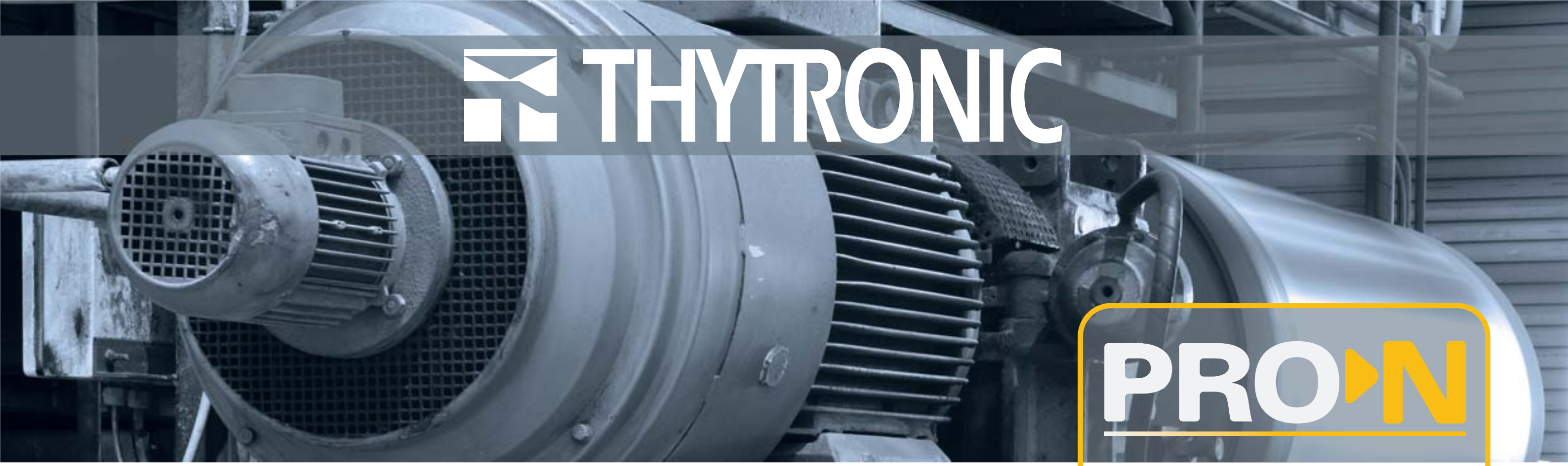


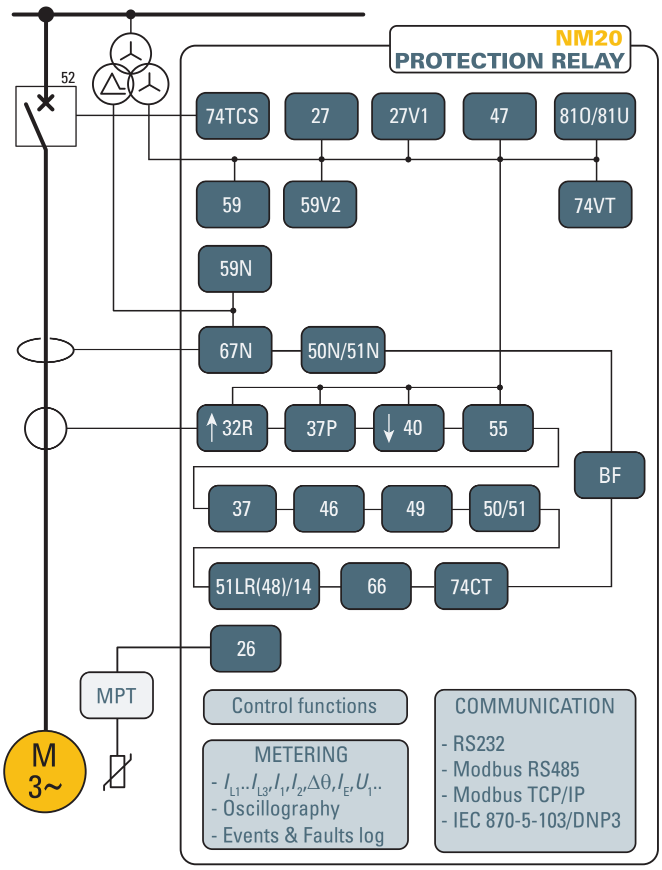
NM20

MOTOR PROTECTION RELAY

MULTIFUNCTION PROTECTION FOR LARGE SIZE MOTORS

— Application

The relay type NM20 can be used for protection of large size motors in MV systems with any grounded systems (solidly grounded, ungrounded or Petersen coil and/or resistance grounded) on feeders of any length.



- Protective & control functions

26	Thermal by Pt100 probes
27	Undervoltage
27V1	Positive-sequence undervoltage
32R	Active reverse power
37	Undercurrent
37P	Low forward power
40	Loss of field
46	Negative-sequence overcurrent
47	Phase reversal
49	Thermal image
50/51	Phase overcurrent
51LR(48)/14	Locked rotor
50N/51N	Residual overcurrent
55	Minimum power factor
59	Overvoltage
59V2	Negative-sequence overvoltage
59N	Residual overvoltage
66	Maximum number of startings (Restart inhibition)
67N	Directional earth fault overcurrent
81O	Overfrequency
81U	Underfrequency
BF	Circuit breaker failure
74CT	Phase CTs monitoring
74TCS	Trip circuit supervision

Measuring inputs

- Three phase current inputs and one residual current input, with nominal currents independently selectable at 1 A or 5 A through DIP-switches.
- Three phase voltage inputs with programmable nominal voltages within range 50...130 V (U_R=100 V) or 200...520 V (U_R=400 V) and one residual voltage input, with programmable nominal voltage within range 50...130 V (U_{ER}=100 V).

Note - Polarity and phase sequence of currents and voltages inputs may be set by the user.

Firmware updating

The use of flash memory units allows on-site firmware updating.

Two set point profiles (A,B)

Two independent groups of settings are provided. Switching from profiles may be operated by means of MMI, binary input and communication.

Construction

According to the hardware configurations, the NM20 protection relay can be shipped in various case styles depending on the required mounting options (flush, projecting mounting, rack or with separate operator panel).

Binary inputs

Two binary inputs are available with programmable active state (active-ON/active-OFF) and programmable timer (active to OFF/ON or ON/OFF transitions).
Several presettable functions can be associated to each input.

Modular design

In order to extend I/O capability, the NM20 hardware can be customized through external auxiliary modules:

- MRI - Output relays and LEDs
- MID16 - Binary inputs
- MCI - 4...20 mA converter
- MPT - Pt100 probe inputs.

Blocking output

One output blocking circuit is provided.
The output blocking circuits of one or several Pro_N relays, shunted together, must be connected to the input blocking circuit of the protection relay, which is installed upstream in the electric plant. The output circuit works as a simple contact, whose condition is detected by the input circuit of the upstream protection relay.
For long distances, when high insulation and high EMC immunity is essential, a suitable pilot wire to fiber optic converter (BFO) is available.

Output relays

Six output relays are available (two changeover, three make and one break contacts); each relay may be individually programmed as normal state (normally energized, de-energized or pulse) and reset mode (manual or automatic).
A programmable timer is provided for each relay (minimum pulse width). The user may program the function of each relay according to a matrix (tripping matrix) structure.

MMI (Man Machine Interface)

The user interface comprises a membrane keyboard, a backlight LCD alphanumeric display and eight LEDs.
The green ON LED indicates auxiliary power supply and self diagnostics, two LEDs are dedicated to the Start and Trip (yellow for Start, red for Trip) and five red LEDs are user assignable.

Communication

Multiple communication interfaces are implemented:

- One RS232 local communication front-end interface for communication with ThySetter setup software
- Two back-end interfaces for communication with remote monitoring and control systems by:
  - RS485 port using ModBus® RTU, IEC 60870-5-103 or DNP3 protocol.
  - Ethernet port (RJ45 or optical fiber) using ModBus/TCP protocol.

