DMRIS01-12 and DMRIS02-1...DMRIS02-12) can be mapped to one of the default functions listed below..

FUNCTIONS	Output relays	
	Output DMRIS01-1	Output DMRIS01-2
CH-port for (BLP) block	■	■
No TFN/ HV client riser (80S)	■	■

Note 1 When assigning functions to the output relays, take care to avoid conflicts between different functions.
The default factory settings provide for deactivation of all output relays.
Note2 The functions of the solid state outputs are not programmable

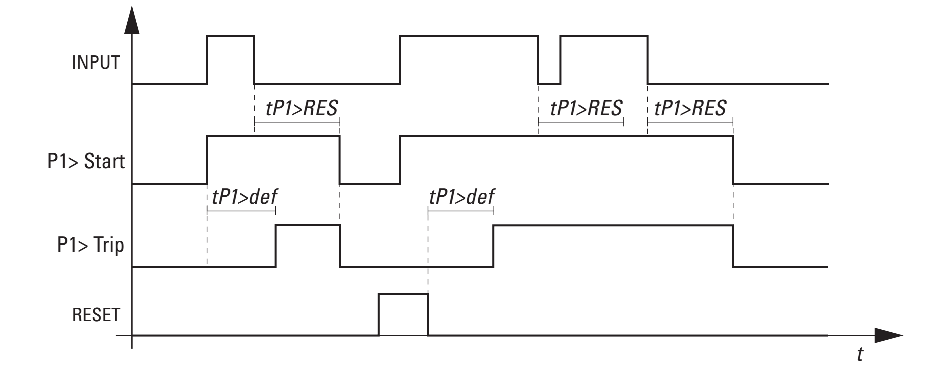
FUNCTIONS	RELAY					
	KS1-1	K1-2	K1-3	K1-4	K1-5	K1-6
Anomaly (Self test)	■	■	■	■	■	■
Start of first protection threshold 27CC (80.S-ST-K)	■	■	■	■	■	■
Trip of first protection threshold 27CC (80.S-ST-K)	■	■	■	■	■	■
Start of first protection threshold 32P (P1>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 32P (P1>TR-K)	■	■	■	■	■	■
Start of second protection threshold 32P (P2>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 32P (P2>ST-K)	■	■	■	■	■	■
Start of first protection threshold 46 (I2>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 46 (I2>TR-K)	■	■	■	■	■	■
Start of second protection threshold 46 (I2>>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 46 (I2>TR-K)	■	■	■	■	■	■
Start of first protection threshold 50/51 (I>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 50/51 (I>TR-K)	■	■	■	■	■	■
Start of second protection threshold 0/51 (I>>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 50/51 (I>>TR-K)	■	■	■	■	■	■
Start of third protection threshold 50/51 (I>>>ST-K)	■	■	■	■	■	■
Trip of third protection threshold 50/51 (I>>>TR-K)	■	■	■	■	■	■
Start of fourth protection threshold 50/51 (I>>>>ST-K)	■	■	■	■	■	■
Trip of fourth protection threshold 50/51 (I>>>>TR-K)	■	■	■	■	■	■
Start of first protection threshold 50N/51N (IE>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 50N/51N (IE>TR-K)	■	■	■	■	■	■
Start of second protection threshold 0N/51N (IE>>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 50N/51N (IE>>TR-K)	■	■	■	■	■	■
Start of third protection threshold 50N/51N (IE>>>ST-K)	■	■	■	■	■	■
Trip of third protection threshold 50N/51N (IE>>>TR-K)	■	■	■	■	■	■
Start of first protection threshold 51N(Eme) (IEeme>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 51N(Eme) (IEeme>TR-K)	■	■	■	■	■	■
Start of first protection threshold 51N(E) (INe>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 51N(E) (INe>TR-K)	■	■	■	■	■	■
Start of second protection threshold 1N(E) (INe>> ST-K)	■	■	■	■	■	■
Trip of second protection threshold 51N(E) (INe>>TR-K)	■	■	■	■	■	■
Start of first protection threshold 51(SQL) (ISQL>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 51(SQL) (ISQL>TR-K)	■	■	■	■	■	■
Start of first protection threshold 59 (U>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 59 (U> TR-K)	■	■	■	■	■	■
Start of second protection threshold 9 (U>>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 59 (U>>TR-K)	■	■	■	■	■	■
Start of first protection threshold 59N (UE>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 59N (UE>TR-K)	■	■	■	■	■	■
Start of second protection threshold 9N (UE>>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 59N (UE>>TR-K)	■	■	■	■	■	■
Start of first protection threshold 59N(Eme) (UEeme>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 59N(Eme) (UEeme>TR-K)	■	■	■	■	■	■
Start of first protection threshold 67 (IPD>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 67 (IPD>TR-K)	■	■	■	■	■	■
Start of second protection threshold 7 (IPD>>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 67 (IPD>>TR-K)	■	■	■	■	■	■
Start of third protection threshold 67 (IPD>>>ST-K)	■	■	■	■	■	■
Trip of third protection threshold 67 (IPD>>>TR-K)	■	■	■	■	■	■
Start of fourth protection threshold 67 (IPD>>>>ST-K)	■	■	■	■	■	■
Trip of fourth protection threshold 67 (IPD>>>>TR-K)	■	■	■	■	■	■
Start of first protection threshold 67N (IED>ST-K)	■	■	■	■	■	■
Trip of first protection threshold 67N (IED>TR-K)	■	■	■	■	■	■
Start of second protection threshold 67N (IED>>ST-K)	■	■	■	■	■	■
Trip of second protection threshold 67N (IED>>TR-K)	■	■	■	■	■	■
Start of third protection threshold 67N (IED>>>ST-K)	■	■	■	■	■	■
Trip of third protection threshold 67N (IED>>>TR-K)	■	■	■	■	■	■
Start of fourth protection threshold 67N (IED>>>>ST-K)	■	■	■	■	■	■
Trip of fourth protection threshold 67N (IED>>>>TR-K)	■	■	■	■	■	■

AUTOMATION AND CONTROL FUNCTIONS	RELAY					
	KS1-1	K1-2	K1-3	K1-4	K1-5	K1-6
Output block of monitoring function VT (74VT-BK-K)	■	■	■	■	■	■
Monitoring function alarm VT (74VT-AL-K)	■	■	■	■	■	■
Monitoring function trip CT (S<TR-K)	■	■	■	■	■	■
Trip circuit supervision function start (74TCS-ST-K)	■	■	■	■	■	■
Trip circuit supervision function trip (74TCS-TR-K)	■	■	■	■	■	■
Closing in progress (79-Run-K)	■	■	■	■	■	■
Reclosing command (79-AR-K)	■	■	■	■	■	■
Reclosing failure (79-Fail-K)	■	■	■	■	■	■
Enable closing state (79-EnableState-K)	■	■	■	■	■	■
PLC (PLC-K)	■	■	■	■	■	■
Sync status (Sync-CK-K)	■	■	■	■	■	■
Breaker position anomaly (CBdiag-K)	■	■	■	■	■	■
Opening count diagnostics (N.Open-K)	■	■	■	■	■	■
Command under load count diagnostics (N.MnvLoad-K)	■	■	■	■	■	■
Command no load count diagnostics (N.MnvNoLoad-K)	■	■	■	■	■	■
Closing count diagnostics (N.Close-K)	■	■	■	■	■	■
Closing time diagnostics (tClose-K)	■	■	■	■	■	■
Interrupted current sum diagnostics (SumI-K)	■	■	■	■	■	■
Interrupted I^2t sum diagnostics (SumI^2t-K)	■	■	■	■	■	■
Breaker open time diagnostics (tbreak-K)	■	■	■	■	■	■
Remote trip (RemTrip-K)	■	■	■	■	■	■

Reset timers

For each threshold of the following protection functions:
- 32P
- 46
- 50/51
- 50N/51N
- 51N(E)
- 51N(Eme)
- 51(SQL)
- 59N
- 59N(eme)
- 67
- 67N
- 2ndh-REST

an adjustable reset time is available (symbol for the first threshold 32 ($t_{P1>RES}$, $t_{P2>RES}$).
The start signal reset is delayed by an adjustable amount when the threshold violation condition expires.

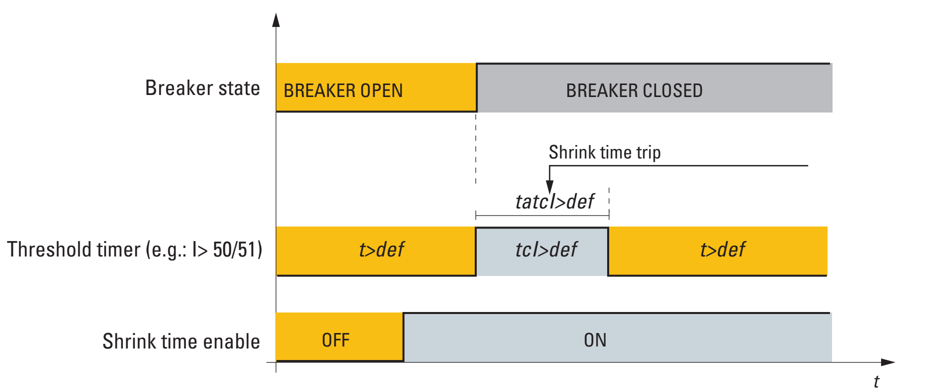


Timers for the first threshold of the active directional maximum power protection - 32P

Shrink time

For each threshold, programmed with an definite time characteristic, of the following protection functions:
- 46
- 50/51
- 50N/51N
- 51N(E)
- 51N(Eme)
- 51(SQL)
- 67
- 67N

the contracted time can be selected.
When the breaker closes, during the operating time (e.g.: *tatcI>def*) the value of the trip time (e.g.: *t>def*) is replaced by the contracted time (e.g.: *tcI>def*).
When the operating time expires, the trip time is reset (e.g.: *t>def*).



Timers for the first threshold of the overcurrent protection 50/51

— Back-up Time

For each threshold, programmed with an definite time characteristic, of the following directional protection functions:

- 32P
- 67
- 67N

the Back-up Time can be set.
Example: directional current function first threshold back-up time (e.g.: *trPD>def*), the parameter is in the menu **Set\Protections\Maximum directional current - 67\Threshold IPD>\Definite time**.
The back-up time is included in the logic of the selective block, the operation of which is described elsewhere.

— Direct undervoltage - 27CC

Preface

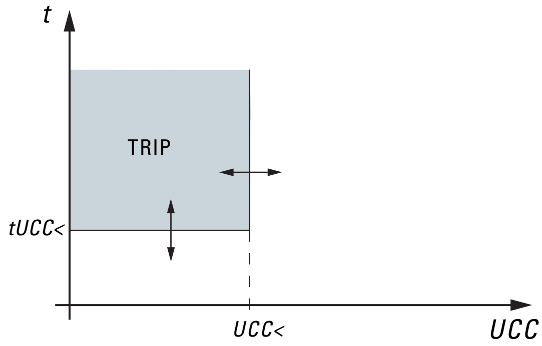
The protection has an adjustable, delayable threshold with definite time characteristic.

Measurement criterion

The protection measures the panel's auxiliary power voltage (U_{aux}):

Operation and settings

The measured voltage is compared with the threshold setpoint; when the measured voltage drops below a set threshold the threshold itself starts (Start) and the respective timer starts counting. If the condition persists, when the operating time expires, the threshold trips (Trip), otherwise the threshold is reset.
The protection threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *UCC< Enable* in the menu **Set \ Protections \ Direct undervoltage - 27CC \ Threshold UCC< \ Parameters** and/or *State* in the menu **Set \ Protections \ Direct undervoltage - 27CC \ Threshold UCC< \ Definite time**.



General characteristic of the minimum DC voltage function - 27CC(80.S)

Logical block (Block1)

If parameter *UCC<BLK1* is set to ON and an input is configured with the block function, the respective threshold is blocked for a time equal to the operating time for the logical input itself. In particular, the trip timer is held in the reset condition, so that the trip timer only starts counting when the block signal expires.
The enable parameter can be set in the menu **Set \ Protections \ Direct undervoltage - 27CC \ Threshold UCC< \ Parameters**, while the block function is mapped to the input in the menu **Set \ Input board inputs \ Input IN1-1, (Input IN1-x).**

Maximum directional active power - 32P

Measurement criterion

The protection calculates the active power P using the formula:

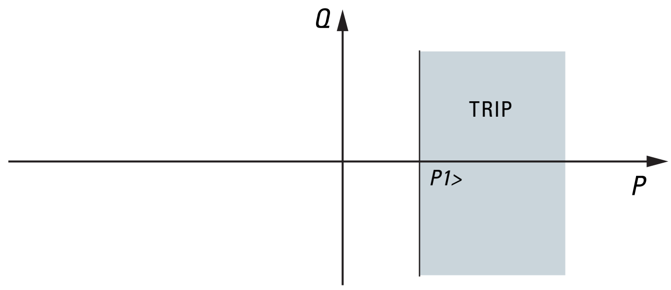
$$P=U_{L1}I_{L1}\cos\phi_{L1}+U_{L2}I_{L2}\cos\phi_{L2}+U_{L3}I_{L3}\cos\phi_{L3}$$

where U_{L1}, U_{L2}, U_{L3} are the fundamental components of the three phase voltages measured by the TVs on the generator side, I_{L1}, I_{L2}, I_{L3} are the fundamental components of the three phase currents, $\cos\phi_{L1}$, $\cos\phi_{L2}$, $\cos\phi_{L3}$ are the power factors of the three phases and ϕ_{L1}, ϕ_{L2}, ϕ_{L3}, are the phase shifts of the phase currents I_{L1}, I_{L2}, I_{L3} relative to the phase voltages U_{L1}, U_{L2}, U_{L3} respectively, considered conventionally positive with the currents delayed relative to the voltages.
If the current I_{L2} is not available, it is reconstructed vectorially.
For the active power sign conventions, refer to the insertion diagram.

Regulations

The protection is enabled at start and trip according to the trip direction settings, which are programmed independently for the two thresholds.
Trip direction setting: *Direct* (Forward):

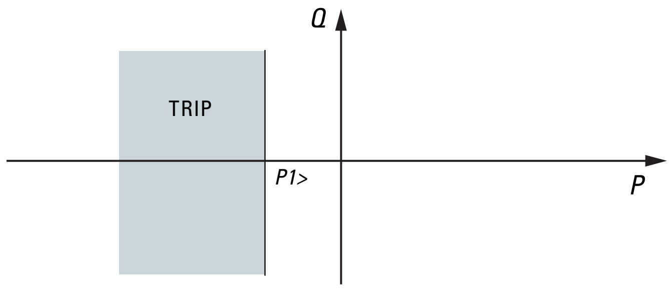
Trip direction setting: P Positive



Trip characteristic of the threshold P1> of the Directional active overpower function (32P)

Trip direction setting: *Inverse* (Reverse):

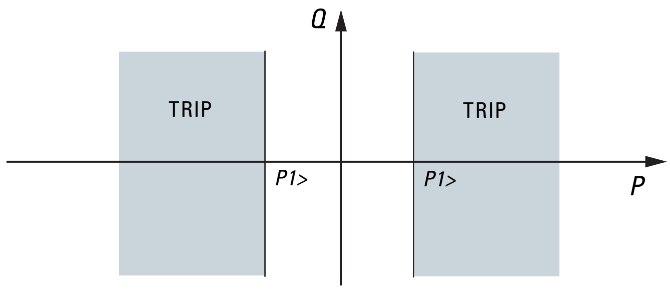
Trip direction setting: P Negative



Trip characteristic of the threshold P1> of the Directional active overpower function (32P)

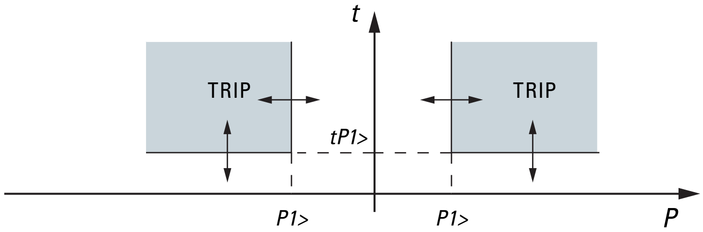
Trip direction setting: Direct/*Inverse* (Forward/Reverse):

Trip direction setting: P Positive/Negative



Trip characteristic of the threshold P1> of the Directional active overpower function (32P)

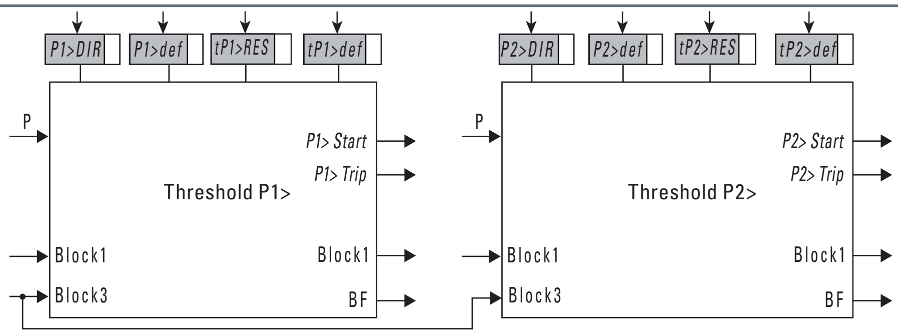
The function has two adjustable trip thresholds (P_1>, P_2>) which can be also be delayed (t_{P1}>, t_{P2}>), with definite time characteristics.



General characteristic of the operating time for the first threshold of the directional active maximum function (32P)

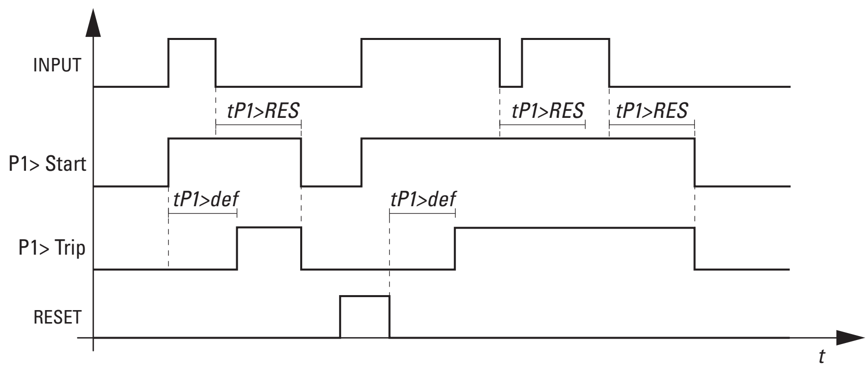
Operating logic

When the measured active power exceeds the set threshold, the threshold itself starts (Start) and the timer starts counting. If the condition persists, when the operating time expires, the threshold trips (Trip), otherwise the threshold is reset.



General functional diagram of the Directional active overpower function (32P)

Each threshold can be enabled or disabled.
An adjustable reset time can be set for each of the two thresholds ($t_{P1>RES}$, $t_{P2>RES}$).



Timers for the first threshold of the active directional maximum power protection - 32P

Logical block (Block1)

If a logical input is configured with a logical block function and one or more thresholds of function 32P are enabled for that block (*P1>BLK1* and/or *P2>BLK1*), the corresponding threshold is blocked for the activation duration of the logical input itself. The trip timer is held in reset, so that the trip time count starts only when the block signal expires.[1]
The enable parameters can be set in **Set \ Protections \ Directional active overpower - 32P \ Threshold P1, Threshold P2 > \ Parameters**, while the logical block is assigned to the input in the menu **Set \ Input board inputs \ Input IN1-1, (Input IN1-x)**.

Functional block (Block3)

If the voltmetric measurement chain fails (function 74VT tripped) or amperometric measurement chain fails (function 74CT tripped), all thresholds of protection 32P are blocked.

Note 1 For details, refer to the paragraph describing the MONITORING AND CONTROL FUNCTIONS *"Logical block (Block1)"*

— Negative sequence overcurrent - 46

Preface

The protection against unbalanced loads calculates the negative sequence current I_2 from the measured phase currents; the function has two settable thresholds with programmable trip time.
The trip characteristic for the two thresholds can be selected with definite or inverse time per IEC 60255-3/BS142.
A constant reset time can be set for each threshold, to reduce the time for eliminating intermittent faults (while being no less than the protection start time).
Each protection threshold can be enabled or disabled.
The first threshold can be inhibited by the start of the second threshold.

Measurement criterion

The protection calculates the negative sequence current I_2 from the values of the three phase current phasors I_{L1}, I_{L2}, I_{L3} using the formula:

$$I_2=(I_{L1}+e^{-j120°}\cdot I_{L2}+e^{+j120°}\cdot I_{L3})/3$$

where $e^{-j120°}=-1/2-j\sqrt{3}/2$, $e^{j120°}=-1/2+j\sqrt{3}/2$.

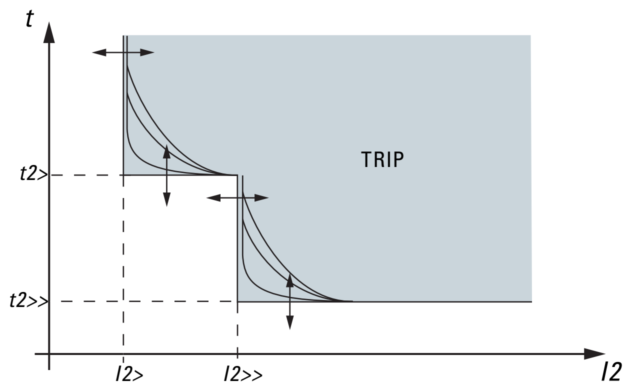
Operation and settings

The negative sequence current I_2 is compared with the set thresholds ($I_2>$, $I_2>>$); exceeding a threshold starts it (START) and starts the respective timer count ($t_2>$, $t_2>>$). If the threshold violation persists, when its trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.
The trip characteristic for the two thresholds can be selected with definite or inverse time per the following characteristic curves (symbology for the first threshold):

- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_2>_{inv} / [(I_2/I_2>_{inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_2>_{inv} / [(I_2/I_2>_{inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_2>_{inv} / [(I_2/I_2>_{inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_2>_{inv} / [(I_2/I_2>_{inv})^2 - 1]$

Where:

t:	operating time
$I_2>$:	trip threshold
$t_2>_{inv}$:	operating time regulation



Trip characteristic of the two thresholds of the negative sequence overcurrent protection - 46

The following applies to all inverse time characteristics:
- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshold regulation exceeds 2.5 I_n, the upper limit of the measurement range is 40 I_n.
- The minimum operating time t is 0.1 s.
- For definite time trip characteristics, the upper limit of the measurement range is 30 I_n.

Each protection threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *I2> Enable* and/or *I2>> Enable* in the menu **Set \ Protections \ Negative sequence overcurrent - 46 \ Threshold I2> (Threshold I2>>) \ Parameters**.
The characteristic can be set to definite or inverse time with *I2>Curve, I2>>Curve* (*DEFINITE, NIT, VIT, EIT, LIT*) in the menu **Set \ Protections \ Negative sequence overcurrent - 46 \ Threshold I2> (Threshold I2>>) \ Parameters**.

Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

The first threshold (I_2>) can be inhibited by the start of the second threshold (I_2>>) with the parameter deactivation I2> from start I2>> (*I2>disbyI2>>*) in the menu **Set \ Protections \ Negative sequence overcurrent - 46 \ Threshold I2>> \ Parameters**.

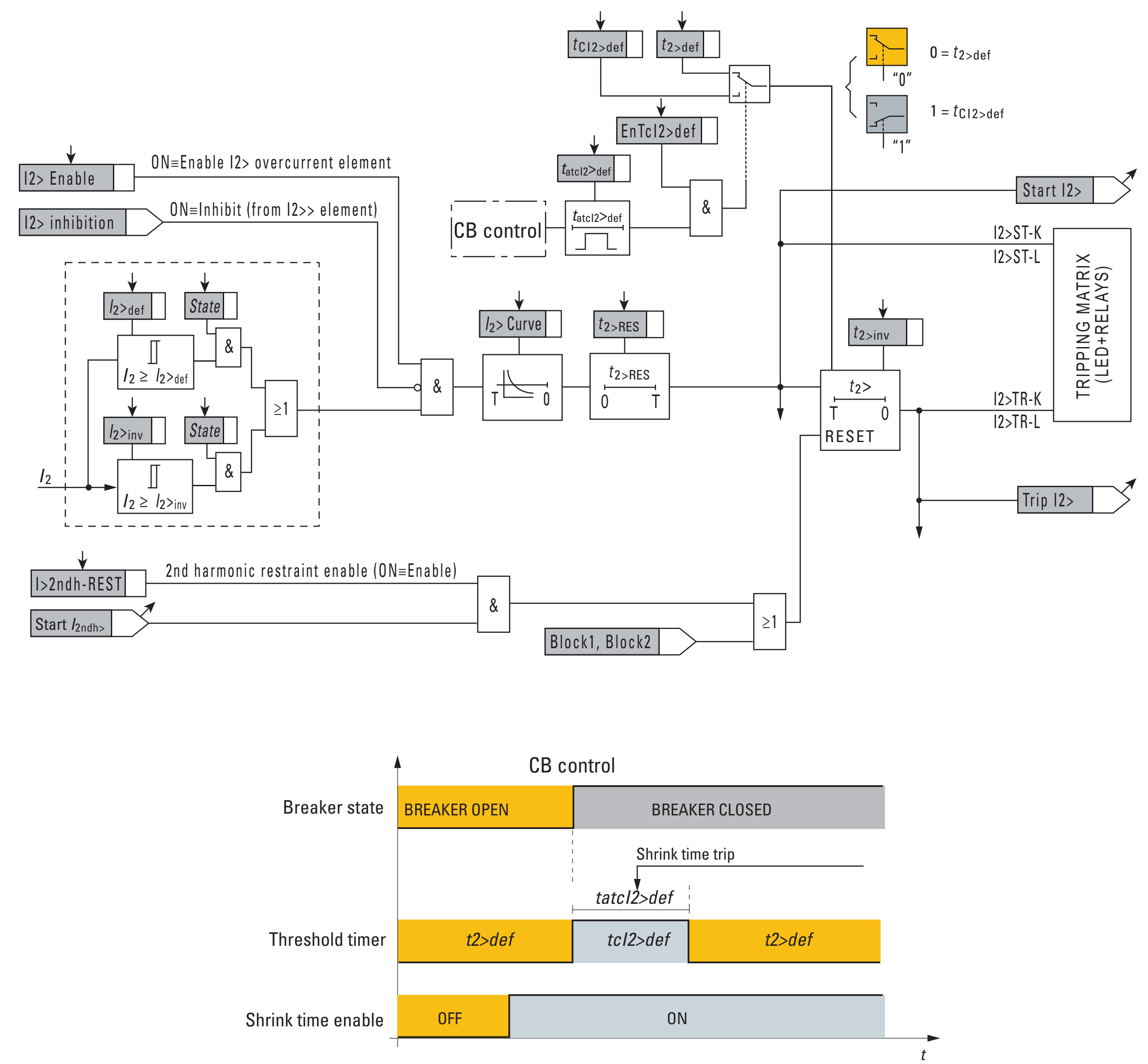
A constant reset time can be set for each of the two thresholds (t_2>RES, t_2>>RES).

Shrink time

For each of the two programmed thresholds with definite time characteristic you can set the contracted time by setting to *ON* the parameter *EnTcI2>def* and *EnTcI2>>def* and regulate the contracted time (*tcI2>def* and *tcI2>>def*) and the related operating time (*tatcI2>def* and *tatcI2>>def*).
Once the breaker closes, during the operating time (e.g.: *tatcI2>def*), the value of the trip time (e.g.: *t2>def*) is replaced by the contracted time (e.g.: *tcI2>def*); when the operating time expires the trip time is reset (e.g.: *t2>def*).
The related parameters are available in the menu **Set \ Protections \ Negative sequence overcurrent - 46 \ Threshold I2> (Threshold I2>>) \ Definite time**.

Second harmonic restraint

For each threshold, a second harmonic restraint block can be set by setting to *ON* the parameter *I2>2ndh-REST, I2>>2ndh-REST*.
The related parameters are available in the menu **Set \ Protections \ Negative sequence overcurrent - 46 \ Threshold I2> (Threshold I2>>) \ Parameters.**.



Functional diagram of the first threshold of the Negative sequence overcurrent protection (46)

Fun-F46M_S1.ai

— Overcurrent - 50/51

Preface

This function has four adjustable thresholds with programmable trip time.
The trip characteristics for thresholds *I*>, *I*>> and *I*>>>> can be selected with definite or inverse time per IEC 60255-3/BS142
The trip characteristic for threshold *I*>>> is definite time.
A constant reset time can be set for each threshold, to reduce the time for eliminating intermittent faults (while being no less than the protection start time).
Each protection threshold can be enabled or disabled.
The first threshold *I*> can be inhibited when at least one of the three thresholds starts, just as the second threshold can be inhibited when the third threshold starts and the third when the fourth starts.

Operation and settings

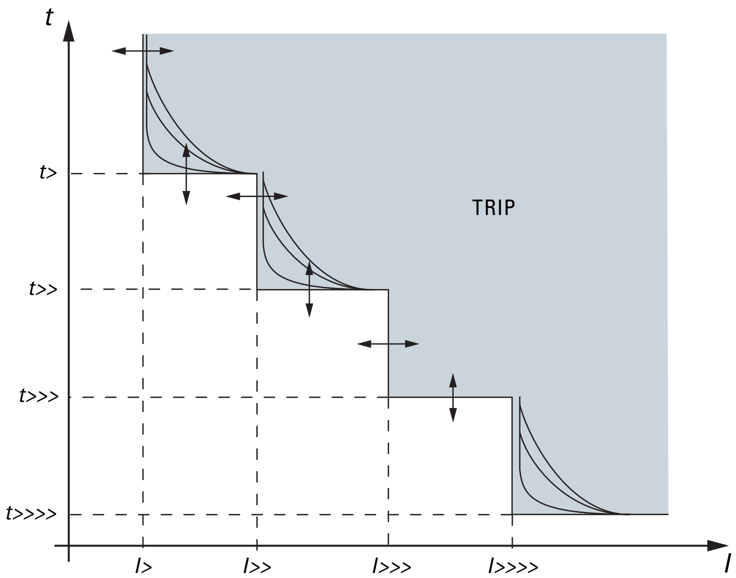
The overcurrent protection compares the fundamental component of each of the three phase currents (I_{L1}, I_{L2}, I_{L3}) with the set thresholds; if current I_{L2} is not available (input C2 dedicated to the measurement of I_{SOL} or I_E) the value of I_{L2} is forced to zero.
Violating a threshold of at least one of the three phase currents starts (START) the threshold in question along with the related timer. If the threshold violation persists, when its trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.
The trip characteristic for the thresholds *I*>, *I*>> e *I*>>>> can be selected with definite or inverse time per the following characteristic curves (symbology for the first threshold):

- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_{>inv} / [(I/I_{>inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_{>inv} / [(I/I_{>inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_{2>inv} / [(I/I_{>inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_{>inv} / [(I/I_{>inv})^2 - 1]$

Where:

t:	operating time
I>:	trip threshold
$t_{>inv}$:	operating time regulation

The trip characteristic for threshold *I*>>> is definite time.



Trip characteristic of the thresholds of the overcurrent protection - 50/51

The following applies to all inverse time characteristics:
- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshold regulation exceeds 2.5 I_n, the upper limit of the measurement range is 40 I_n.
- The minimum operating time *t* is 0.1 s.
- For definite time trip characteristics, the upper limit of the measurement range is 40 I_n.

Each threshold of the protection can be enabled or disabled by setting to *ON* or *OFF* the parameter *I> Enable*, *I>> Enable* and/or *I>>> Enable* in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I> (Threshold I>>, Threshold I>>>, Threshold I>>>>) \ Parameters**.

Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

The first threshold can be set to definite or inverse time with parameter *I>Curve* (*DEFINITE, NIT, VIT, EIT, LIT*) in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I> \ Parameters**.
The second threshold can be set to definite or inverse time with parameter *I>>Curve* (*DEFINITE, NIT, VIT, EIT, LIT*) in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I>> \ Parameters**.
The fourth threshold can be set to definite or inverse time with parameter *I>>>>Curve* (*DEFINITE, NIT, VIT, EIT, LIT*) in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I>> \ Parameters**.

The first threshold I> can be inhibited when at least one of the thresholds I>>, I>>>, I>>>> starts using the Deactivation I> by start I>>, Deactivation I> by start I>>>, Deactivation I> by start I>>>> (*I>disbyI>>, I>disbyI>>>, I>disbyI>>>>*) in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I>>, Threshold I>>>, Threshold I>>>> \ Parameters**.
In the same way, the second threshold I>> can be inhibited by the start of thresholds I>>> and I>>>> by Deactivation I>> by start I>>>, Deactivation I>> by start I>>>> (*I>>disbyI>>, I>>disbyI>>>, I>>disbyI>>>>*) in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I>>>, Threshold I>>>> \ Parameters**.
In the same way, the third threshold I>>> can be inhibited by the start of the fourth threshold I>>> with Deactivation I>> by start I>>> (*I>>disbyI>>,*) in the menu **Set \ Protections \ Overcurrent -50/51 \ Threshold I>>>> \ Parameters**.

A constant reset time can be set for each of the thresholds (*t*>RES, *t*>>RES, *t*>>>RES, *t*>>>>RES).

Shrink time

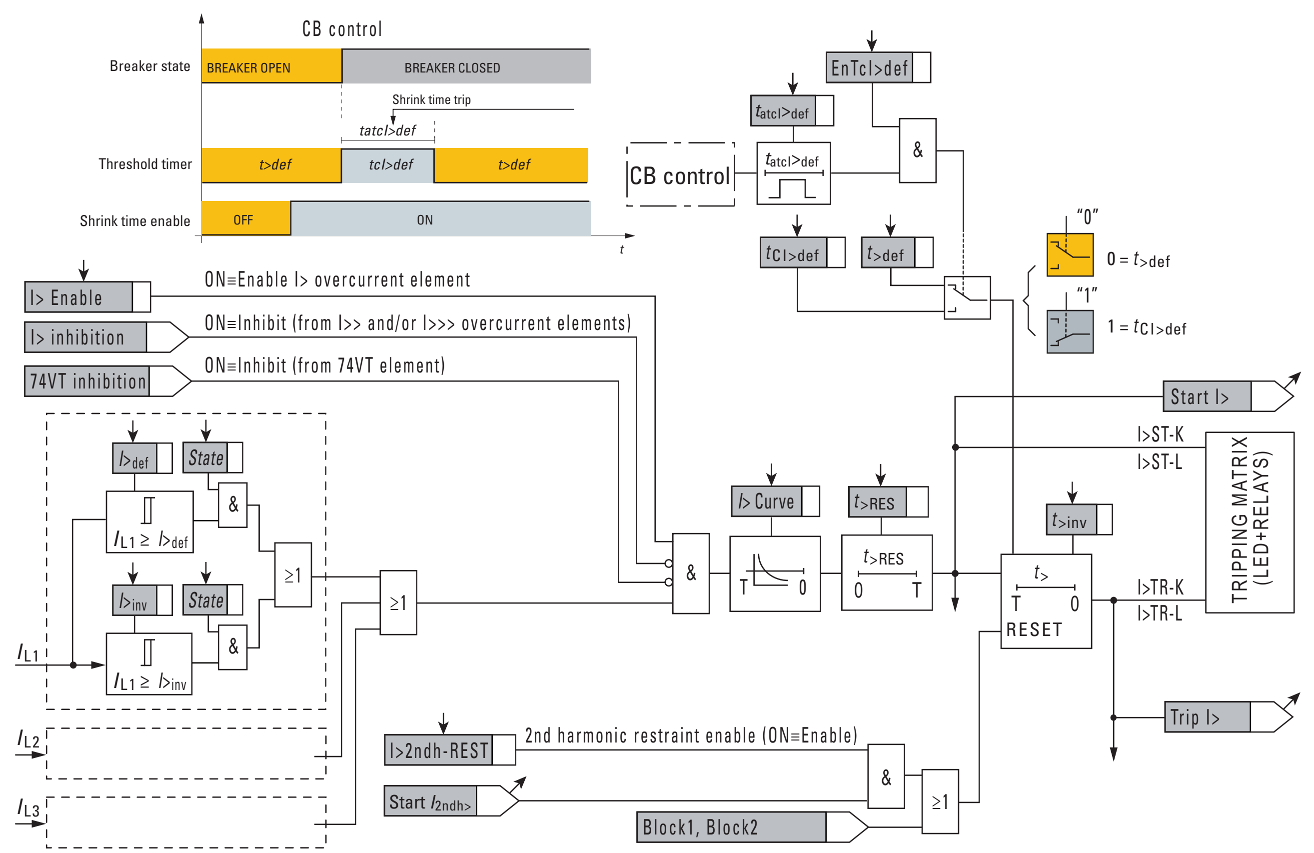
For each of the thresholds programmed with definite time characteristic, you can select contracted time by setting to *ON* the parameter *EnTcI>def, EnTcI>>def, EnTcI>>>def, EnTcI>>>>def* and adjusting the contracted time (*tcI>def, tcI>>def, tcI>>>def, tcI>>>>def*) and operating time (*tatcI>def, tatcI>>def, tatcI>>>def, tatcI>>>>def*). When the breaker closes, during the operating time (e.g.: *tatcI>def*), the value of the trip time (e.g.: *t>def*) is replaced by the contracted time (e.g.: *tcI>def*); when the operating time expires the trip time is reset (e.g.: *t>def*).
The parameters are available in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I> (Threshold I>>, Threshold I>>>, Threshold I>>>>) \ Definite time**.

Second harmonic restraint

For each threshold, a second harmonic restraint block can be set by setting to *ON* the parameter *I>2ndh-REST, I>>2ndh-REST, I>>>2ndh-REST, I>>>>2ndh-REST*. The parameters are available in the menu **Set \ Protections \ Overcurrent - 50/51 \ Threshold I> (Threshold I>>, Threshold I>>>, Threshold I>>>>) \ Parameters.**

Functional block (Block3)

If the amperometric measurement chain fails (function 74CT tripped), all thresholds of protection 51 are blocked.



