NC20

BANK CAPACITOR PROTECTION RELAY

THE COMPREHENSIVE SOLUTION

FOR CAPACITOR BANK PROTECTION

— Application

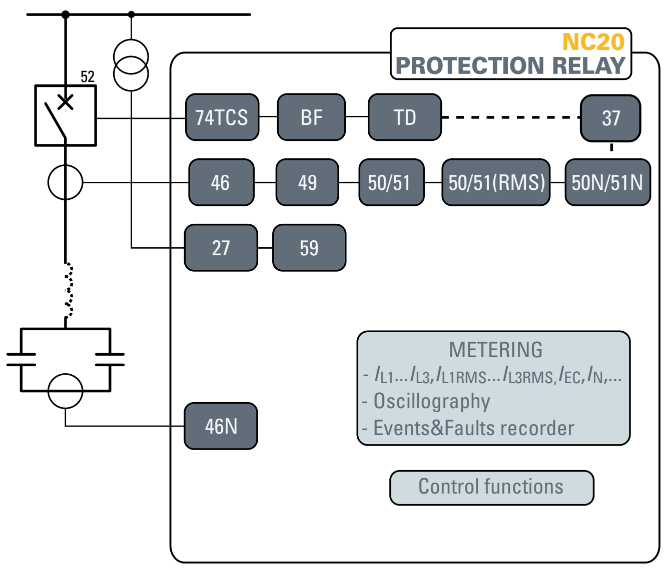
The relay type NC20 provides protection of shunt capacitor banks and harmonic filter circuits.

- The capacitor banks may have the following configurations:
- Single Wye grounded.
- Single Wye ungrounded (with a resistor on the output of the neutral unbalance voltage transformer in order to develop the appropriate input current for the unbalance protection).
- Double Wye ungrounded.

The capacitor banks may be: internally/externally fused or fuseless capacitor units.

A suitable compensation method is provided to compensate the inherent unbalance neutral current

Protection 37, 49 and 50/51 (RMS) are based on RMS value measurement of the three phase currents (fundamental and harmonics up to the 11th)



- Protective & control functions

27	Undervoltage
37	Undercurrent
46	Phase unbalance
46N	Neutral unbalance overcurrent with inherent unbalance compensation
49	Thermal image (for series reactor)
50/51	Fundamental frequency phase overcurrent
50/51(RMS)	RMS phase overcurrent
50N/51N	Computed residual overcurrent
59	Overvoltage
BF	Breaker Failure
74CT	CTs monitoring
74TCS	Trip Circuit Monitoring
TD	Discharge Timer

COMMUNICATION
- USB
- Modbus RS485
- Modbus TCP/IP
- IEC 870-5-103/DNP3

IEC 61850 IS NOW AVAILABLE

Measuring inputs

- Three phase current inputs and one unbalance neutral 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).

Construction

According to the hardware configurations, the NC20 protection relay can be shipped in various case styles depending on the required mounting options (flush, projecting mounting, rack or with separate operator panel).

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.

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 NC20 hardware can be customized through external auxiliary modules:

- MRI - Output relays and LEDs (provided with NA80)
- MID16 - Binary inputs
- MCI - 4...20 mA converters
- MPT - Pt100 probe inputs.

Blocking input/outputs

One output blocking circuit and one input blocking circuit are 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.
The block circuit is feeded internally to the relay by the input.
For long distances, when high insulation and high EMC immunity is essential, a suitable pilot wire to fiber optic converter (BFO) is available.

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.