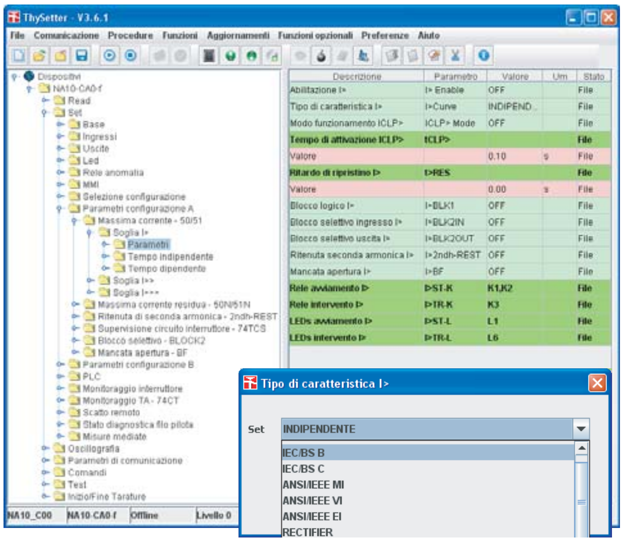
Programming and settings

All relay programming and adjustment operations may be performed through MMI (Keyboard and display) or using a Personal Computer with the aid of the ThySetter software.
The same PC setup software is required to set, monitor and configure all Pro_N devices.
Full access to the available data is provided:

- Read status and measures.
- Read/edit settings (on-line or off-line edit).

Two session level (User or Administrator) with password for sensible data access are provided.

ThySetter



Control and monitoring

Several predefined functions are implemented:

- Activation of two set point profiles
- Phase CTs monitoring (74CT)
- Phase VTs monitoring (74VT)
- Logic selectivity
- Cold load pickup (CLP) with block or setting change
- Trip circuit supervision (74TCS)
- Remote tripping
- Synchronization
- Circuit Breaker commands and diagnostic

Circuit Breaker

Several diagnostic, monitoring and control functions are provided:

- Health thresholds can be set; when the accumulated duty (ΣI or $\Sigma I^2 t$), the number of operations or the opening time exceeds the threshold an alarm is activated
- Breaker failure (BF); breaker status is monitored by means 52a-52b and/or through line current measurements
- Trip circuit supervision (74TCS)
- Breaker control; opening and closing commands can be carried out locally or remotely

Cold Load Pickup (CLP)

Cold load pickup element prevents unwanted tripping in case of temporary overcurrents produced at the motor starting.
Two different operating modes are provided:

- Each protective element can be blocked for a programmable time.
- Each threshold can be increased for a programmable time.

Logic selectivity

With the aim of providing a fast selective protection system some protective functions may be blocked (pilot wire accelerated logic). To guarantee maximum fail-safety, the relay performs a run time monitoring for pilot wire continuity and pilot wire shorting. Exactly the output blocking circuit periodically produces a pulse, having a small enough width in order to be ignored as an effective blocking signal by the input blocking circuit of the upwards protection, but suitable to prove the continuity of the pilot wire.

Self diagnostics

All hardware and software functions are repeatedly checked and any anomalies reported via display messages, communication interfaces, LEDs and output relays.
Anomalies may refer to:

- Hw faults (auxiliary power supply, output relay coil interruptions, MMI board...)
- Sw faults (boot and run time tests for data base, EEPROM memory checksum failure, data BUS,...)
- Pilot wire faults (break or short in the wire)
- Circuit breaker faults.

Metering

NM20 provides metering values for phase and residual currents and voltages, making them available for reading on a display or to communication interfaces.
Input signals are sampled 24 times per period and the RMS value of the fundamental component is measured using the DFT (Discrete Fourier Transform) algorithm and digital filtering.
With DFT the RMS value of 2nd, 3rd, 4th and 5th harmonic of phase current are also measured.
On the base of the direct measurements, the minimum-peak-fixed-rolling demand, mean-minimum-maximum absolute phase currents, active and reactive power/energy, power factor are processed.
The measured signals can be displayed with reference to nominal values or directly expressed in amperes, volts, watt, var, wh and varh.

Event storage

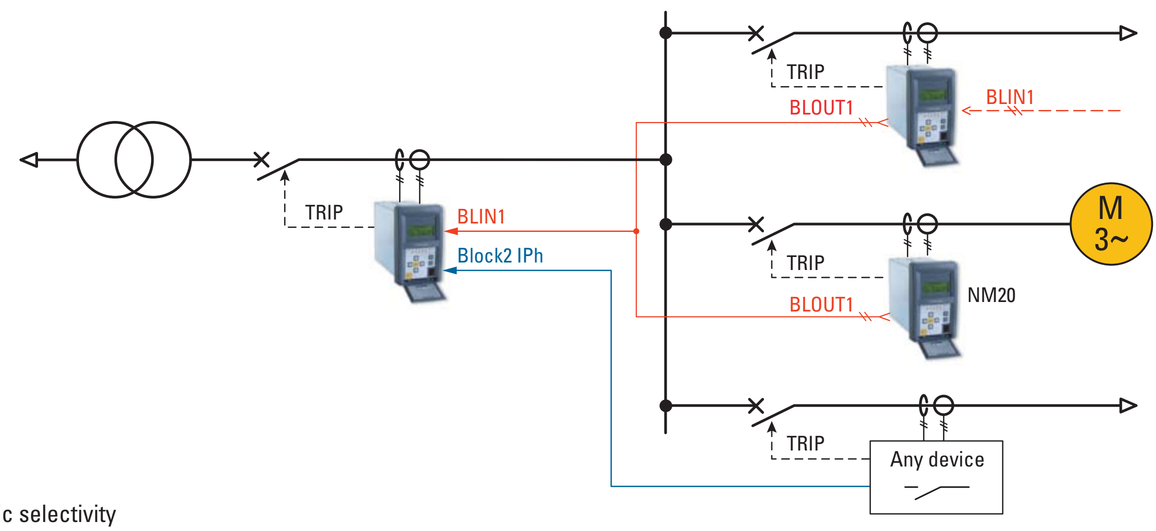
Several useful data are stored for diagnostic purpose; the events are stored into a non volatile memory.
They are graded from the newest to the older after the “Events reading” command (ThySetter) is issued:

- Sequence of Event Recorder (SER)
  The event recorder runs continuously capturing in circular mode the last three hundred events upon trigger of binary input/output.
- Sequence of Fault Recorder (SFR)
  The event recorder runs continuously capturing in circular mode the last twenty events upon trigger of binary input/output and/or element pickup (start-trip).
- Trip counters

Digital Fault Recorder (DFR)

Upon trigger of tripping/starting of each function or external signals, the relay records in COMTRADE format:

- Oscillography with instantaneous values for transient analysis
- RMS values of the measured signals for long time periods analysis
- Logic states (binary inputs and output relays).



Logic selectivity

SPECIFICATIONS

GENERAL

Mechanical data

Mounting:	flush, projecting, rack or separated operator panel
Mass (flush mounting case)	2.0 kg

Insulation tests

Reference standards	EN 60255-5
High voltage test 50Hz	2 kV 60 s
Impulse voltage withstand (1.2/50 µs)	5 kV
Insulation resistance	>100 MΩ

Voltage dip and interruption

Reference standards	EN 61000-4-29

EMC tests for interference immunity

1 MHz damped oscillatory wave	EN 60255-22-1	1 kV-2.5 kV
Electrostatic discharge	EN 60255-22-2	8 kV
Fast transient burst (5/50 ns)	EN 60255-22-4	4 kV
Conducted radio-frequency fields	EN 60255-22-6	10 V
Radiated radio-frequency fields	EN 60255-4-3	10 V/m
High energy pulse	EN 61000-4-5	2 kV
Magnetic field 50 Hz	EN 61000-4-8	1 kA/m
Damped oscillatory wave	EN 61000-4-12	2.5 kV
Ring wave	EN 61000-4-12	2 kV
Conducted common mode (0...150 kHz)	EN 61000-4-16	10 V

Emission

Reference standards	EN 61000-6-4 (ex EN 50081-2)
Conducted emission 0.15...30 MHz	Class A
Radiated emission 30...1000 MHz	Class A

Climatic tests

Reference standards	IEC 60068-x, ENEL R CLI 01, CEI 50

Mechanical tests

Reference standards	EN 60255-21-1, 21-2, 21-3

Safety requirements

Reference standards	EN 61010-1
Pollution degree	3
Reference voltage	250 V
Overvoltage	III
Pulse voltage	5 kV
Reference standards	EN 60529
Protection degree:	
• Front side	IP52
• Rear side, connection terminals	IP20

Environmental conditions

Ambient temperature	-25...+70 °C
Storage temperature	-40...+85 °C
Relative humidity	10...95 %
Atmospheric pressure	70...110 kPa

Certifications

Product standard for measuring relays	EN 50263
CE conformity	
• EMC Directive	89/336/EEC
• Low Voltage Directive	73/23/EEC
Type tests	IEC 60255-6

COMMUNICATION INTERFACES

Local PC RS232	19200 bps
Network:	
• RS485	1200...57600 bps
• Ethernet 100BaseT	100 Mbps
Protocol	ModBus® RTU/IEC 60870-5-103/DNP3 -TCP/IP