Functional diagram of the first threshold (I>) of the overcurrent function 50/51

— Residual overcurrent - 50N/51N

Preface

This function has three adjustable thresholds with programmable trip time.
The trip characteristic for the first threshold can be selected with definite or inverse time per IEC 60255-3/BS142.
The trip characteristic for the second and third thresholds is definite time.
A constant reset time can be set for each threshold, to reduce the time for eliminating intermittent faults (while being no less than the protection start time).
Each protection threshold can be enabled or disabled.
The first threshold can be inhibited when at least one of the two thresholds starts, just as the second threshold can be inhibited when the third threshold starts.

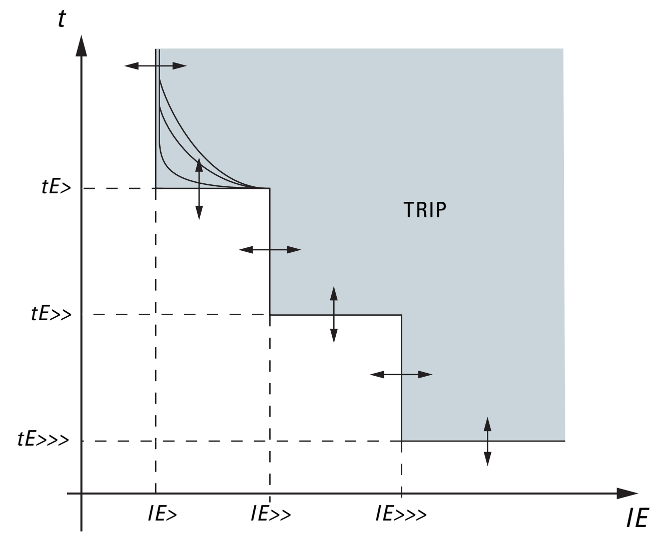
Operation and settings

The residual overcurrent protection compares the fundamental component of the residual current (I_E) with the set thresholds ($I_{E>}$, $I_{E>>}$, $I_{E>>>}$); violating a threshold starts (START) the threshold itself and the corresponding timer ($t_{E>}$, $t_{E>>}$, $t_{E>>>}$). If the threshold violation persists, when its trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.
The first threshold $I_{E>}$ can be set to definite or inverse time with the following characteristic curves:

- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_{E>inv} / [(I_E/I_{E>inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_{E>inv} / [(I_E/I_{E>inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_{E>inv} / [(I_E/I_{E>inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_{E>inv} / [(I_E/I_{E>inv})^2 - 1]$

Where:

t:	operating time
$I_{E>}$:	trip threshold
$t_{E>inv}$:	operating time regulation



Trip characteristic of the three thresholds of the residual overcurrent protection - 50N/51N

The following applies to all the above inverse time characteristics:

- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The minimum operating time t is 0.1 s.
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshodl regulation exceeds 2.5 I_n, the upper limit of the measurement range is 10 I_{En}.

For definite time trip characteristics, the upper limit of the measurement range is 10 I_{En}.

Each threshold of the protection can be enabled or disabled by setting to *ON* or *OFF* the parameter *IE> Enable*, *IE>> Enable* and/or *IE>>> Enable* in the menu **Set \ Protections \ Residual overcurrent - 50N/51N \ Threshold IE>** (**Threshold IE>>**, **Threshold IE>>>**) **\ Parameters**.

The first threshold can be set to definite or inverse time with parameter *IE>Curve* (*DEFINITE, NIT, VIT, EIT, LIT*) in the menu **Set \ Protections \ Overcurrent - 50N/51N \ Threshold IE> \ Parameters**.

Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

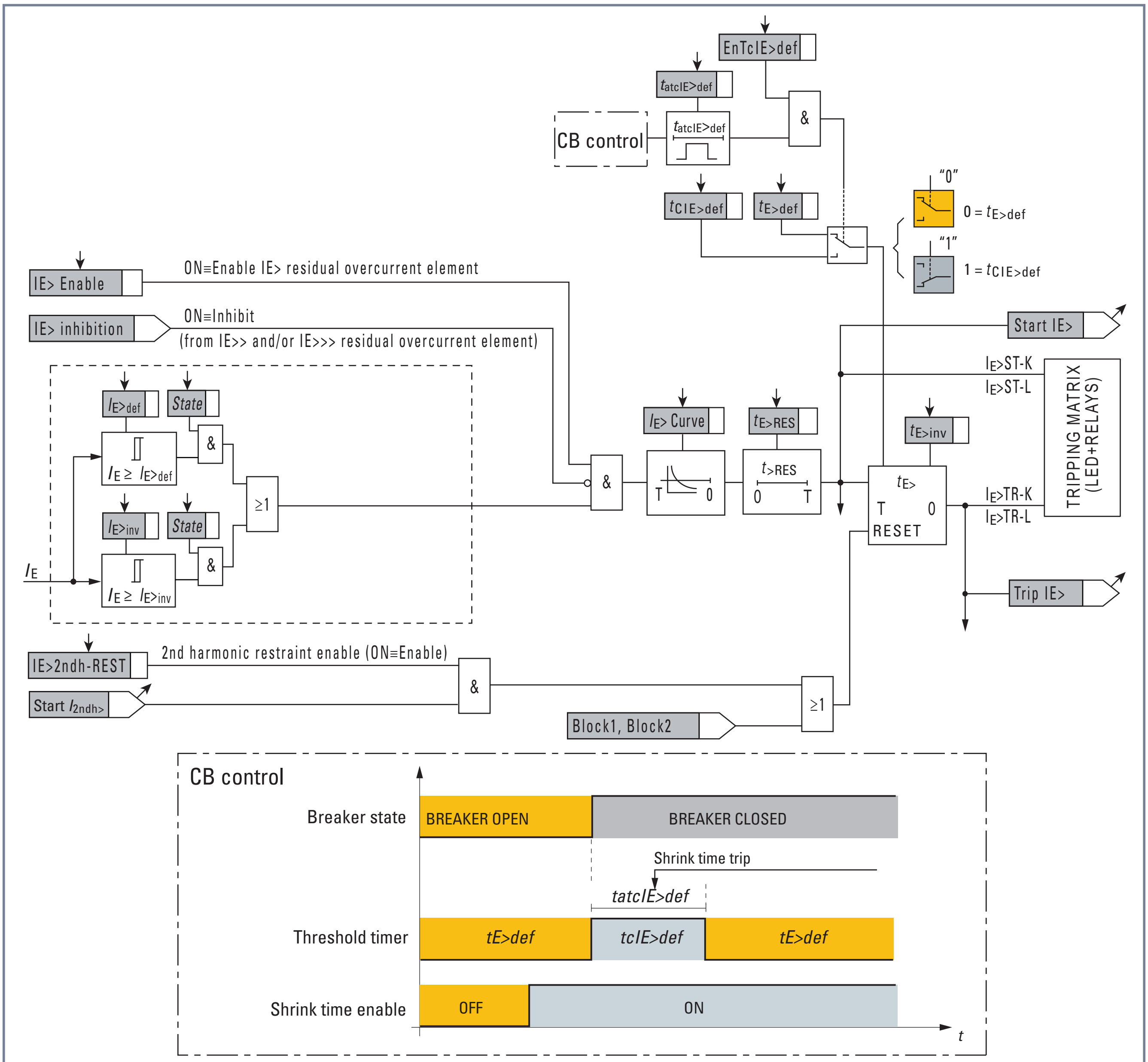
The first threshold IE> can be inhibited by the start of at least one of the two thresholds IE>>, IE>>> with Deactivation IE> by start IE>>, Deactivation IE> by start IE>>> (*IE>disbyIE>>, IE>disbyIE>>>*) in the menu **Set \ Protections \ Residual overcurrent - 50N/51N \ Threshold IE>>, Threshold IE>>>\ Parameters**.
In the same way, the second threshold IE>> can be inhibited by the start of the third threshold IE>>> with Deactivation IE>> by start IE>>> (*IE>>disbyIE>>>*) in the menu **Set \ Protections \ Residual overcurrent - 50N/51N \ Threshold IE>>>\ Parameters.**.
A constant reset time can be set for each of the thresholds ($t_{E>RES}$, $t_{E>>RES}$, $t_{E>>>RES}$).

Shrink time

For each of the thresholds programmed with definite time characteristic, you can select contracted time by setting to *ON* the parameter *EnTcIE>def, EnTcIE>>def, EnTcIE>>>def* and regulating the contracted time (*tcIE>def, tcIE>>def, tcIE>>>def*) and operating time (*tatcIE>def, tatcIE>>def, tatcIE>>>def*).
Once the breaker closes, during the operating time (e.g.: *tatcIE>def*), the value of the trip time (e.g.: *tE>def*) is replaced by the contracted time (e.g.: *tcIE>def*); when the operating time expires the trip time is reset (e.g.: *tE>def*).
The parameters are available in the menu **Set \ Protections \ Residual overcurrent - 50N/51N \ Threshold IE> (Threshold IE>>, Threshold IE>>>) \ Definite time**.

Second harmonic restraint

For each of the three thresholds ($I_{E>}$, $I_{E>>}$, $I_{E>>>}$) you can set a second harmonic restraint block by setting to *ON* the parameter *IE>2ndh-REST, IE>>2ndh-REST, IE>>>2ndh-REST*.
The parameters are available in the menu **Set \ Configuration parameters A(or B) \ Residual overcurrent - 50N/51N \ Threshold IE> (Threshold IE>>, Threshold IE>>>) \ Parameters.**



Functional diagram of the first threshold (IE>) of the residual overcurrent function 50N/51N

Fun_50N-51NS1.ai

— Neutral overcurrent - 51(E)

Preface

This function has two adjustable thresholds with programmable trip time.
The trip characteristic for the first threshold can be selected with definite or inverse time per IEC 60255-3/BS142.
The trip characteristic for the second threshold is definite time.
A constant reset time can be set for each threshold, to reduce the time for eliminating intermittent faults (while being no less than the protection start time).
Each protection threshold can be enabled or disabled.
The first threshold can be inhibited by the start of the second threshold.

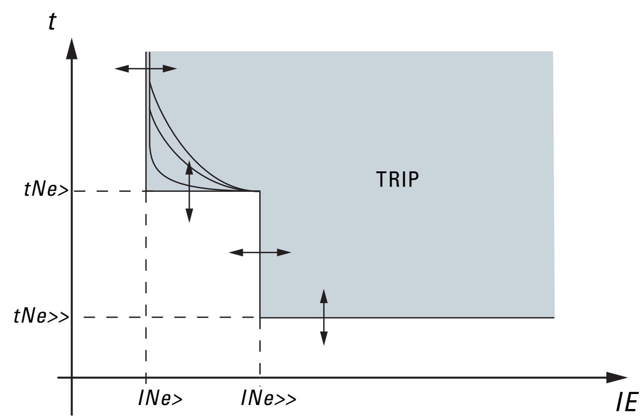
Operation and settings

The residual overcurrent protection compares the fundamental component of the residual current (I_E) with the set thresholds ($I_{Ne}>$, $I_{Ne}>>$); violating a threshold starts (START) the threshold itself and the corresponding timer ($t_{ne}>$, $t_{ne}>>$). If the threshold violation persists, when its trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.
The first threshold $I_E>$ can be set to definite or inverse time with the following characteristic curves:

- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_{Ne>inv} / [(I_E/I_{Ne>inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_{Ne>inv} / [(I_E/I_{Ne>inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_{Ne>inv} / [(I_E/I_{Ne>inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_{Ne>inv} / [(I_E/I_{Ne>inv})^2 - 1]$

Where:

t:	operating time
$I_{Ne}>$:	trip threshold
$t_{Ne>inv}$:	operating time regulation



Trip characteristic of the thresholds of the neutral overcurrent protection - 51N(E)

The following applies to all inverse time characteristics:

- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The minimum operating time t is 0.1 s.
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshodl regulation exceeds 2.5 I_n, the upper limit of the measurement range is 10 I_{En}.

For definite time trip characteristics, the upper limit of the measurement range is 10 I_{En}.

Each threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *INe> Enable*, *INe>> Enable* in the menu **Set \ Protections \ Neutral overcurrent - 51N(E) \ Threshold INe> (Threshold INe>>) \ Parameters**.

The first threshold can be set to definite or inverse time with parameter *INe>Curve* (*INDIPENDENTE, NIT, VIT, EIT, LIT*) in the menu **Set \ Portections \ Neutral overcurrent - 51N(E) \ Threshold INe> \ Parameters**.

In the same way, the first threshold can be inhibited by the start of the second threshold with Deactivation INe> by start INe>> (*INe>>disbyIE>>*) in the menu **Set \ Protections \ Neutral overcurrent - 50N/51N \ Threshold IE>>> \ Parameters**.

A constant reset time can be set for each of the two thresholds $t_{Ne>RES}$, $t_{Ne>>RES}$.

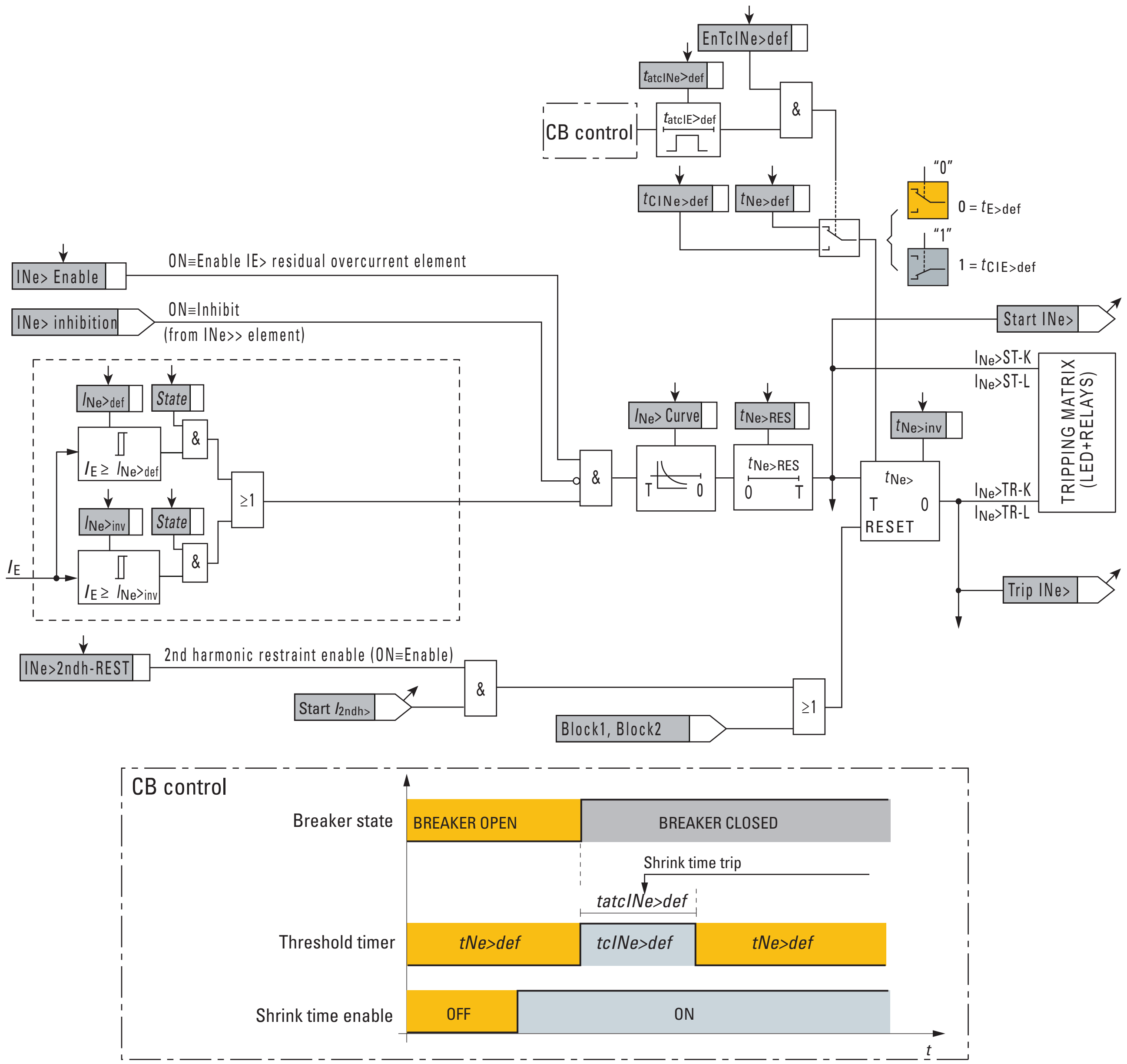
Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

Shrink time

For each of the programmed thresholds with definite time characteristic you can set the contracted time by setting to *ON* the parameter *EnTcINe>def*, *EnTcINe>>def* and regulating the contracted time (*tcINe>def, tcINe>>def*) and operating time (*tatcINe>def, tatcINe>>def*). Once the breaker closes, during the operating time (e.g.: *tatcINe>def*), the value of the trip time (e.g.: *tNe>def*) is replaced by the contracted time (e.g.: *tcINe>def*); when the operating time expires the trip time is reset (e.g.: *tNe>def*).
The related parameters are available in the menu **Set \ Protections \ Neutral overcurrent - 51N(E) \ Threshold INe> (Threshold INe>>) \ Definite time**.

Second harmonic restraint

For each of the thresholds (I_{Ne}>, I_{Ne}>>) you can set a second harmonic restraint block by setting to *ON* the parameter *INe>2ndh-REST, INe>>2ndh-REST*.
The related parameters are available in the menu **Set \ Configuration parameters A(or B) \ Neutral overcurrent - 51N(E) \ Threshold INe> (Threshold INe>>) \ Parameters**.



Functional diagram of the first threshold of the neutral overcurrent function 51N(E)

— Residual emergency overcurrent - 51(Eme)

Preface

This function has one adjustable threshold with programmable trip time.
The trip characteristic can be selected with definite or inverse time per IEC 60255-3/BS142.
A constant reset time can be set to reduce the time for eliminating intermittent faults (while being no less than the protection start time).
The threshold can be enabled or disabled; the function is automatically enabled if the voltmetric measurement chain fails (function 74VT tripped).

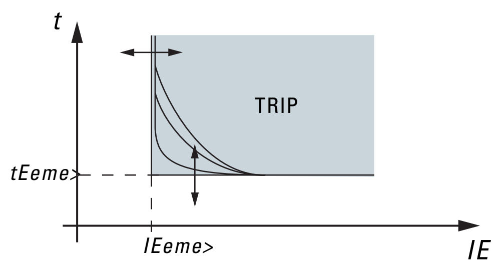
Operation and settings

The residual overcurrent protection compares the fundamental component of the residual current (I_E) with the set threshold (I_{Eeme}>); violating the threshold starts (START) the threshold itself and the corresponding timer (t_{Eeme}>). If the threshold violation persists, when its trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.
The threshold can be set to definite or inverse time with the following characteristic curves:

- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_{Eeme>inv} / [(I_E/I_{Eeme>inv})^2 - 1]$

Where:

t:	operating time
$I_{Eeme>}$:	trip threshold
$t_{Eeme>inv}$:	operating time regulation



Trip characteristic of the threshold of the maximum emergency residual current protection - 51N(Eme)

The following applies to all inverse time characteristics:

- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The minimum operating time t is 0.1 s.
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshodl regulation exceeds 2.5 I_n, the upper limit of the measurement range is 10 I_{En}.

For definite time trip characteristics, the upper limit of the measurement range is 10 I_{En}.

The threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *IEeme> Enable* in the menu **Set \ Protections \ Residual emergency overcurrent - 51N(Eme) \ Threshold IEeme>** \ Parameters.

The first threshold can be set to definite or inverse time with parameter *IEeme>Curve* (*INDIPENDENTE, NIT, VIT, EIT, LIT*) in the menu **Set \ Portections \ Residual emergency overcurrent - 51N(Eme) \ Threshold IEeme> \ Parameters**.

In the same way, the first threshold can be inhibited by the start of the second threshold with Deactivation INe> by start INe>> (*INe>>disbyIE>>*) in the menu **Set \ Protections \ Residual emergency overcurrent - 51N(Eme) \ Threshold IEeme> \ Parameters**.

A constant reset time can be set for each of the thresholds $t_{Eeme>RES}$.

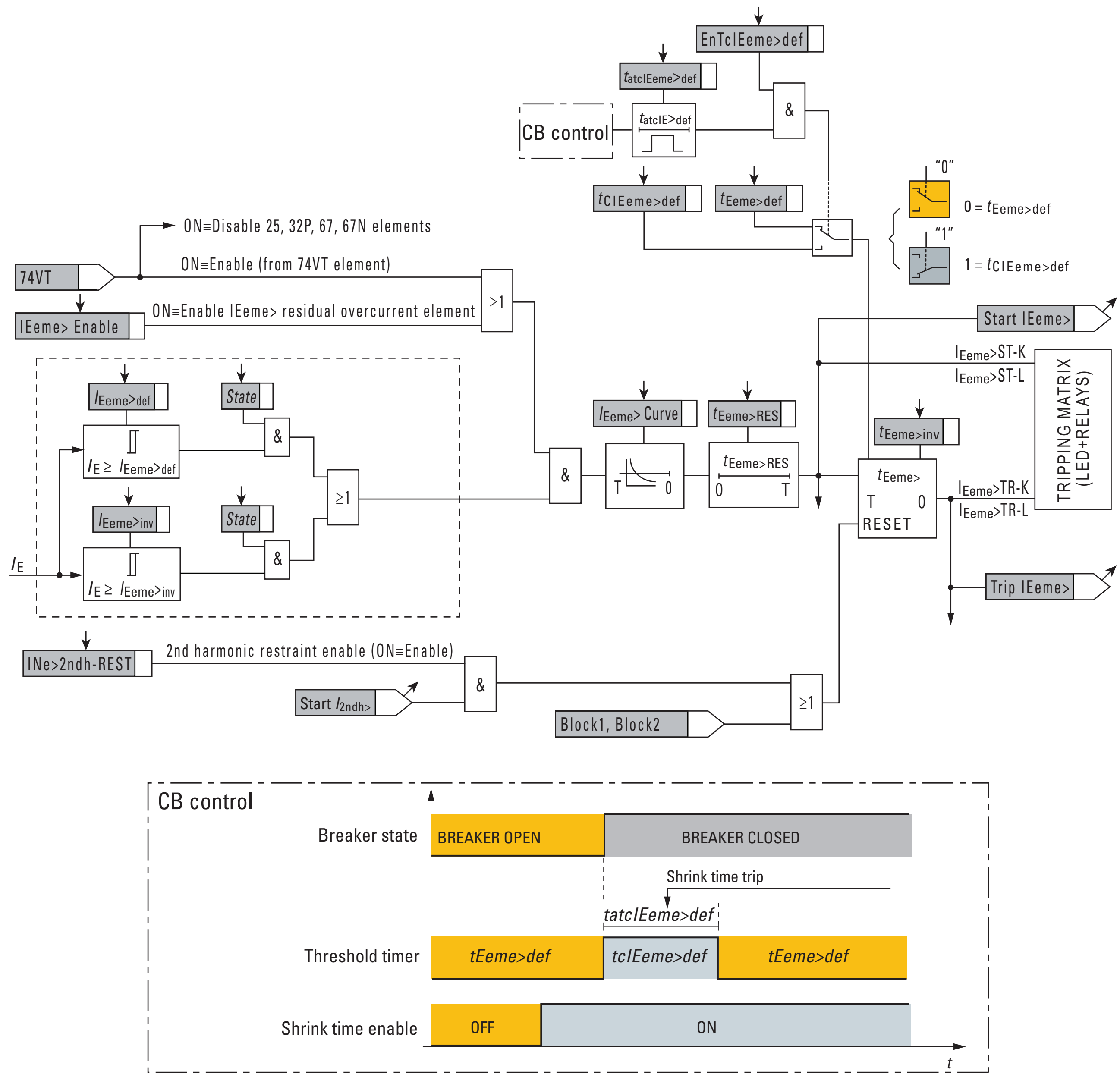
Shrink time

If the threshold is programmed with definite time characteristic you can set the contracted time by setting to *ON* the parameter *EnTcIEeme>def* and regulating the contracted time (*tcIEeme>-def*) and the operating time (*tatcIEeme>def*).
Once the breaker closes, during the operating time (e.g.: *tatcIEeme>def*), the value of the trip time (e.g.: *tEeme>def*) is replaced by the contracted time (e.g.: *tcIEeme>def*); when the operating time expires the trip time is reset (e.g.: *tEeme>def*).
The related parameters are available in the menu **Set \ Protections \ Residual emergency overcurrent - 51N(Eeme) \ Threshold IEeme>**\ Definite time.

Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

Second harmonic restraint

Asecond harmonic restraint block can be set by setting to *ON* the parameter *IEeme>2ndh-REST*.
The related parameters are available in the menu **Set \ Protections \ Residual emergency overcurrent - 51N(Eeme) \ Threshold IEeme>**\ Parameters.



Functional diagram of the threshold of the residual emergency overcurrent function 51N(Eme)

— Neutral current unbalance - 51(SQL)

Preface

Neutral unbalance current protection between the star centres of two capacitor arrays with an adjustable threshold with programmable operating time.
The trip characteristic can be selected with definite or inverse time per IEC 60255-3/BS142.
A constant reset time can be set to reduce the time for eliminating intermittent faults (while being no less than the protection start time).
The threshold can be enabled or disabled.

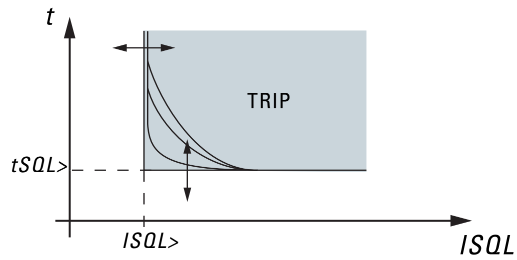
Operation and settings

The protection compares the fundamental component of the residual current (I_{SQL}) with the set threshold (I_{SQL}>); violating the threshold starts (START) the threshold itself and the corresponding timer (t_{SQL}>). If the threshold violation persists, when its trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.
The first threshold can be set to definite or inverse time with the following characteristic curves:

- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_{SQL>inv} / [(I_{SQL}/I_{SQL>inv})^2 - 1]$

Where:

t:	operating time
I_{Eeme}>:	trip threshold
$t_{Eeme>inv}$:	operating time regulation



Trip characteristic of the threshold of the neutral unbalance overcurrent protection - 51N(SQL)

The following applies to all inverse time characteristics:

- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The minimum operating time t is 0.1 s.
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshodl regulation exceeds 2.5 I_n, the upper limit of the measurement range is 10 I_{En}.

For definite time trip characteristics, the upper limit of the measurement range is 10 I_{En}.

The threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *IEeme> Enable* in the menu **Set\Protections \Residual emergency overcurrent - 51N(Eme)\Threshold IEeme>** \ Parameters.

The first threshold can be set to definite or inverse time with parameter *IEeme>Curve* (*INDIPENDENTE, NIT, VIT, EIT, LIT*) in the menu **Set\Portections \ Residual emergency overcurrent - 51N(Eme)\Threshold IEeme>\Parameters**.

In the same way, the first threshold can be inhibited by the start of the second threshold with Deactivation INe> by start INe>> (*INe>>disbyIE>>*) in the menu **Set\Protections\Residual emergency overcurrent - 51N(Eme) \Threshold IEeme>\Parameters**.

A constant reset time can be set for each of the thresholds $t_{Eeme>RES}$.

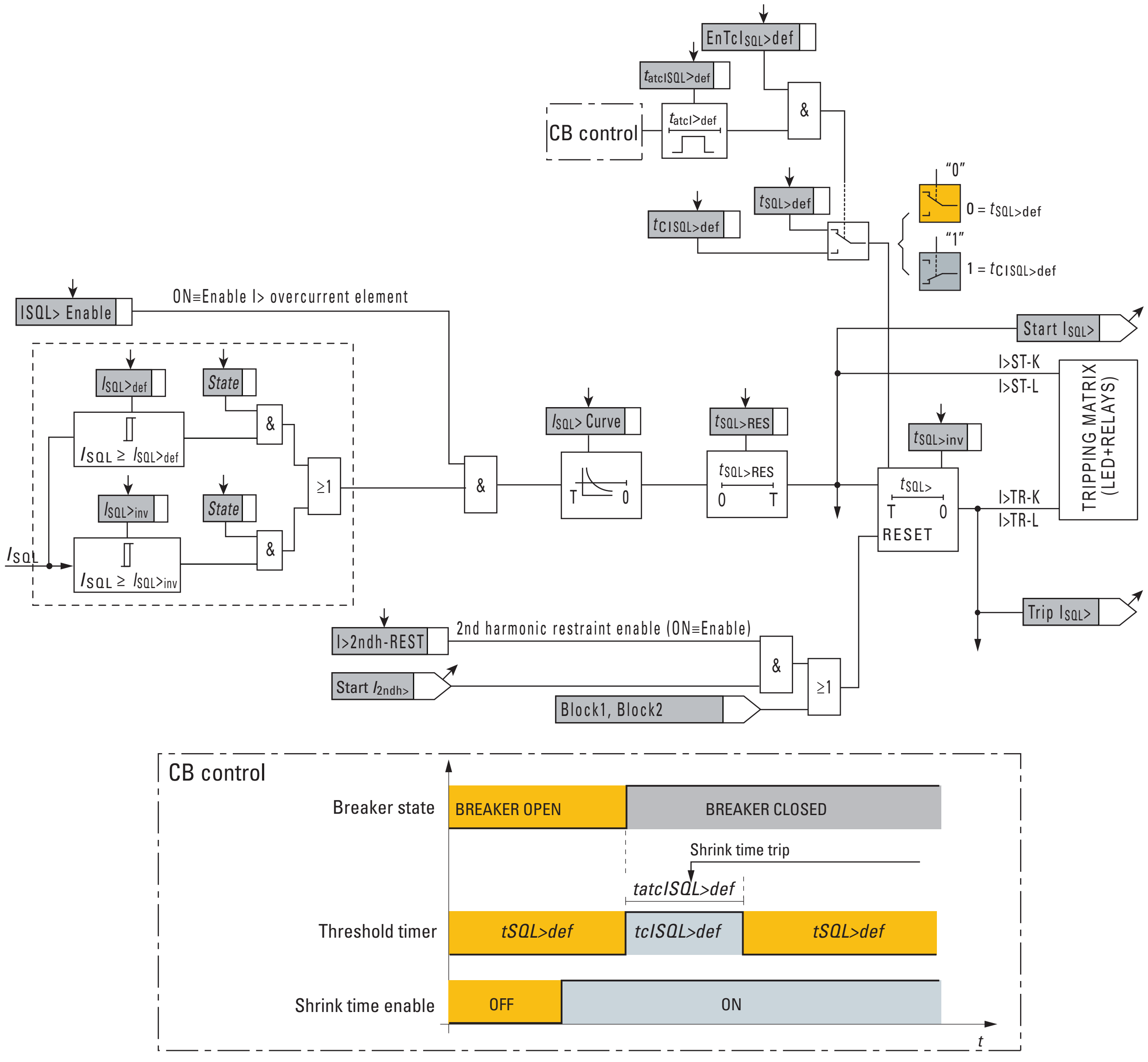
Shrink time

If the threshold is programmed with definite time characteristic you can set the contracted time by setting to *ON* the parameter *EnTcIEeme>def* and regulating the contracted time (*tcIEeme>-def*) and the operating time (*tatcIEeme>def*).
Once the breaker closes, during the operating time (e.g.: *tatcIEeme>def*), the value of the trip time (e.g.: *tEeme>def*) is replaced by the contracted time (e.g.: *tcIEeme>def*); when the operating time expires the trip time is reset (e.g.: *tEeme>def*).
The related parameters are available in the menu **Set\Protections\Residual emergency overcurrent - 51N(Eeme)\Threshold IEeme>**\ Definite time.

Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

Second harmonic restraint

Asecond harmonic restraint block can be set by setting to *ON* the parameter *IEeme>2ndh-REST*.
The related parameters are available in the menu **Set \ Protections \ Residual emergency overcurrent - 51N(Eeme) \ Threshold IEeme>**\ Parameters.



Functional diagram of the threshold of the neutral current unbalance function 51(SQL)

— Overvoltage - 59

Preface

This function has two adjustable thresholds with programmable trip time.
The trip characteristic for the first threshold can be selected with definite or inverse time per IEC 60255-3/BS142.
The trip characteristic for the second threshold is definite time.
Each protection threshold can be enabled or disabled.
The first threshold can be inhibited by the start of the second threshold.

Measurement criterion

The undervoltage protection measures the fundamental component of three voltages, selected from the three phase voltages U_{L1}, U_{L2}, U_{L3} or the three phase-to-phase voltages U_{12}, U_{23}, U_{31}, where the latter are calculated as:

$U12=|\vec{UL1}-\vec{UL2}|$

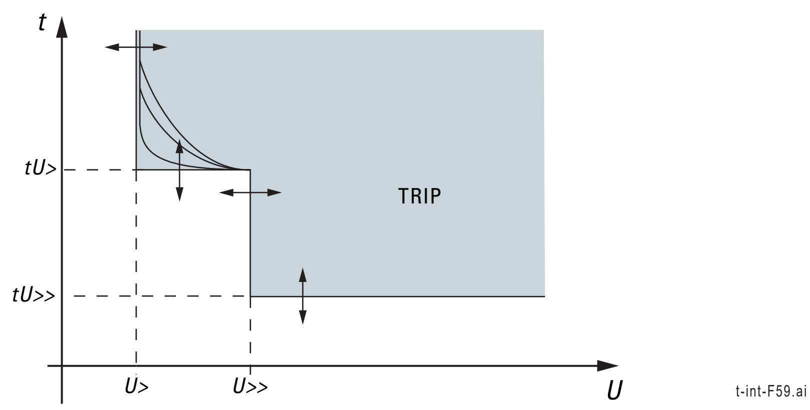
$U23=|\vec{UL2}-\vec{UL3}|$

$U31=|\vec{UL2}-\vec{UL1}|$

Operation and settings

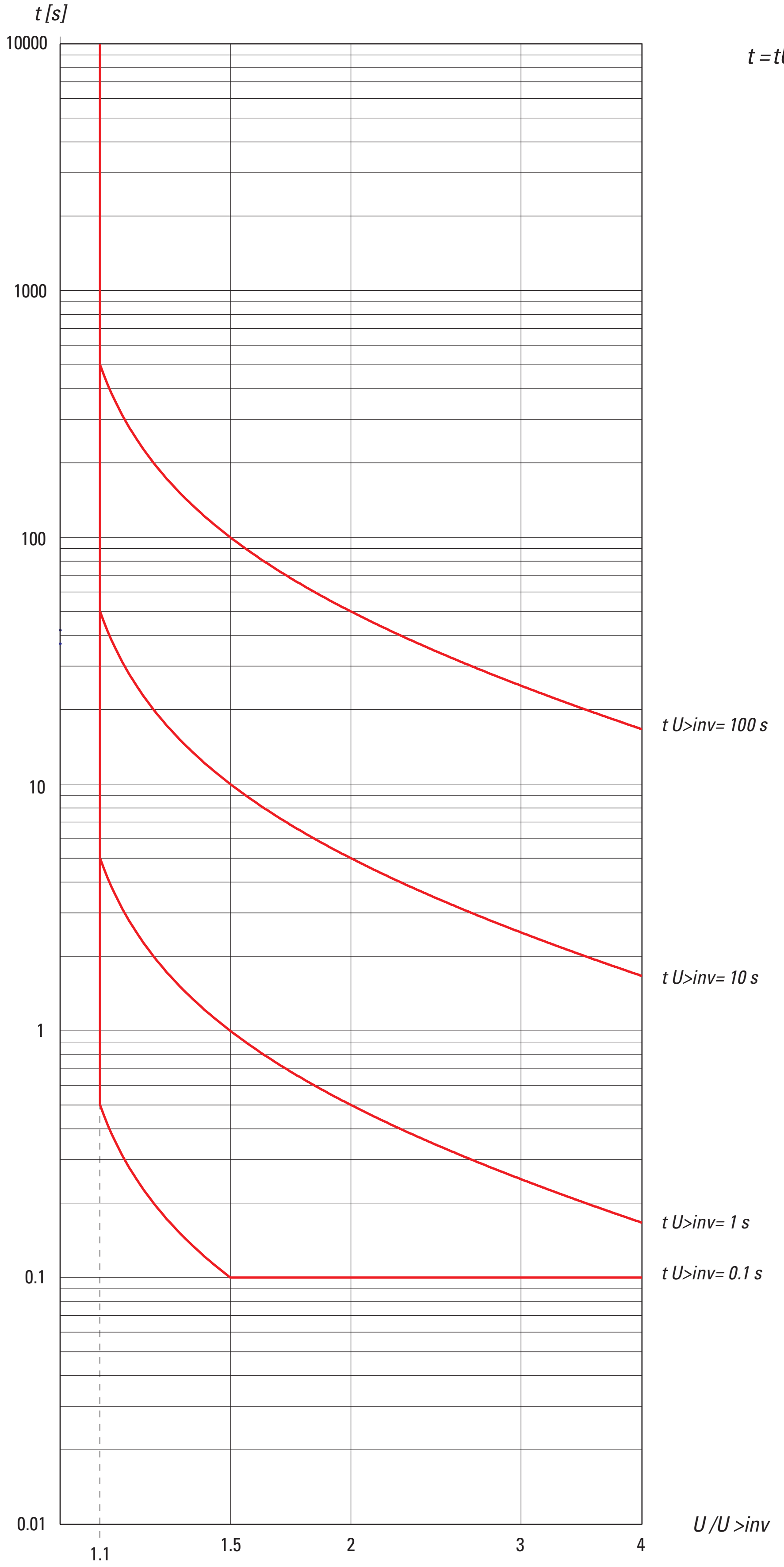
Each of the three measured voltages is compared with the set thresholds (*U*>, *U*>>). The start and trip logic for each threshold can be set to "OR" or "AND".
When set to OR, when at least one of the three measured voltages exceeds the set threshold, the threshold itself starts (Start) and the timer starts counting.
If the condition persists, when the operating time expires ($t_{U>}$, $t_{U>>}$), the threshold trips (Trip), otherwise the threshold is reset.
When set to *AND*, when all three measured voltages exceed the set threshold, the threshold itself starts (Start) and the timer starts counting.
If the condition persists, when the operating time expires ($t_{U>}$, $t_{U>>}$), the threshold trips (Trip), otherwise the threshold is reset.