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:

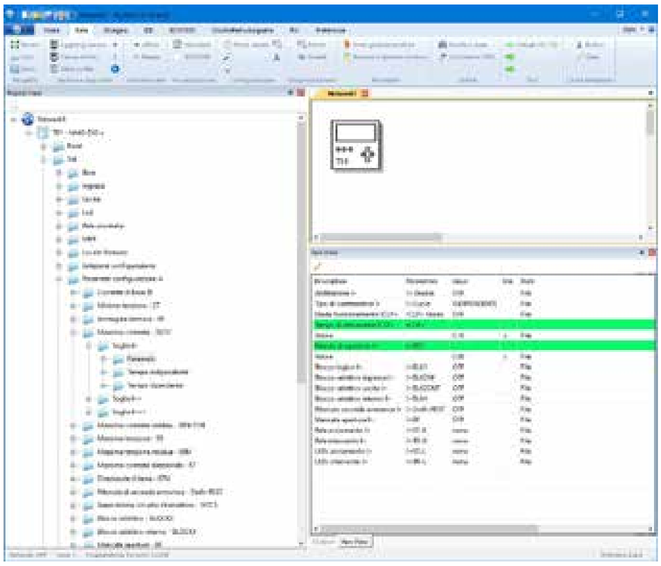
- One USB local communication front-end interface for communication with ThyVisor setup software
- Two back-end interfaces for communication with remote monitoring and control systems by:
  - RS485 port - ModBus® RTU, IEC 60870-5-103 or DNP3 protocol,
  - Ethernet port (RJ45 or optical fiber) - ModBus/TCP or IEC61850 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 ThyVisor 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.



— 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

NC20 provides metering values for voltages, phase and neutral currents, 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.
The RMS value of phase currents are also calculated taking into account the contribution of fundamental and harmonic up to eleventh order.
On the base of the direct measurements, the calculated residual current, the unbalance compensated current, phase displacements, harmonic distortion factors, minimum-peak-fixed-rolling demand, mean-minimum-maximum absolute phase currents and voltage are processed.
The measured signals can be displayed with reference to nominal values or directly expressed in amperes and volts.

— 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 (ThyVisor) is issued:

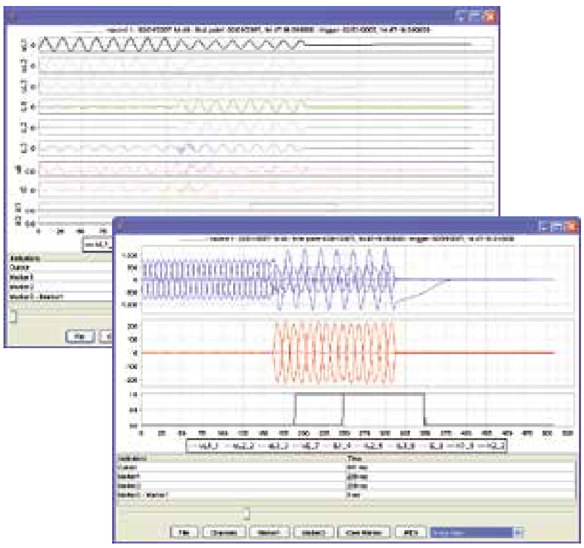
- Sequence of Event Recorder (SER)
  The event recorder runs continuously capturing in circular mode the last three hundred events upon trigger of binary input/output.
- Sequence of Fault Recorder (SFR)
  The event recorder runs continuously capturing in circular mode the last twenty events upon trigger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

— Digital Fault Recorder (Oscillography)

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 for long time periods analysis.
- Logic states (binary inputs and output relays).

Oscillografia (DFR)



Note - A license for Digital Fault Recorder function is required, the records are stored in nonvolatile memory

— Control and monitoring

Several predefined functions are implemented:

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

Moreover user defined logic must be customized in accordance with IEC 61131-3 protocol by means programmable logic controller (PLC).

Circuit Breaker

Several diagnostic, monitoring and control functions are provided:

- Health thresholds can be set; when the accumulated duty (ΣI or ΣI^2t), 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.

Virtual I/O

Through ThySetter and ThyVisor tools the type of operation and links between eight outputs (Virtual Output - VOUT1 ... 8) and ten virtual inputs (Virtual Inputs - VIN1 ... VIN10) may be defined using RPC or IEC 61850 communication protocols over Ethernet network.
The system allows:

- Availability of eight inputs and ten outputs independently programmable by the user
- Simplify wiring using one channel as the Ethernet
- Eliminate the need to install communication devices and / or external conversion
- Significantly reduce costs
- Dynamically change from sw connections and associated functions.