INPUT CIRCUITS

Auxiliary power supply Uaux

Nominal value (range) 24...48 Vac/dc, 115...230 Vac/110...220 Vdc
Operative range (each one of the above nominal values) 19...60 Vac/dc
85...265 Vac/75...300 Vdc

Power consumption:

• Maximum (energized relays, Ethernet TX)	10 W (20 VA)
• Maximum (energized relays, Ethernet FX)	15 W (25 VA)

Phase current inputs

Nominal current I_n	1 A or 5 A selectable by DIP Switches
Permanent overload	25 A
Thermal overload (1s)	500 A
Rated consumption (for any phase)	≤ 0.002 VA (I_n = 1 A) ≤ 0.04 VA (I_n = 5 A)

Residual current input

Nominal current I_{En}	1 A or 5 A selectable by DIP Switch
Permanent overload	25 A
Thermal overload (1s)	500 A
Rated consumption	≤ 0.006 VA (I_{En} = 1 A), ≤ 0.012 VA (I_{En} = 5 A)

Voltage inputs

Reference voltage U_R	100 V or 400 V selectable on order
Nominal voltage U_n	50...130 V or 200...520 V selectable by sw
Permanent overload	1.3 U_R
1s overload	2 U_R
Rated consumption (for any phase)	≤ 0.5 VA

Residual voltage input

Reference voltage U_{ER}	100 V
Nominal voltage U_{En}	50...130 V adjustable via sw
Permanent overload	1.3 U_{ER}
1s overload	2 U_{ER}
Rated consumption	≤ 0.5 VA

Binary inputs

Quantity	2
Type	dry inputs
Max permissible voltage	19...265 Vac/19...300 Vdc
Max consumption, energized	3 mA

Pt100 inputs (MPT module)

Quantity	8
Range	0...200 °C

OUTPUT CIRCUITS

Output relays K1...K6

Quantity	6
• Type of contacts K1, K2	changeover (SPDT, type C)
• Type of contacts K3, K4, K5	make (SPST-NO, type A)
• Type of contacts K6	break (SPST-NC, type B)
Nominal current	8 A
Nominal voltage/max switching voltage	250 Vac/400 Vac
Breaking capacity:	
• Direct current (L/R = 40 ms)	50 W
• Alternating current (λ = 0,4)	1250 VA
Make	1000 W/VA
Short duration current (0,5 s)	30 A

Block output (Logic selectivity)

Quantity	1
Type	optocoupler

LEDs

Quantity	8
• ON/fail (green)	1
• Start (yellow)	1
• Trip (red)	1
• Allocatable (red)	5

GENERAL SETTINGS

— Rated values
Relay nominal frequency (f_n) 50, 60 Hz
Relay phase nominal current I_n 1 A, 5 A
Phase CTs nominal primary current I_{np} 1 A...10 kA
Relay residual nominal current I_{En} 1 A, 5 A
Residual CT nominal primary current I_{Enp} 1 A...10 kA
Relay nominal voltage (phase-to-phase) (U_n)50...130 V or 200...520 V
Relay nominal voltage (phase-to-ground) $E_n = U_n/\sqrt{3}$ -
Line VT primary nominal voltage (phase-to-phase) (U_{np}) 50 V..500 kV
Relay residual nominal voltage (direct measure) (U_{En}) 50...130 V
Residual primary nominal voltage (phase-to-phase) $\cdot \sqrt{3}$ (U_{Enp}) 50 V...500 kV

— Binary input timers
ON delay time (IN1 t_{ON}, INx t_{ON}) 0.00...100.0 s
OFF delay time (IN1 t_{OFF}, INx t_{OFF}) 0.00...100.0 s

— Relay output timers
Minimum pulse width t_{TR} 0.000...0.500 s

— Starting control
CLP control IRUN or CB

PROTECTIVE FUNCTIONS

— Base current - IB
Base current (I_B) 0.20...1.50 I_n

Note - Assuming that the secondary rated current of the line CT's equals the rated current of the relay, as usually happens, the I_B value is the ratio between the rated current of the protected motor and the primary rated current of the CT's.

— Thermal with PT100 thermometric probes - 26
PTx probe (x = 1...8):

ThALx Alarm
- PTx Alarm threshold (*ThALx*) 0...200 °C
- *ThALx* Operating time (t_{ThALx}) 0...100 s

Th>x Trip
- PTx Trip threshold (*Th>x*) 0...200 °C
- *Th>1* Operating time ($t_{Th>x}$) 0...100 s

Note - The element is available when the MPT module, connected to the Thybus, is enabled

— Undervoltage - 27
Common configuration:
- Voltage measurement type for 27 (*Utype27*) [1] U_{ph-ph}/U_{ph-n}
- 27 Operating logic (*Logic27*) AND/OR

U< Element
- *U<* Curve type (*U<Curve*) DEFINITE, INVERSE [2]

Definite time
- 27 First threshold definite time ($U_{<def}$) 0.05...1.10 U_n/E_n
- $U_{<def}$ Operating time ($t_{U<def}$) 0.03...100.0 s

Inverse time
- 27 First threshold inverse time ($U_{<inv}$) 0.05...1.10 U_n/E_n
- $U_{<inv}$ Operating time ($t_{U<inv}$) 0.10...100.0 s

U<< Element
Definite time
- 27 Second threshold definite time ($U_{<<def}$) 0.05...1.10 U_n/E_n
- $U_{<<def}$ Operating time ($t_{U<<def}$) 0.03...100.0 s

Note [1] - With U_{ph-ph} setting all threshold are in p.u. U_n
With U_{ph-n} setting all threshold are in p.u. E_n

Note [2] - The mathematical formula for INVERSE curves is:
$t = 0.75 \cdot t_{U<inv} / [1 - (U/U_{<inv})]$ where:
t = trip time (in seconds)
$t_{U<inv}$ = operating time setting (in seconds)
U = input voltage
$U_{<inv}$ = threshold setting

— Positive sequence undervoltage - 27V1
U_1< Element
- 27V1 First threshold definite time ($U_{1<def}$) 0.05...1.10 U_n
- $U_{1<def}$ Operating time ($t_{U1<def}$) 0.03...100.0 s

— Active reverse power - 32R
P-> Element
- *P->* Reset time delay ($t_{P->RES}$) 0.00...100.0 s
- 32R First threshold definite time ($P_{->def}$) -1.00...-0.01 P_n
- *P->* Operating time ($t_{P->def}$) 0.07...100.0 s

— Undercurrent - 37
I< Element
I< Inhibition time ($t_{inh<}$) 0.00...200 s

Definite time
- 37 First threshold definite time ($I_{<def}$) 0.30...1.00 I_B
- $I_{<def}$ Operating time ($t_{<def}$) 0.10...600 s

— Underpower - 37P
P+< Element
- CB-37P delay ($t_{ARM-P+<}$) 0.07...300 s
- 37P First threshold definite time ($P_{+<def}$) 0.01...1.20 P_n
- $P_{+<def}$ Operating time ($t_{P+<def}$) 0.07...100.0 s

— Loss of field - 40
- *Common configuration:*
- Operating mode Motor/Generator
- Undervoltage threshold ($U_{SUP<}$) 0.50...1.00 U_n

Alarm Element
- 40AL Alpha angle α 10...75°
- 40AL Operating time (t_{40AL}) 0.07...100.0 s

XC1-XD1 Element
- XC1 Absolute center coordinate (X_{C1}) 0.00...+4.50 Z_{nf}
- XD1 Diameter (X_{D1}) 0.20...+5.00 Z_{nf}
- XC1-XD1 Operating time ($t_{XC1-XD1}$) 0.07...100.0 s
- XC1-XD1 Reset time delay ($t_{XC1XD1-RES}$) 0.0...10.0 s

XC2-XD2 Element
- XC2 Absolute center coordinate (X_{C2}) 0.00...+4.50 Z_{nf}
- XD2 Diameter (X_{D2}) 0.20...+5.00 Z_{nf}
- XC2-XD2 Operating time ($t_{XC2-XD2}$) 0.07...100.0 s
- XC2-XD2 Reset time delay ($t_{XC1XD2-RES}$) 0.0...10.0 s

— Negative sequence overcurrent - 46
I_2> Element
- *I_2>* Curve type (*I_2>Curve*) DEFINITE
IEC/BS A, B, C, ANSI/IEEE MI, VI, EI, EM, I²t
- $I_{2CLP>}$ Activation time ($t_{2CLP>}$) 0.00...200 s
- *I_2>* Reset time delay ($t_{2>RES}$) 0.00...100.0 s

Definite time
46 First threshold definite time ($I_{2>def}$) 0.03...1.00 I_B
- $I_{2>def}$ within CLP ($I_{2CLP>def}$) 0.03...5.00 I_B
- $I_{2>def}$ Operating time ($t_{2>def}$) 0.03...200 s