The first threshold can be set to definite or inverse time with the following characteristic curves:
$t=0.5\ t_{U>inv} / [(U/U_{>inv}) - 1]$
where *t* is the operating time, *U* is the measured voltage, $U_{>inv}$ and $t_{U>inv}$ are the set threshold and trip time. The set operating time refers to a voltage of 1.5 times the set threshold. The minimum trip voltage is 1.1 times the set threshold. The characteristic is defined between 1.1 and 4 times the set threshold; if the threshold regulation exceed 0.5 U_n, the upper limit of the measurement range is 2 U_n.
The minimum operating time t is 0.1 s.
The definite or inverse time characteristic is selected with the parameter *U> Curve* in the menu **Set \ Protections \ Overvoltage - 59 \ Threshold U> \ Parameters**.
Each protection threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *U> Enable* in the menu **Set \ Protections \ Overvoltage - 59 \ Threshold U> \ Parameters** and/or *State* in the menu **Set \ Protections \ Overvoltage - 59 \ Threshold U>> \ Definite time**.



General characteristic of the operating time of the Overvoltage function (59)

The type of three-phase voltage measurement (phase voltage or phase-to-phase voltage), like the protection logic (AND or OR of the three voltages), is set in the menu **Set \ Protections \ Overvoltage - 59 \ Common configurations**, by setting parameter *Utype59;* the possible settings are *Uph-ph* (phase-to-phase) and *Uph-n* (phase).
When set to *Uph-ph* (phase-to-phase), the thresholds are expressed in p.u. Un; when set to *Uph-n* (phase), the thresholds are expressed in p.u. En.



$$t = tU{>}inv \cdot \left[\frac{0.5}{[(U/U{>}inv) - 1]} \right]$$

Note: the set operating time refers to a voltage of U/U>inv = 1.5

Inverse time trip characteristics of the first threshold of the overvoltage protection (59)

F_59-Char.ai

— Residual overvoltage - 59N

Preface

This function has two adjustable thresholds with programmable trip time.
Since only the fundamental component of the residual voltage is measured (direct or calculated), the protection is not sensitive to the components of the third harmonic and its multiples.
The trip characteristic for the first threshold can be selected with definite or inverse time per IEC 60255-3/BS142.
The trip characteristic for the second threshold is definite time.
Each protection threshold can be enabled or disabled.
The first threshold can be inhibited by the start of the second threshold.

Measurement criterion

Two separate measurements of the residual voltage are available:
- Direct.
- Calculated.

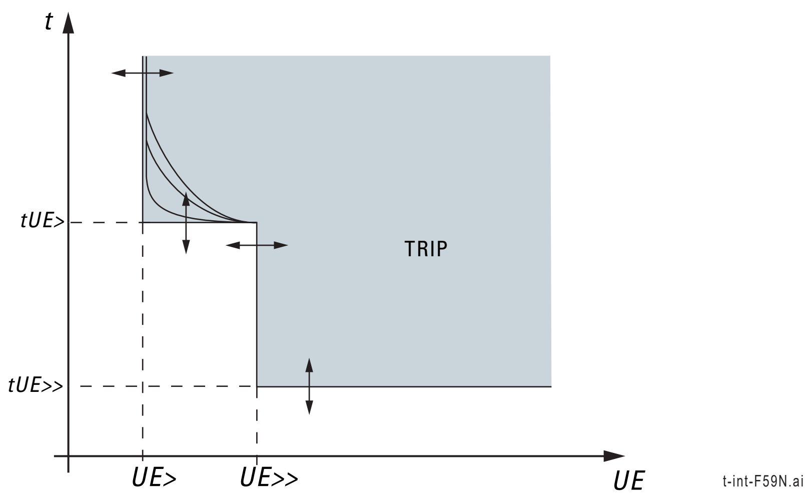
In the first case, the protection uses the fundamental component of the residual voltage U_E measured at the residual voltage input, while in the second it uses the fundamental component of the residual voltage U_{EC} resulting from the vectorial sum of the phasors of the three phase voltages measured at the voltmetric phase inputs.

$$UEC = |\vec{U}L1 + \vec{U}L2 + \vec{U}L3|$$

Operation and settings

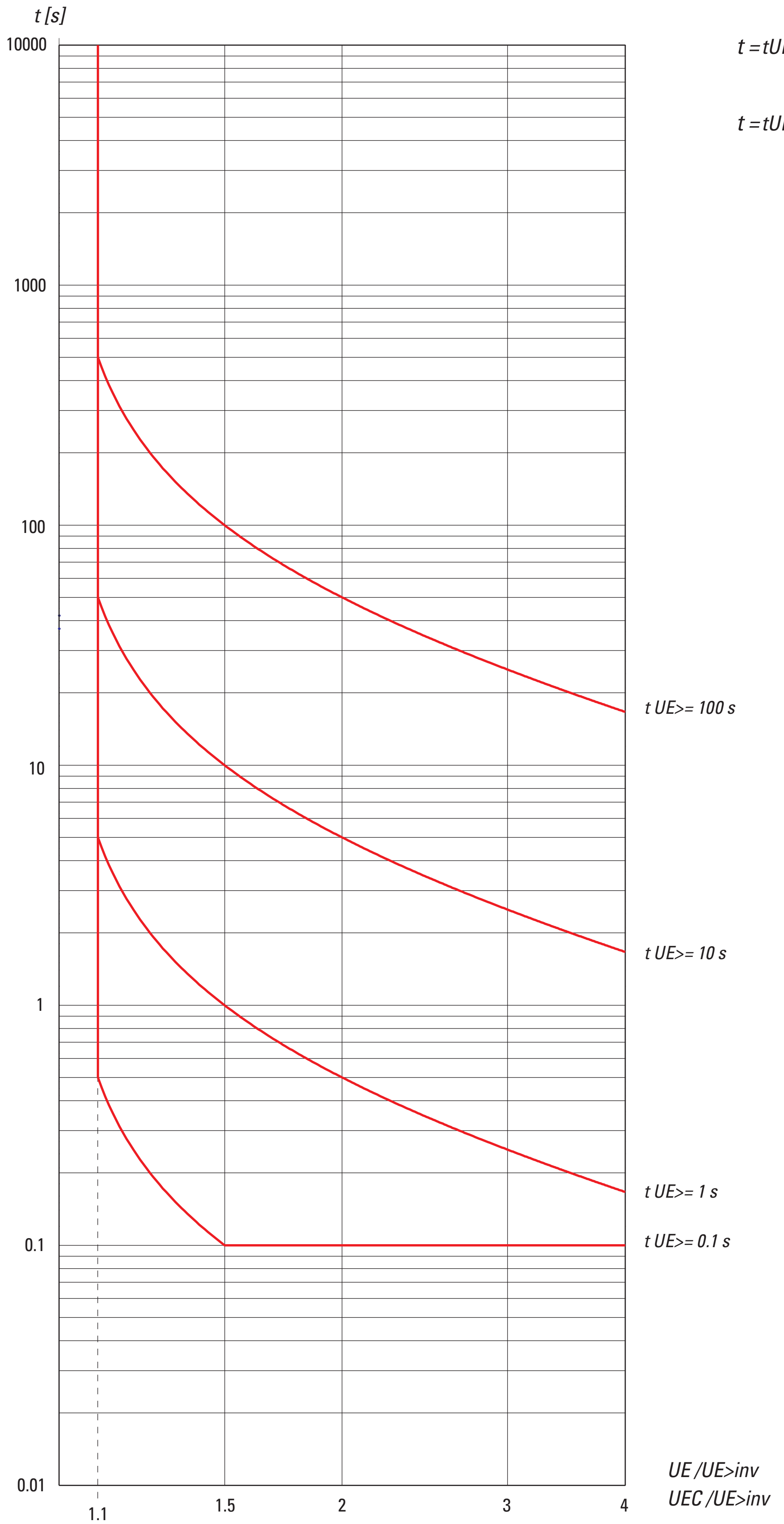
The protection compares the above residual voltage measurement (U_E or U_{EC}) with the set thresholds (U_E>, U_E>>) and violating either threshold starts (START) the threshold and its counter ($t_{UE>}$, $t_{UE>>}$). If the threshold violation persists, when its set trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.

The first threshold U_E> can be set to definite or inverse time with a trip characteristic of the type:
t=0.5 $t_{UE>}$ / [(U_E/$U_{E>inv}$) - 1] o
t=0.5 $t_{UE>}$ / [(U_{EC}/$U_{E>inv}$) - 1]
where t is the trip time, U_E and U_{EC} are the direct and calculated measurements of the residual voltage respectively, and U_E> and $t_{UE>}$ are the set threshold and operating time. The set operating time refers to a voltage of 1.5 times the set threshold. The minimum trip voltage is 1.1 times the set threshold. The characteristic is defined between 1.1 and 4 times the set threshold.
The minimum operating time t is 0.1 s.
The definite or inverse time characteristic is selected with the parameter *UE> Curve* in the menu **Set \ Protections \ Residual overvoltage - 59N \ Threshold UE> \ Parameters**.
Each protection threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *UE> Enable* in the menu **Set \ Protections \ Residual overvoltage - 59N \ Threshold UE> \ Parameters** and/or *State* in the menu **Set \ Protections \ Residual overvoltage - 59N \ Threshold UE>> \ Definite time**.



General characteristic of the operating time of the residual overvoltage function (59N)

The type of residual voltage measurement (direct or calculated) can be set in the menu **Set \ Protections \ Residual overvoltage - 59N \ Common configurations**, by setting *3Votype59N;* the available settings are *UE* (direct) and *UEC* (calculated).
When set to *UE* (direct measurement), the thresholds are expressed in p.u. U_{En}; when set to *UEC* (calculated voltage) the thresholds are expressed in p.u. U_{ECn}.



$$t = tUE{>}inv \left[\frac{0.5}{[(UE/UE{>}inv) - 1]} \right]$$

$$t = tUE{>}inv \left[\frac{0.5}{[(UEC/UE{>}inv) - 1]} \right]$$

Note: the set operating time refers to a voltage of UE /UE>inv = 1.5

Inverse time trip characteristics of the first threshold of the residual overvoltage protection (59N)

F_59N-Char.ai

— Residual emergency overvoltage - 59N(Eme)

Preface

This function has one adjustable threshold with programmable trip time.
Since only the fundamental component of the residual voltage is measured (direct or calculated), the protection is not sensitive to the components of the third harmonic and its multiples.
The trip characteristic for the threshold can be selected with definite or inverse time per IEC 60255-3/BS142.
The protection can be enabled or disabled; the function is automatically enabled if the amperometric measurement chain fails (function 74CT tripped).

Measurement criterion

Two separate measurements of the residual voltage are available:
- Direct.
- Calculated.

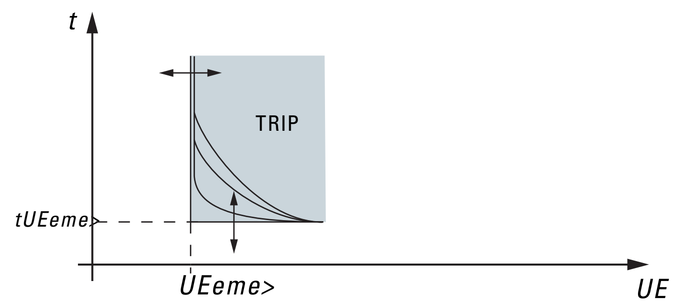
In the first case, the protection uses the fundamental component of the residual voltage U_E measured at the residual voltage input, while in the second it uses the fundamental component of the residual voltage U_{EC} resulting from the vectorial sum of the phasors of the three phase voltages measured at the voltmetric phase inputs.

$$UEC=|\vec{U}L1+\vec{U}L2+\vec{U}L3|$$

Operation and settings

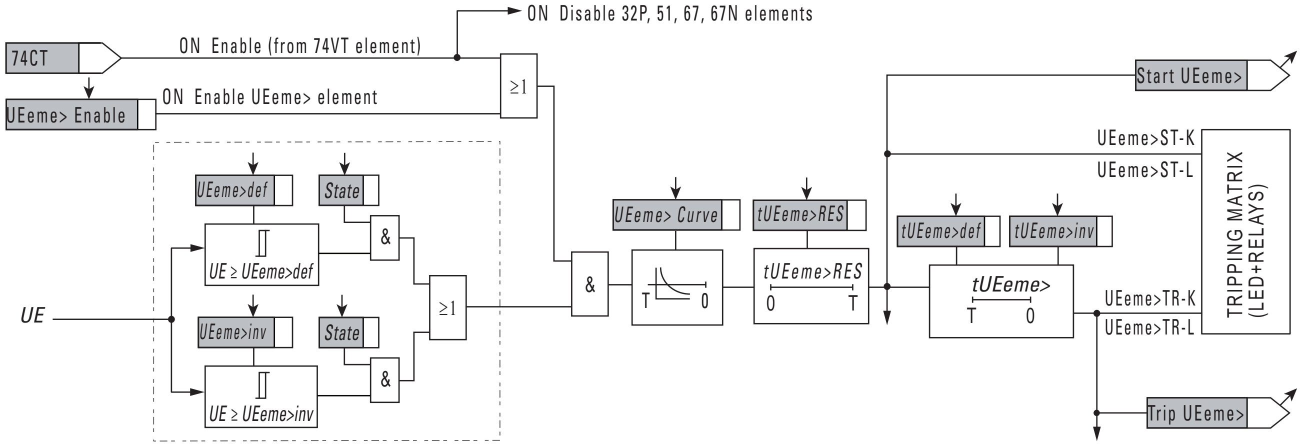
The protection compares the above residual voltage measurement (U_E or U_{EC}) with the set thresholds ($U_{Eeme>}$) and violating the threshold starts (START) the threshold and its counter ($t_{UEeme>}$). If the threshold violation persists, when its set trip time expires, the threshold trips (TRIP), otherwise the threshold is reset.

The threshold $U_{Eeme>}$ can be set to definite or inverse time with a trip characteristic of the type:
$t=0.5\ t_{UEeme>} / [(U_E/U_{Eeme>inv}) - 1]$ o
$t=0.5\ t_{UEeme>} / [(U_{EC}/U_{Eeme>inv}) - 1]$
where t is the trip time, U_E and U_{EC} are the direct and calculated measurements of the residual voltage respectively, and $U_{Eeme>}$ and $t_{UEeme>}$ are the set threshold and operating time. The set operating time refers to a voltage of 1.5 times the set threshold. The minimum trip voltage is 1.1 times the set threshold. The characteristic is defined between 1.1 and 4 times the set threshold.
The minimum operating time t is 0.1 s.
The definite or inverse time characteristic is selected with the parameter *UEeme> Curve* in the menu **Set \ Protections \ Residual overvoltage - 59N(Eme) \ Threshold UEeme> \ Parameters**.
The protection threshold can be enabled or disabled by setting to *ON* or *OFF* the parameter *UEme> Enable* in the menu **Set \ Protections \ Residual overvoltage - 59N(Eme) \ Threshold UEeme> \ Parameters** and/or *State* in the menu **Set \ Protections \ Residual overvoltage - 59N(Eme) \ Threshold UEeme>> \ Definite time**.



General characteristic of the operating time of the maximum emergency residual voltage function 59N(Eme)

The type of residual voltage measurement (direct or calculated) can be set in the menu **Set \ Protections \ Residual overvoltage - 59N(Eme) \ Common configurations**, by setting *3Votype59N;* the available settings are *UE* (direct) and *UEC* (calculated).
When set to *UE* (direct measurement), the thresholds are expressed in p.u. U_{En}; when set to *UEC* (calculated voltage) the thresholds are expressed in p.u. U_{ECn}.



Functional diagram of the threshold of the residual emergency overvoltage protection 59N(Eme)

— Maximum directional current - 67

Preface

This function has four adjustable thresholds with programmable trip time.

The trip characteristic for the first two thresholds can be selected with definite or inverse time per IEC 60255-3/BS142.
The trip characteristic for thresholds *I*>>> and *I*>>>> is definite time.
A constant reset time can be set for each threshold, to reduce the time for eliminating intermittent faults (while being no less than the protection start time).
Each protection threshold can be enabled or disabled.
The first threshold can be inhibited when at least one of the three thresholds starts, just as the second threshold can be inhibited when the third threshold starts and the third when the fourth starts.
The protection includes a voltage memory which, should all three voltages be lower than 2% U_n, saves the phase shift of the currents relative to the voltages prior to the fault for at least 1 s.

Operation and settings

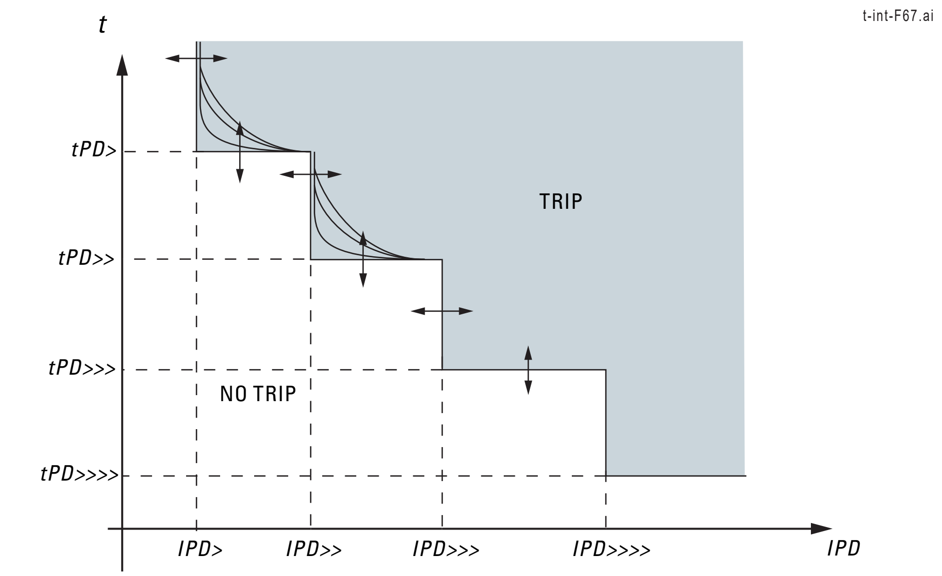
If the current I_{L2} is not available, it is reconstructed vectorially.
The trip characteristic for thresholds I_{PD}>, I_{PD}>> can be selected with definite or inverse time per the following characteristic curves:

- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_{PD>inv} / [(I_{PD}/I_{PD>inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_{PD>inv} / [(I_{PD}/I_{PD>inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_{PD>inv} / [(I_{PD}/I_{PD>inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_{PD>inv} / [(I_{PD}/I_{PD>inv})^2 - 1]$

Where:

t:	operating time
$I_{PD>inv}$:	trip threshold ($I_{PD>inv}$, $I_{PD>>inv}$) for the first and second threshold
$t_{PD>inv}$:	trip threshold regulation ($t_{PD>inv}$, $t_{PD>>inv}$) for the first and second threshold

The trip characteristic for the third and fourth thresholds ($I_{PD>>>def}$, $I_{PD>>>>def}$) is definite time.



Trip characteristic of the four thresholds of the maximum directional current protection - 67

The following applies to all the above inverse time characteristics:
- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshold regulation exceeds 2.5 I_n, the upper limit of the measurement range is 30 I_n.
- The minimum operating time *t* is 0.1 s.
- For definite time trip characteristics, the upper limit of the measurement range is 30 I_n.

Two separate detection criteria are available:
- Violation of the phase current threshold **(modulus mode)**
- Violation of the projection of the phase current along the characteristic axis (**projection mode**).

For both criteria, the polarising parameter used as a reference for the measurement of the current phase shift in each of the three phases is the phase-to-phase voltage relative to the two remaining phases (phase-to-phase voltage delayed by 90° relative to the current when the electrical system power factor is one).

Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

It follows that for both the above criteria, the protection measures:
- For phase L1, the phase shift α_1 of current phasor I_{L1} relative to phasor U_{23}, negative with current delayed relative to the voltage ($\alpha_1 = \angle I_{L1} - \angle U_{23}$, where $\angle$ is the argument operator).
- For phase L2, the phase shift α_2 of current phasor I_{L2} relative to phasor U_{31}, negative with current delayed relative to the voltage ($\alpha_2 = \angle I_{L2} - \angle U_{31}$).

If the current I_{L2} is not available, it is reconstructed vectorially.
- For phase L3, the phase shift α_3 of current phasor I_{L3} relative to phasor U_{12}, negative with current delayed relative to the voltage ($\alpha_3 = \angle I_{L3} - \angle U_{12}$).

The operating mode can be selected in the menu **Set \ Protections \ Maximum directional current - 67 \ Common configurations**, by setting `Mode67`; the available values are `I` (modulus mode) and `I*cos` (projection mode). For each of the four thresholds ($I_{PD>}$, $I_{PD>>}$, $I_{PD>>>}$, $I_{PD>>>>}$) the characteristic angle can be regulated (in the range 0…359° common to the three phases) relative to the polarising parameter (θ>, θ>>, θ>>>, θ>>>>), conventionally assumed to be positive in the clockwise direction.
The regulation of the characteristic angle identifies the angular position of the characteristic half-axis, which represents the bisector of the angular trip sector with an angular amplitude of 180°.
A regulation of the characteristic angle in the range 0°...90° or 270°...359° corresponds to protection "towards line", while regulation in the range 91°...269° corresponds to protection "towards bar".
The parameters are available in the menu relating to the four thresholds, separately for the definite and inverse time functions (where available).

Two separate protection trip logics are available:
- One of three - 1/3, in which it is sufficient that one of the three phases violate the set threshold.
- Two of three - 2/3, in which at least two of the three phases must violate the set threshold.

The trip logic can be selected in the menu **Set \ Protections \ Maximum directional current - 67 \ Common configurations**, by setting `Logic67`; the available values are `1/3` (at least one current) and `2/3` (at least two currents).

When **modulus mode** detection and **one of three - 1/3** trip logic are selected, the start (START) of any threshold of protection 67 occurs when the following two conditions are both satisfied:
A) In at least one phase, the fundamental component of the current (I_{L1}, I_{L2}, I_{L3}) violates the set threshold ($I_{PD>}$, $I_{PD>>}$, $I_{PD>>>}$, $I_{PD>>>>}$).
B) The current phasor for the phase in point A) is in the angular sector with semi-amplitude 90° and bisector the characteristic half-axis of the threshold in point A) (*Theta*P>, *Theta*P>>, *Theta*P>>>, *Theta*P>>>>), i.e. the condition -90° ≤ (*Theta*P-α_x) ≤ +90° is satisfied, in which x is the index of the phase/s in point A) (x = 1, 2 or 3) and *Theta*P is the regulation of the characteristic angle of the threshold in point A (*Theta*P>, *Theta*P>>, *Theta*P>>>, *Theta*P>>>>).

When the threshold starts, so does its timer.
If for the entire operating time of the threshold ($t_{PD>}$, $t_{PD>>}$, $t_{PD>>>}$, $t_{PD>>>>}$) the conditions in points A) and B) persist, when the time expires the threshold trips (TRIP), otherwise it resets.

When **modulus mode** detection and **two of three - 2/3** trip logic are selected, the start (START) of any threshold of protection 67 occurs when the following two conditions are both satisfied:
C) In at least one pair of phases the fundamental component of the current (I_{L1} e I_{L2}, I_{L2} e I_{L3}, I_{L3} e I_{L1}) violates the threshold ($I_{PD>}$, $I_{PD>>}$, $I_{PD>>>}$, $I_{PD>>>>}$).
D) The current phasors for the pair of phases in point C) are both in the angular sector with semi-amplitude 90° and bisector the characteristic sector for the threshold in point C) (*Theta*P>, *Theta*P>>, *Theta*P>>>, *Theta*P>>>>), i.e. the condition -90° ≤ (*Theta*P-α_x) ≤ +90° is satisfied, where x is the index of the pair of phases in point 1 (I_{L1} and I_{L2}, I_{L2} and I_{L3}, I_{L3} and I_{L1}) and *Theta*P is the regulation of the characteristic angle of the threshold in point C (*Theta*P>, *Theta*P>>, *Theta*P>>>, *Theta*P>>>>).

When the threshold starts, so does its timer.
If for the entire operating time of the threshold ($t_{PD>}$, $t_{PD>>}$, $t_{PD>>>}$, $t_{PD>>>>}$) the conditions in points C) and D) persist, when the time expires the threshold trips (TRIP), otherwise it resets.
When projection **mode detection** and one of three **- 1/3**, trip logic are selected, the start (START) of any threshold of protection 67 occurs when one of the following two conditions is satisfied:
- the projection of the current phasor for at least one phase along the characteristic axis I_{Lx}cos(*Theta*P>-α_x), I_{Lx}cos(*Theta*P>>-α_x), I_{Lx}cos(*Theta*P>>>-α_x), I_{Lx}cos(*Theta*P>>-α_x) (x=1, 2, 3) is positive and violates the threshold ($I_{PD>}$, $I_{PD>>}$, $I_{PD>>>}$, $I_{PD>>>>}$).
- in at least one phase, the fundamental component of the current (I_{L1}, I_{L2}, I_{L3}) violates the set threshold ($I_{PD>}$, $I_{PD>>}$, $I_{PD>>>}$, $I_{PD>>>>}$).

When the threshold starts, so does its timer.
If for the entire operating time of the threshold ($t_{PD>}$, $t_{PD>>}$, $t_{PD>>>}$, $t_{PD>>>>}$) the above condition persists, when the time expires the threshold trips (TRIP), otherwise it resets.

When **projection mode** detection and **two of three - 2/3** trip logic are selected, the start (START) of any threshold of protection 67 occurs when one of the following two conditions is satisfied:

- the projection of the current phasor for at least one pair of phases along the characteristic axis $I_{Lx}\cos(\theta{>}-\alpha_x)$, $I_{Lx}\cos(\theta{>>}-\alpha_x)$, $I_{Lx}\cos(\theta{>>>}-\alpha_x)$, $I_{Lx}\cos(\theta{>}-\alpha_x)$ (x=1 and 2, 2 and 3, 3 and 1) is positive and violates the threshold ($I_{PD>}$, $I_{PD>>}$, $I_{PD>>>}$, $I_{PD>>>>}$).
- In at least one pair of phases the fundamental component of the current (I_{L1} e I_{L2}, I_{L2} e I_{L3}, I_{L3} e I_{L1}) violates the threshold ($I_{PD>}$, $I_{PD>>}$, $I_{PD>>>}$, $I_{PD>>>>}$).

When the threshold starts, so does its timer.
If for the entire operating time of the threshold ($t_{PD>}$, $t_{PD>>}$, $t_{PD>>>}$, $t_{PD>>>>}$) the above condition persists, when the time expires the threshold trips (TRIP), otherwise it resets.

Each threshold of the protection can be enabled or disabled by setting to *ON* or *OFF* the parameter *IPD> Enable*, *IPD>> Enable*, , *IPD>>> Enable* and/or *IPD>>>> Enable* in the menu **Set \ Protections \ Maximum directional current - 67 \ Threshold IPD>** (**Threshold IPD>>**, **Threshold IPD>>>**, **Threshold IPD>>>>**) **\ Parameters**.
The first two thresholds can be set to definite or inverse time with the parameter *IPD>Curve* and/or *IPD>>Curve* (*IDEFINITE, NIT, VIT, EIT, LIT*) in the menus **Set \ Protections \ Maximum directional current - 67 \ Threshold IPD> \ Parameters** and **Set \ Protections \ maximum directional current - 67 \ Threshold IPD>>\ Parameters**.

The first threshold IPD> can be inhibited when at least one of the three thresholds IPD>>, IPD>>>, IPD>>>> starts using the Deactivation IPD> by start IPD>>, Deactivation IPD> by start IPD>>>, Deactivation IPD> by start IPD>>>> (*IPD>disbyIPD>>, IPD>disbyIPD>>>, IPD>disIPD>>>>*) in the menu **Set \ Protections \ Overcurrent - 67 \ Threshold IPD>>**, **Threshold IPD>>>**, **Threshold IPD>>>> \ Parameters.**
The same applies to the inhibition of:

- Second threshold IPD>> by the start of at least one of IPD>>>, IPD>>>> with the Deactivation IPD>> by start IPD>>>, Deactivation IPD>> by start IPD>>>> parameters (*IPD>>disbyIPD>>>, IPD>>disIPD>>>>*) in the menu **Set \ Protections \ Maximum directional current - 67 \ Threshold IPD>>>**, **Threshold IPD>>>> \ Parameters.**
- Third threshold IPD>>> by the start of the fourth threshold IPD>>>> with the Deactivation IPD>>> by start IPD>>>> parameter (*IPD>>>disIPD>>>>*) in the menu **Set \ Protections \ Maximum directional current - 67 \ Threshold IPD>>>> \ Parameters.**

Shrink time

For each of the thresholds programmed with definite time characteristic, you can select contracted time by setting to *ON* the parameter *EnTcIPD>def* , *EnTcIPD>>def*, *EnTcIPD>>>def* e *EnTcIPD>>>>def* and regulating the contracted time (*tcIPD>def* , *tcIPD>>def*, *tcIPD>>>def* e *tcIPD>>>>def*) and operating time (*tatcIPD>def*, *tatcIPD>>def*, *tatcIPD>>>def* e *tatcIPD>>>>def*).
Once the breaker closes, during the operating time (e.g.: *tatcIPD>def*), the value of the trip time (e.g.: *tPD>def*) is replaced by the contracted time (e.g.: *tcIPD>def*); when the operating time expires the trip time is reset (e.g.: *tPD>def*).
The parameters are available in the menu **Set \ Protections \ Overcurrent - 67 \ Threshold IPD> (Threshold IPD>>, Threshold IPD>>>, Threshold IPD>>>>) \ Definite time**.

Second harmonic restraint

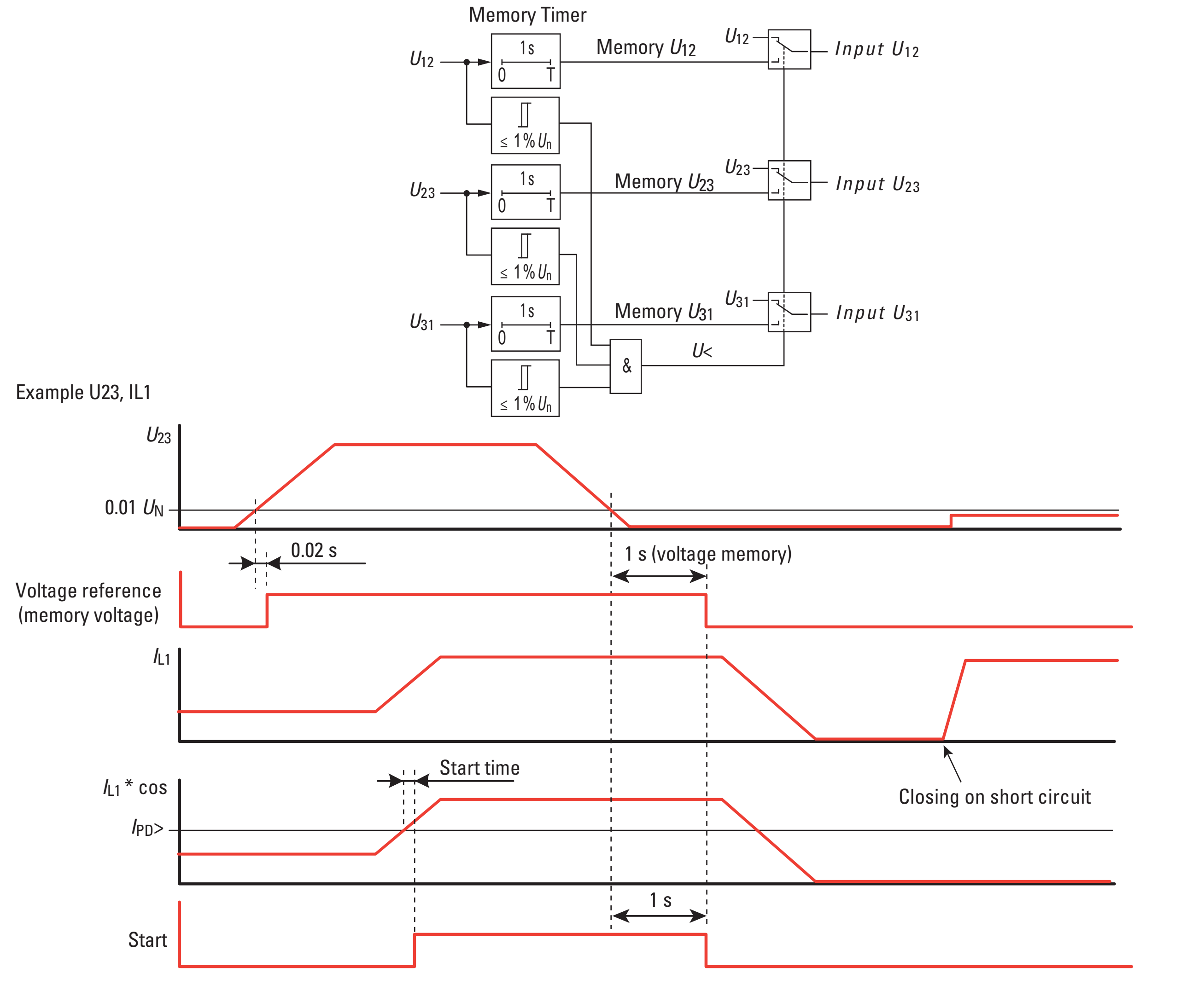
For each threshold, a second harmonic restraint block can be set by setting to *ON* the parameter *IPD>2ndh-REST, IPD>>2ndh-REST, IPD>>>2ndh-REST, IPD>>>>2ndh-REST*.
The parameters are available in the menu **Set \ Protections \ Overcurrent - 67 \ Threshold IPD> (Threshold IPD>>, Threshold IPD>>>,Threshold IPD>>>>) \ Parameters.**

Functional block (Block3)

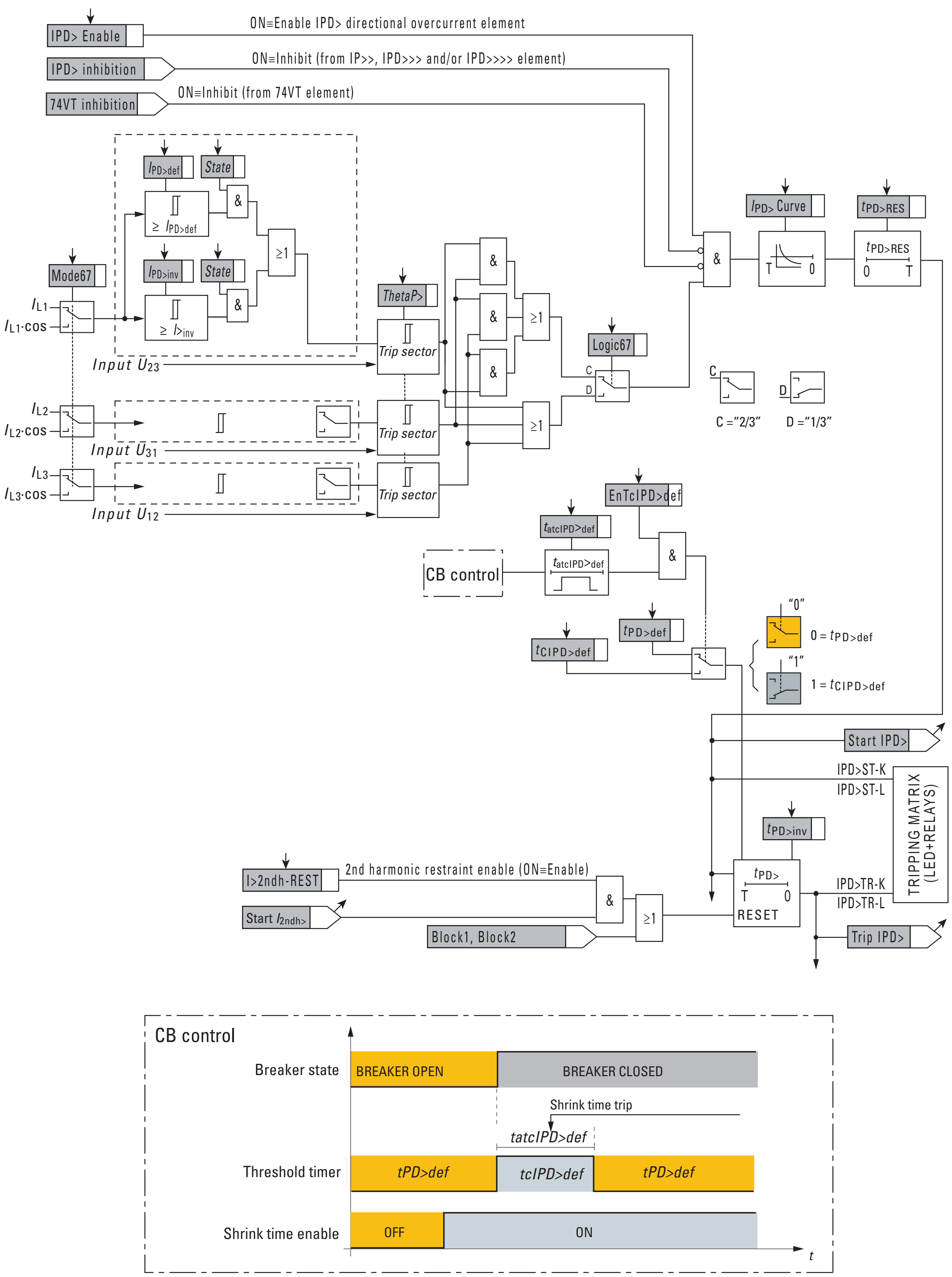
If the voltmetric measurement chain fails (function 74VT tripped) or amperometric measurement chain fails (function 74CT tripped), all thresholds of protection 67 are blocked.