The virtual I / O can be usefully employed for:

- Transmit information between protections installed in distance
- Achieve accelerated logic discrimination in which some protection elements can be blocked by the activation of the downstream protection start
- Circuit Breaker commands, Selection of setting profiles, Remote trip, etc...

Logic selectivity

With the aim of providing a fast selective protection system some protective functions may be blocked.
The selectivity logic may be accomplished by:

- input and output block circuits,
- output relays and logic inputs,
- virtual input and output with messages on Ethernet network.

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, with small width in order to be ignored as an effective blocking signal by the input blocking circuit of the upstream protection, but suitable to prove continuity of the pilot wire.
Furthermore a permanent activation (or better, with a duration longer than a preset time) of the blocking signal is identified, as a warning for a possible short circuit in the pilot wire or in the output circuit of the downstream protection.

Cold Load Pickup (CLP)

Cold load pickup element prevents unwanted tripping in case of temporary overcurrents produced when a feeder is being connected after an extended outage (e.g. motor starting).
Two different operating modes are provided:

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

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 USB	Type B
Network:	
• RS485	1200...57600 bps
• Ethernet 100BaseT	100 Mbps
Protocol	ModBus® RTU/IEC 60870-5-103/DNP3, TCP/IP, IEC61850

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)

— Unbalanced neutral current input

Nominal current I_{Nn}	1 A or 5 A selectable by DIP Switch
Permanent overload	25 A
Thermal overload (1 s)	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
Nominal voltage U_n	50...130 V selectable by sw
Permanent overload	1.3 U_R
1s overload	2 U_R
Rated consumption (for any phase)	≤ 0.5 VA

— Binary inputs

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

— Block input (Logic selectivity)

Quantity	1
Type	polarized wet input (powered by internal isolated supply)
Max consumption, energized	5 mA

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 unbalance nominal current (I_{Nn})	1 A, 5 A
Unbalance CT nominal primary current (I_{Nnp})	1 A...10 kA
Relay nominal voltage (U_n)	50...130 V
Line VT primary nominal voltage (U_{np})	50 V...500 kV

— Compensation - 46N

Compensation current (I_C)	0.01...0.50 I_{Nn}
Compensation angle (Phi_C)	0...359 °
Automatic compensation enable	ON/OFF

— Binary input timers

ON delay time (t_{IN1ON}, t_{IN2ON})	0.00...100.0 s
OFF delay time (t_{IN1OFF}, t_{IN2OFF})	0.00...100.0 s
Logic	Active-ON/Active-OFF

— Relay output timers

Minimum pulse width (t_{TR})	0.000...0.500 s

PROTECTIVE FUNCTIONS

— Base current IB

Base current (I_B)	0.10...2.50 I_n

— Thermal protection with RTD thermometric probes - 26

Alarm

• Alarm threshold θ_{ALx} (x=1...8)	0...200 °C
• Operating time $t_{\theta ALx}$ (x=1...8)	0....100 s

Trip

• Trip threshold $\theta{>}_x$ (x=1...8)	0...200 °C
• Operating time $t_{\theta >x}$ (x=1...8)	0....100 s

Note: The element becomes available when the MPT module is enabled and connected to Thybus

— Undervoltage - 27

Common configuration:

• 27 Operating logic (*Logic27*)	AND/OR

U< Element

• $U<$ Curve type ($U<$Curve)	DEFINITE, INVERSE [1]
Definite time	
• 27 First threshold definite time ($U_{<def}$)	0.05...1.10 U_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
• $U_{<inv}$ 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
• $U_{<<def}$ Operating time ($t_{U<<def}$)	0.03...100.0 s

Note [1] - 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

— Undercurrent - 37[1]

I< Element

• $I_{<def}$ Operating logic	OR[2]
Definite time	
• 37 First threshold definite time ($I_{<def}$)	0.05...1.00 I_n
• $I_{<def}$ Operating time ($t_{<def}$)	0.04...200.0 s

I<< Element

• $I_{<<def}$ Operating logic	AND[3]
Definite time	
• 37 Second threshold definite time ($I_{<<def}$)	0.05...1.00 I_n
• $I_{<<def}$ Operating time ($t_{<<def}$)	0.04...200.0 s

Note [1] - The 37 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.)