Inverse time
- 46 First threshold inverse time ($I_{2>inv}$) 0.03...1.00 I_B
- $I_{2>inv}$ within CLP ($I_{2CLP>inv}$) 0.03...5.00 I_B
- $I_{2>inv}$ Operating time ($t_{2>inv}$) 0.10...60.0 s

I_2>> Element
- $I_{2CLP>>}$ Activation time ($t_{2CLP>>}$) 0.00...200 s
- *I_2>>* Reset time delay ($t_{2>>RES}$) 0.00...100.0 s

Definite time
- 46 Second threshold definite time ($I_{2>>def}$) 0.03...1.00 I_B
- $I_{2>>def}$ within CLP ($I_{2CLP>>def}$) 0.03...5.00 I_B
- $I_{2>>def}$ Operating time ($t_{2>>def}$) 0.03...200 s

— Phase reversal- 47
Definite time
- Us1< threshold ($U_{s1<}$) 0.05...0.30 E_n
- Us1> threshold ($U_{s1>}$) 0.70...1.00 U_n

— Thermal image - 49
Common configuration:
- Initial thermal image $\Delta\theta_{IN}$ (Dth_{IN}) 0.0...1.0 $\Delta\theta_B$
- Starting overload coefficient (K_{ST}) 1.0...3.0
- Negative sequence coefficient (K_2) 0...10
- Heating time constant τ+ (*T+*) 1...200 min
- Cooling time constant τ– (*T-*) 1...6 τ+
- DthCLP Operating mode Dth_{CLP} ($Dth_{CLP\ Mode}$) Blocking/Change
- DthCLP Activation time (t_{DthCLP}) 0.00...200 s

- *DthAL1 Element*
- 49 First alarm threshold $\Delta\theta_{AL1}$ (Dth_{AL1}) 0.3...1.0 $\Delta\theta_B$

DthAL2 Element
- 49 Second alarm threshold $\Delta\theta_{AL2}$ (Dth_{AL2}) 0.5...1.2 $\Delta\theta_B$

Dth> Element
- 49 Trip threshold $\Delta\theta$ (*Dth>*) 0.9...1.5 $\Delta\theta_B$

Note - The 49 protective function protection is based on RMS value measurement of three phase currents (the computed RMS value takes into account the contribution of fundamental and harmonic up to eleventh order)

— Phase overcurrent - 50/51

I> Element
- *I>* Curve type (*I>*Curve) DEFINITE IEC/BS A, B, C, ANSI/IEEE MI, VI, EI RECTIFIER, EM, I²t
- $I_{CLP>}$ Activation time ($t_{CLP>}$) 0.00...200 s
- *I>* Reset time delay ($t_{>RES}$) 0.00...100.0 s

Definite time
- 50/51 First threshold definite time ($I_{>def}$) 0.100...40.0 I_n
- $I_{>def}$ within CLP ($I_{CLP>def}$) 0.100...40.0 I_n
- $I_{>def}$ Operating time ($t_{>def}$) 0.04...200 s

Inverse time
- 50/51 First threshold inverse time ($I_{>inv}$) 0.100...20.00 I_n
- $I_{>inv}$ within CLP ($I_{CLP>inv}$) 0.100...20.00 I_n
- $I_{>inv}$ Operating time ($t_{>inv}$) 0.02...60.0 s

I>> Element
- *I>>* Curve type (*I>>*Curve) DEFINITE, I²t
- $I_{CLP>>}$ Activation time ($t_{CLP>>}$) 0.00...200 s
- *I>>* Reset time delay ($t_{>>RES}$) 0.00...100.0 s

Definite time
- 50/51 Second threshold definite time ($I_{>>def}$) 0.100...40.0 I_n
- $I_{>>def}$ within CLP ($I_{CLP>>def}$) 0.100...40.0 I_n
- $I_{>>def}$ Operating time ($t_{>>def}$) 0.03...10.00 s

Inverse time
- 50/51 Second threshold inverse time ($I_{>>inv}$) 0.100...20.00 I_n
- $I_{>>inv}$ within CLP ($I_{CLP>>inv}$) 0.100...20.00 I_n
- $I_{>>inv}$ Operating time ($t_{>>inv}$) 0.02...10.00 s

I>>> Element
- $I_{CLP>>>}$ Activation time ($t_{CLP>>>}$) 0.00...200 s
- *I>>>* Reset time delay ($t_{>>>RES}$) 0.00...100.0 s

Definite time
- 50/51 Third threshold definite time ($I_{>>>def}$) 0.100...40.0 I_n
- $I_{>>>def}$ within CLP ($I_{CLP>>>def}$) 0.100...40.0 I_n
- $I_{>>>def}$ Operating time ($t_{>>>def}$) 0.03...10.00 s

— Locked rotor - 50S/51LR/14

I_{LR}> Element
- $I_{LRCLP>}$ Operating mode (*Mode 51LR>*) With/without speed contr.

Inverse time
- 51LR First threshold inverse time ($I_{LR>inv}$) 0.80...8.00 I_B
- Motor starting current I-MOT-ST (I_{MOT-ST}) 0.80...15.00 I_B
- $I_{LR>inv}$ Operating time ($t_{LR>inv}$) 0.10...200 s

I_{LR}>> Element
- $I_{LRCLP>>}$ Operating mode (*Mode 51LR>>*) With/without speed contr.
- $I_{LRCLP>>}$ Activation time ($t_{LRCLP>>def}$) 0.00...200 s

Definite time
- 51LR Second threshold definite time ($I_{LR>>def}$) 0.90...8.00 I_B
- $I_{LR>>def}$ Operating time ($t_{LR>>def}$) 0.10...200 s

Note - The mathematical formula for INVERSE curves is:
$t = t_{LR>inv} (I_{MOT-ST} / I)^2$ where:
t = trip time (in seconds)
$t_{LR>inv}$ = operating time setting (in seconds)
I_{MOT-ST} = starting current with nominal voltage
I = max phase voltage (fundamental component)

— Residual overcurrent - 50N/51N

I_E> Element
- I_E> Curve type (I_E>Curve) DEFINITE IEC/BS A, B, C, ANSI/IEEE MI, VI, EI, EM
- $I_{ECLP>}$ Activation time ($t_{ECLP>}$) 0.00...200 s
- I_E> Reset time delay ($t_{E>RES}$) 0.00...100.0 s

Definite time
- 50N/51N First threshold definite time ($I_{E>def}$) 0.002...10.00 I_{En}
- $I_{E>def}$ within CLP ($I_{ECLP>def}$) 0.002...10.00 I_{En}
- $I_{E>def}$ Operating time ($t_{E>def}$) 0.04...200 s

Inverse time
- 50N/51N First threshold inverse time ($I_{E>inv}$) 0.002...2.00 I_{En}
- $I_{E>inv}$ within CLP ($I_{ECLP>inv}$) 0.002...2.00 I_{En}
- $I_{E>inv}$ Operating time ($t_{E>inv}$) 0.02...60.0 s

I_E>> Element
- $I_{ECLP>>}$ Activation time ($t_{ECLP>>}$) 0.00...200 s
- I_E>> Reset time delay ($t_{E>>RES}$) 0.00...100.0 s

Definite time
- 50N/51N Second threshold definite time ($I_{E>>def}$) 0.010...10.00 I_{En}
- $I_{E>>def}$ within CLP ($I_{ECLP>>def}$) 0.010...10.00 I_{En}
- $I_{E>>def}$ Operating time ($t_{E>>def}$) 0.03...10.00 s

I_E>>> Element
- $I_{ECLP>>>}$ Activation time ($t_{ECLP>>>}$) 0.00...200 s
- $I_{ECLP>>>}$ Reset time delay ($t_{E>>>RES}$) 0.00...100.0 s

Definite time
- 50N/51N Third threshold definite time ($I_{E>>>def}$) 0.010...10.00 I_{En}
- $I_{ECLP>>>def}$ within CLP ($I_{ECLP>>>def}$) 0.010...10.00 I_{En}
- $I_{ECLP>>>def}$ Operating time ($t_{E>>>def}$) 0.03...10.00 s

— Minimum power factor - 55

CPhi< Element
- CB55 delay ($t_{ARM-CPhi<}$) 0.07...300 s

Definite time
- CPhiLAG< First threshold definite time (*CPhiLAG<*) 0.1...0.9
- CPhiLAG< Operating time ($t_{CPhiLAG<}$) 0.04...100.0 s
- CPhiLEAD< First threshold definite time (*CPhiLEAD<*) 0.1...0.9
- CPhiLEAD< Operating time ($t_{CPhiLEAD<}$) 0.04...100.0 s