Voltage memory

To increase reliability in all fault conditions, the protection has a voltage memory.
This makes it possible to determine the direction of the current even in case of a fault in the immediate vicinity of the voltage transformers. In this situation the protection uses a fictitious polarisation voltage signal which corresponds to the memorised voltage from the cycle preceding the fault.
The memorised voltage is used as a reference for one second after all three phase-to-phase voltages drop to a value of less than 2% U_n.



Voltage memory - protection 67



Functional diagram of the first threshold (IPD>) of the maximum directional current function 67

Fun_67S1.ai

— Ground directional overcurrent - 67N

Preface

This function has five adjustable thresholds with programmable trip time.
The trip characteristic for the first two thresholds can be selected with definite or inverse time per IEC 60255-3/BS142.
The trip characteristic for thresholds $I_{ED}>>_b$, $I_{ED}>>>$ and $I_{ED}S_b$ is definite time.
There are also protection functions against intermittent arcs and evolving faults, based on measuring the directional ground current and residual voltage, implementing the logics described below.
A constant reset time can be set for each of the thresholds.
Each protection threshold can be enabled or disabled.

Operation and settings

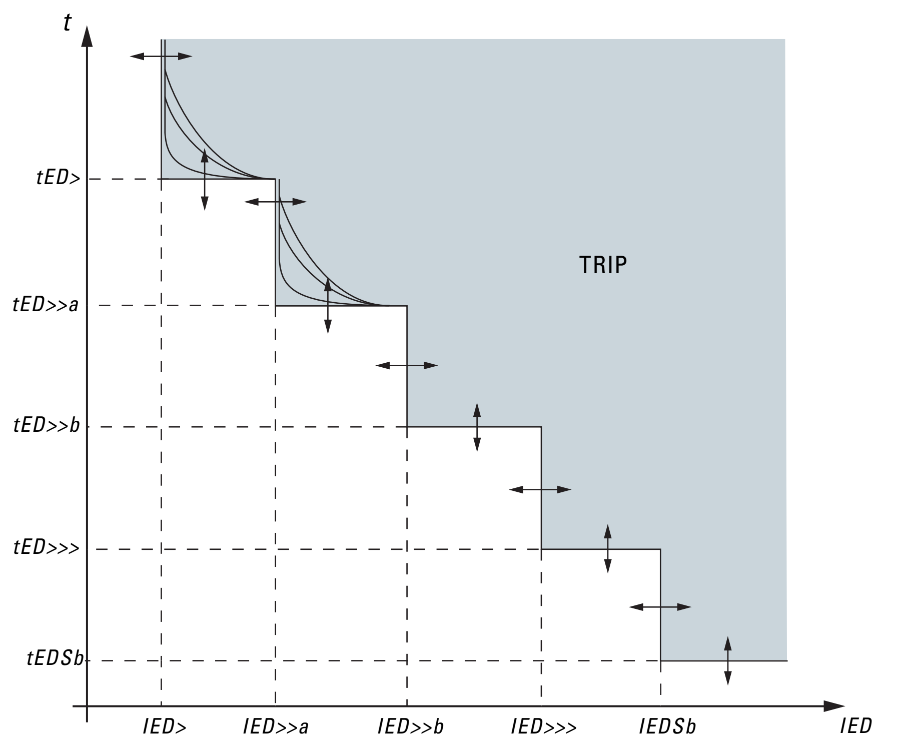
Two separate detection criteria are available:
- Violation of the residual current threshold **(modulus mode)**
- Violation of the projection of the residual current along the characteristic axis (**projection mode**).

The first and second thresholds $I_{ED}>$, $I_{ED}>>_b$ can be selected with definite or inverse time per the following characteristic curves:
- IEC 255-3/BS142 type A or SIT, inverse time: $t = 0.14 \cdot t_{ED>inv} / [(I_{ED}/I_{ED>inv})^{0.02} - 1]$
- IEC 255-3/BS142 type B or VIT, very inverse time: $t = 13.5 \cdot t_{ED>inv} / [(I_{PD}/I_{ED>inv}) - 1]$
- IEC 255-3/BS142 type LTI, long time inverse: $t = 120 \cdot t_{ED>inv} / [(I_{ED}/I_{ED>inv}) - 1]$
- IEC 255-3/BS142 type C or EIT, extremely inverse time: $t = 80 \cdot t_{PD>inv} / [(I_{ED}/I_{ED>inv})^2 - 1]$

Where:

t:	operating time
$I_{ED>inv}$:	trip threshold ($I_{ED>inv}$, $I_{ED>>ainv}$) for the first and second threshold
$t_{ED>inv}$:	trip threshold regulation ($t_{ED>inv}$, $t_{ED>>ainv}$) for the first and second threshold

The trip characteristic for thresholds $I_{ED}>>_b$, $I_{ED}>>>$ and I_{EESb} is definite time.

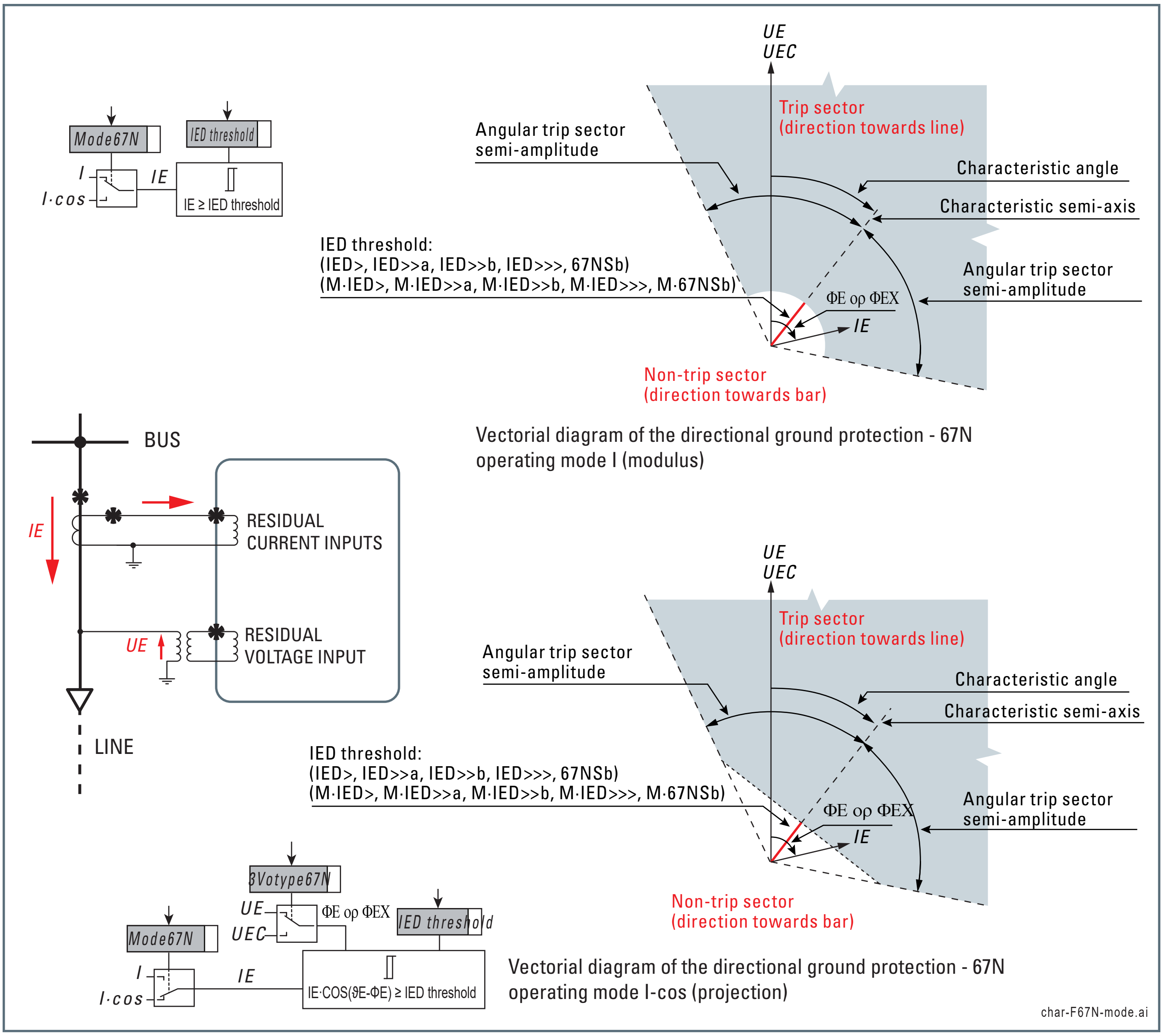


Trip characteristic of the thresholds of the ground directional overcurrent protection - 67N t-int-F67N.ai

The following applies to all the above inverse time characteristics:
- The minimum trip current is 1.1 times the set threshold (asymptotic reference time).
- The characteristics are defined between 1.1 and 20 times the set threshold;[1] if threshold regulation exceeds 0.5 I_{En}, the upper limit of the measurement range is 10 I_{En}.
- The minimum operating time t is 0.1 s.
- For definite time trip characteristics, the upper limit of the measurement range is 10 I_{En}.

Note 1 For input values greater than 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold

The operating mode can be selected in the menu **Set \ Protections \ Ground directional overcurrent - 67N \ Common configurations**, by setting *Mode67N;* the available values are *I* (modulus mode) and *I*cos* (projection mode).



Vectorial diagram of the directional ground protection - 67N operating mode I (modulus)

Vectorial diagram of the directional ground protection - 67N operating mode I-cos (projection)

For both operating modes, the polarising parameter used as a reference in measuring the phase shift of the residual current can be selected from the following two options:

- Direct residual voltage, in which the protection uses the residual voltage U_E phasor measured directly at the residual voltage input.
- Calculated residual voltage, in which the protection uses the residual voltage U_{EC} phasor whose modulus and argument are calculated as the fundamental component and phase respectively of the sum of the instantaneous values of the three phase voltages measured at the voltmetric phase inputs.

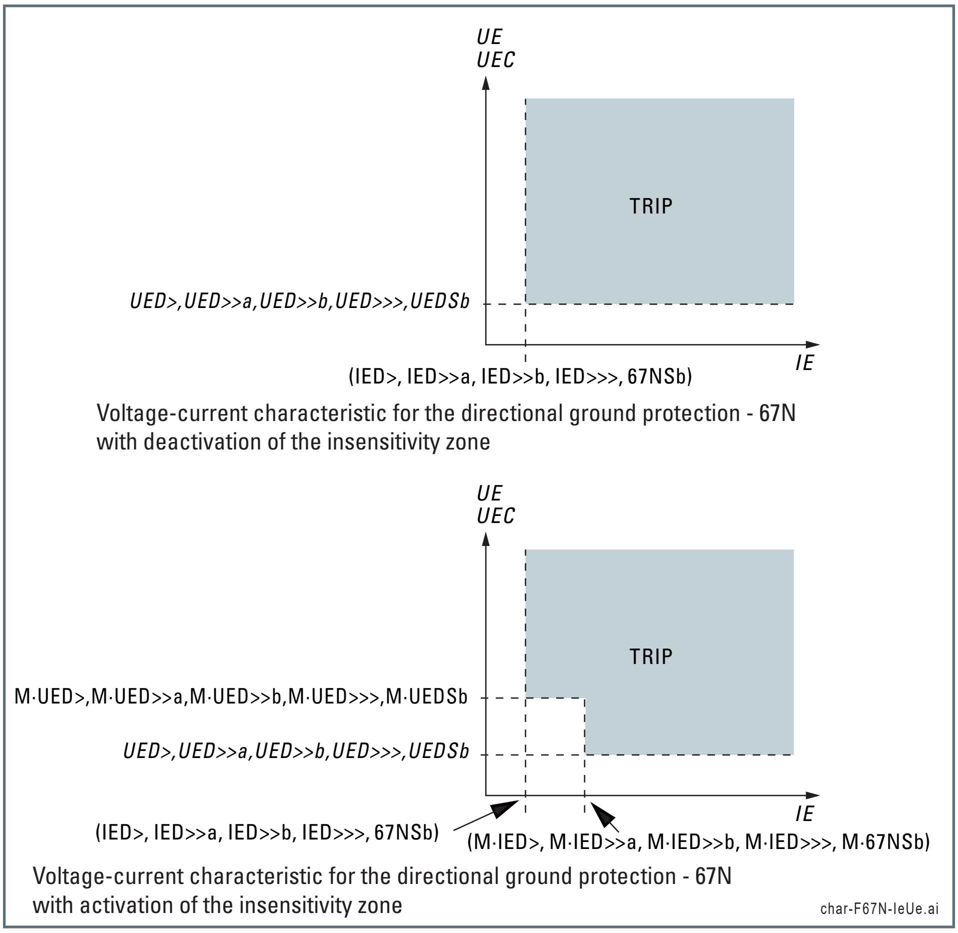
It follows that for both of the above detection criteria, the protection measures the phase shift of the residual current I_E phasor relative to the residual current phasor (U_E con for "direct residual voltage" or U_{EC} for "calculated residual voltage"), positive when the current is delayed relative to the voltage (Φ_E=($\angle U_E$ - $\angle I_E$, Φ_{EC}=($\angle U_{EC}$ - $\angle I_E$, where $\angle$ is the argument operator).

The type of residual voltage measurement can be set in the menu **Set \ Configuration parameters A(or B) \ Ground directional overcurrent - 67N \ Common configurations**, parameter *3Votype67N;* the available settings are *UE* (direct) and *UEC* (calculated).
When set to *UE* (direct measurement), the thresholds are expressed in p.u. U_{En}; when set to *UEC* (calculated voltage) the thresholds are expressed in p.u. U_{ECn}.

For each of the thresholds $I_{ED>}$, $I_{ED>>a}$, $I_{ED>>b}$, $I_{ED>>>}$ and $I_{ED}S_b$ the characteristic angle can be regulated relative to the polarising parameter, conventionally positive in the clockwise direction. The characteristic angle can be regulated in the range 0…359°. The regulation of the characteristic angle identifies the angular position of the characteristic half-axis, which represents the bisector of the angular trip sector. In an electrical system with isolated neutral, a 90° regulation of the characteristic angle corresponds to a directionality of the protection "towards line", while 270° corresponds to "towards bar".

For each of the thresholds $I_{ED}>$, $I_{ED}>>_a$, $I_{ED}>>_b$, $I_{ED}>>>$ and $I_{ED}S_b$ the angular trip semi-sector can be regulated relative to the characteristic half-axis in the range 1…180°.

For all four thresholds (common configuration), ("Insens-Zone=ON") activates and ("Insens-Zone=OFF") deactivates a zone of insensitivity in the voltage current characteristic of protection 67N. When activated, the insensitivity zone remains defined between the set amperometric and voltmetric thresholds and their values multiplied by M, which can be set in the range 1.5…10.0 for all four thresholds together. This insensitivity zone can be used to prevent undesirable trip of the protection due to permanent residual voltages and currents which violate the configured thresholds. The parameters *Insens-Zone* (*OFF, ON*) and *M* can be set in the menu **Set\Protections\Ground directional overcurrent - 67N\Common configurations.**



Voltage-current characteristic for the directional ground protection - 67N with deactivation of the insensitivity zone

Voltage-current characteristic for the directional ground protection - 67N with activation of the insensitivity zone

Form

In **modulus** operating mode, if the protection is not switched to non-directional, the start (START) of any threshold of protection 67N occurs when the following conditions A) and B) are both satisfied:
A) With "Insens-Zone=OFF":
- Value of the residual current (I_E) greater than the amperometric threshold ($I_{ED>}$, $I_{ED>>}$, $I_{ED>>>}$, $I_{ED>>>>}$)
AND
- Value of the residual voltage (U_E or U_{EC}) greater than the corresponding voltmetric threshold ($U_{ED>}$, $U_{ED>>}$, $U_{ED>>>}$, $U_{ED>>>>}$).
With "Insens-Zone=ON":
- Value of the residual current (I_E) greater than the amperometric threshold ($I_{ED>}$, $I_{ED>>}$, $I_{ED>>>}$, $I_{ED>>>>}$)
AND
- Value of the residual voltage (U_E or U_{EC}) greater than the corresponding voltmetric threshold ($M \cdot U_{ED>}$, $M \cdot U_{ED>>}$, $M \cdot U_{ED>>>}$, $M \cdot U_{ED>>>>}$)

OR
- Value of the residual current (I_E) greater than the amperometric threshold ($M \cdot I_{ED>}$, $M \cdot I_{ED>>}$, $M \cdot I_{ED>>>}$, $M \cdot I_{ED>>>>}$)
AND
- Value of the residual voltage (U_E or U_{EC}) greater than the corresponding voltmetric threshold ($U_{ED>}$, $U_{ED>>}$, $U_{ED>>>}$, $U_{ED>>>>}$).

B) The residual current (I_E) phasor is included in the angular sector with half-amplitude corresponding to the regulation of the threshold in point A) with bisector the characteristic semi-axis of the threshold in point A).

With detection criterion in "modulus mode", if the protection is switched to non-directional by the start of function 74VT, the start (START) of any threshold of protection 67N occurs when the following condition is satisfied:

- Value of the residual current (I_E) greater than the amperometric threshold ($I_{ED>}$, $I_{ED>>}$, $I_{ED>>>}$, $I_{ED>>>>}$).

The parameters *Mode67N* (operating mode), *Type67N* (residual voltage measurement type), *Insens-Zone* (insensitivity zone), *M* (threshold multiplier for insensitivity zone), *74VTint67N* (operation with internal 74VT) and *74VText67N* (operation with external 74VT), common to all thresholds, can be set in the menu: **Set \ Protections \ Ground directional overcurrent - 67N \ Common configurations.**

Projection

With detection criterion in "projection mode", the start (START) of any threshold of protection 67N occurs when the following condition C) obtains:
C) With "Insens-Zone=OFF":
- Projection of the residual current (I_E) along the characteristic axis > 0
AND
- Value of the projection of the residual current (I_E) along the characteristic axis greater than the amperometric threshold ($I_{ED>}$, $I_{ED>>}$, $I_{ED>>>}$, $I_{ED>>>>}$)
AND
- Value of the residual voltage (U_E or U_{EC}) greater than the corresponding voltmetric threshold ($U_{ED>}$, $U_{ED>>}$, $U_{ED>>>}$, $U_{ED>>>>}$)
AND
The residual current (I_E) phasor is included in the angular sector with half-amplitude corresponding to the regulation of the threshold with bisector the characteristic semi-axis of the threshold.[1]

With "Insens-Zone=ON":
- Projection of the residual current (I_E) along the characteristic axis > 0
AND
- Value of the projection of the residual current (I_E) along the characteristic axis greater than the amperometric threshold ($I_{ED>}$, $I_{ED>>}$, $I_{ED>>>}$, $I_{ED>>>>}$)
AND
- Value of the residual voltage (U_E or U_{EC}) greater than the corresponding voltmetric threshold ($M \cdot U_{ED>}$, $M \cdot U_{ED>>}$, $M \cdot U_{ED>>>}$, $M \cdot U_{ED>>>>}$)

OR
- Value of the projection of the residual current (I_E) along the characteristic axis greater than the amperometric threshold ($M \cdot I_{ED>}$, $M \cdot I_{ED>>}$, $M \cdot I_{ED>>>}$, $M \cdot I_{ED>>>>}$)
AND
- Value of the residual voltage (U_E or U_{EC}) greater than the corresponding voltmetric threshold ($U_{ED>}$, $U_{ED>>}$, $U_{ED>>>}$, $U_{ED>>>>}$)
AND
The residual current (I_E) phasor is included in the angular sector with half-amplitude corresponding to the regulation of the threshold with bisector the characteristic semi-axis of the threshold.[2]

Each threshold of the protection can be enabled or disabled by setting to *ON* or *OFF* the parameter *IED> Enable*, *IED>> Enable*, , *IED>>> Enable* and/or *IED>>>> Enable* in the menu **Set \ Protections \ Ground directional overcurrent - 67N \ Threshold IED> (Threshold IED>>, Threshold IED>>>, Threshold IED>>>>) \ Parameters**.
The first two thresholds can be set to definite or inverse time with the parameter *IED>Curve* and/or *IED>Curve* (*DEFINITE, IEC/BS A, IEC/BS B, IEC/BS C, ANSI/IEE MI, ANSI/IEE VI, ANSI/IEE EI, EM*) in the menus **Set \ Protections \ Ground directional overcurrent - 67N \ Threshold IED> \ Parameters** and **Set \ Configuration parameters A(or B) \ Ground directional overcurrent - 67N \ Threshold IED>> \ Parameters**.

The first threshold IED> can be inhibited when at least one of the three thresholds IED>>, IED>>>, IED>>>> starts using the Deactivation IED> by start IED>>, Deactivation IED> by start IED>>>, Deactivation IED> by start IED>>>> (*IED>disbyIED>>, IED>disbyIED>>>, IED>disbyIED>>>>*) in the menu **Set \ Protections \ Ground directional overcurrent - 67N \ Threshold IED>>, Threshold IED>>>, Threshold IED>>>> \ Parameters.**
The same applies to the inhibition of:
- Second threshold IED>> by the start of at least one of IED>>>, IED>>>> with the Deactivation IED>> by start IED>>>, Deactivation IED>> by start IED>>>> parameters (*IED>>disbyIED>>>, IED>>disIED>>>>*) in the menu **Set \ Protections \ Ground directional overcurrent - 67N \ Threshold IED>>>, Threshold IED67N.sb \ Parameters.**

Note 1 *The projection of the residual current phasor along the characteristic axis of each threshold is given by* $I_E cos(\vartheta_{E>}-\Phi_E)$, $I_E cos(\vartheta_{E>>}-\Phi_E)$, $I_E cos(\vartheta_{E>>>}-\Phi_E)$, $I_E cos(\vartheta_{E>>>>}-\Phi_E)$ *for "direct residual voltage", or:*
$I_E cos(\vartheta_{E>}-\Phi_{EC})$, $I_E cos(\vartheta_{E>>}-\Phi_{EC})$, $I_E cos(\vartheta_{E>>>}-\Phi_{EC})$, $I_E cos(\vartheta_{E>>>>}-\Phi_{EC})$ *for "calculated residual voltage".*
The symbols ϑ_E *and* Φ_{EC} *are not available in the Thysetter and MMI menus*

Note 2 *The projection of the residual current phasor along the characteristic axis of each threshold is given by* $I_E cos(\vartheta_{E>}-\Phi_E)$, $I_E cos(\vartheta_{E>>}-\Phi_E)$, $I_E cos(\vartheta_{E>>>}-\Phi_E)$, $I_E cos(\vartheta_{E>>>>}-\Phi_E)$ *for "direct residual voltage", or:*
$I_E cos(\vartheta_{E>}-\Phi_{EC})$, $I_E cos(\vartheta_{E>>}-\Phi_{EC})$, $I_E cos(\vartheta_{E>>>}-\Phi_{EC})$, $I_E cos(\vartheta_{E>>>>}-\Phi_{EC})$ *for "calculated residual voltage".*
The symbols ϑ_E *and* Φ_{EC} *are not available in the Thysetter and MMI menus*

- Third threshold IED>>> by the start of the fourth threshold IED>>>> with the Deactivation IED>>> by start IED>>>> parameter (*IED>>>disIED>>>>*) in the menu **Set \ Protections \ Ground directional overcurrent - 67N \ Threshold IED67N.Sb \ Parameters.**

A constant reset time can be set for each threshold (tED>RES, tED>>aRES, tED>>bRES, tED>>>RES, tED67N.SbRES).

Shrink time

For each of the thresholds programmed with definite time characteristic, you can select contracted time by setting to *ON* the parameter *EnTcIED>def*, *EnTcIED>>adef*, *EnTcIED>>bdef*, *EnTcIED>>>def* and *EnTcIEDSbdef*, and regulating the contracted time (*tcIED>def* , *tcIED>>adef*, *tcIED>>bdef*, *tcIED>>>def* and *tcIEDSbdef*) and operating time (*tatcIED>def*, *tatcIED>>adef*, *tatcIED>>bdef* , *tatcIED>>>def* and *tatcIEDSbdef*).
Once the breaker closes, during the operating time (e.g.: *tatcIPE>def*), the value of the trip time (e.g.: *tED>def*) is replaced by the contracted time (e.g.: *tcIED>def*); when the operating time expires the trip time is reset (e.g.: *tED>def*).
The parameters are available in the menu **Set \ Protections \ Ground directional overcurrent - 67N \ Threshold IED> (Threshold IED>>a, Threshold IED>>b, Threshold IED>>>,Threshold 67N.Sb) \ Definite time**.

Second harmonic restraint

For each threshold, a second harmonic restraint block can be set by setting to *ON* the parameter *IED>2ndh-REST, IED>>a2ndh-REST, IED>>b2ndh-REST, IED>>>2ndh-REST, 67N.Sb2ndh-REST*.
The parameters are available in the menu **Set \ Protections \ Ground directional overcurrent - 67N \ Threshold IED> (Threshold IED>>a, Threshold IED>>b, Threshold IED>>>,Threshold 67N.Sb) \ Parameters.**

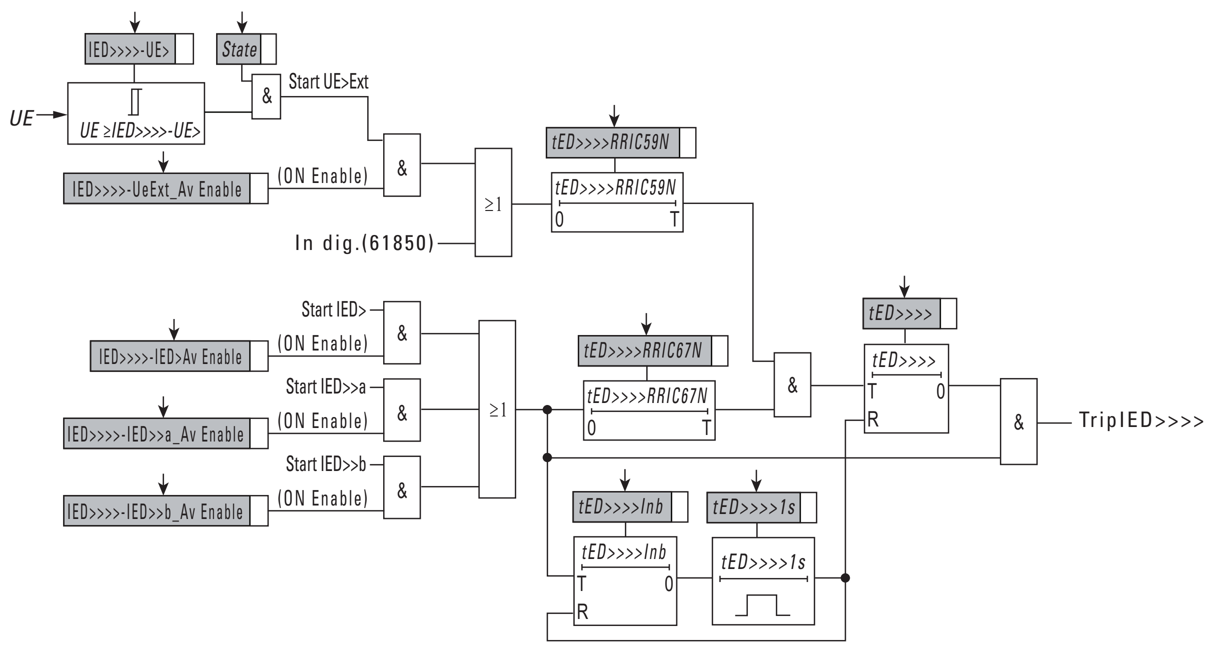
Functional block (Block3)

If the voltmetric measurement chain fails (function 74VT tripped) or amperometric measurement chain fails (function 74CT tripped), all thresholds of protection 67N are blocked.

— Ground directional overcurrent - 67N (Intermittent faults)

Preface

The maximum directional ground current protection function IED>>>> detects intermittent "Arcing ground" faults
Detection is done by protection function 67N logically controlling the start statuses, by starting a specific 59N threshold or by receiving the Goose IEC61850 for the state of start by residual overvoltage of the protection DV7500.
The logic of threshold IED>>>> is shown in the following figure:

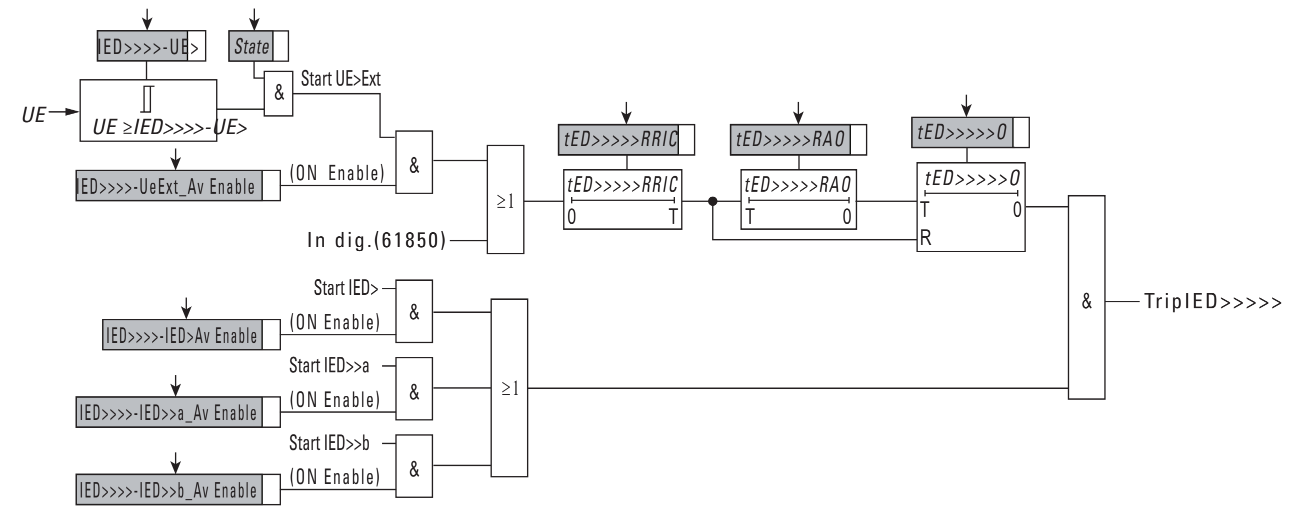


Functional diagram of the threshold of the directional ground protection against intermittent faults (67N) char-F67N-intermittenti.ai

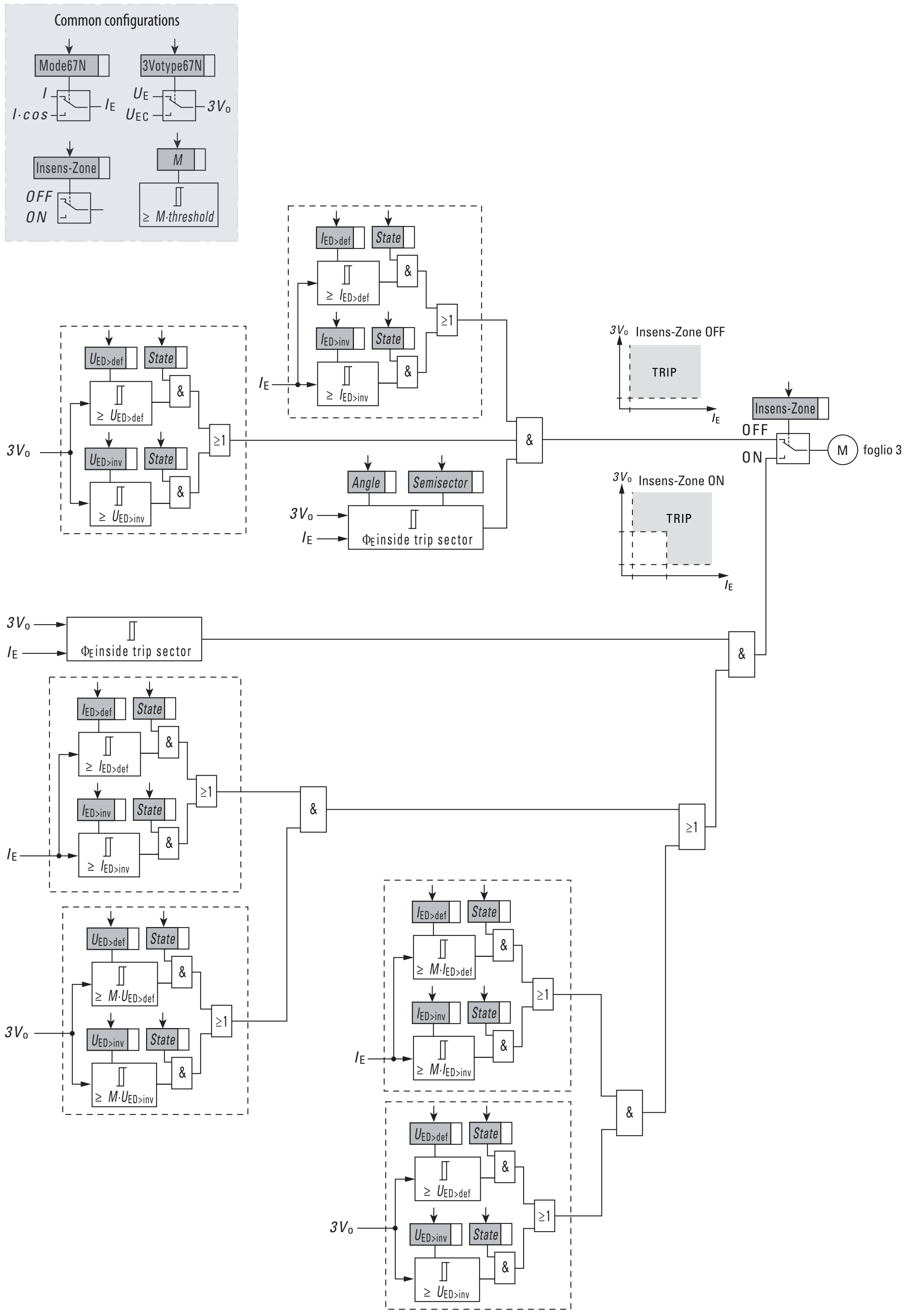
— Ground directional overcurrent - 67N (Evolving faults)

Preface

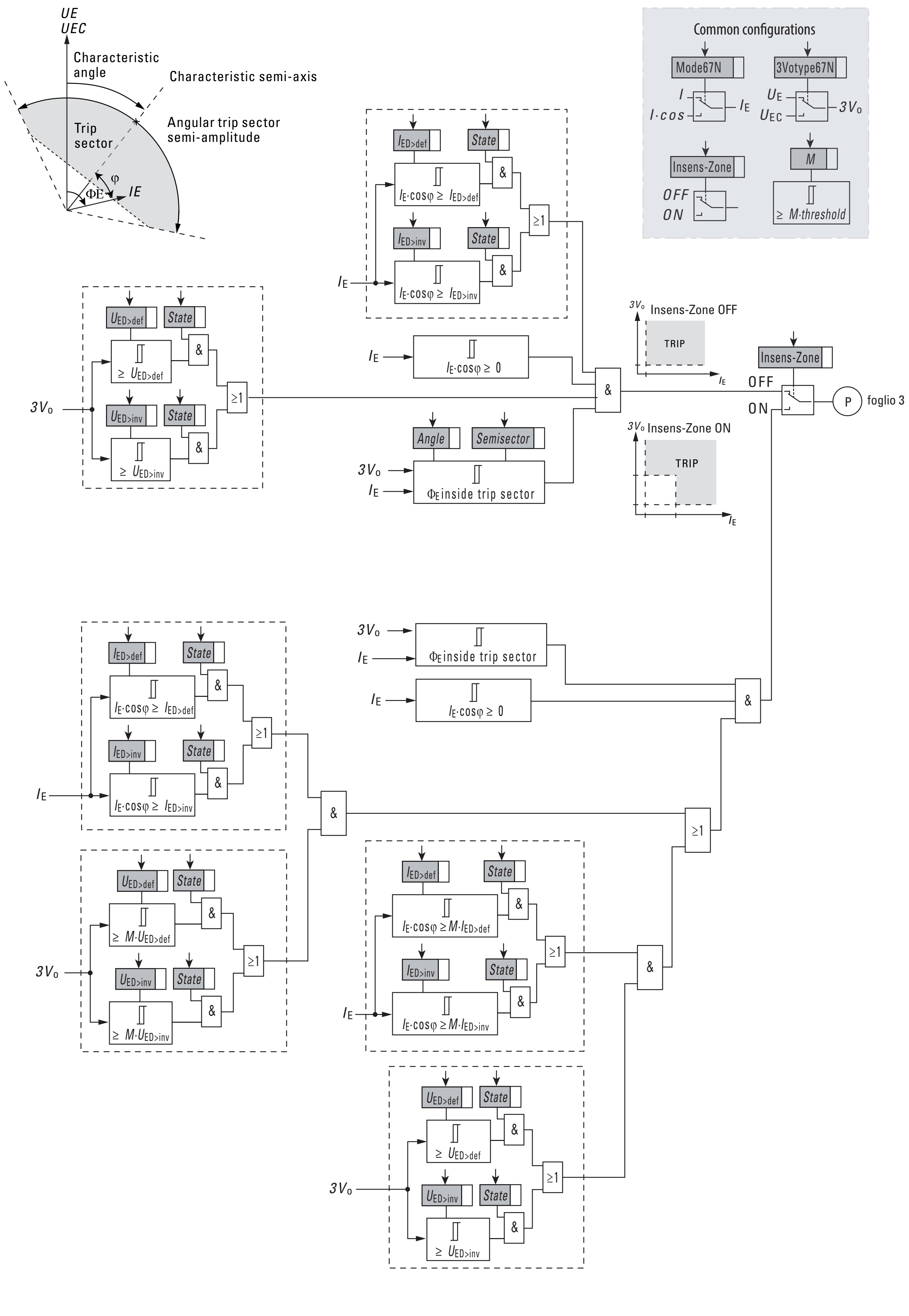
The maximum directional ground current protection function 67N for detecting evolving arcs detects the type of intermittent fault originating in sequence on different feeders.
Detection is done logically controlling the start statuses generated by protection function 67N, by starting a specific 59N threshold, or by receiving the Goose IEC61850 for the state of start by residual overvoltage of the protection.
The logic of threshold IED>>>>> is shown in the following figure:



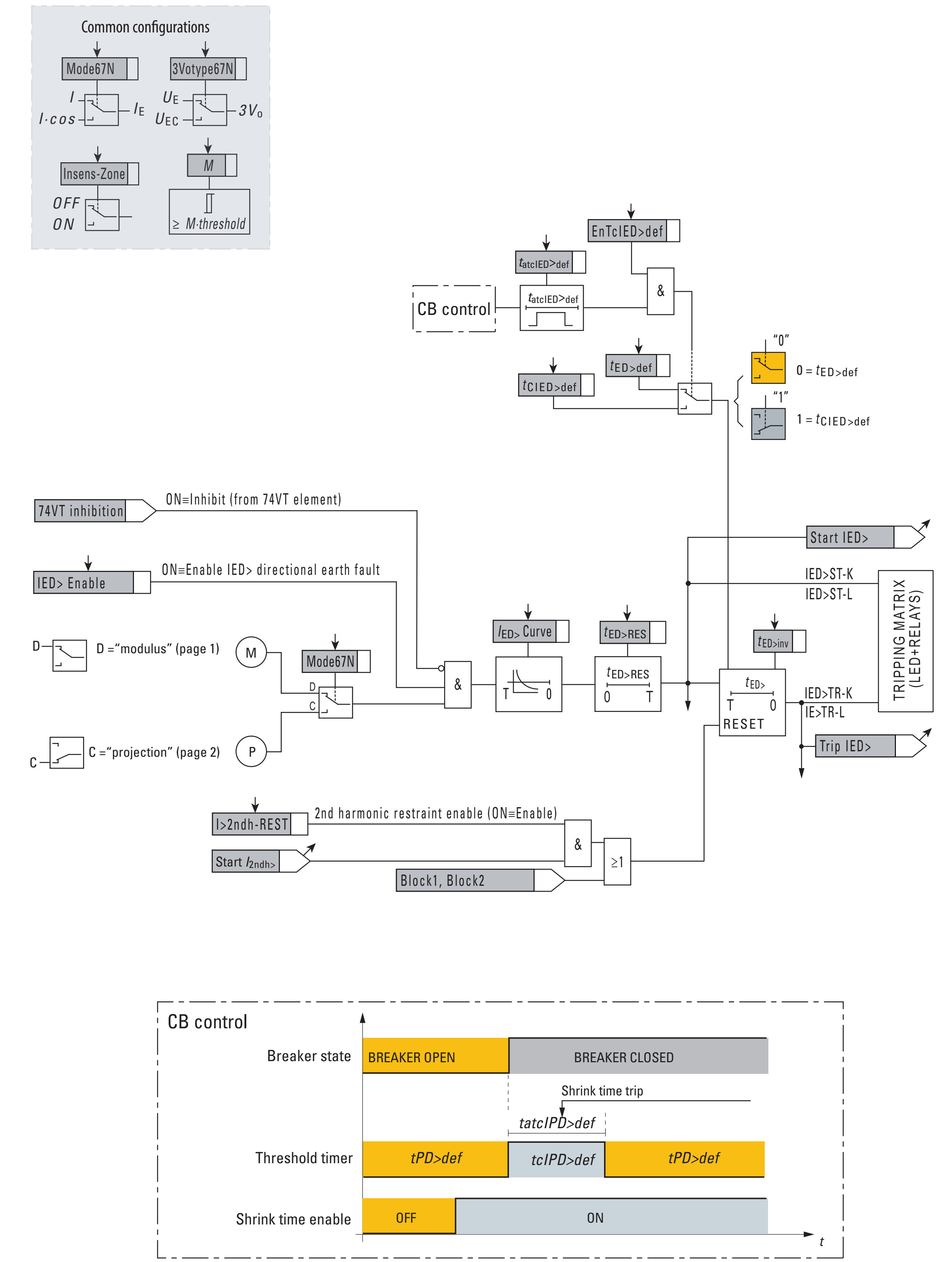
Functional diagram of the threshold of the directional ground protection against evolving faults (67N) char-F67N-evolutivi.ai



Functional diagram of the first threshold (IED>) of the ground directional overcurrent function 67N - Modulus mode (sheet 1 of 3)



Functional diagram of the first threshold (IED>) of the ground directional overcurrent function 67N - Projection mode (sheet 2 of 3)



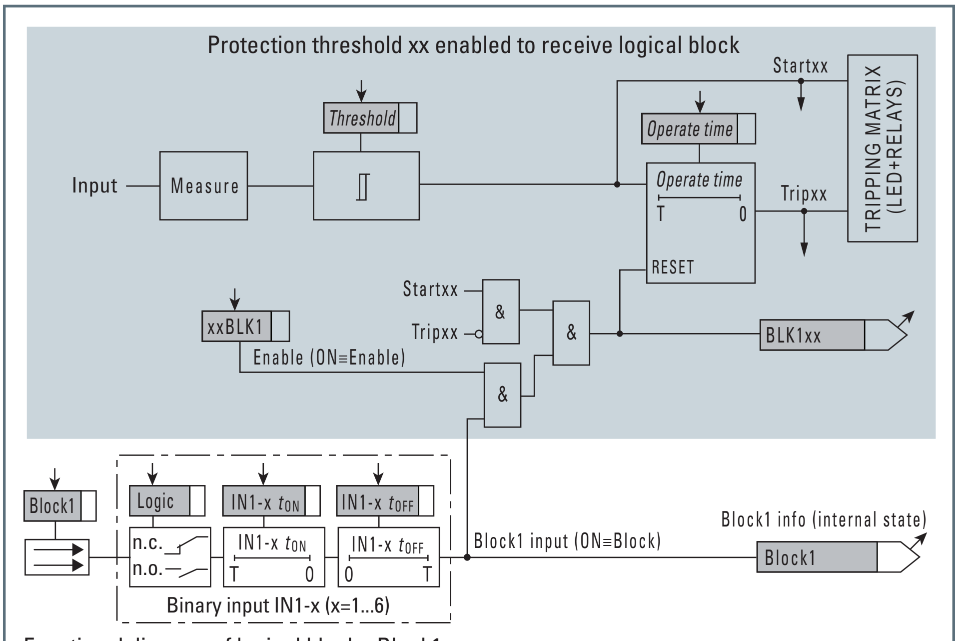
Functional diagram of the first threshold (IED>) of the ground directional overcurrent function 67N (sheet 3 of 3)

Fun_67NS1-3.ai

— Logical block - Block1

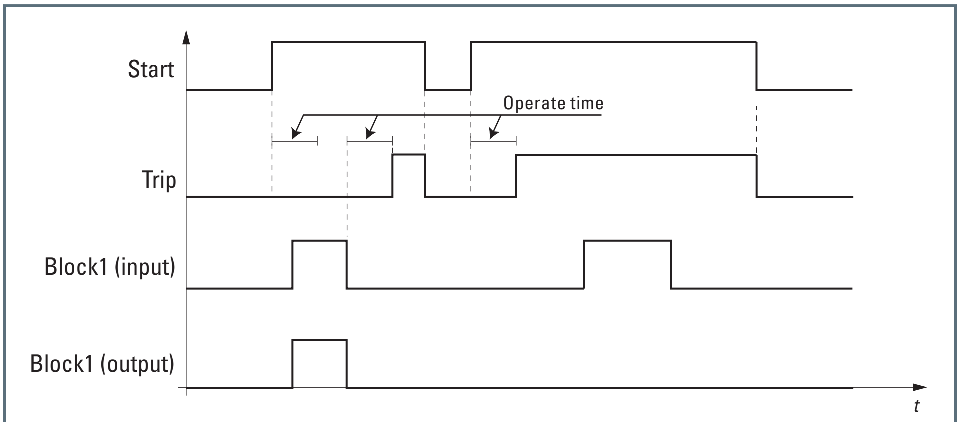
To block the trip of a given protection function, one can map to the logical block function to the logical inputs.[1]
The logical inputs are mapped in the menu **Set \ Input board inputs \ Input IN1-1 (Input IN1-6)**; select *Logical block* for the parameter *Input function IN1-x* (x=1...6)
All protection functions for which the logical block is enabled are blocked when the signal is active.
The status of the function's logical block is available in read (ThySetter and comms interfaces); it is active when the following conditions obtain simultaneously:

- Logical input activated,
- Start of function active (ON),
- Trip of function in standby (OFF).



Functional diagram of logical block - Block1

The logical block is not subject to inhibition criteria after a programmable delay, hence the associated protection function is block for as long as the input remains active.[2]



Logical block timers (Block1)

CAUTION — The activation of a logical input to which the logical block has been mapped blocks all protections for which the block is enabled

Note 1 In this description, the logical block is called both "Logical block" and "Block1" without distinction
Note 2 The block signal holds the timer in reset

— EAC (Equilibratore Automatico di Carico) [ALB frequency (Automatic Load Balancer)] protection

Preface

EAC (Equilibratore Automatico di Carico) [ALB frequency (Automatic Load Balancer)] protection processes the following values:
• frequency [Hz];
• derivative of the frequency [Hz/s].

The introduction of the derivative of the frequency is motivated by the need to quickly deal with situations caused by large power deficits.

The protection has the following regulations:
• Block functions
• Filter functions (measurement means and times)
• EAC1 : 81U, 81O, 81R
• EAC2 : 81U, 81O, 81R

The frequency and frequency derivative values are measured for each phase voltage:
• UL1
• UL2
• UL3

Operating logic

The functions EACx (EAC1, EAC2):

• First maximum/minimum threshold (81O/81U) frequency f>/f<1a [fxa]

• Second maximum/minimum threshold (81O/81U) frequency f>/f<1b [fxb]

• Maximum frequency derivative threshold (81R) df>1 [dfx/dt]

can be blocked when one of the following thresholds is violated:

• Minimum voltage Ueac<
• Maximum voltage Ueac>

• Maximum unbalance ULS>
the reference value is the difference in absolute value of one of the phase voltages |UL1|, |UL2|, |UL3 | and the mean of the three (|UL1|+|UL2|+|UL3|)/3

• Maximum frequency difference UG>
the reference value is the difference in absolute value of the phase frequencies max(f1-f2, f2-f3, f3-f1)

• Maximum variation between consecutive periods UDT>
if T1 and T2 are the amplitudes of two consecutive periods, the reference value is given by their difference DT=|T1-T2|

• Maximum active return power P->
the reference parameter is the active power input at the bar side, the function can be enabled/disabled

With EACx enabled (no block) LEDs and relays can be associated for local and remote verification.

Increasing reliability

For more precise measurements and improved insensitivity to transients, the following settings can be made:

• Number of semi-periods for the average of the frequencies

• Number of semi-periods for calculating the first scale df/dt

• Number of semi-periods for calculating the second scale df/dt

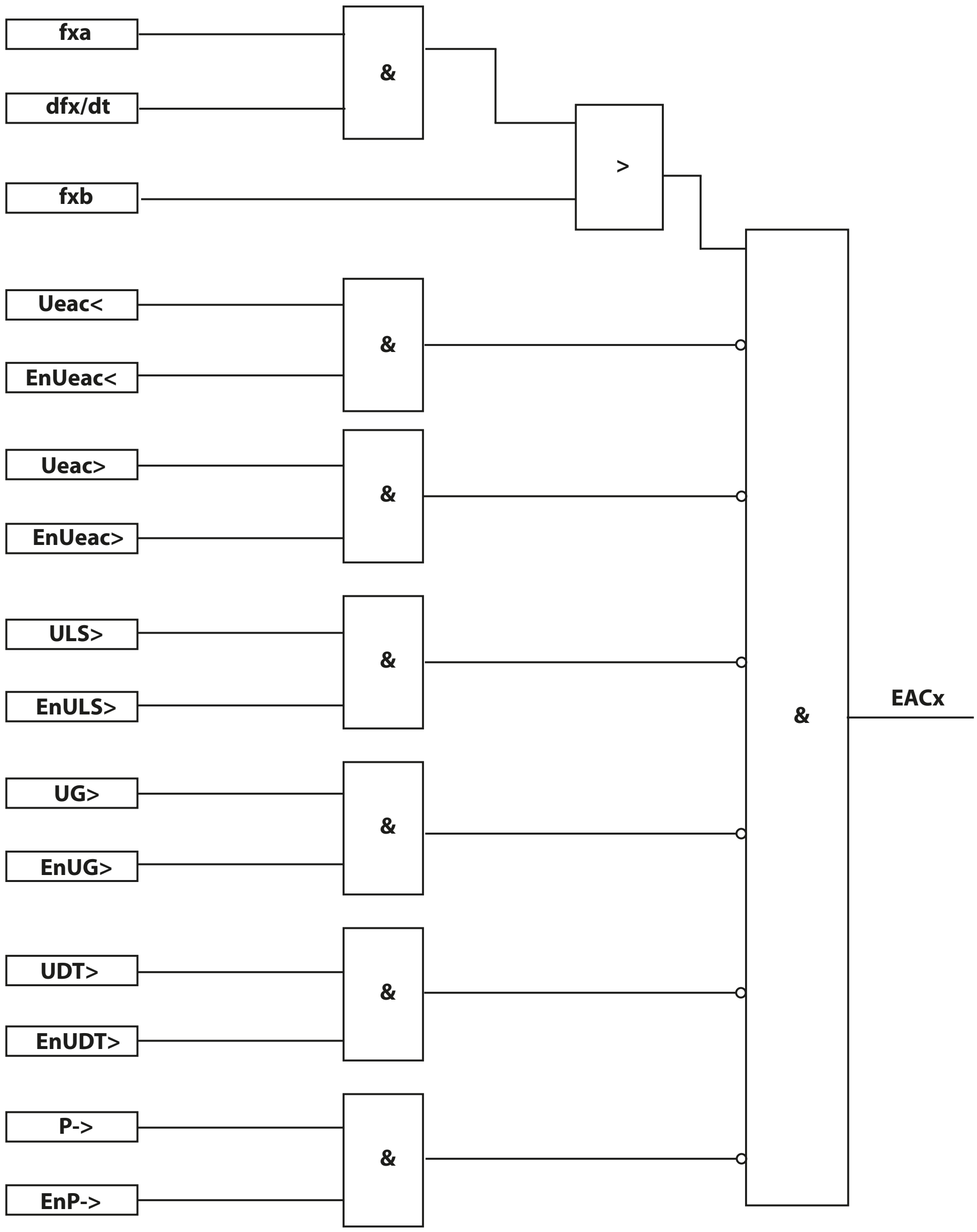
• Number of semi-periods for calculating the third scale df/dt

• Number of averages for calculating the first scale df/dt

• Number of averages for calculating the second scale df/dt

• Number of averages for calculating the third scale df/dt

EAC Logic


fxa
dfx/dt
&
fxb
>
Ueac<
EnUeac<
&
Ueac>
EnUeac>
&
ULS>
EnULS>
&
UG>
EnUG>
&
UDT>
EnUDT>
&
P->
EnP->
&
&
EACx

— Second harmonic restraint - 2ndh-REST

Preface

When a power transformer is powered up, the phenomenon of inrush current occurs, teh amount and duration of which depends on a variety of factors, including:

- Instantaneous value of the power voltage.
- Structural characteristics of the transformer, magnetisation characteristic and dimensions.
- Residual flux.

The maximum value of the inrush current is obtained when the transformer is powered with voltage applied when the sine wave passes through zero, in the positive or negative direction, with positive or negative residual flux respectively.

Furthermore, the ratio between the maximum inrush current and the nominal transformer current diminishes with the size of the transformer itself.

In any case, the inrush current contains a significant second harmonic component.

To prevent the slow intervention of certain protections due to the inrush current, the second harmonic restraint function can be enabled for each threshold of protections 46, 50/51, 50N/51N, 51N(E), 51N(Eme), 51(SQL), 67 and 67N.

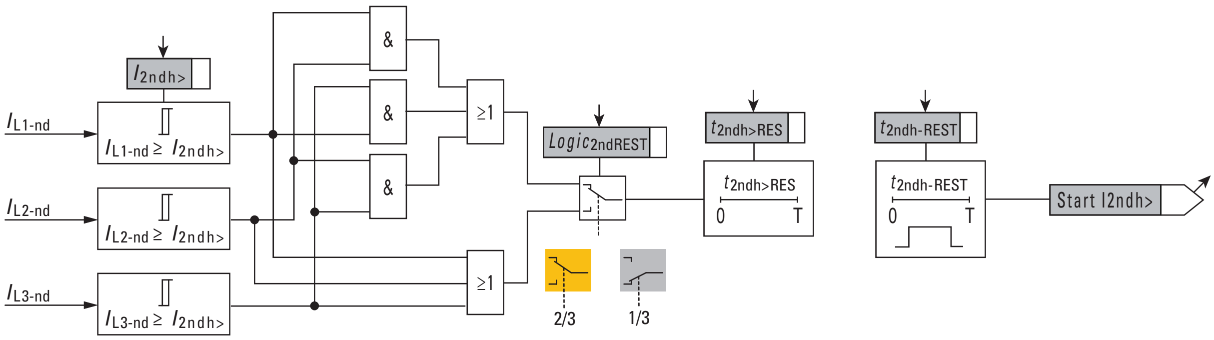
Operating logic

The second harmonic component of each phase current ($I_{L1\text{-}2nd}$, $I_{L2\text{-}2nd}$, $I_{L3\text{-}2nd}$) is compared with an adjustable threshold $I_{2ndh>}$.

When one or two of the three second harmonic components violate the threshold, the threshold itself starts.

To keep the protection functions blocked until they are reset, the second harmonic restraint function features an adjustable reset time $t_{2ndh>RES}$.

Protections for which the second harmonic restraint is enabled are blocked for an adjustable maximum time; the parameter *t2ndH-REST* can be set in the menu **Set\Protections\Second harmonic restraint - 2ndh-REST.**



Functional diagram of the second harmonic restraint - 2NDH/REST

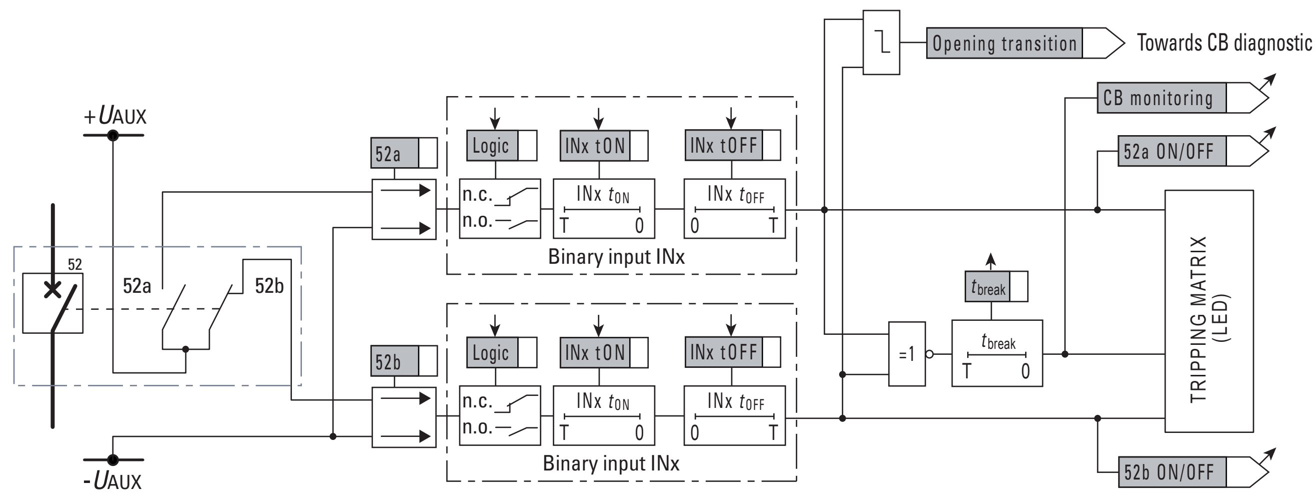
2NDH-REST-diagram.ai

— Breaker monitoring

Preface

A variety of diagnostic, measurement and control functions are provided:

- The relay determines the position of the breaker by monitoring the status of auxiliary contacts 52a and 52b. This information enables the user to issue the open/close commands in complete safety.
- An approximate threshold for the wear of the breaker's poles can be set; when the sum of the interrupted currents (ΣI or ΣI^2) or the number of opening commands violates this threshold, an alarm signal is issued. This function enables the user to schedule maintenance.
- The relay determines the opening time by monitoring the status of auxiliary contacts 52a and 52b; if it is too high, an alarm signal is issued.



Functional diagram of the breaker position monitoring function

Fun-CB-position.ai

Operating logic

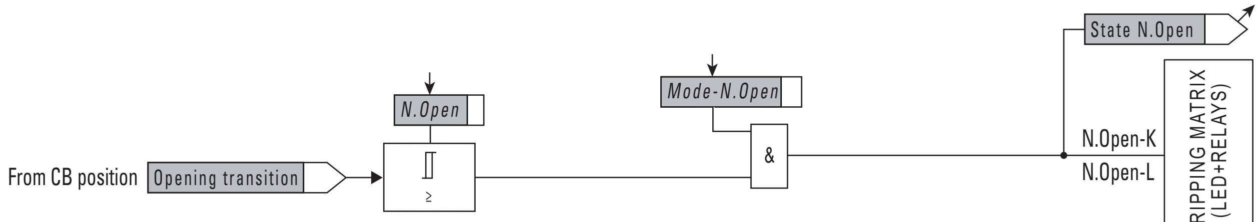
By convention, the status of auxiliary contact 52a corresponds to the position of the breaker (52a open = breaker open), while that of 52b is opposite to the position of the breaker (52b open = breaker closed); the two auxiliary contacts must be mapped to two logical inputs.
To do so, the functions *52a* and *52b* must be configured in the menu **Set \ Input board inputs \ Input IN1-1...(Input IN1-6)**.
The said logical inputs must be programmed with Direct logic and the activation/deactivation timers *IN1 tON*, *INx tON*, *IN1 tOFF* and *INx tOFF* must be zeroed and set to *DIRECT* operating logic.

BREAKER CONTROL
Two output relays can be programmed to open and close the breaker; to do so, set the parameters *CBopen-K* and *CBclose-K* in the menu **Set \ Breaker monitoring \ Associated relays-LEDs**; the position of the breaker can be displayed by assigning the status to two LEDs (parameters *CBopen-L* and *CBclosed-L*).
All parameters are common to the two calibration configurations.

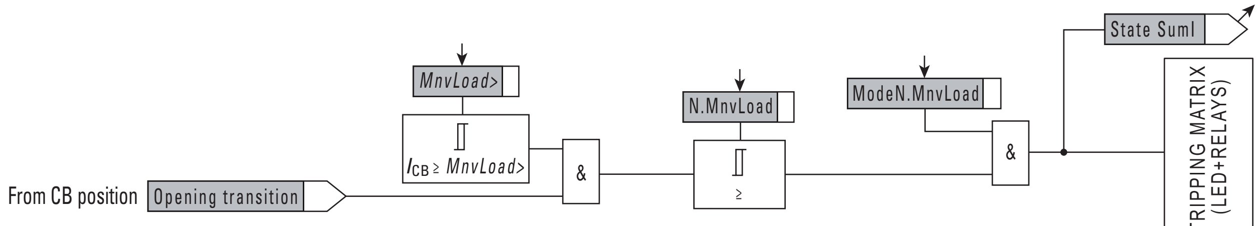
OPENING COMMAND BREAKER DIAGNOSTICS
The breaker diagnostic function uses a variety of criteria to estimate the wear of the breaker.

1) Opening command count (*ModeN.Open ON*). When the set threshold is violated (*N.Open*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED.
2) Opening load command count (*ModeN.MnvLoad ON*). When the set threshold is violated (*N.MnvLoad*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED.
3) Opening no load command count (*ModeN.MnvNoLoad ON*). When the set threshold is violated (*N.MnvNoLoad*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED.
4) Sum of interrupted currents at each pole (*ModeSumI ON*). When the set threshold is violated (*SumI*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED..
5) I^2t sum of interrupted currents at each pole (*ModeSumI ON*). The protection calculates the sum of the specific pass-through energy I^2t on the basis of the measurement of the phase currents at the time of the open command, and using the user programmable breaker opening time specifically provided for calculating I^2t (*tbreak*). When the set threshold is violated (*SumI^2t*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED..
6) Duration of open command (*Mode-tOpen ON*). The protection measures the time between the trip command of a protection function, selected in relation to the associated final relay (*Ktrig-break*), and acquisition of the breaker open status. When the set time period is exceeded (*tbreak>*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED..

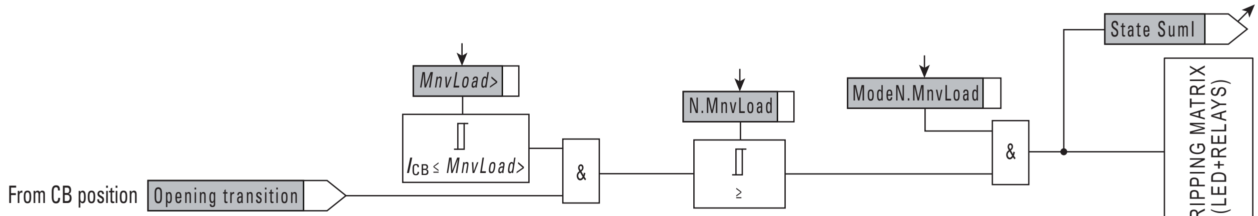
The criteria can be used separately or together at the user's discretion, depending on his selected maintenance schedule.
All the above parameters, as well as the mapping of output relays and LEDs, are available in the menu **Set \ Breaker monitoring \ Breaker diagnostics**.



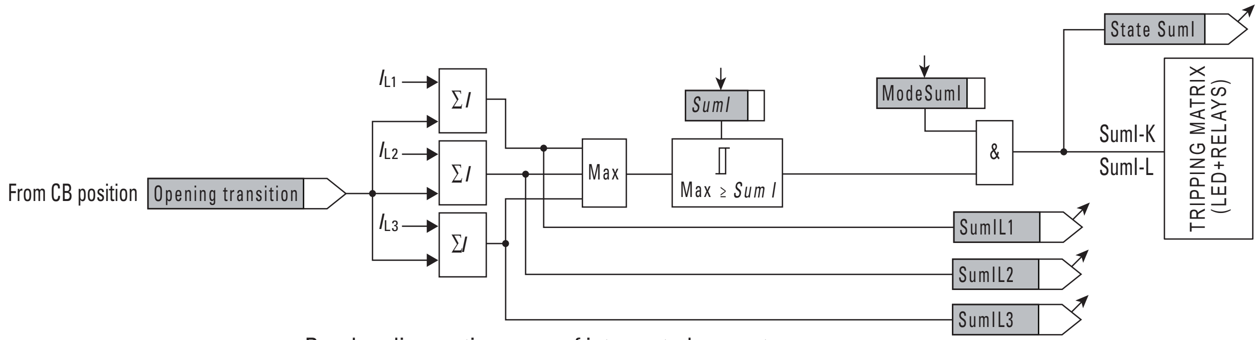
Breaker diagnostics - opening count



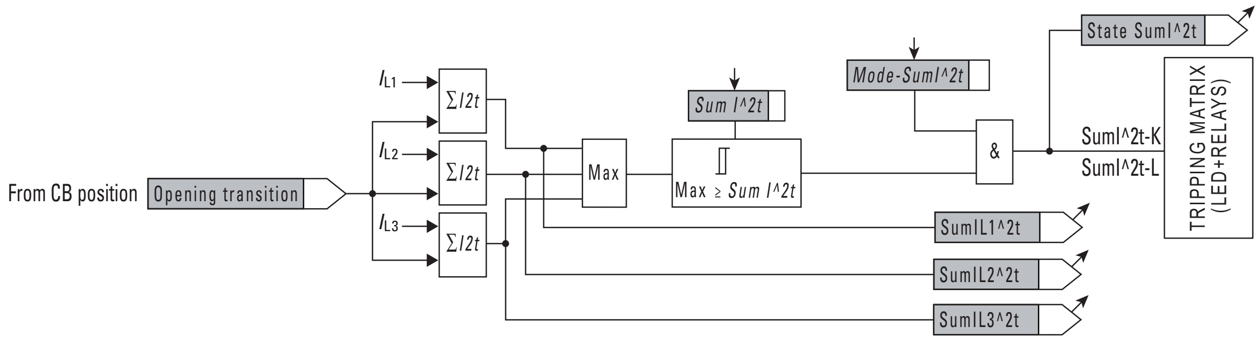
Breaker diagnostics - command under load count



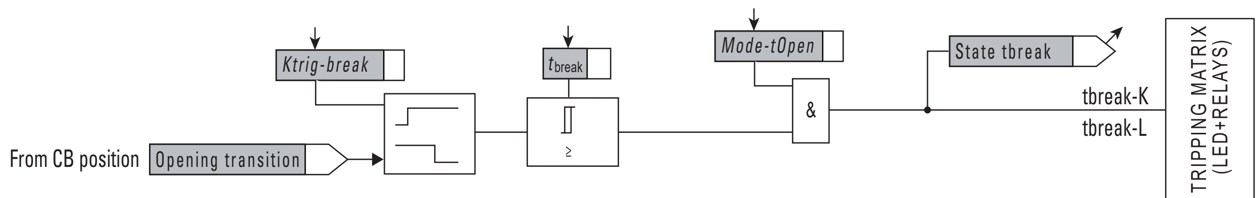
Breaker diagnostics - command no load count



Breaker diagnostics - sum of interrupted currents



Breaker diagnostics - sum of interrupted energy

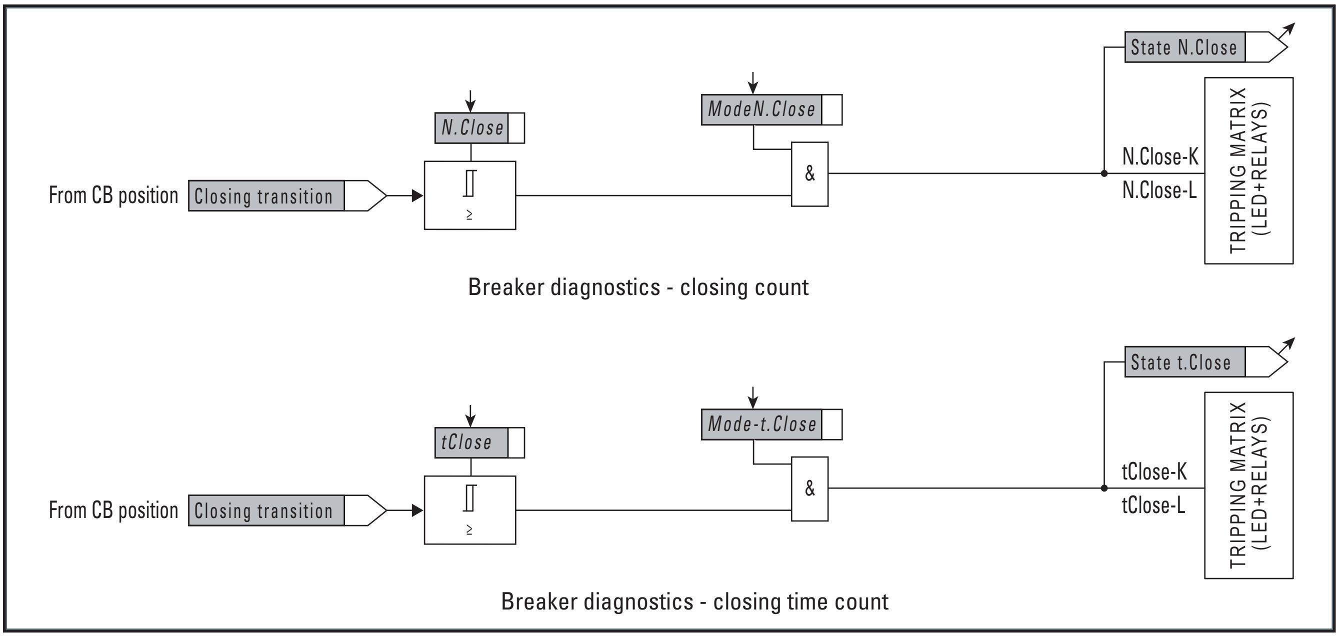


Breaker diagnostics - maximum opening time

CLOSING COMMAND BREAKER DIAGNOSTICS

The breaker diagnostic function uses a variety of criteria to estimate the wear of the breaker.

1) Closing command count (*ModeN.Close ON*). When the set threshold is violated (*N.Close*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED.
2) Duration of close command (*Mode-tClose ON*). The protection measures the time between the close command, selected in relation to the associated final relay (*Ktrig-Close*), and acquisition of the breaker closed status. When the set time period is exceeded (*tClose>*) an alarm signal is issued, which can be assigned to a final relay and/or indicator LED..



Breaker diagnostics - closing count

Breaker diagnostics - closing time count

CYCLIC OPERATION OF THE BREAKER

The DMC panel has a function (which can be enabled/disabled) which cyclically operates the breaker.

The function is active:

- when the breaker is closed,
- when the line is in service,
- when no protection functions have been actuated,
- when no cyclic reclosing is in progress.

Cyclic operation is characterised by an Open-Close cycle scheduled by days, time periods and frequencies, with programmable duration of the Open state.

The function is automatically delayed by 60 minutes if a protection function is in start status (not followed by trip). If a function has tripped or a manual command is given (whether local/remote), the cyclic function is postponed to the next programmed trip day.

— Average measures

The average measures (Demand) are calculated as follows:

Fixed mean

I_{L1FIX}, I_{L2FIX}, I_{L3FIX}
Arithmetic mean of the values I_{L1}, I_{L2}, I_{L3} acquired every 1 s, over a time period t_{FIX}, from 1 to 60 minutes, updated at the end of the period itself.
The mean can be reset with the keypad, with the command **Reset average measures** (in the menu **Commands** Thysetter), or via a logical input. The parameter *tFIX* is in the menu **Set \ Average measures**.

Mobile mean

I_{L1ROL}, I_{L2ROL}, I_{L3ROL}
The arithmetic mean, in a mobile window of *N.Rol* * *tROL*, of the values I_{L1}, I_{L2}, I_{L3} acquired every 1 s, where T is the length of each subinterval of time *tROL*, from 1 to 60 minutes, and *N.Rol* is the number of subintervals of time (from 1 to 24), updated at the end of each subinterval. The mean can be reset with the keypad, with the command **Reset average measures** (in the menu **Commands** Thysetter), or via a logical input.
The parameters *tROL* and *N.Rol* are in the menu **Set \ Average measures**.

Maximum

I_{L1MAX}, I_{L2MAX}, I_{L3MAX}
Maximum value of the arithmetic mean of the values I_{L1}, I_{L2}, I_{L3} acquired every 1 s, over a window equal to the time subinterval *tROL* (setting shared with Mobile mean), updated at the end of the subinterval itself.
The mean can be reset with the keypad, with the command **Reset average measures** (in the menu **Commands** Thysetter), or via a logical input.
tROL is the same parameter as that used for the Mobile mean.

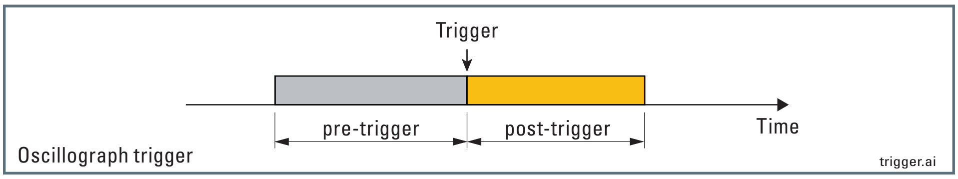
Minimum

I_{L1MIN}, I_{L2MIN}, I_{L3MIN}
Minimum value of the arithmetic mean of the values I_{L1}, I_{L2}, I_{L3} acquired every 1 s, over a window equal to the time subinterval *tROL* (setting shared with Mobile mean), updated at the end of the subinterval itself.
The mean can be reset with the keypad, with the command **Reset average measures** (in the menu **Commands** Thysetter), or via a logical input.
tROL is the same parameter as that used for the Mobile mean.

— Oscillographyy

Set trigger

The following parameters in the menu **Oscillography \ Set trigger** are user programmable:
- *Pre-trigger time* and *Post-trigger time*.



- When the parameter *Enable triggers with outputs* is set to *ON*, registration starts when any protection threshold changes state.
- When the parameter *Trigger with outputs* is set to *ON* , registration starts when one or more outputs selected in the menu *trigger with outputs* (51AP, 52CH, 80S, KS1-1...6) and *trigger with DMRIS0 control outputs* (OUTD1-1, OUTD1-2, OUTD2-1, OUTD2-2) change status.
- When the parameter *Enable triggers with inputs* is set to *ON*, registration starts when any logical input selected in the menu changes state.
  - *Trigger with inputs* (IN1-1...IN1-6, INC-1...INC-5)
  - *Trigger with DMRIS01 inputs* (IND1-1...IND1-12)
  - *Trigger with DMRIS02 inputs* (IND2-1...IND2-12)
- Filling 80% of memory will generate an alarm if the parameter *80% buffer alarm* is set to *ON*.

Set sampled channels

The instantaneous values (i_{L1}, i_{L2}, i_{L3}, i_E, u_{L1}, u_{L2}, u_{L3}, u_E, u_{AUX}, i_{CBCOIL}, i_{L2C}, i_{L2C}, u_{12}, u_{23}, u_{311}, u_{L41}, I_{SQL1}, I_{Ne}) to be registered can be selected in the menu **Set \ Oscillography \ Set sampled channels**.