Note [2] - Starting of $I_{<def}$ threshold takes place when at least one phase currents is undershot.

Note [3] - Starting of $I_{<<def}$ threshold takes place when all three phase currents are undershot.

— Discharge time (TD)

TD discharge time (t_D)	0.1...100.0 min

Note - When enabled it is started by the second threshold of the undercurrent protection (I<<).

— Phase unbalance - 46

I_2> Element

• I_{2CLP}> Activation time ($t_{2CLP>}$)	0.00...100.0 s
• I_2> Reset time delay ($t_{2>RES}$)	0.00...100.0 s
Definite time	
• 46 First threshold definite time ($I_{2>def}$)	1...150 %
• $I_{2>def}$ within CLP ($I_{2CLP>def}$)	1...150 %
• $I_{2>def}$ Operating time ($t_{2>def}$)	0.05...60.0 s

I_2>> Element

• I_{2CLP}>> Activation time ($t_{2CLP>>}$)	0.00...100.0 s
• I_2>> Reset time delay ($t_{2>>RES}$)	0.00...100.0 s
Definite time	
• 46 Second threshold definite time ($I_{2>>def}$)	1...150 %
• $I_{2>>def}$ within CLP ($I_{2CLP>>def}$)	1...150 %
• $I_{2>>def}$ Operating time ($t_{2>>def}$)	0.05...60.0 s

— Neutral unbalance current - 46N

$I_{N>AL}$ Element

• $I_{NCLP>AL}$ Activation time ($t_{NCLP>AL}$)	0.00...100.0 s
Definite time	
• 46N Alarm threshold definite time ($I_{N>ALdef}$)	0.01...1.00 I_{Nn}
• $I_{N>ALdef}$ within CLP ($I_{NCLP>ALdef}$)	0.01...1.00 I_{Nn}
• $I_{N>ALdef}$ Operating time ($t_{N>ALdef}$)	0.03...500 s

$I_{N>}$ Element

• $I_{N>}$ Curve type ($I_{N>}$Curve)	DEFINITE IEC/BS A, B, C, ANSI/IEEE MI, VI, EI
• $I_{NCLP>}$ Activation time ($t_{NCLP>}$)	0.00...100.0 s
Definite time	
• 46N First threshold definite time ($I_{N>def}$)	0.01...2.00 I_{Nn}
• $I_{N>def}$ within CLP ($I_{NCLP>def}$)	0.01...2.00 I_{Nn}
• $I_{N>def}$ Operating time ($t_{N>def}$)	0.03...50.0 s
Inverse time	
• 46N First threshold inverse time ($I_{N>inv}$)	0.01...1.00 I_{Nn}
• $I_{N>inv}$ within CLP ($I_{NCLP>inv}$)	0.01...1.00 I_{Nn}
• $I_{N>inv}$ Operating time ($t_{N>inv}$)	0.02...60.0 s

$I_{N>>}$ Element

• $I_{NCLP>>}$ Activation time ($t_{NCLP>>}$)	0.00...100.0 s
Definite time	
• 46N Second threshold definite time ($I_{N>>def}$)	0.01...2.00 I_{Nn}
• $I_{N>>def}$ within CLP ($I_{NCLP>>def}$)	0.01...2.00 I_{Nn}
• $I_{N>>def}$ Operating time ($t_{N>>def}$)	0.03...50.0 s

— Thermal image - 49

Common configuration:

• Initial thermal image $\Delta\theta_{IN}$ (Dth_{IN})	0.0...1.0 $\Delta\theta_B$
• Reduction factor at inrush (K_{INR})	1.0...3.0
• Thermal time constant τ (T)	1...200 min
• Dth_{CLP} Activation time (t_{DthCLP})	0.00...100.0 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>*) 1.100...1.300 $\Delta\theta_B$