— Overvoltage - 59

Common configuration:
- Voltage measurement type for 59 (*U*type59) [1] U_{ph-ph}/U_{ph-n}
- 59 Operating logic (*Logic*59) AND/OR

U> Element
- *U>* Curve type (*U>*Curve) DEFINITE or INVERSE [2]

Definite time
- 59 First threshold definite time ($U_{>def}$) 0.50...1.50 U_n/E_n
- $U_{>def}$ Operating time ($t_{U>def}$) 0.03...100.0 s

Inverse time
- 59 First threshold inverse time ($U_{>inv}$) 0.50...1.50 U_n/E_n
- $U_{>inv}$ Operating time ($t_{U>inv}$) 0.10...100.0 s

U>> Element

Definite time
- 59 Second threshold definite time ($U_{>>def}$) 0.50...1.50 U_n/E_n
- $U_{>>def}$ Operating time ($t_{U>>def}$) 0.03...100.0 s

Note [1] - With U_{ph-ph} setting all threshold are in p.u. U_n
With U_{ph-n} setting all threshold are in p.u. E_n

Note [2] - The mathematical formula for INVERSE curves is:
$t = 0.5 \cdot t_{U>inv} / [(U/U_{>inv}) - 1]$, where:
t = trip time (in seconds)
$t_{U>inv}$ = operating time setting (in seconds)
U = input voltage
$U_{>inv}$ = threshold setting

— Residual overvoltage - 59N

Common configuration:
- Residual voltage measurement for 59N- direct/calc. U_E / U_{EC}
- 59N Operating mode from 74VT internal (*74VTint59N*) OFF/Block
- 59N Operating mode from 74VT external (*74VText59N*) OFF/Block

U_E> Element
- U_E> Curve type (U_E>Curve) DEFINITE OR INVERSE [1]
- U_E> Reset time delay ($t_{UE>RES}$) 0.00...100.0 s

Definite time
- 59N First threshold definite time ($U_{E>def}$) 0.01...0.70 U_{En}
- $U_{E>def}$ Operating time ($t_{UE>def}$) 0.07...100.0 s

Inverse time
- 59N First threshold inverse time ($U_{E>inv}$) 0.01...0.50 U_{En}
- $U_{E>inv}$ Operating time ($t_{UE>inv}$) 0.10...100.0 s

U_E>> Element
- U_E>> Reset time delay ($t_{UE>>RES}$) 0.00...100.0 s
- 59N Second threshold definite time ($U_{E>>def}$) 0.01...0.70 U_{En}
- $U_{E>>def}$ Operating time ($t_{UE>>def}$) 0.07...100.0 s

Note [1] - The mathematical formula for INVERSE curves is:
$t = 0.5 \cdot t_{UE>inv}/[(U_E/U_{E>inv}) - 1]$ where:
t = trip time (in seconds)
$t_{UE>inv}$ = operating time setting (in seconds)
U_E = residual input voltage
$U_{E>inv}$ = threshold setting

— Negative sequence overvoltage - 59V2

U_2> Element
Definite time
- 59V2 First threshold definite time ($U_{2>def}$) 0.01...0.50 U_n
- $U_{2>def}$ Operating time ($t_{U2>def}$) 0.07...100.0 s

— Maximum number of startings (Restart inhibition) - 66

Operating mode (*Type66*) NST/TST
Control window (t_C) 1...60 min
N_{ST} (Starts inside t_C) 1...30
T_{ST} (Cumulative start time inside t_C) 1...600 s
66 Inhibition time (t_{IN}) 0...60 min

— Ground directional overcurrent - 67N

Common configuration:
- 67N Operating mode (*Mode67N*) *I/I·cos*
- Residual voltage measurement type for 67N - direct/calculated (*3VoType67N*) U_E / U_{EC}
- 67N Multiplier of threshold for insensitive zone (*M*) 1.5...10.0
- 67N Operating mode from 74VT internal (*74VTint67N*) OFF/Block/Not directional
- 67N Operating mode from 74VT external (*74VText67N*) OFF/Block/Not directional

I_{ED}> Element
- I_{ED}> Curve type DEFINITE IEC/BS A, B, C, ANSI/IEEE MI, VI, EI, EM
- I_{EDCLP}> Activation time ($t_{EDCLP>}$) 0.00...100.0 s
- I_{ED}> Reset time delay ($t_{ED>RES}$) 0.00...100.0 s

Definite time
67N First threshold definite time ($I_{ED>def}$ - $U_{ED>def}$)
- Residual current pickup value 0.002...10.00 I_{En}
- Residual voltage pickup value 0.004...0.500 U_{En}
- Characteristic angle 0...359°
- Half operating sector 1...180°
- $I_{ED>def}$ within CLP ($I_{EDCLP>def}$) 0.002...10.00 I_{En}
- $I_{ED>def}$ Operating time ($t_{ED>def}$) 0.05...200 s

Inverse time
67N First threshold inverse time ($I_{ED>inv}$ - $U_{ED>inv}$)
- Residual current pickup value 0.002...2.00 I_{En}
- Residual voltage pickup value 0.004...0.500 U_{En}
- Characteristic angle 0...359°
- Half operating sector 1...180°
- $I_{ED>inv}$ within CLP ($I_{EDCLP>inv}$) 0.002...2.00 I_{En}
- $I_{ED>inv}$ Operating time ($t_{ED>inv}$) 0.02...60.0 s

I_{ED}>> Element
- I_{ED}> Curve type (I_{ED}>>Curve) DEFINITE IEC/BS A, B, C, ANSI/IEEE MI, VI, EI, EM
- I_{EDCLP}>> Activation time ($t_{EDCLP>>}$) 0.00...100.0 s
- I_{ED}>> Reset time delay ($t_{ED>>RES}$) 0.00...100.0 s

Definite time
67N Second threshold definite time ($I_{ED>>def}$ - $U_{ED>>def}$)
- Residual current pickup value 0.002...10.00 I_{En}
- Residual voltage pickup value 0.004...0.500 U_{En}
- Characteristic angle 0...359°
- Half operating sector 1...180°
- $I_{ED>>def}$ within CLP ($I_{EDCLP>>def}$) 0.002...10.00 I_{En}
- $I_{ED>>def}$ Operating time ($t_{ED>>def}$) 0.05...10.00 s

Inverse time
67N Second threshold inverse time ($I_{ED>>inv}$ - $U_{ED>>inv}$)
- Residual current pickup value 0.002...2.00 I_{En}
- Residual voltage pickup value 0.004...0.500 U_{En}
- Characteristic angle 0...359°
- Half operating sector 1...180°
- $I_{ED>inv}$ within CLP ($I_{EDCLP>>inv}$) 0.002...2.00 I_{En}
- $I_{ED>inv}$ Operating time ($t_{ED>>inv}$) 0.02...10.00 s

I_{ED}>>> Element
- I_{EDCLP}>>> Activation time ($t_{EDCLP>>>}$) 0.00...100.0 s
- I_{ED}>>> Reset time delay ($t_{ED>>>RES}$) 0.00...100.0 s

Definite time
67N Third threshold definite time ($I_{ED>>>def}$ - $U_{ED>>>def}$)
- Residual current pickup value 0.002...10.00 I_{En}
- Residual voltage pickup value 0.004...0.500 U_{En}
- Characteristic angle 0...359°
- Half operating sector 1...180°
- $I_{ED>>>def}$ within CLP ($I_{EDCLP>>>def}$) 0.002...10.00 I_{En}
- $I_{ED>>>def}$ Operating time ($t_{ED>>>def}$) 0.05...10.00 s

I_{ED}>>>> Element
- I_{EDCLP}>>>> Activation time ($t_{EDCLP>>>>}$) 0.00...100.0 s
- I_{ED}>>>> Reset time delay ($t_{ED>>>>RES}$) 0.00...100.0 s

Definite time
67N Fourth threshold definite time ($I_{ED>>>>def}$ - $U_{ED>>>>def}$)
- Residual current pickup value 0.002...10.00 I_{En}
- Residual voltage pickup value 0.004...0.500 U_{En}
- Characteristic angle 0...359°
- Half operating sector 1...180°
- $I_{ED>>>>def}$ within CLP ($I_{EDCLP>>>>def}$) 0.002...10.00 I_{En}
- $I_{ED>>>>def}$ Operating time ($t_{ED>>>>def}$) 0.05...10.00 s

— Overfrequency - 81O

f> Element
Definite time
- 81O First threshold definite time ($f_{>def}$) 1.000....1.200 f_n
- $f_{>def}$ Operating time ($t_{f>def}$) 0.05...100.00 s

f>> Element>
Definite time
- 81O Second threshold definite time ($f_{>>def}$) 1.000....1.200 f_n
- $f_{>>def}$ Operating time ($t_{f>>def}$) 0.05...100.00 s