Set measurement channels

The analogue values (Frequency, I_{L1}, I_{L2}, I_{L3}, I_E, U_{L1}, U_{L2}, U_{L3}, U_E, U_{12},...etc.) to be registered can be selected in the menu **Set \ Oscillography \ Set measurement channels.**
Each of the twelve measurement channels can be mapped to a measurement.

Set digital channels

The I/O signals (52AP, 52CH, 80S, TripMV, KS1-1... KS1-6, KC2-1...KC2-8, KS1-1... KS1-6, IN1-1... IN1-6, INC-1... INC-5) to be registered cxan be selected in the menu **Set \ Oscillography \ Set digital channels**.

Set DMRIS0 digital channels

The I/O signals related to the first external DMRIS0 module (IND1-1...IND1-12, OUT1-1, OUT1-2) and second external DMRIS0 module (IND2-1...IND2-12, OUT2-1, OUT2-2) to be registered can be selected in the menu **Set \ Oscillography \ Set digital channels** and **Set \ Oscillography \ Set DMRIS0 digital channels**.
Each of the sixteen digital channels can be mapped to an I/O signal.

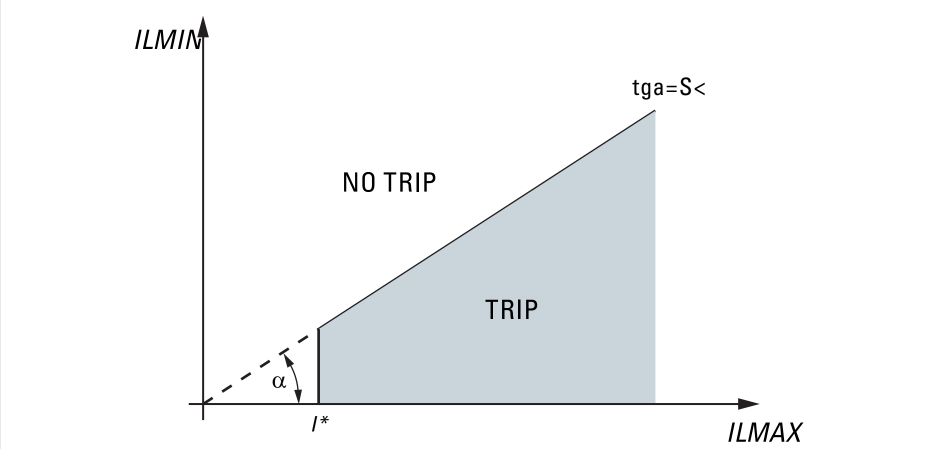
— CT Monitoring - 74CT

Preface

The function detects interruptions of the secondary phase CT circuits and/or DMC3S panel input circuits by measuring the symmetry of the secondary CT currents themselves. The symmetry is measured in terms of the ratio between the minimum and maximum RMS values of the three fundamental components of the three phase currents (I_{LMIN} / I_{LMAX}).
The function starts if both the following conditions are satisfied:

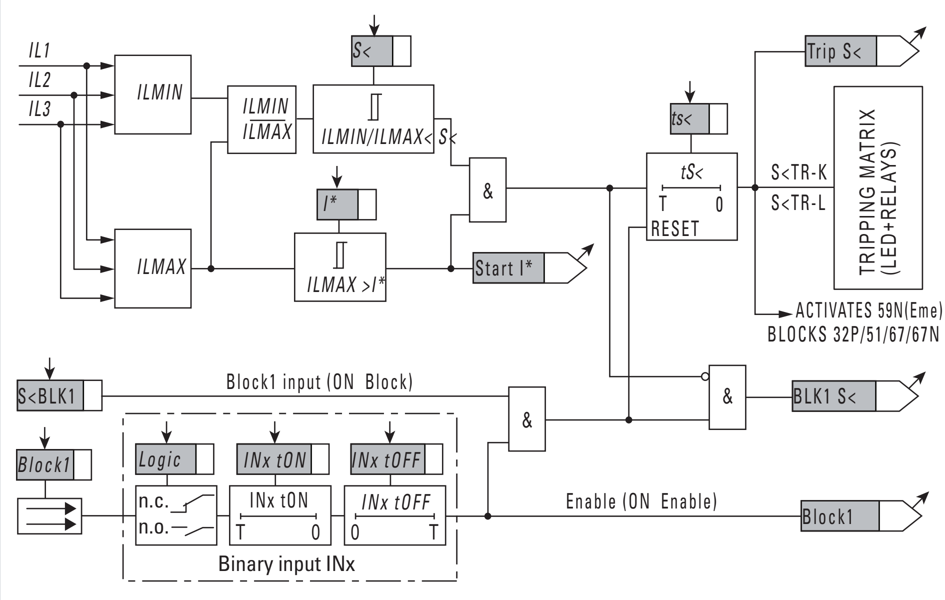
- (I_{LMIN} / I_{LMAX}) < S<
- I_{LMAX} > I*

where S< is the trip threshold and I* is the maximum threshold of the three phase currents, both of which can be set by the user.
When the function starts, so does the count of timer $t_{S<}$. If the two above conditions persist, when the operating time expires, the function trips (Trip), otherwise it is reset. The trip characteristic is definite time.
When the function is actuated, the associated final relay *S<TR-K* and/or LED *S<TR-L* is triggered.
The function can be enabled or disabled (ON/OFF).
When a fault is detected, the CT monitoring function activates the 59N emergency function (59N eme), blocks functions 32P, 50/51, 67 and 67N) and, after a configurable delay t_{VT-AL}, issues an alarm.



Phase CT monitoring function trip characteristic -74CT

char74CT.ai



Functional diagram of the phase CT monitoring function - 74CT

Fun-74CT.ai

If the parameter *S<-BLK1* is set to *ON* and a logical input is set to acquire the logical block (Block1), the function is blocked for the activation time of the logical input in question. The operating timer is held in reset mode so that the operating time count starts when the block signal expires;[1]the logical block function can be assigned to the input in the menu **Set \ Input board inputs \ Input IN1-1... (Input IN1-6)**.
All parameters are available in the menu **Set \ CT -74CT monitoring**

Notes 1 For a detailed description of the operation of the logical block (Block 1) refer to the paragraph "Logical block" in the chapter MONITORING AND CONTROL. .

— VT monitoring - 74VT

Preface

The line VT monitoring function is used to detect faults on the voltmetric inputs from the VT line relay. Such faults may typically be due to interruptions in the secondary connections of the TVs or faults on the relay's internal measurement circuitry.
The function is used both to provide an alarm signal and activate emergency function 51N (51N Eme) and to block functions 25, 32P, 67 and 67(N) which may intervene incorrectly in the absence of the measured voltages. The function detects VT faults under the following conditions:
• loss of one or two phase voltages;
• loss of the three phase voltages under load;
• absence of the three phase voltages after power up.

• **Loss of one or two phase voltages;**
This fault in the voltage measurement circuits causes a negative sequence voltage component to appear, but without the negative sequence current component. The loss of one or two phase voltages is detected when the negative sequence voltage component violates an adjustable threshold (U_{2VT}>) and the negative sequence current component is below an adjustable threshold (I_{2VT}>).
The negative sequence current component is calculated as follows:

$$I_2 = (\vec{I}_{L1} + e^{-j120°}\vec{I}_{L2} + e^{+j120°}\vec{I}_{L3})/3,$$

The negative sequence voltage component is calculated as follows:

$$U_2 = (\vec{U}_{L1} + e^{-j120°}\vec{U}_{L2} + e^{+j120°}\vec{U}_{L3})/3,$$

where $e^{-j120°} = -1/2 - j\sqrt{3}/2$ e $e^{+j120°} = -1/2 + j\sqrt{3}/2$

• **Loss of the three phase voltages under load**
Loss of the three phase voltages under load is detected when the fundamental component of all three phase voltages falls below a configurable threshold (U_{VT}<) and all three phase currents during the current grid parameter period ($I_{L1(k)}$, $I_{L2(k)}$, $I_{L3(k)}$) do not differ from an adjustable threshold (ΔI_{VT}<) from the value of the same currents measured over the preceding period ($I_{L1(k-1)}$, $I_{L2(k-1)}$, $I_{L3(k-1)}$). By checking whether the currents vary between the current and previous grid periods we avoid erroneous activation of function 74VT in case of a three-phase dead short close to the TVs, when the voltages suffer a drastic drop and the currents increase rapidly. Under load, on the other hand, the currents do not vary, or the variation due to a change in the load, is lower than that experienced during a short circuit.

• **Absence of the three phase voltages after power up**
The absence of the three phase voltages after power up is detected when the breaker is closed and the three phase voltages (U_{L1}, U_{L2}, U_{L3}) are all below the adjustable threshold (U_{VT}<) and the three phase currents (I_{L1}, I_{L2}, I_{L3}) are all below the adjustable threshold (I_{VT}>) - the latter must be set to a value greater than the current present when the load is powered up, but lower than the short circuit current.

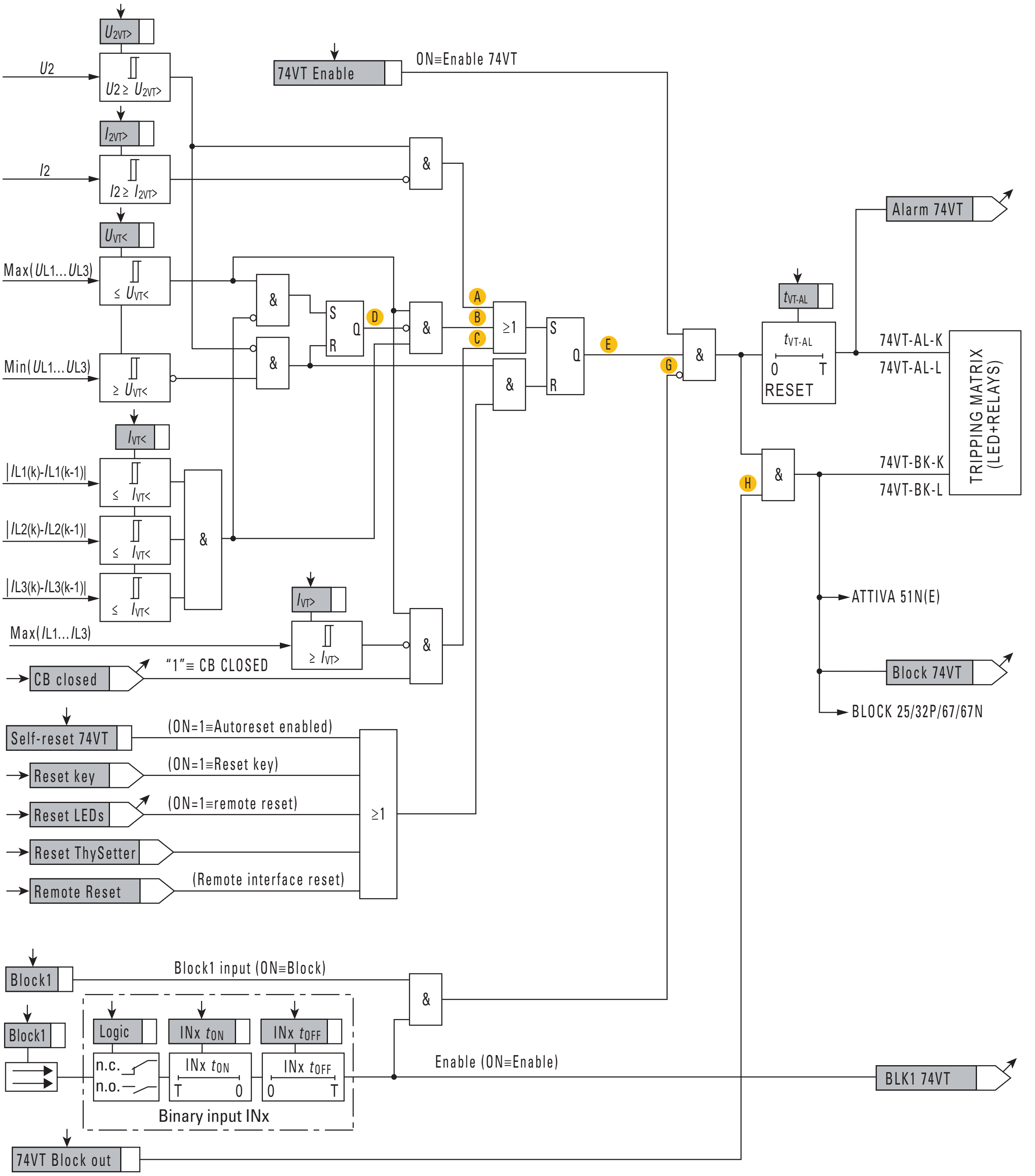
If the parameter *74VT-BLK1* is set to *ON* and a logical input is set to acquire the logical block (Block1), the function is blocked for the activation time of the logical input in question. The operating timer is held in reset mode so that the operating time count starts when the block signal expires;[1]the logical block function can be assigned to the input in the menu **Set\Input board inputs\Input IN1-1... (Input IN1-6)**.

All parameters are available in the menu **Set\VT -74VT monitoring**

Functional block (Block3)

When a fault is detected under one of the three preceding conditions, the VT monitoring function activates the 51N emergency function (51N eme), blocks functions 25, 32P, 67 and 67N) and, after a configurable delay t_{VT-AL}, issues an alarm.

Notes 1 For a detailed description of the operation of the logical block (Block 1) refer to the paragraph "Logical block" in the chapter MONITORING AND CONTROL. .



(A) Activates 74VT when one or more phase voltages is lost and no negative sequence current is available (to discriminate disymmetric short circuits).

(B) Activates 74VT when all three phase voltages are lost with e generator under load.

(C) Activates 74VT when all three phase voltage are absent during line power up (VT not connected), and checks that none of the three currents are greater than IVT>. To not activate 74VT on closing to a polyphase shirt circuit, IVT> must be set to a value lower than ICC (but greater than the maximum load inrush current). In any case the breaker must be closed, otherwise 74VT activates with the machine stopped.

(D) Inhibits activation of 74VT on polyphase short circuits, by setting the flip-flop when the current variation of at least one phase is subject to a pulse variation. The inhibition of 74VT automatically resets when all three phase voltages return above the threshold and the negative sequence voltage falls below the threshold.

(E) The activation of 74VT is maintained when at least one of conditions A, B and C is satisfied. The function 74VT can be reset manually (so long as the automatic reset conditions in point D are satisfied) or automatically, if configured to do so by the user.

(G) Activation of 74VT can be inhibited by a block command applied to a digital input.

(H) Activation of 74VT is always reported. The voltage inverse protections can also be blocked, if so configured by the user.

Functional diagram of the VT monitoring function (74VT)

Fun_74VT.ai

— Breaker coils control monitoring

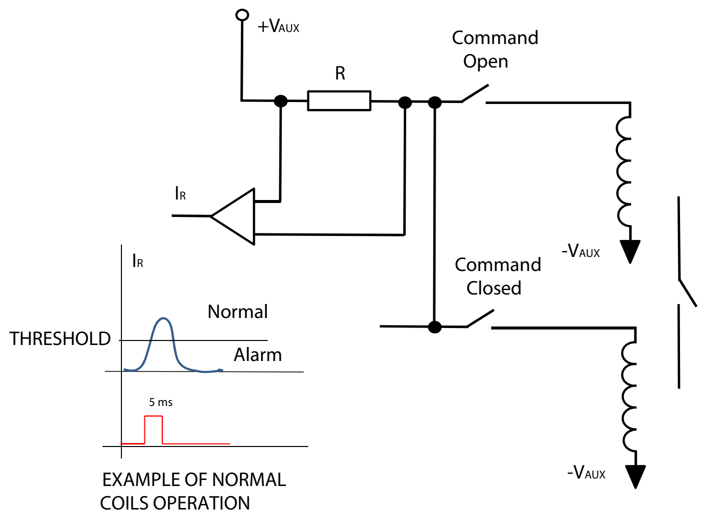
Preface

The breaker open/close circuit can be controlled by the relay to report any faults capable of causing failure of operation of the breaker due to trip of protections or due to the operator's intentional commands.
The 74TCS monitoring function detects faults such as circuit interruptions, loss of auxiliary voltage or interruption/short circuit of the open/close coils.
The supervision is implemented by means of detection of the current circulating in the breaker's coilss, the operating logic is selected automatically by the protection function itself.

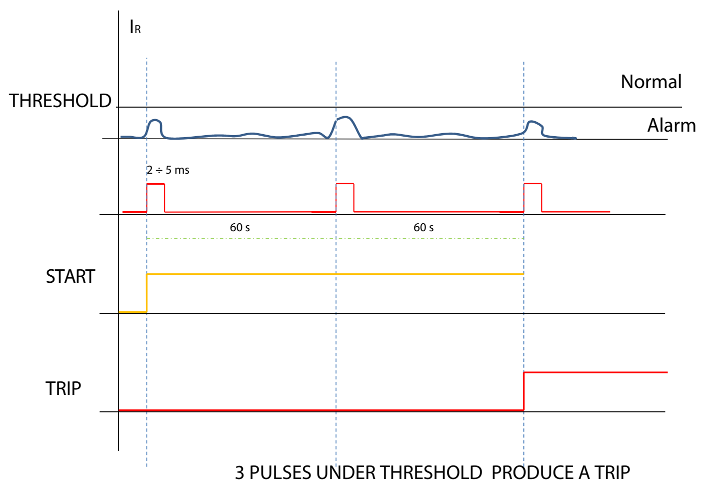
Operating logic

The command circuit monitoring function can be enabled or disabled; to do so set to *ON* or *OFF* the parameter *FMCBCOIL Enable* in the menu **Set \ Breaker coils control monitoring**.

When the breaker is closed, diagnostics are run on the opening coils, and vice-versa.
If the position is not congruent, diagnostics are run on both coilss.



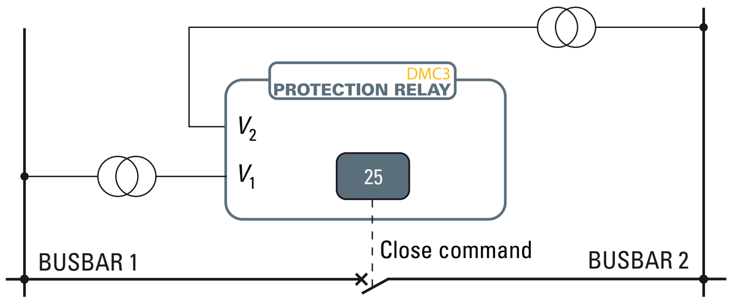
A circuit fault is reported when the current I_R is below the set threshold during the CH pulse (close command) or AP pulse (open command). The duration of the CH and AP pulses can be set in the menu **Set \ Breaker coils control monitoring \ CH pulse duration** and **Set \ Breaker coils control monitoring \ AP pulse duration.**
Since this condition can arise even when the breaker's opening circuit is operating (e.g.: the protection has commanded opening but the opening time has not yet passed), to prevent incorrect reporting, the fault condition is controlled cyclically every 60 s, the first under threshold condition initiates the START, and if this condition persists for a further 120 s (60+60) the TRIP is actuated; if, on the other hand, I_R returns above the thrshold everything is working properly and the START is aborted.



— Synchrocheck relay (Synchro check) - 25

Preface

The synchro check function checks that the connection between two grids (synchronous or asynchronous) can be made without risking the stability of the power system.
A typical application is the synchronisation of two bars by means of a coupler.



Synchronisation of two bars

Measurement inputs

The grid voltages measured at the inputs are used:
- V_1: the reference measurement: the parameter *Voltage measurement for synchro check* in the menu **Set \ Base** selects the parameter (phase voltage U_{L1}, U_{L2} U_{L3})[1].
- V_2 voltage measurement (phase-ground) to be synchronised. The input otherwise used to measure the residual voltage is used (clamps MV5-MV6); the selection uses the parameter *Measurement UE or V2* in the menu **Set \ Base**.[1]

Output relays

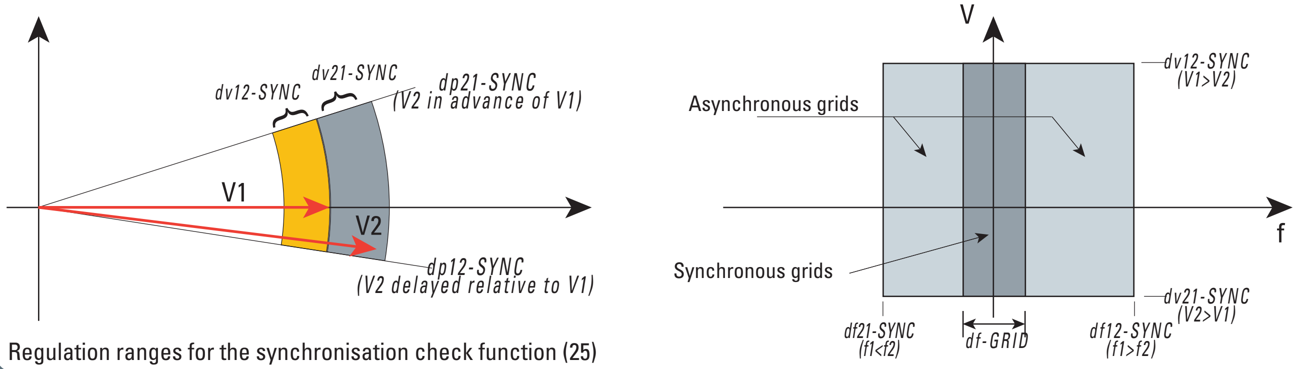
The synchro check function can activate one or more output relays according to the usual matrix assignment criterion.
You must select Pulse mode (menu **Set \ Relay**) and program the duration according to the specifications of the breaker.

The devices uses the measured difference in frequency between the two grids to determine whether the grids are **synchronous** or **asynchronous**.

Synchronous grids

For **synchronous grids** the final relay is commanded (synchronisation ok) when the following conditions obtain:
- the trip signal (keypad, logical input or communication) is active,
- the block input signal (keypad, logical input or communication) is inactive,
- the breaker is open,
- the control of inputs V_1 and V_2 (function 74VT) is ok,
- the two measured frequencies are in the permitted operating range ($f_n \pm f_{RANGE}$) for an adjustable time of no less than t_{STAB},
- the difference, which defines the synchronous grid condition, between the two measured frequencies is less than an adjustable threshold (df_{-GRID}) for an adjustable time of no less than t_{STAB},
- the value of the two voltages is between a minimum threshold ($V_{min-SYNC}$) and a maximum threshold ($V_{max-SYNC}$), both adjustable, for an adjustable time of no less than t_{STAB},
- the difference between the voltages V_1 and V_2 (with $V_1 > V_2$) is less than an adjustable threshold ($dV12_{-SYNC}$), or the difference between V_2 and V_1 (with $V_1 < V_2$) is less than an adjustable threshold ($dV21_{-SYNC}$), for an adjustable time no less than t_{STAB},
- the phase shift between V_1 and V_2 (with V_2 delayed relative to V_1) is less than an adjustable threshold ($dp12_{-SYNC}$), or that between V_1 and V_2 (with V_1 delayed relative to V_2) is less than an adjustable threshold ($dp21_{-SYNC}$), for an adjustable time no less than t_{STAB},
- the above conditions persist for a time no less than the adjustable parameter (t_{SYNC}).

If any of the above conditions does not obtain, the close command is not issued.



Regulation ranges for the synchronisation check function (25)

Note 1 This parameter can only be modified at Level 1

Asynchronous grids

For **asynchronous grids** (e.g. two separate distribution grids) the final relay is operated (synchronisation ok) once the comparison between the amplitudes and frequencies has been passed. The close command is issued in advance of the null phase shift condition, when the measured phase shift is equal to the value calculated from the delays (relay + breaker close time) and frequency difference between the two grids (slip frequency). In this way, the contacts close in a condition of perfect synchronisation.
If a power transformed is present between the two voltage measurement inputs, the amplitude differences on both sides must be compensated for. This compensation can be done externally (using adapter transformers) or internally (software).
The software compensation is programmed using the parameter *Phase correction V1-V2* in the menu **Set \ Base**[1], so as to compensate for the phase shift without the need for external adapter transformers. If there is no power transformer or external adapter transformers are used, a null phase shift must be set.

Control Functions

The following parameters are controlled cyclically:
- Instability of the frequency measurement: if the measurement is unstable, a report is issued, and if the difference between consecutive measurements is greater than the adjustable value of parameter $Rof>_{SYNC}$, execution of the parallel is suspended. Setting $Rof>_{SYNC}$ = 0 disables stability control.
- Status of the line VT monitoring function; if faults are detected on the secondary VT connections or due to intervention of function 74VT, execution of the parallel is suspended.

Operating logic

The synchronisation control sequence can be started by a pulse command generated by:
- automatic reclosing, internal to the protection relay,
- a local command on the front keypad with the I (closing) button
- a command over the comms interface.

When synchronisation control is requested, the congruence controls are run (see the preceding paragraph). If a non-permitted state is detected, the *Fault Sync* report is issued and synchronisation control is not run.
If, on the other hand, the checks are positive, the synchronisation control sequence is initiated (report *SYNC - n IN PROGRESS;* with n = 0, 1, 2, depending on the operating mode)..
Only the enable conditions for the current operating mode are checked.
If both voltages are incoming (Mode 0), the device checks whether the two grids are synchronous or asynchronous by comparing the measured frequency difference to the threshold Df_{GRID}; if the difference is less than the threshold, the grids are deemed to be synchronous.
The various operating situations are reported by messages:
If the conditions are satisfied, the synchronisation function issues a close enable signal.
The duration of the enable signal can be adjusted by setting the parameter *Operating mode* to *PULSE* and the duration (*Minimum pulse duration*) to the desired value for the final relay programmed in function 25; the parameters are available in the menu **Set \ Control board 1 outputs**.
You can set the synchronisation attempt timeout ($timeout_{SYNC}$) in the menu **Set \ Configuration parameters A \ Synchrocheck relay - 25 \ Common configurations**; if the conditions are not satisfied within this time, the sequence is suspended.

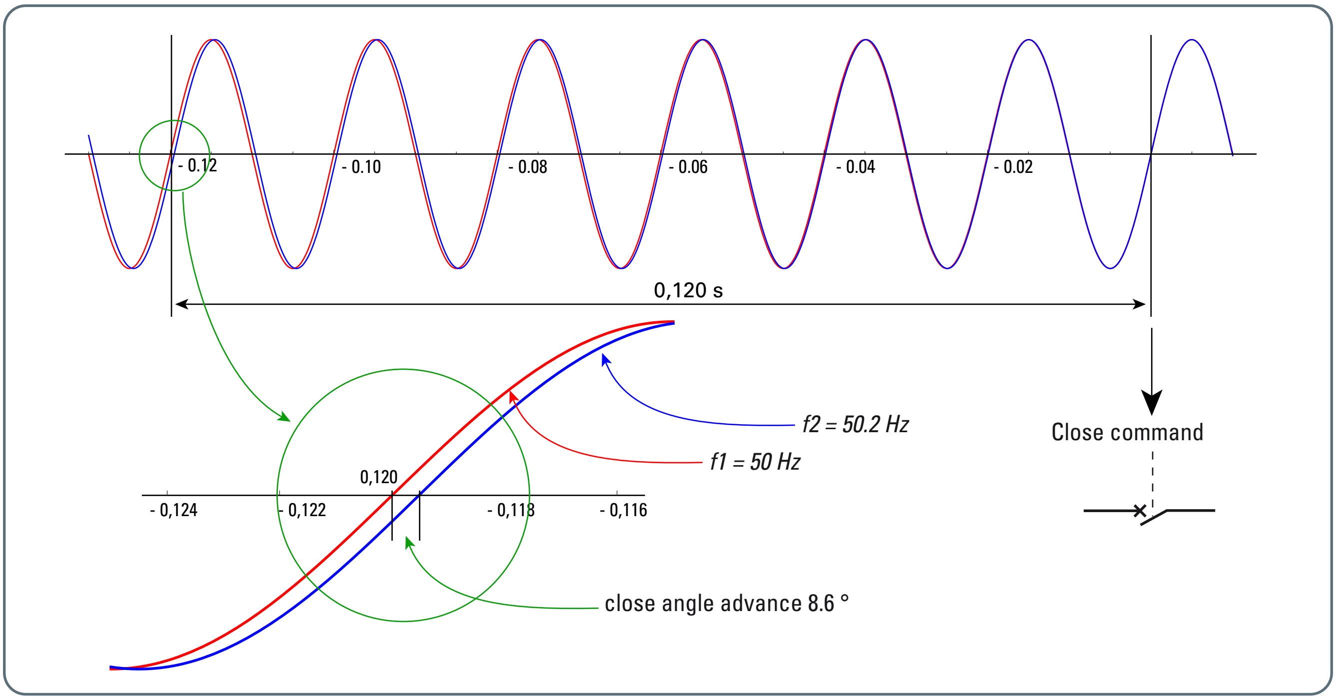
Close command advance

For **asynchronous grids** the final relay must be commanded (synchronisation ok) in advance to ensure that the breaker closes in conditions of perfect synchronisation.
Depending on the breaker closing time and the frequency difference (slip frequency) and phase shift of the measured voltages V1 and V2, the device determines the next synchronisation time. The close commanded is issued in advance of the synchronisation time by the advance time calculated on the basis of the frequency difference (Δf).
The electrical advance angle required to compensate for the closing delay of the breaker is defined by:
$\varphi_A = 360 \cdot (t_{CB-CLOSE} + t_{MEAS}) \cdot \Delta f$
where:
φ_A: electric angle
$t_{CB-CLOSE}$: breaker closing time in seconds
t_{MEAS}: protection relay measurement time (acquisition + measurement + final relay time) in seconds
Δf: difference between the measured values of the two grid frequencies (slip frequency) in Hz

For example, with the following values:
$t_{CB-CLOSE}$: breaker closing time in seconds = 80 ms
t_{MEAS}: protection relay measurement time (acquisition + measurement + final relay time) = 40 ms
f_1: frequency of V1 signal = 50 Hz
f_4: frequency of V signal = 50.2 Hz
Δf: difference between the measured values of the two grid frequencies (slip frequency) = 0.20 Hz

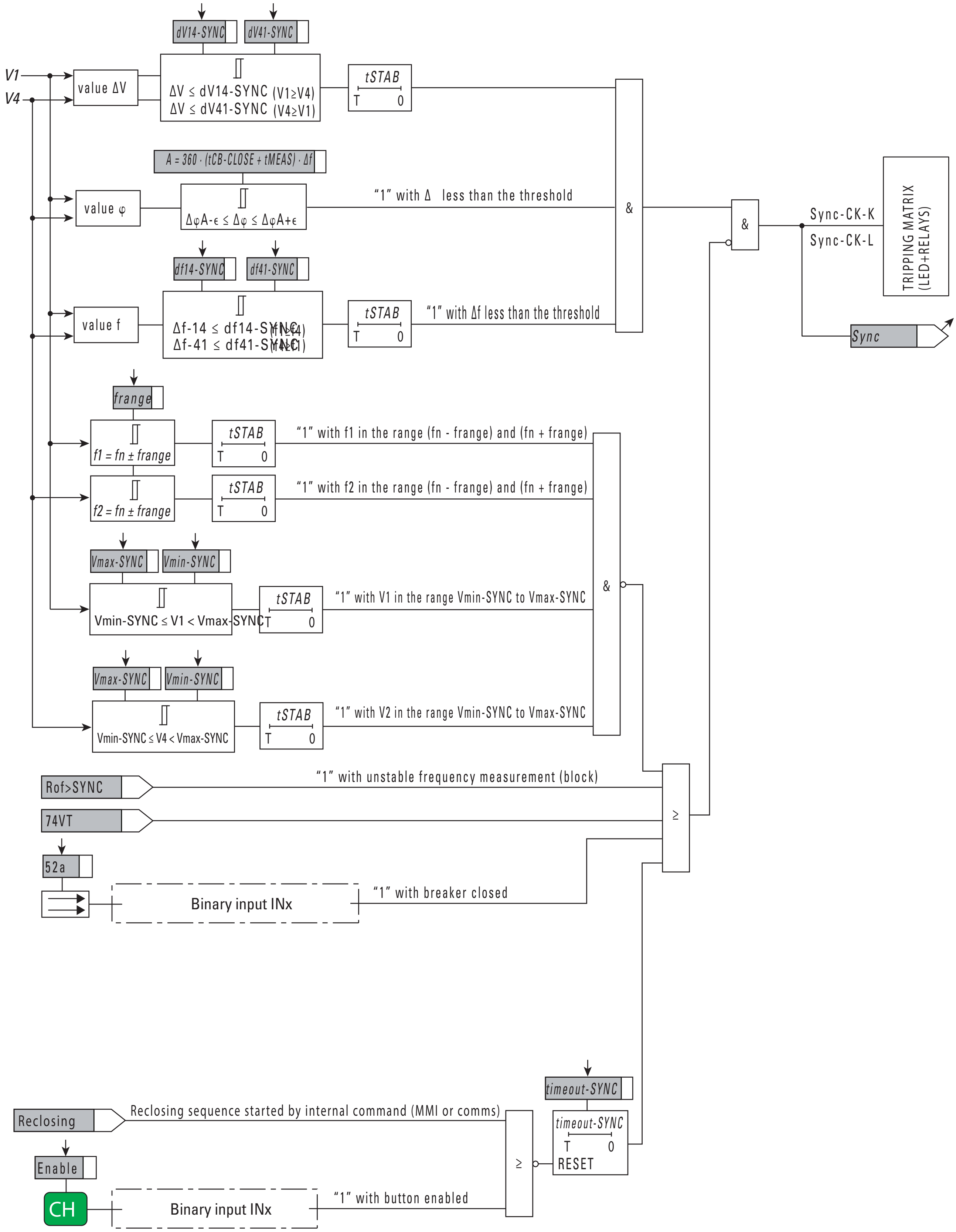
Note 1 This parameter can only be modified at Level 1

To ensure that the breaker closes in perfect synchronisation, the relay must send the close command when the phase difference is = 8.6 degrees and V_2 is delayed relative to V_1.

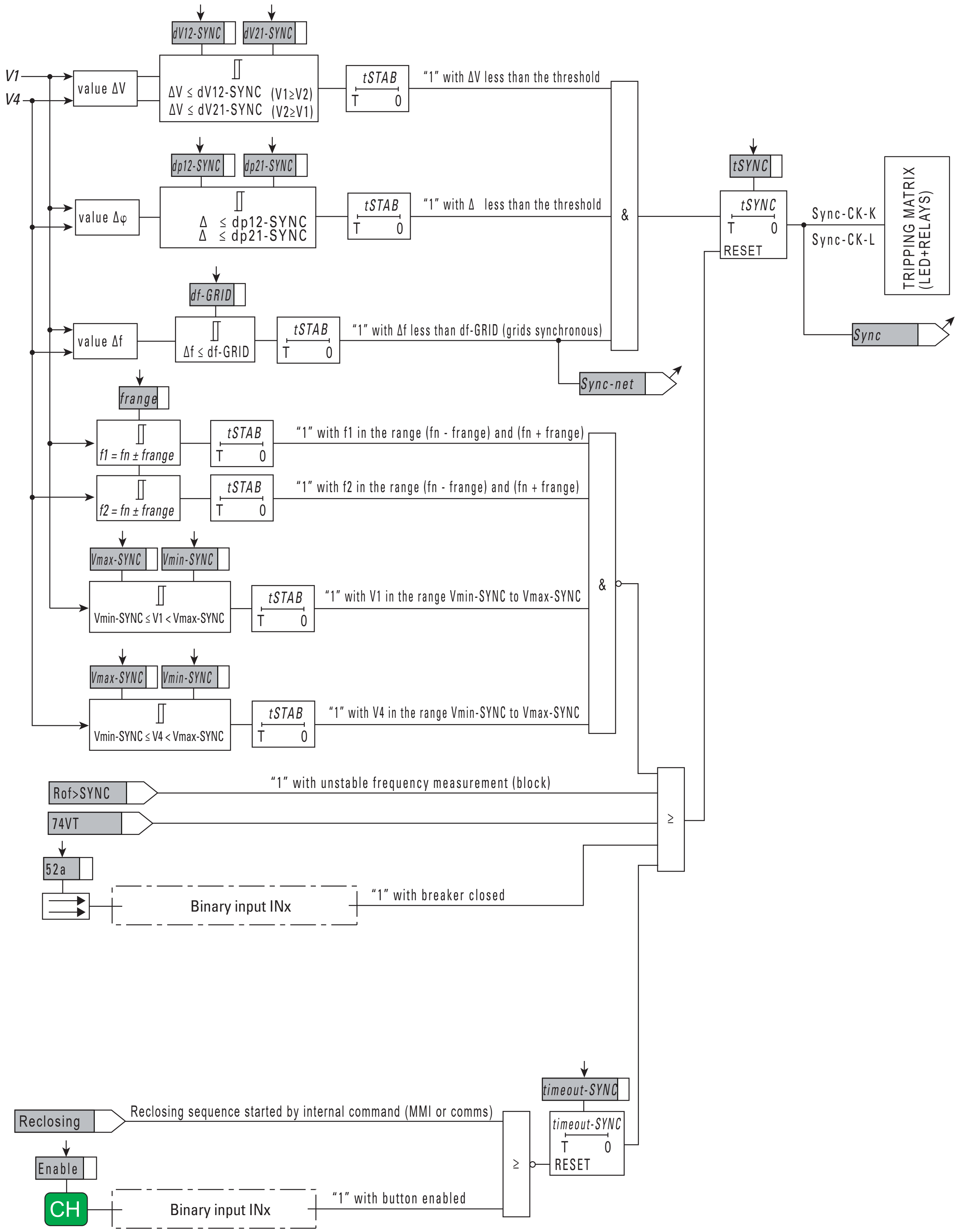


Functional block (Block3)

If the voltmetric measurement chain fails (function 74VT tripped), the synchronisation control function is blocked.