Note - The 49 protection is based on maximum of the 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 Fundamental

I>> Element

I_{CLP}>> Activation time ($t_{CLP>>}$) 0.00...100.0 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

I>>> Element
- I_{CLP}>>> Activation time ($t_{CLP>>>}$) 0.00...100.0 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

— Phase overcurrent - 50/51 RMS [1]

$I_{>AL}$ element
- $I_{CLP>AL}$ Activation time ($t_{CLP>AL}$) 0.00...100.0 s

Definite time
- 50/51 Alarm threshold definite time ($I_{>ALdef}$) 0.100...10.00 I_n
- $I_{>ALdef}$ within CLP ($I_{CLP>ALdef}$) 0.100...10.00 I_n
- $I_{>ALdef}$ Operate time ($t_{>ALdef}$) 0.03...200 s

I> Element
- *I*> Curve type (*I*>Curve) DEFINITE
  IEC/BS A, B, C, ANSI/IEEE MI, VI, EI
  CAPACITOR [2]
- I_{CLP}> Activation time ($t_{CLP>}$) 0.00...100.0 s
- *I*> Reset time delay ($t_{>RES}$) 0.00...100.0 s

Definite time
- 50/51 First threshold definite time ($I_{>def}$) 0.100...10.00 I_n
- $I_{>def}$ within CLP ($I_{CLP>def}$) 0.100...10.00 I_n
- $I_{>def}$ Operating time ($t_{>def}$) 0.03...200 s

Inverse time
- 50/51 First threshold inverse time ($I_{>inv}$) 0.100...10.00 I_n
- $I_{>inv}$ within CLP ($I_{CLP>inv}$) 0.100...10.00 I_n
- $I_{>inv}$ Operating time ($t_{>inv}$) 0.02...60.0 s

Note [1] - The 50/51 RMS 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)

Note [2] - The mathematical formula for CAPACITOR curves is:

$$t = \frac{t_{>inv} \cdot 50000}{[1.1 \cdot (I_{RMS}/I_{>inv})^{17} - 1]} + 0.1$$

where:

t = trip time (in seconds)
$t_{>inv}$ = operating time setting (in seconds)
I_{RMS} = input current
$I_{>inv}$ = threshold setting

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

Definite time
- 50N/51N First threshold definite time ($I_{E>def}$) 0.100...10.00 I_n
- $I_{E>def}$ within CLP ($I_{ECLP>def}$) 0.100...10.00 I_n
- $I_{E>def}$ Operating time ($t_{E>def}$) 0.04...200 s

Inverse time
- 50N/51N First threshold inverse time ($I_{E>inv}$) 0.100...10.00 I_n
- $I_{E>inv}$ within CLP ($I_{ECLP>inv}$) 0.100...10.00 I_n
- $I_{E>inv}$ Operating time ($t_{E>inv}$) 0.02...60.0 s

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

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

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

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

Note - The residual current I_{EC} is calculated from the vector sum of the three phase currents.

— Overvoltage - 59

59 Operating logic (*Logic*59) AND/OR

U> Element
- *U*> Curve type (*U*>Curve) DEFINITE, INVERSE [1]

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

Note [1] - The mathematical formula for INVERSE curves is:

$$t = \frac{0.5 \cdot t_{U>inv}}{[(U/U_{>inv}) - 1]}$$

where:

t = trip time (in seconds)
$t_{U>inv}$ = operating time setting (in seconds)
U = input voltage
$U_{>inv}$ = threshold

— Circuit Breaker supervision

Number of CB trips threshold (*N.Open*) 0...10000
Cumulative CB tripping currents threshold (*SumI*) 0...5000 I_n
CB opening time for ΣI^2t computation (t_{break}) 0.05...1.00 s
Cumulative CB tripping ΣI^2t threshold (*SumI^2t*) 0...5000 $(I_n)^2 \cdot s$
CB Max allowed opening time (t_{break}>) 0.050...1.000 s