— Underfrequency - 81U

$f<$ Element
Definite time
- 81U First threshold definite time ($f_{<def}$) 0.800...1.000 f_n
- $f_{<def}$ Operating time ($t_{f<def}$) 0.07...100.0 s

$f<<$ Element
Definite time
- 81U Second threshold definite time ($f_{<<def}$) 0.800...1.000 f_n
- $f_{<<def}$ Operating time ($t_{f<<def}$) 0.07...100.0 s

— Breaker failure - BF

- BF Phase current threshold ($I_{BF>}$) 0.05...1.00 I_n
- BF Residual current threshold ($I_{EBF>}$) 0.01..2.00 I_{En}
- BF Time delay (t_{BF}) 0.06...10.00 s

— CT supervision - 74CT

- 74CT Threshold ($S<$) 0.10...0.95
- 74CT Overcurrent threshold (I_*) 0.10...1.00 I_n
- $S<$ Operating time ($t_{S<}$) 0.03...200 s

— VT supervision - 74VT

74VT Negative sequence overvoltage threshold ($U_{2VT>}$) 0.05...0.50 E_n
74VT Negative sequence overvoltage threshold ($I_{2VT>}$) 0.05...0.50 I_n
74VT Phase undervoltage threshold ($U_{VT<}$) 0.05...0.50 E_n
74VT Minimum change of current threshold 74VT ($D_{IVT<}$) 0.05...0.50 I_n
74VT Undercurrent inhibition threshold ($I_{VT<}$) 0.100...40.0 I_n
74VT Alarm time delay (t_{VT-AL}) 0.0...10.0 s

— Selective block - BLOCK2

Selective block IN:
- BLIN Max activation time for phase protections (t_{B-IPh}) 0.10...10.00 s
- BLIN Max activation time for ground protections (t_{B-IE}) 0.10...10.00 s

Selective block OUT:
- BLOUT Dropout time delay for phase protections (t_{F-IPh}) 0.00...1.00 s
- BLOUT Drop-out time delay for ground protections (t_{F-IE}) 0.00...1.00 s
- BLOUT Drop-out time delay for phase and ground protections ($t_{F-IPh/IE}$) 0.00...1.00 s

Circuit Breaker supervision

- Number of CB trips (*N.Open*) 0...10000
- Cumulative CB tripping currents (*SumI*) 0...5000 I_n
- CB opening time for I^2t calculation (t_{break}) 0.05...1.00 s
- Cumulative CB tripping I^2t (*SumI^2t*) 0...5000 $(I_n)^2 \cdot s$
- CB max allowed opening time (t_{break}>) 0.05...1.00 s

Pilot wire diagnostic

BLOUT1 Diagnostic pulses period (*PulseBLOUT1*)
OFF - 0.1-1-5-10-60-120 s

METERING & RECORDING

Measured parameters

Direct:

- Frequency f
- Fundamental RMS phase currents I_{L1}, I_{L2}, I_{L3}
- True RMS phase currents [1] I_{L1rms}, I_{L2rms}, I_{L3rms}
- Fundamental RMS residual current I_E
- Fundamental RMS input voltages U_{L1}, U_{L2}, U_{L3}
- Fundamental RMS residual voltage U_E

Note [1] - the computed RMS value takes into account the contribution of fundamental and harmonic up to eleventh order

Calculated:

- Thermal image *DTheta*
- Phase-to-phase voltages U_{12}, U_{23}, U_{31}
- Fundamental RMS calculated residual voltage U_{EC}
- Fundamental RMS calculated residual current I_{EC}
- Maximum current between I_{L1}-I_{L2}-I_{L3} I_{Lmax}
- Maximum current between I_{L1rms}, I_{L2rms}, I_{L3rms} $I_{Lmax-rms}$
- Minimum current between I_{L1}-I_{L2}-I_{L3} I_{Lmin}
- Minimum current between I_{L1rms}, I_{L2rms}, I_{L3rms} $I_{Lmin-rms}$
- Average current between I_{L1}-I_{L2}-I_{L3} I_L
- Average current between I_{L1rms}, I_{L2rms}, I_{L3rms} I_{L-rms}
- Maximum voltage between U_{L1}-U_{L2}-U_{L3} U_{Lmax}
- Average voltage between U_{L1}-U_{L2}-U_{L3} U_L
- Maximum voltage between U_{12}-U_{23}-U_{31} U_{max}
- Average voltage between U_{12}-U_{23}-U_{31} U

Phase:

- Displacement angle of I_{L1} respect to U_{L1} *PhiL1*
- Displacement angle of I_{L2} respect to U_{L2} *PhiL2*
- Displacement angle of I_{L3} respect to U_{L3} *PhiL3*
- Displacement angle of U_E respect to I_E *PhiE*
- Displacement angle of U_{EC} respect to I_E *PhiEC*

Sequence:

- Positive sequence current I_1
- Negative sequence current I_2
- Positive sequence voltage U_1
- Negative sequence voltage U_2

Power:

- Total active power P
- Total reactive power Q
- Total apparent power S
- Power factor *cosPhi*
- Phase active powers P_{L1}, P_{L2}, P_{L3}
- Phase reactive powers Q_{L1}, Q_{L2}, Q_{L3}
- Power factors *cosPhiL1, cosPhiL2, cosPhiL3*

Impedance:

- L1 phase impedance (40 element) Z_{L1}
- Resistive component of the L1 phase impedance $\pm R_{L1}$
- Reactive component of the L1 phase impedance $\pm X_{L1}$

Start:

- Number of starts N_{Start}
- Time of starts T_{Start}

Demand phase:

- Phase fixed currents demand I_{L1FIX}, I_{L2FIX}, I_{L3FIX}
- Phase rolling currents demand I_{L1ROL}, I_{L2ROL}, I_{L3ROL}
- Phase peak currents demand I_{L1MAX}, I_{L2MAX}, I_{L3MAX}
- Phase minimum currents demand I_{L1MIN}, I_{L2MIN}, I_{L3MIN}

Demand power:

- Fixed active power demand P_{FIX}
- Fixed reactive power demand Q_{FIX}
- Rolling active power demand P_{ROL}
- Rolling reactive power demand Q_{ROL}
- Peak active power demand P_{MAX}
- Peak reactive power demand Q_{MAX}
- Minimum active power demand P_{MIN}
- Minimum reactive power demand Q_{MIN}

Energy:

- Positive active energy E_{A+}
- Negative active energy E_{A-}
- Total active energy E_A
- Positive reactive energy E_{Q+}
- Negative reactive energy E_{Q-}
- Total reactive energy E_Q

Motor state:

- Operating time counter P_{-RMT}
- Total operating time counter T_{-RMT}

Temperature

- Pt1...Pt8 diagnostic ON/LOW/HIGH
- Pt1...Pt8 temperature -40...240 °C

Event recording (SER)

Number of events 300
300
Recording mode circular

Trigger:

- Output relays switching K1...K6...K10
- Binary inputs switching IN1, IN2...INx
- Setting changes

Data recorded:

- Event counter (resettable by ThySetter) $0...10^9$
- Event cause binary input/output relay/setting changes
- Time stamp Date and time

Fault recording (SFR)

Number of faults 20
Recording mode circular

Trigger:

- External trigger (binary inputs) IN1, IN2...INx
- Element pickup (OFF-ON transition) Start/Trip

Data recorded:

- Time stamp Date and time
- Fault cause start, trip, binary input
- Fault counter (resettable by ThySetter) $0...10^9$
- Fundamental RMS phase currents I_{L1r}, I_{L2r}, I_{L3r}
- True RMS phase currents $I_{L1rms-r}$, I_{L2rmsr}, $I_{L3rms-r}$
- Fundamental RMS residual current I_{Er}
- Fundamental RMS phase voltages U_{L1r}, U_{L2r}, U_{L3r}
- Fundamental RMS phase-to-phase voltages U_{12r}, U_{23r}, U_{31r}
- Fundamental RMS residual voltages (measured and calculated) U_{Er}, U_{EC}
- Displacement angles (I_{L1}-U_{L1}, I_{L2}-U_{L2}, I_{L3}-U_{L3}) Phi_{L1r}, Phi_{L2r}, Phi_{L3r}
- Displacement angles (U_E-I_E) and (U_{EC}-I_E) Phi_{Er}, Phi_{ECr}
- Negative sequence current I_{2r}
- Positive and negative sequence voltages U_{1r}, U_{2r}
- Total active and reactive powers P_r, Q_r
- Power factor $cosPhi_r$
- Resistive component of the L1 phase impedance $\pm R_{L1r}$
- Reactive component of the L1 phase impedance $\pm X_{L1r}$
- Thermal image *DTheta*-r
- Number of starts $N_{Start-r}$
- Time of starts $T_{Start-r}$
- Binary inputs state IN1, IN2...INx
- Output relays state K1...K6...K10
- Fault cause info (operating phase) L1, L2, L3