Functional diagram of the synchronisation check function (25) for asynchronous grids



Functional diagram of the synchronisation check function (25) for synchronous grids

— Auto-reclose (79)

Preface

The reclosing function can be enabled with:
- The front panel switch,
- The ThySetter configuration software
- The IEC61850 comms protocol

A variety of reclosing sequences can be set, corresponding to:
- Rapid reclosing,
- Rapid reclosing followed by slow reclosing,
- Rapid reclosing following slow reclosing and one or more memorized reclosings (0...5).

The reclosing sequence is initiated following trip of the following protection functions to open the breaker:
- 79-I> Reclosing due to trip of threshold I> (50/51)
- 79-I>> Reclosing due to trip of threshold I>> (50/51)
- 79-I>>> Reclosing due to trip of threshold I>>> (50/51)
- 79I->>>> Reclosing due to trip of threshold I>>>> (50/51)
- 79-IPD> Reclosing due to trip of threshold IPD> (67)
- 79-IPD>> Reclosing due to trip of threshold IPD>> (67)
- 79-IPD>>> Reclosing due to trip of threshold IPD>>> (67)
- 79-IPD>>>> Reclosing due to trip of threshold IPD>>>> (67)
- 79-IE> Reclosing due to trip of threshold IE> (50N/51N)
- 79-IE>> Reclosing due to trip of threshold IE>> (50N/51N)
- 79-IE>>> Reclosing due to trip of threshold IE>>> (50N/51N)
- 79-INe> Reclosing due to trip of threshold INe> (51N(E))
- 79-INe>> Reclosing due to trip of threshold INe>> (51N(E))
- 79-IED> Reclosing due to trip of threshold IED> (67N)
- 79-IED>>a Reclosing due to trip of threshold IED>>a (67N)
- 79-IED>>b Reclosing due to trip of threshold IED>>b (67N)
- 79-IED>>> Reclosing due to trip of threshold IED>>> (67N)
- 79-IED>>>> Reclosing due to trip of threshold IED>>>> (67N)
- 79-IED>>>>> Reclosing due to trip of threshold IED>>>>> (67N)

Symbols

The following parameters can be adjusted (in the menu **Set \ Auto-reclose - 79**):
- N.DAR Number of memorized reclosings
- t_{rdt} Rapid reclosing wait time
- t_{sdt} Slow reclosing wait time
- t_{rf} Neutralisation time[1] following trip due to phase fault
- t_{rt} Neutralisation time following trip due to ground fault
- t_{dr} Discrimination time[2] following rapid reclosing
- t_{dl} Discrimination time following slow reclosing
- t_{dm} Discrimination time following memorized reclosing
- t_{d} Discrimination time following intentional reclosing

Rapid reclosing

Rapid reclosing program (79 Mode = Rapid).
Figure 1 below shows a successful rapid reclosing; no fault resulting in breaker opening during the neutralisation time (t_{rf} or t_{rt}).
The automation returns to standby once the neutralisation timer has counted down, and a successive trip will activate rapid reclosing again.

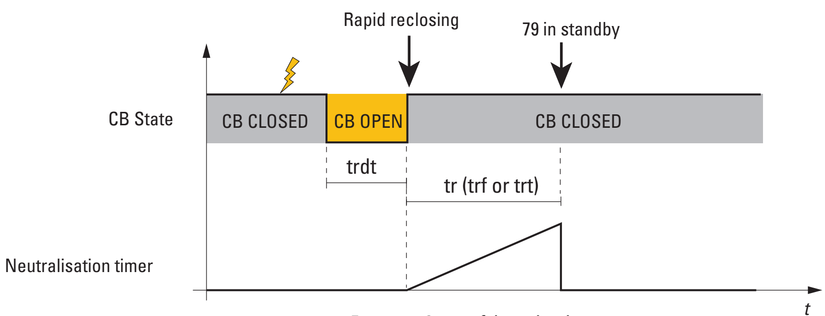


Figure 1 - Successful rapid reclosing

Note 1 The neutralisation timer, which starts when the breaker closes, is a time during which no faults resulting in breaker opening may occur for the reclosing to be considered to have terminated successfully

Note 2 The discrimination timer, which starts when the breaker closes, is a time during which no faults resulting in breaker opening may occur for subsequent reclosing attempts to be permitted

Rapid reclosing program (79 Mode = Rapid).
Figure 2 below shows a rapid reclosing followed by a fault resulting in breaker opening during the neutralisation time (t_{rf} or t_{rt}).
Any trip during the neutralisation time (t_{rf} or t_{rt}) opens the breaker, blocking of the reclosings and a reclosing failure report.
The automation returns to standby once the neutralisation timer has counted down (the greater of t_{rf} and t_{rt}) which follows a condition of the breaker closed manually without faults.

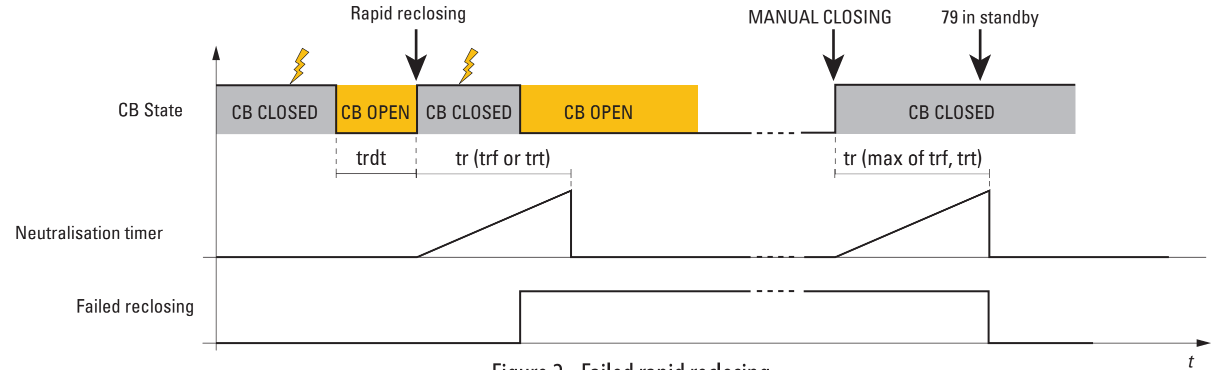


Figure 2 - Failed rapid reclosing

Rapid reclosing and slow reclosing

Rapid+slow reclosing program (79 Mode = Rapid+slow).
Figure 3 below shows a rapid reclosing followed by a fault resulting in breaker opening during the neutralisation time (t_{rf} or t_{rt}). A slow reclosing is actuated after a programmable time t_{sdt}; if no faults occur during the neutralisation time, the slow reclosing is successful and the automation returns to standby.

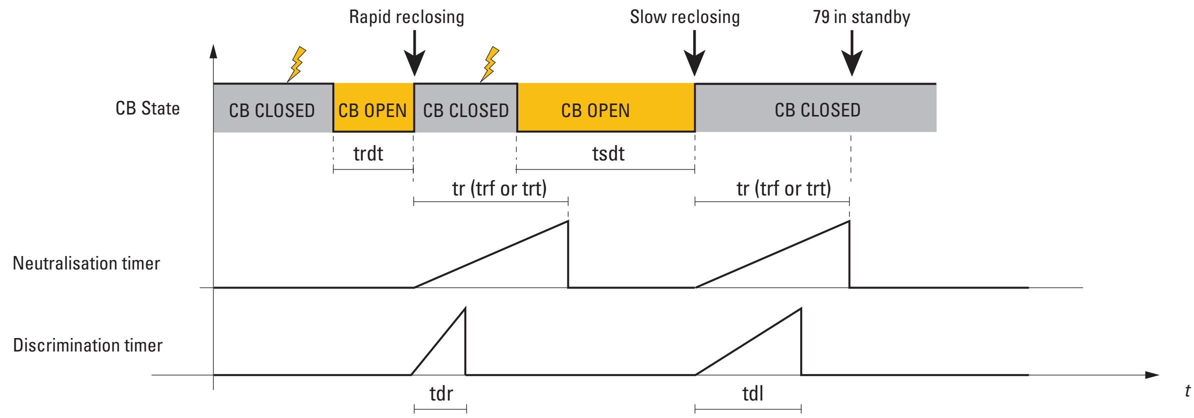


Figure 3 - Rapid reclosing followed by fault and subsequent successful slow reclosing

Figure 4 below shows a rapid reclosing followed by a fault which opens the breaker within the neutralisation time (t_{rf} or t_{rt}) followed by a slow reclosing run on the fault within the discrimination time t_{dl}; the reclosing is considered unsuccessful and the respective report is issued. (if no memorized reclosings have been programmed the reclosing is considered unsuccessful even if the fault occurs within the neutralisation time)

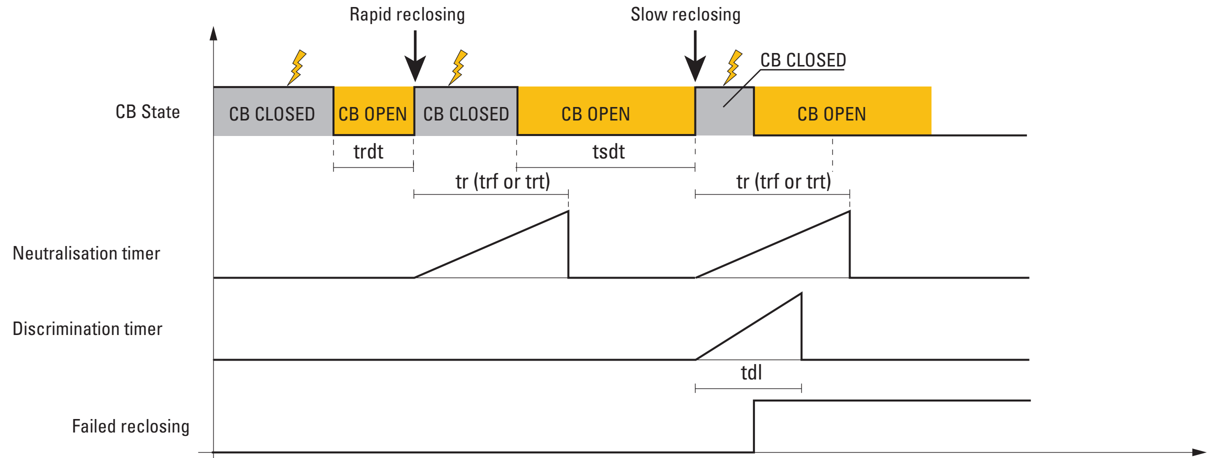


Figure 4 - Rapid reclosing followed by fault and subsequent slow reclosing on fault

Rapd reclosing + slow reclosing and subsequent memorized reclosings

Rapid+slow+memorized reclosing program (79 Mode = Rapid+slow, N.DAR = 1..5).
Figure 5 below shows a rapid reclosing followed by a fault which opens the breaker within the neutralisation time, followed by a slow reclosing and a fault detected beyond t_{dl} but within the neutralisation time t_r; when t_r times out, the memorized reclosing is run.
If t_d=0; if the fault occurs immediately, the sequence proceeds with a non-definitive trip and wait for the first memorized reclosing.
If the fault occurs within t_r, the sequence opens the breaker and the following memorized reclosing is run when t_r expires. Every subsequent memorized reclosing starts timers t_r and t_{dm}. If a fault occurs within t_r, but after t_{dm}, the sequence opens the breaker and the next memorized reclosing occurs when t_r expires; if, on the other hand, the fault is detected within t_{dm}, a definitive trip occurs and an unsuccessful reclosing is reported.

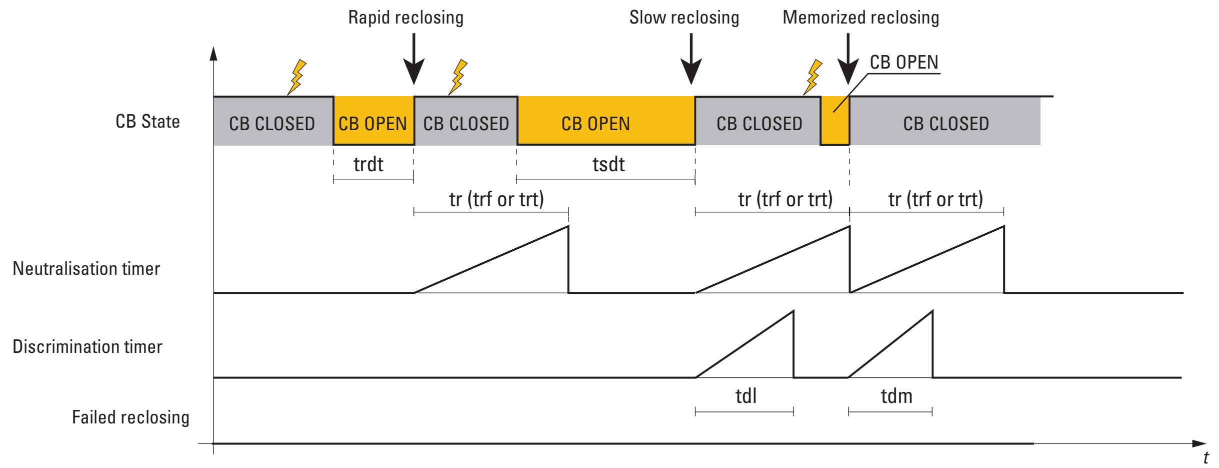


Figure 5 - Rapid reclosing followed by fault and subsequent slow and memorized reclosings

— Breaker failure - BF

Preface

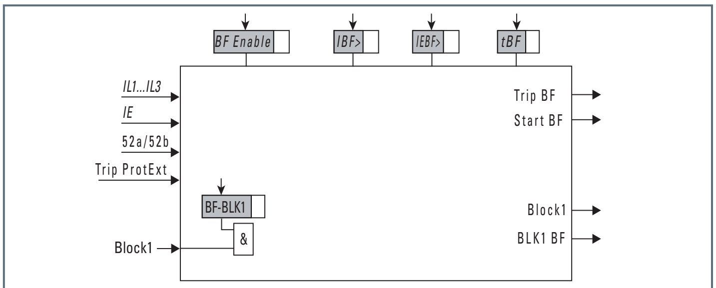
Should a fault cause a protection to open the breaker but, due to a fault, the breaker cannot open, the BF protection opens another or other breaker/s to shut off the fault current.
The BF protection can be started when the relay's internal protection trips, so long as the latter is mapped to the BF protection, or when an external protection connected to one of the relay's logical inputs trips.

Operating logic

The BF timer starts when both the following conditions are satisfied:
1) The relay's internal protection functions have started and tripped (BF protection thresholds tripped) or, if enabled, an external protection mapped to one of the relay's logical inputs has tripped.
2) The state of the breaker's auxiliary contacts 52a and 52b corresponds to breaker closed or the value of the fundamental component of at least one phase current I_{L1}, I_{L2}, I_{L3} is greater than an adjustable threshold I_{BF}> or the fundamental component of the residual current I_E is greater than an adjustable threshold I_{EBF}>. If no information about the state of the breaker is available (e.g.: auxiliary contacts not accessible or no free logical inputs on the relay), this control must be disabled.

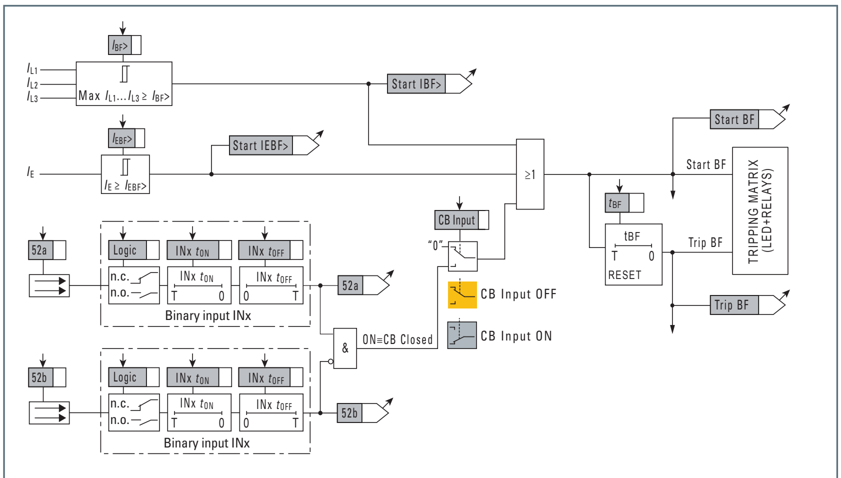
If the two above conditions persist for the duration of the set operating time t_{BF}>, when the time expires the BF protection trips, otherwise the timer and protection are both reset.
To reset the BF protection as quickly as possible, following the start of the protection itself (condition 1), the relay's internal protections must not only trip but also start (resetting the start of the protection functions is faster than resetting their trip).

The protection can be enabled or disabled by setting to *ON* or *OFF* the parameter *BF Enable* in the menu **Set \ Protections \ Breaker failure - BF**.



General block diagram of the breaker failure function (BF) all-FBF.ai

Starting BF with a switch: set to *ON* the parameter *CB Input*, if two logical inputs are configured to acquire the state of the breaker's auxiliary contacts 52a and 52b, breaker state control is enabled. Breaker state control is enabled in the menu **Set \ Protections \ Breaker failure - BF**, while the acquisition of the breaker position is mapped to the logical inputs (*52a* and *52b*) in the menu **Set \ Input board inputs \ Input IN1-1...IN1-6**. If no information about the state of the breaker is available, the control must be disabled by setting to *OFF* the parameter *CB Input*.
All parameters I_{BF}>, I_{EBF} and t_{BF} can be programmed separately; they are available in the menu **Set \ Protections \ Breaker failure - BF.**



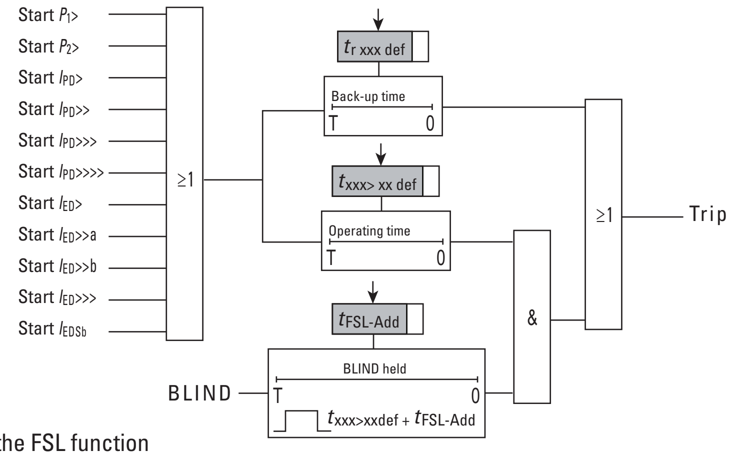
Functional diagram of the breaker failure function - BF

5 AUTOMATION FUNCTIONS

— Logical selectivity block - FSL

Preface

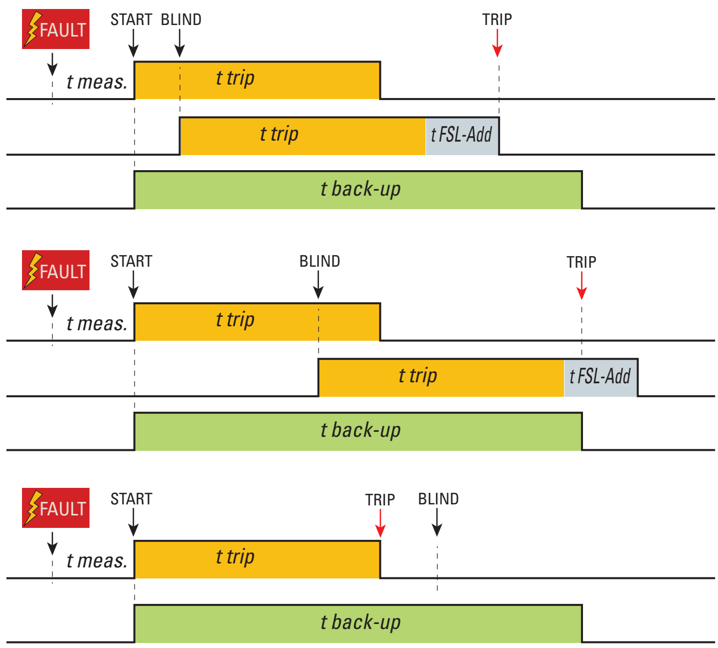
Logical selectivity reduces the time to eliminate faults which, in scalar time system would require programming significantly long operating times for the power sources.
The implementation of the IEC 61850 protocol provides that panels DV7500, DV7203 and RGDM use their real time communications capacity to send and receive BLIND signals.
These signals temporarily inhibit the open orders issued by the directional protection functions (67, 67N and 32P) and thus enable exclusive selection of the branch of the line affected by the fault.



Functional diagram of the FSL function

When a directional protection function threshold is started, the DMC panel:
- Issues a BLIND GOOSE (IEC61850) over its LAN
- Starts the operating timer (Tatt)
- Starts the back-up timer (Tr) (with Tr>Tatt)

The following situations may occur:
A) If the function resets within the operating time Tatt, so that the start signal returns to standby, all timers are reset,
B) If the function does not reset within the operating time Tatt and not even one BLIND signal is received from a device in the list of subscribers, when Tatt expires the DMC panel opens the breaker and remotely reports the tripped status to the RTU/display,
C) If, whether a BLIND signal is received or not, the function does not drop-out within the drop-out time Tr, the DMC panel opens the breaker and remotely reports the tripped status to the RTU/ display.



BLIND received within the operating time:
the operating timer is forced to zero when the BLIND is received and the open command (Trip) is issued when (t trip +t FSL-Add) times out

BLIND received within the operating time:
the operating timer is forced to zero when the BLIND is received and the open command (Trip) is issued when the back-up time times out, which is less than (t trip +t FSL-Add)

BLIND received after the operating time:
the operating timer is not forced to zero when the BLIND is received and the open command (Trip) is issued when (t trip) times out

6 CYBER SECURITY

Preface

The cyber security functions implemented by the DMC3S relays mitigate cyber threats, by providing:
- Protected communications between the DMC3S protection relays and the mapped tool via **SSH** (**S**ecure **SH**ell)
- Password based user authentication
- Management of authorisations for **R**ole **B**ased **A**ccess **C**ontrol (**RBAC**)
- Protected log filing (**Syslog** service)

The following operative areas can be identified:

- Configuration Management
- HW Systems and Networking Equipment
- Initial System Configuration
- Threat and Vulnerability Management
- Access Control
- Authentication and Authorization Management
- Auditing
- Network Communication Security

The described procedures have been selected in consideration of the following standards and guidelines:
- ISO/IEC 27001:2013
- **NERC CIP** – **N**orth American **E**lectric **R**eliability **C**orporation **C**ritical **I**nfrastructure **P**rotection
- IEC 62351

IEC 62351 will be applied if expressly requested, to guarantee control of communications protocols and data flows.

— Configuration management

Configuration management is a set of procedures which control modifications to hardware, firmware, software and documentation to ensure that all devices are protected against unwanted modification before, during and after system implementation.

— Hardware systems and networking equipment

The devices are industrial and satisfy industrial quality and EMC standards. Only passive systems without fans are used for heat management. The devices can be assigned IP addresses on the basis of pertinent network planning rules. On request, HW protection systems can be installed (tamper-proofing, etc.).

— Initial system configuration

The protection relays are equipped only with the network services required to execute their protection programs, thus limiting the number of open TCP / UDP ports. All services and operating systems are updated to the latest version at the time of release. Access even for "known" users is eliminated and only one local non-administrator user is left active to install and configure the device initially.

— Threat and vulnerability management

The device's operating system is supported by the vendor to ensure conformity with regular security bulletins and patches.

— Access control

Further to the local non-administrator user, user authentication can be delegated to a centralised platform by the RADIUS client, to obtain access to the active Windows directory.

— Authentication and authorization management

AAM ius based on the "**RBAC**" (**R**ule **B**ased **A**ccess **C**ontrol) model, i.e. the device allows execution of functions in relation to the user's assigned role.
The following roles are available:

- "Administrator": Complete control of the device
- "Operator1": Limited Level 1 read/write access
- "Operator2": Limited Level 2 read/write access

— Auditing

The device tracks the most important system operations/actions, like accesses and modifications to the configuration, with a "syslog" service.

— Network communication security

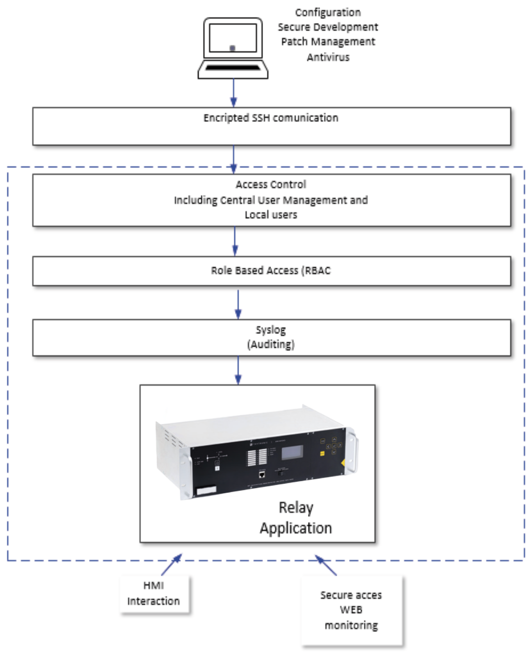
The device does not use unencrypted protocols like telnet, ftp. All communications required to configure the equipment, such as calibrations, CID transmission, etc. are handled by the “SSH” protocol in encrypted mode.
Protocols for data exchange with SCADA, e.g. IEC61850 / DNP3 / MODBUSTCP, are not encrypted, if implementation of IEC62351 specifications is not expressly requested.
The NTP, PTP synchronisation protocols are not normally encrypted.

— Cybersecurity application scheme

The configuration of the DMC3S protection relay and monitoring functions pose problems relating to the security and privacy of the data traffic exchanged between the equipment and the remote control centre.

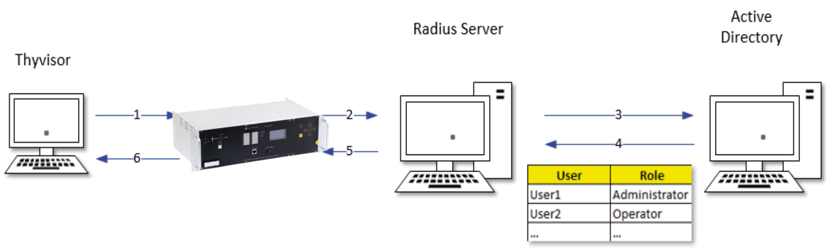
The following aspects must be considered:

- Traffic encryption, so that the data may not be intercepted, analysed and modified freely by third parties
- Implementation of the authentication mechanism to prevent generation of false third party messages and their acceptance as valid



— Access procedure

The authentication mechanism consists in sending authentication requests from the incoming board to a remote RADIUS authentication server which handles user validation, and returns positive or negative feedback to the CPU depending on whether the user's credentials are valid or not, along with user level information.
RADIUS authentication employs a remote server and uses a secret shared by the board and the server to validate requests for access. The configurator enables definition of all the parameters required for this type of authentication.



1	login
2	forward to Radius Server
3	Forward to Active Directory
4	Reply fromActive Directory
5	Replay from Radius
6	login replay (granted / not granted)

7 APPENDIX

— DMC3S - INVERSE TIME CURVES

General formula

The general formula, pursuant to IEC 60255-3/BS142, is:[1]

$$t = t_{>inv} \cdot \left[\frac{K}{[(I/I_{>inv})^{\alpha} - 1]} \right]$$

Where:
- t = operating time (in seconds).
- $t_{>inv}$ = operating time regulation (in seconds).
- I = measured current.
- $I_{>inv}$ = trip threshold regulation.

Constant α

- α = 0.02 for the IEC type A normal inverse curve.
- α = 1 for the IEC type B very inverse curve.
- α = 1 for the IEC type LTI long time inverse curve.
- α = 2 for the IEC type C extremely inverse curve.

Coefficient K

- K = 0.14 for the IEC type A normal inverse curve
- K = 13.5 for the IEC type B very inverse curve.
- K = 120 for the IEC type LTI long time inverse curve.
- K = 80 for the IEC type C extremely inverse curve.

The following applies to all inverse time characteristics:
- The asymptotic reference value (minimum trip current) is 1.1 time the set threshold.
- The minimum operating time is 0.1 s.
- The characteristics are defined between 1.1 and 20 times the set threshold[2][3]

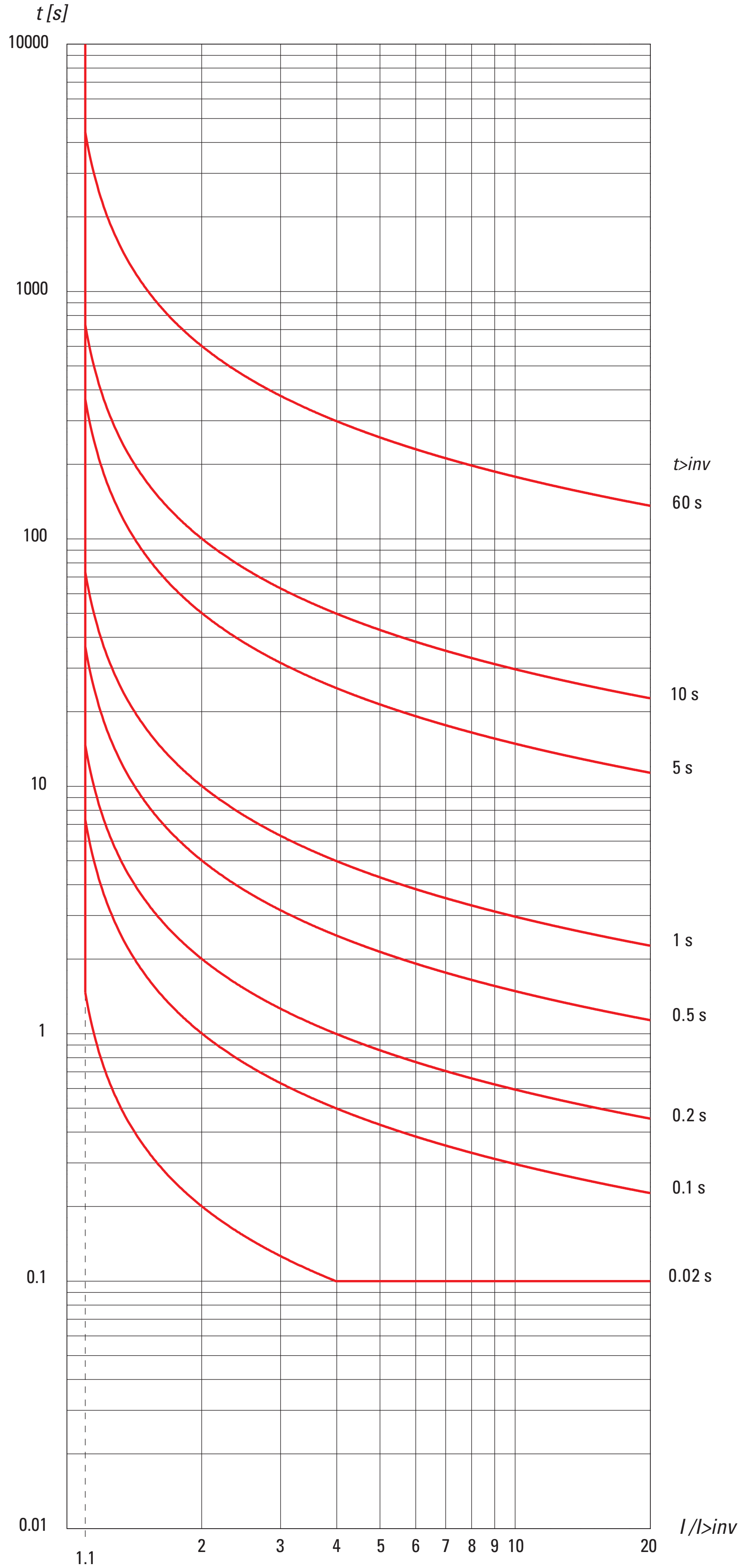
For all the following thresholds, with exception of the threshold relating to protections 59 and 59 N,[4] normalised IEC type A, B, B-LI and C curves can be set.

Protection Functions	Thresholds	Operating time
46	I2>	DEFINITE/INVERSE
	I2>>	DEFINITE/INVERSE
50/51	I>	DEFINITE/INVERSE
	I>>	DEFINITE/INVERSE
	I>>>>	DEFINITE/INVERSE
50N/51N	IE>	DEFINITE/INVERSE
51N(E)	INe>	DEFINITE/INVERSE
51N(Eme)	IEeme>	DEFINITE/INVERSE
51(SQL)	ISQL>	DEFINITE/INVERSE
59	U>	DEFINITE/INVERSE
59N	UE>	DEFINITE/INVERSE
59N(Eme)	UEeme>	DEFINITE/INVERSE
67	IPD>	DEFINITE/INVERSE
	IPD>>	DEFINITE/INVERSE
	IPD>>>>	DEFINITE/INVERSE
67N	IED>	DEFINITE/INVERSE
	IED>>a	DEFINITE/INVERSE

Note 1 The formula uses the symbols relating to the overcurrent function. The full description of the symbols used in the inverse time curves for protections 50/51 and 50N/51N are given in 4.4 PROTECTION FUNCTIONS
Note 2 When the threshold regulation exceeds 2.5 In for protection 50/51 and 0.5 IEn for protection 50N/51N, the upper limit of the measurement range is limited to 30 In and 10 IEn respectively
Note 3 when the threshold regulation exceeds 20 times the threshold, the operating time is limited to the value corresponding to 20 times the threshold
Note 4 The trip characteristic is given in the paragraph describing the operation of the system (Chapter 4)

— DMC3S - IEC normal inverse curves (type A)

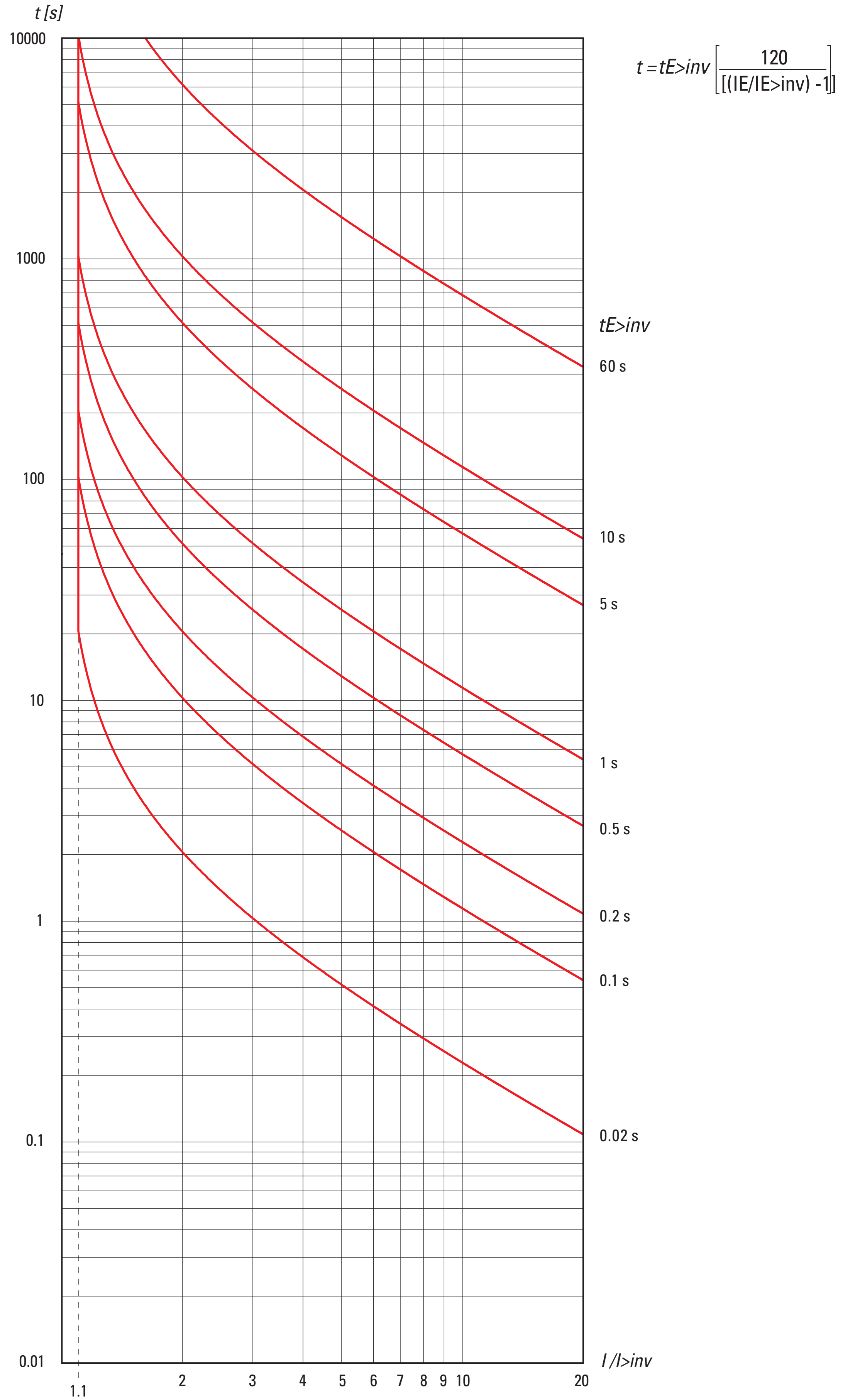
$$t = t{>}inv \left[\frac{0.14}{[(I/I{>}inv)^{0.02}-1]}\right]$$