— Digital Fault Recorder (Oscillography)

File format	COMTRADE
Records	depending on setting [1]
Recording mode	circular
Sampling rate	24 sample/cycle

Trigger setup:

• Pre-trigger time	0.05...1.00 s
• Post-trigger time	0.05...60.00 s
• Trigger from inputs	IN1, IN2...INx
• Trigger from outputs	K1...K6...K10
• Communication	ThySetter

Set sample channels:

• Instantaneous currents	i_{L1}, i_{L2}, i_{L3}, i_E
• Instantaneous voltages	u_{L1}, u_{L2}, u_{L3}, u_E

Set analog channels (Analog 1...12):

• Frequency	f
• Fundamental RMS phase currents	I_{L1}, I_{L2}, I_{L3}
• True RMS phase currents	I_{L1}, I_{L2}, I_{L3}
• Fundamental RMS positive and negative sequence currents	$I_{1, L2}$
• Fundamental RMS residual currents (measured and calc.)	I_E, I_{EC}
• Fundamental RMS phase voltages	U_{L1}, U_{L2}, U_{L3}
• Fundamental RMS phase-to-phase voltages	U_{12}, U_{23}, U_{31}
• Fundamental RMS residual voltage	U_E
• Fundamental RMS calculated residual voltage	U_{EC}
• Active total Power	P
• Rective total Power	Q
• Power factor	*cosPhi*
• Phase Active Powers	$\pm P_{L1}$, $\pm P_{L2}$, $\pm P_{L3}$
• Phase Reactive Powers	$\pm Q_{L1}$, $\pm Q_{L2}$, $\pm Q_{L3}$
• Phase Power factors	*cosPhiL1, cosPhiL2, cosPhiL3*
• Resistive component of the L1 phase impedance	$\pm R_{L1}$
• Reactive component of the L1 phase impedance	$\pm X_{L1}$
• L1 phase impedance (40 element)	Z_{L1}
• Displacement angle (U_E-I_E)	Phi_E
• Displacement angle (U_{EC}-I_E)	Phi_{EC}
• Thermal image	$\Delta\theta$

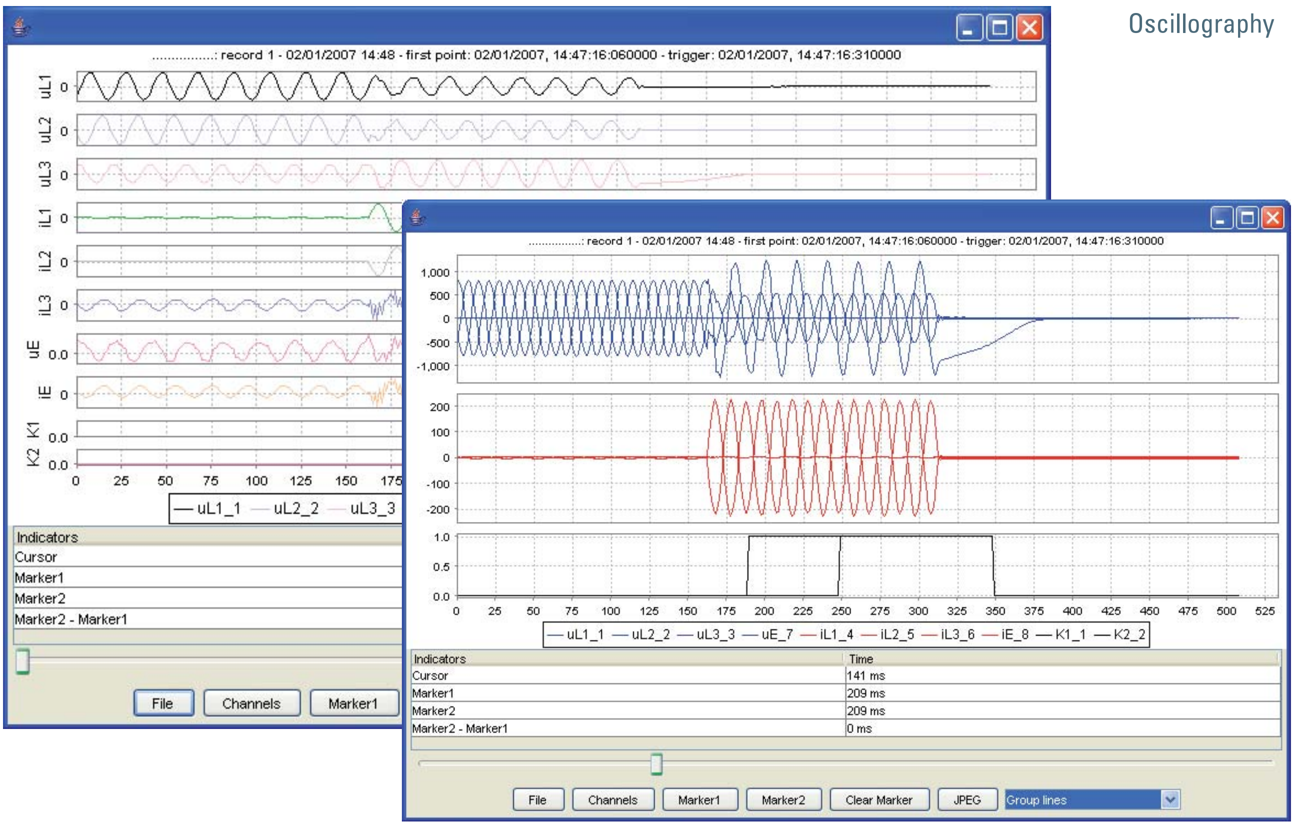
Set digital channels (Digital 1...12):

• Output relays state	K1...K6...K10
• Binary inputs state	IN1, IN2...INx

Note [1] - For instance, with following setting:

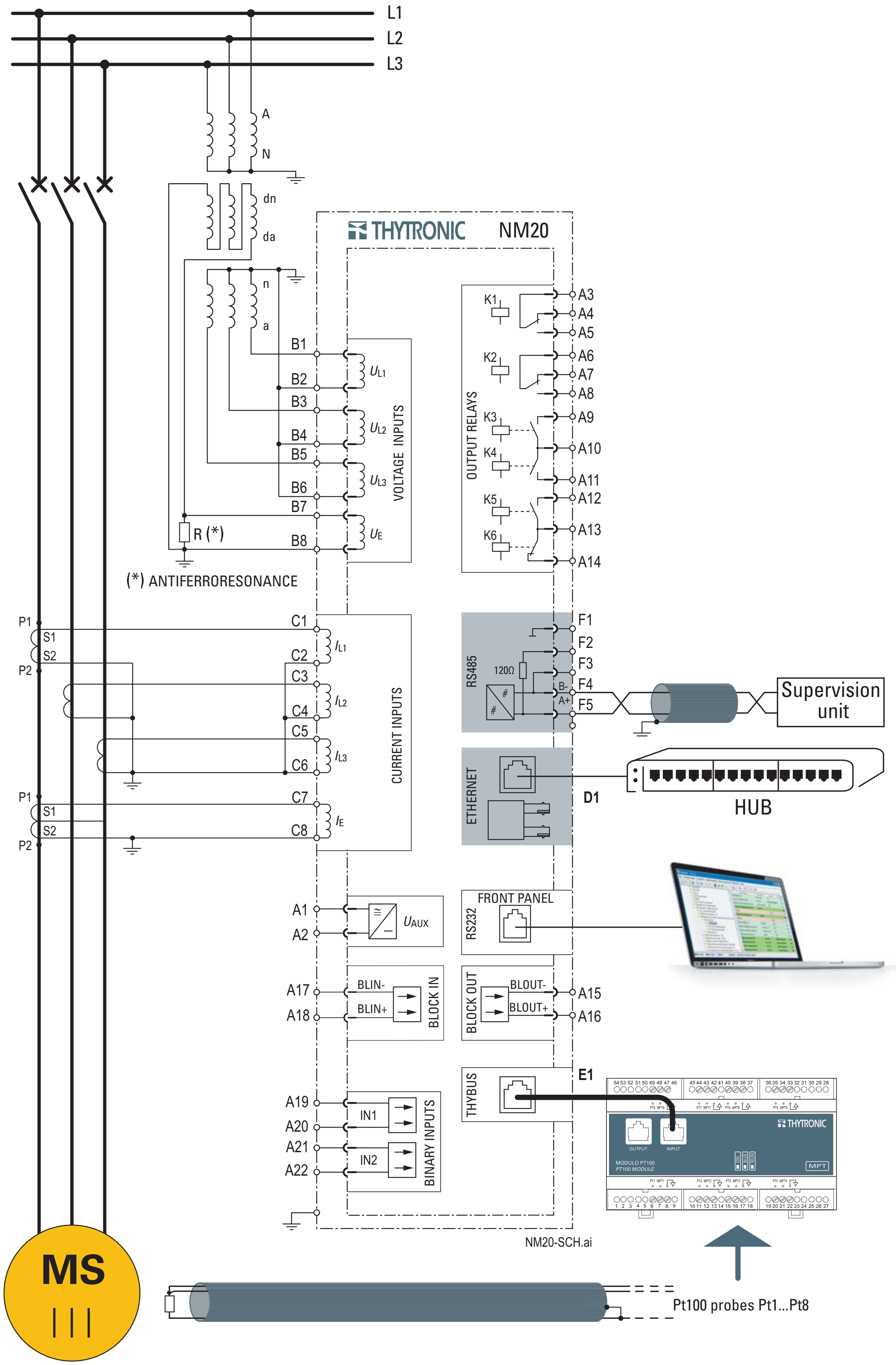
• *Pre-trigger time and Post-trigger time*	*0.25 s*
• *Sampled channels*	i_{L1}, i_{L2}, i_{L3}, i_E, u_{L1}, u_{L2}, u_{L3}, u_E
• *Analog channels*	I_{L1}, I_{L2}, I_{L3}, I_{L1rms}, I_{L2rrms}, I_{L3rms}, I_E, I_1, I_2, U_1, U_2
• *Digital channels*	*K1, K2, K3, K4, K5, K6, IN1, IN2*