Note: the set operating time refers to a ratio I/I>inv = 700

F_51-IECA-Char.ai

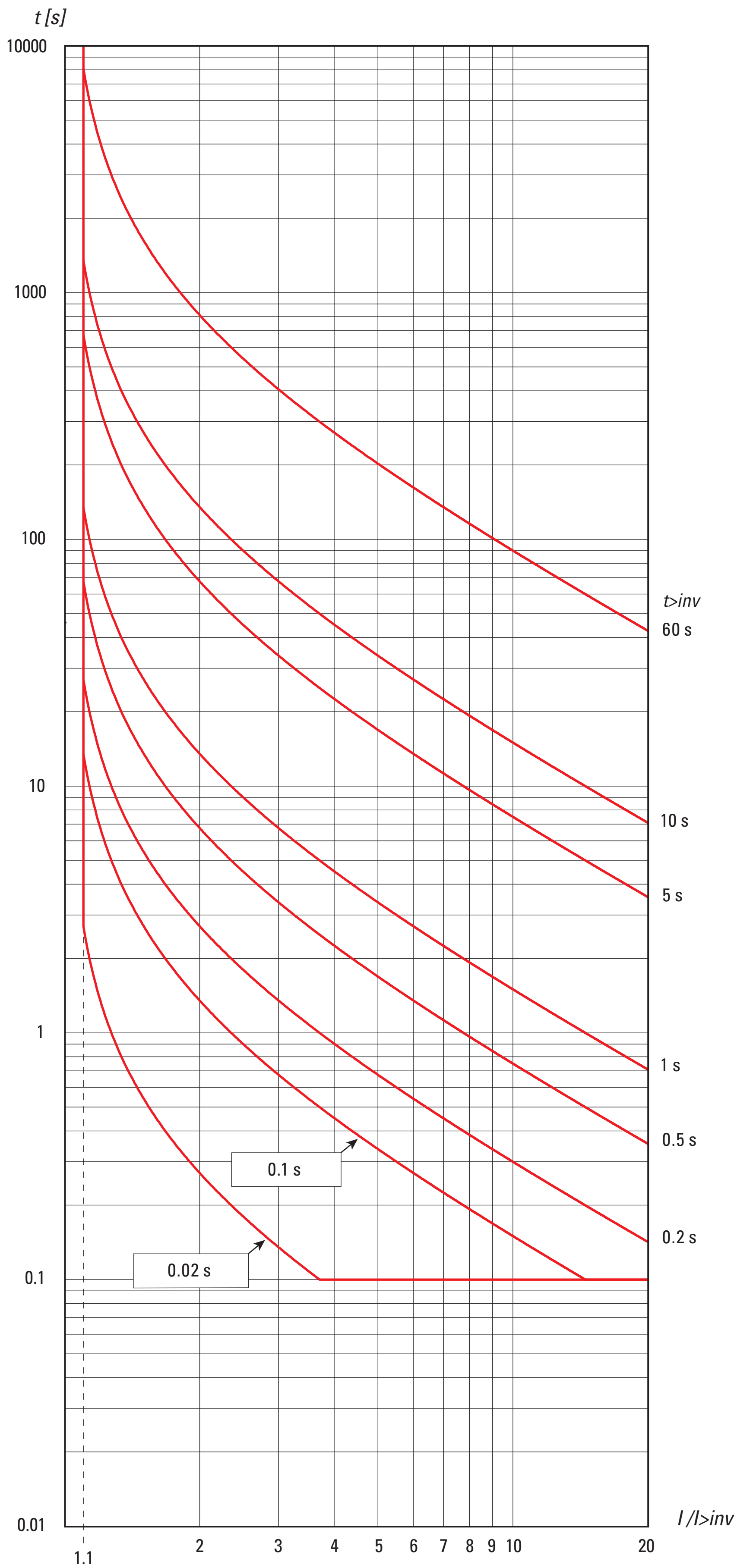
— DMC3S - IEC long time inverse curves (type LTI)



Note: the set operating time refers to a ratio I/I>inv = 121

F_51N-IEC-LITB-Char.ai

— DMC3S - IEC very inverse curves (type B)

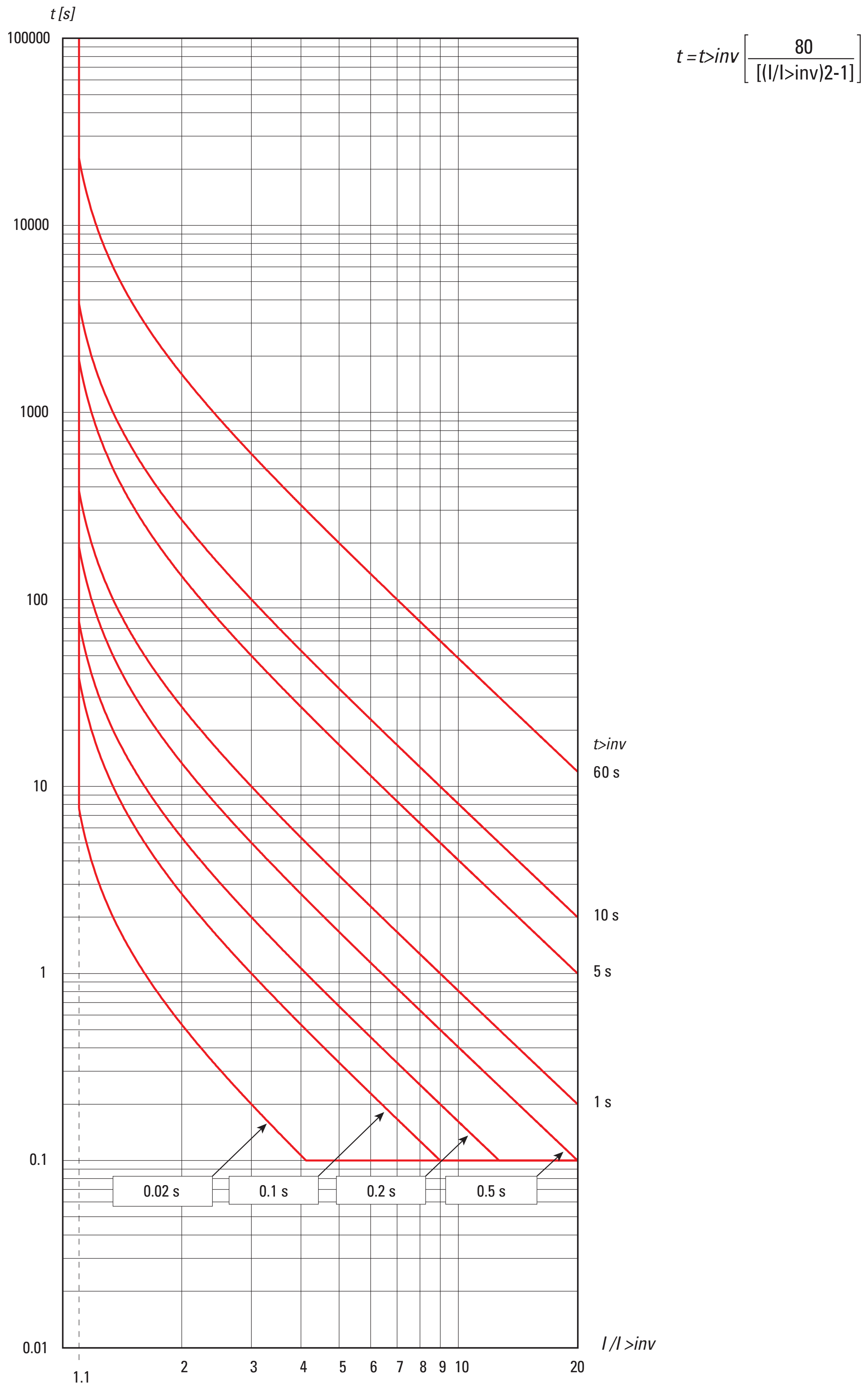


$$t = t{>}inv \left[\frac{13.5}{[(I/I{>}inv) - 1]} \right]$$

Note: the set operating time refers to a ratio I/I>inv = 14.5

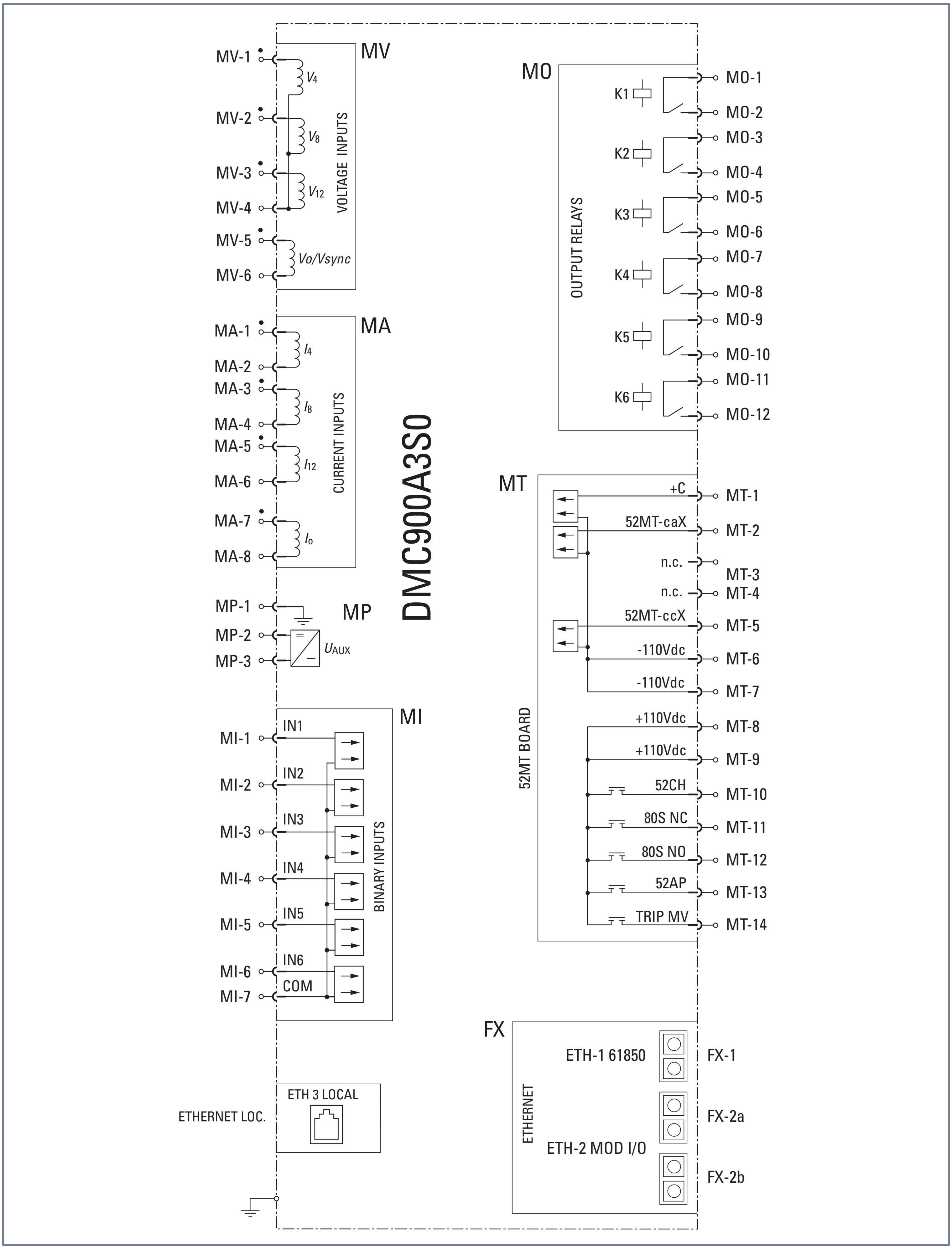
F_51-IECB-Char.ai

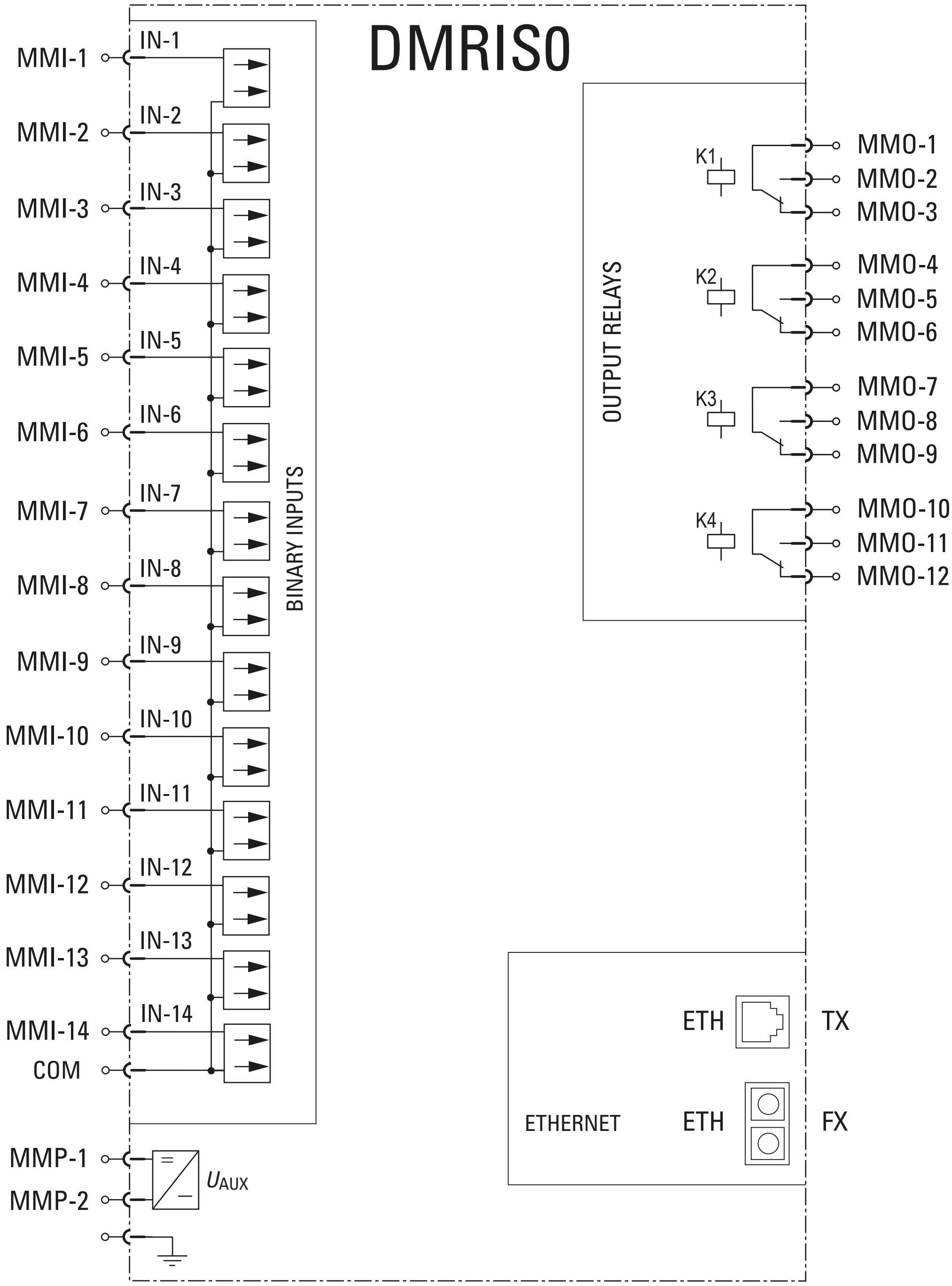
— DMC3S - IEC extremely inverse curves (type B)



Note: the set operating time refers to a ratio I/I>inv = 9

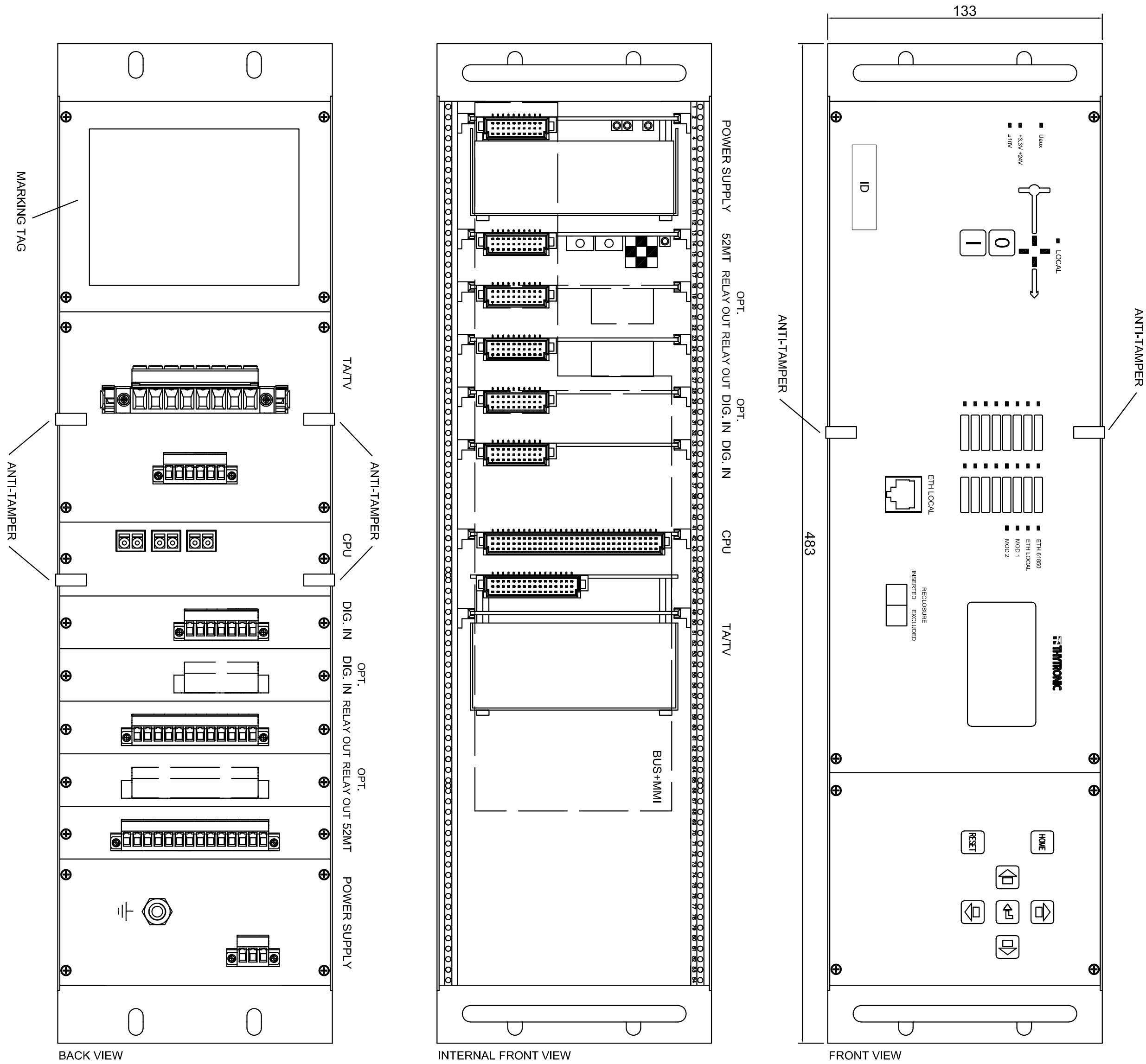
F_51-IECC-Char.ai


DMC900A3S0
MV
VOLTAGE INPUTS
MV-1
MV-2
MV-3
MV-4
MV-5
MV-6
V4
V8
V12
Vo/Vsync
MA
CURRENT INPUTS
MA-1
MA-2
MA-3
MA-4
MA-5
MA-6
MA-7
MA-8
I4
I8
I12
Io
MP
MP-1
MP-2
MP-3
UAUX
MI
BINARY INPUTS
MI-1
MI-2
MI-3
MI-4
MI-5
MI-6
MI-7
IN1
IN2
IN3
IN4
IN5
IN6
COM
ETHERNET LOC.
ETH 3 LOCAL
MO
OUTPUT RELAYS
K1
K2
K3
K4
K5
K6
MO-1
MO-2
MO-3
MO-4
MO-5
MO-6
MO-7
MO-8
MO-9
MO-10
MO-11
MO-12
MT
52MT BOARD
+C
52MT-caX
n.c.
n.c.
52MT-ccX
-110Vdc
-110Vdc
+110Vdc
+110Vdc
52CH
80S NC
80S NO
52AP
TRIP MV
MT-1
MT-2
MT-3
MT-4
MT-5
MT-6
MT-7
MT-8
MT-9
MT-10
MT-11
MT-12
MT-13
MT-14
FX
ETHERNET
ETH-1 61850
ETH-2 MOD I/O
FX-1
FX-2a
FX-2b

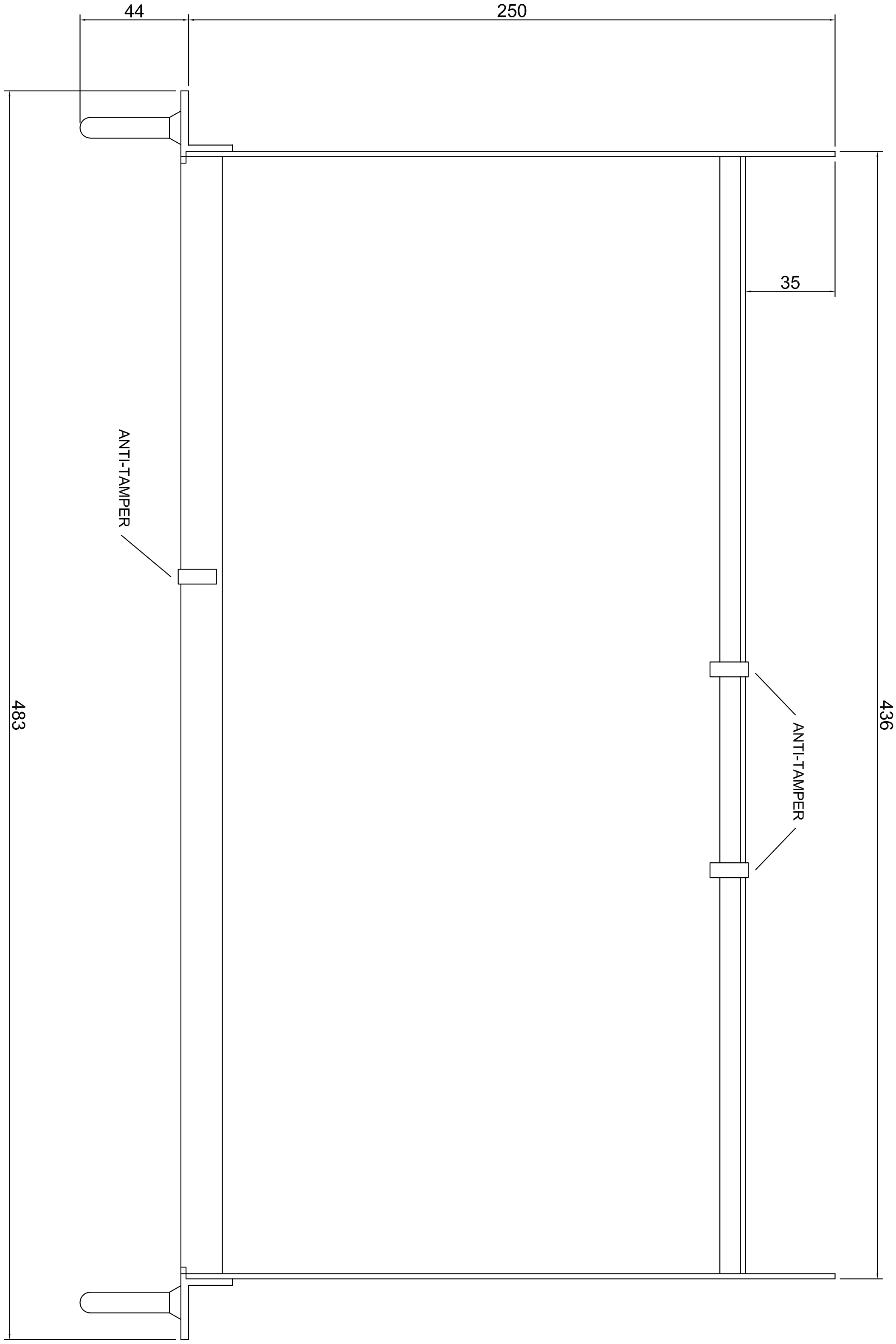


DMRIS0
MMI-1
IN-1
MMI-2
IN-2
MMI-3
IN-3
MMI-4
IN-4
MMI-5
IN-5
MMI-6
IN-6
MMI-7
IN-7
MMI-8
IN-8
MMI-9
IN-9
MMI-10
IN-10
MMI-11
IN-11
MMI-12
IN-12
MMI-13
IN-13
MMI-14
IN-14
COM
BINARY INPUTS
MMP-1
MMP-2
UAUX
OUTPUT RELAYS
K1
MMO-1
MMO-2
MMO-3
K2
MMO-4
MMO-5
MMO-6
K3
MMO-7
MMO-8
MMO-9
K4
MMO-10
MMO-11
MMO-12
ETHERNET
ETH
TX
ETH
FX

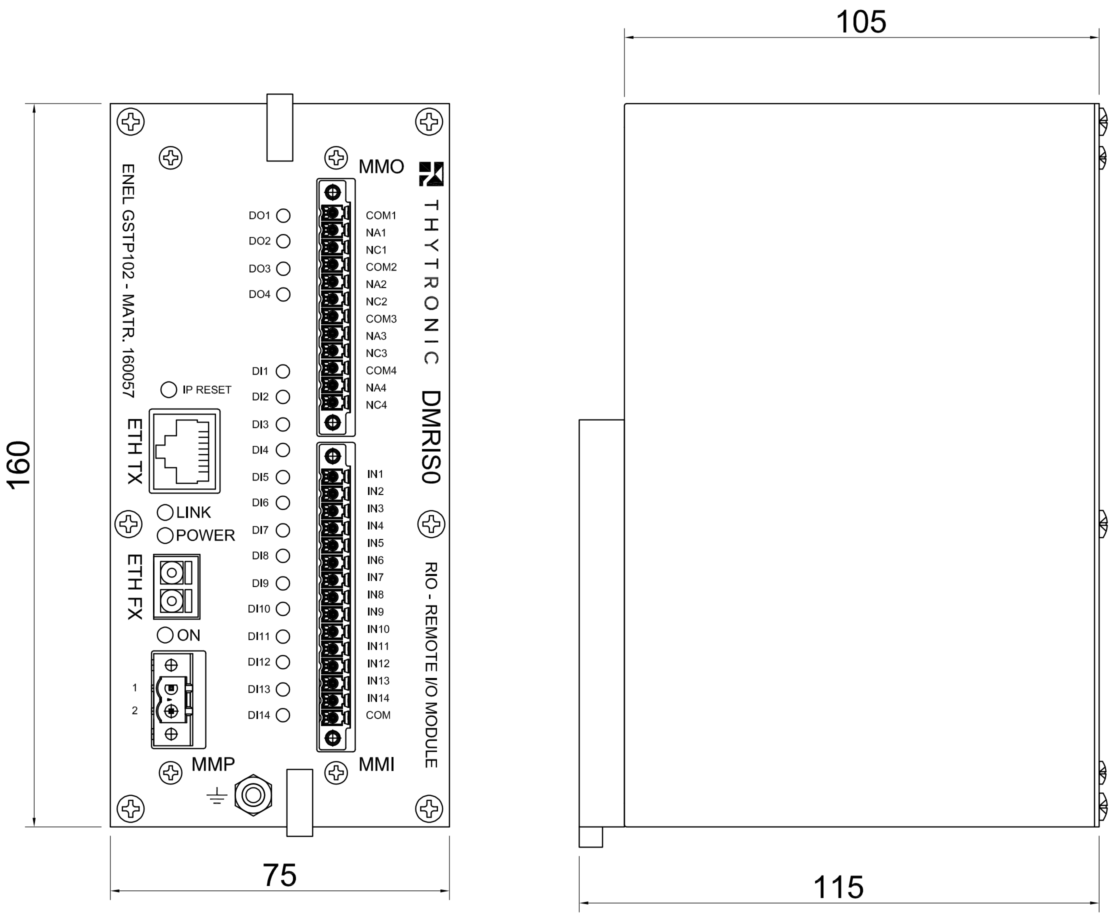
— DMC3S- DIMENSIONS - front, internal and rear views

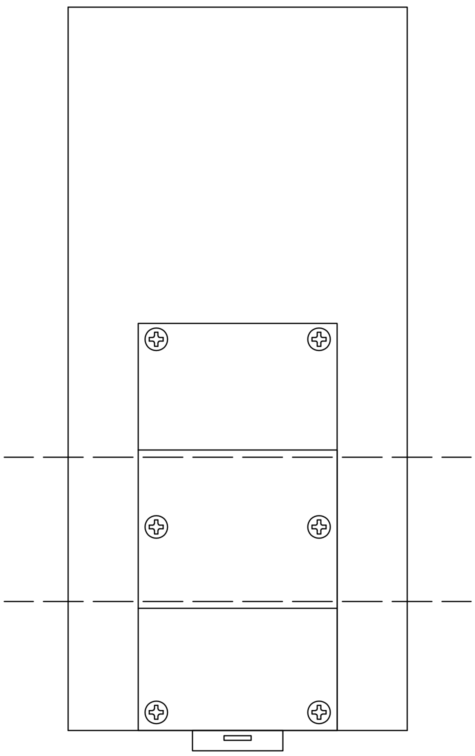


— DMC3S - DIMENSIONS - viewed from above

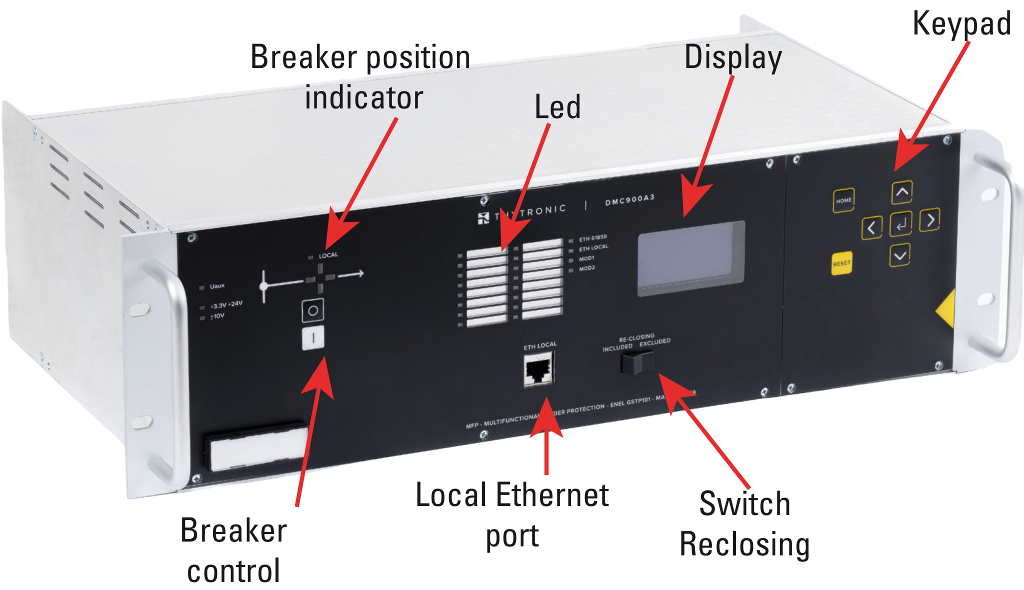


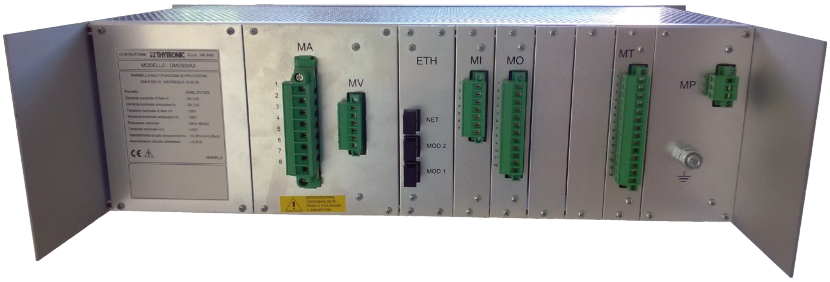
— DMC3S - DIMENSIONS - DMRIS0 module

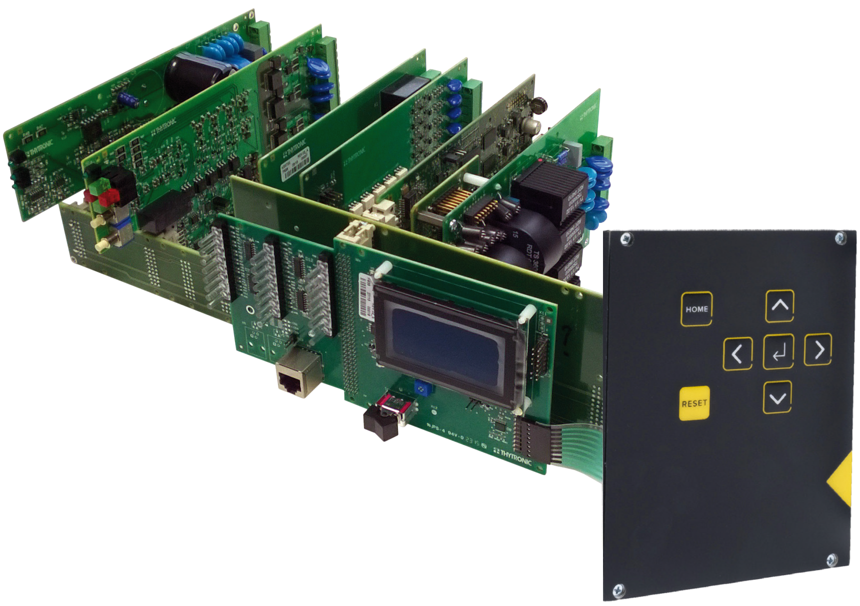




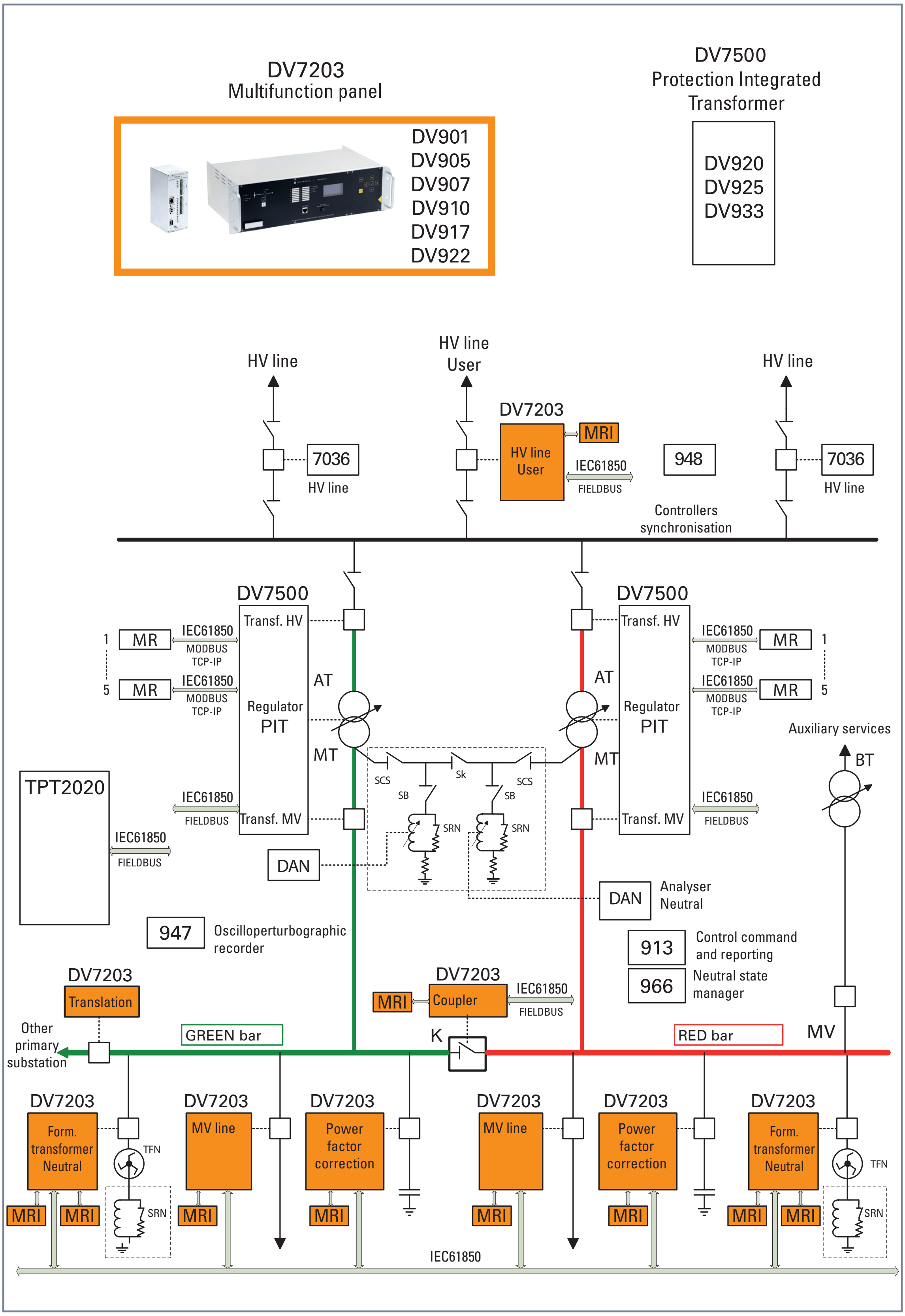
DIN RAIL FIXTURE


Breaker position
indicator
Led
Display
Keypad
Breaker
control
Local Ethernet
port
Switch
Reclosing


MA
MV
ETH
MI
MO
MT
MP


HOME
RESET

— DMC3S - EXAMPLE OF APPLICATION TO A A3 PRIMARY SUBSTATION



— DMC3S - CE DECLARATION OF CONFORMITY

For CE Declaration, please refer to www.thytronic.it in the section covering the DMC3S multifunction panel.

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