More than 260 records can be stored with f = 50 Hz



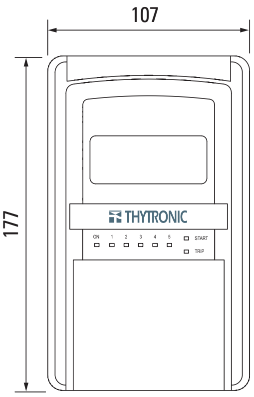
Oscillography

Connection diagram example

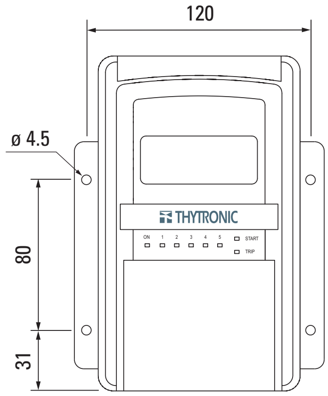


DIMENSIONS

FRONT VIEW

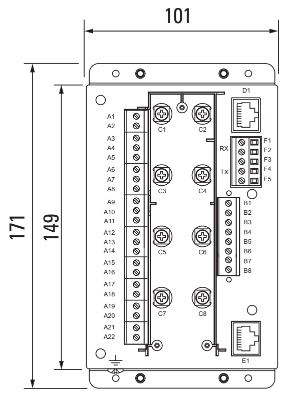


FLUSH MOUNTING



PROJECTING MOUNTING

REAR VIEW



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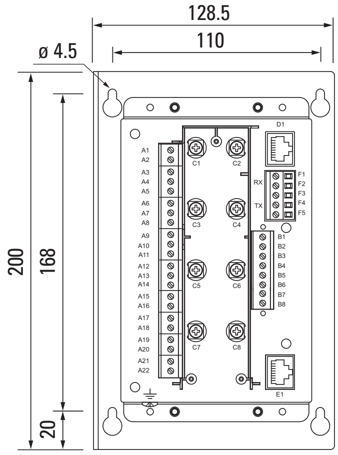
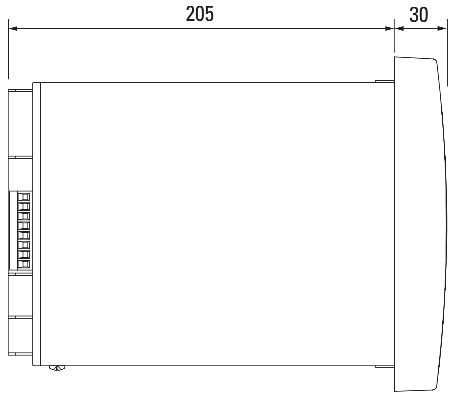
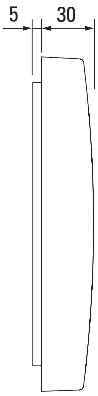


PROJECTING MOUNTING
(Separate operator panel)

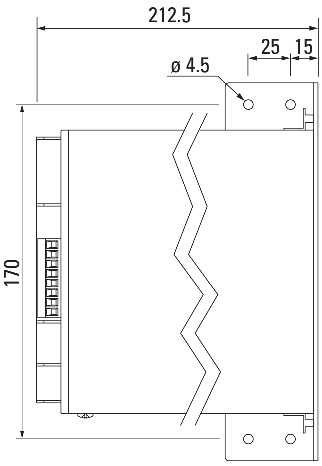
SIDE VIEW



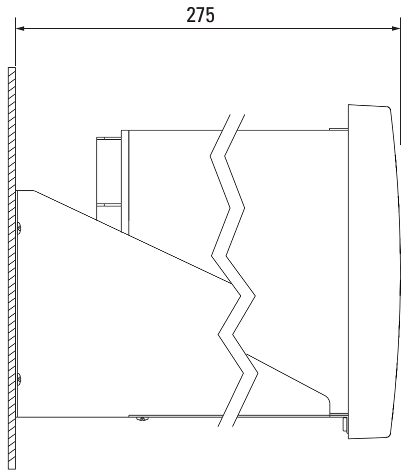
FLUSH MOUNTING



SEPARATE
OPERATOR PANEL

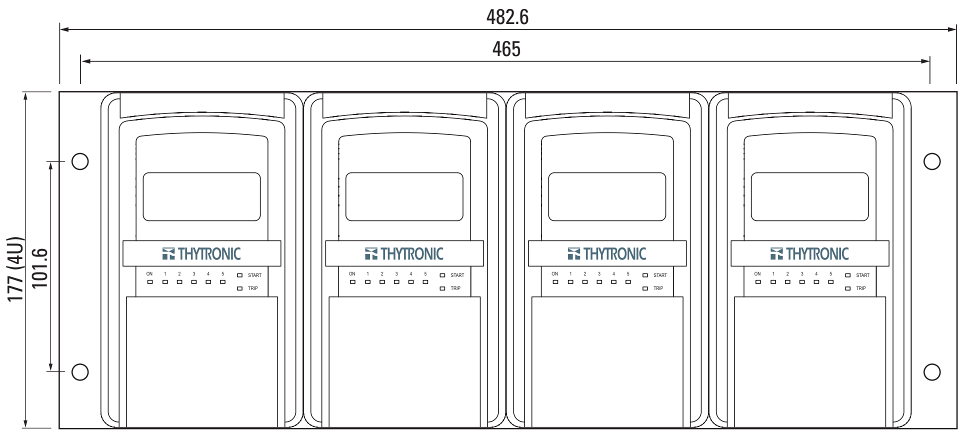


PROJECTING MOUNTING
(Separate operator panel)

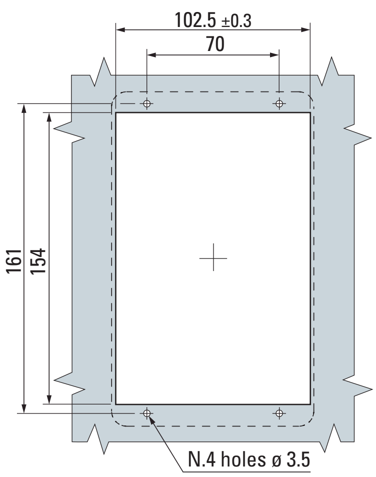


PROJECTING MOUNTING
(Stand alone)

RACK MOUNTING



FLUSH MOUNTING CUTOUT



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Headquarter: 20139 Milano - Piazza Mistral, 7 - Tel. +39 02 574 957 01 ra - Fax +39 02 574 037 63
Factory: 35127 Padova - Z.I. Sud - Via dell'Artigianato, 48 - Tel. +39 049 894 770 1 ra - Fax +39 049 870 139 0

www.thytronic.it **www.thytronic.com** **thytronic@thytronic.it**