— Pilot wire diagnostic

BLOUT1 Diagnostic pulses period (*PulseBLOUT1*)
OFF - 0.1-1-5-10-60-120 s
BLIN1 Diagnostic pulses window (*PulseBLIN1*)
OFF - 0.1-1-5-10-60-120 s

— Breaker failure - BF

BF Phase current threshold ($I_{BF>}$) 0.05...1.00 I_n
BF Residual current threshold ($I_{EBF>}$) 0.05...1.00 I_n
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

— Selective block - BLOCK2

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

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

METERING & RECORDING

— Measured parameters

Direct:
- Frequency f
- RMS value of fundamental component for phase currents I_{L1}, I_{L2}, I_{L3}
- RMS value for phase currents [1] I_{L1RMS}, I_{L2RMS}, I_{L3RMS}
- RMS value of fundamental component for input voltages U_{L1}, U_{L2}, U_{L3}
- RMS value of fundamental component for unbalance neutral current I_N
- Phase displacement angle of I_N with respect to I_{L1} (φ_N) Phi_N

Calculated:
- Thermal image $\Delta\theta$ *DTheta*
- RMS value of fundamental component for unbalance compensated current I_{NC}
- Phase displacement angle of I_{NC} with respect to I_{L1} (φ_{NC}) Phi_{NC}
- RMS value of fundamental component for calculated residual current I_{EC}
- Maximum RMS value between I_{L1RMS}, I_{L2RMS}, I_{L3RMS} $I_{Lmax\text{-}RMS}$
- Minimum current between I_{L1RMS}, I_{L2RMS}, I_{L3RMS} $I_{Lmin\text{-}RMS}$
- Average current between I_{L1RMS}, I_{L2RMS}, I_{L3RMS} $I_{L\text{-}RMS}$
- Maximum voltage between U_{L1}-U_{L2}-U_{L3} U_{Lmax}
- Average voltage between $(U_{L1}+U_{L2}+U_{L3})/3$ U_L
- Harmonic distortion factor $THD_{\text{-}L1}$, $THD_{\text{-}L2}$, $THD_{\text{-}L3}$

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

Note [1] - The computed RMS values takes into account the contribution of harmonic up to eleventh order.

— Event recording (SER)

Number of events 300
Recording mode circular

Trigger:
- Start/Trip of enabled protection or control element
- Binary inputs switching (OFF/ON or ON/OFF) IN1...INx
- Setting changes
- Auxiliary supply Power UP/Power DOWN

Data recorded:
- Counter (resettable by ThyVisor) $0...10^9$
- Cause binary input/trip/setting change/Power ON/OFF
- Time stamp Date and time

— Fault recording (SFR)

Number of faults 20
Recording mode circular

Trigger:
- Output relays of enabled protection or control element (OFF-ON)
- External trigger (binary inputs) IN1...INx

Data recorded:
- Counter (resettable by ThyVisor) $0...10^9$
- Time stamp Date and time
- Cause tripped element
- Fundamental component currents I_{L1r}, I_{L2r}, I_{L3r}, I_{Nr}, I_{NCr}, I_{ECr}
- RMS phase currents $I_{L1RMS\text{-}r}$, $I_{L2RMS\text{-}r}$, $I_{L3RMS\text{-}r}$
- Fundamental frequency input voltages U_{L1r}, U_{L2r}, U_{L3r}
- Thermal image $DTheta_{\text{-}r}$
- Phase displacement angle of I_{NC} with respect to I_{L1} (φ_{NC}) Phi_{NCr}
- Phase displacement angle of I_N with respect to I_{L1} (φ_N) Phi_{Nr}
- 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 per power frequency 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 ThyVisor

Data recorded on sampled channels:
- Instantaneous currents i_{L1}, i_{L2}, i_{L3}, i_N
- Instantaneous voltages u_{L1}, u_{L2}, u_{L3}

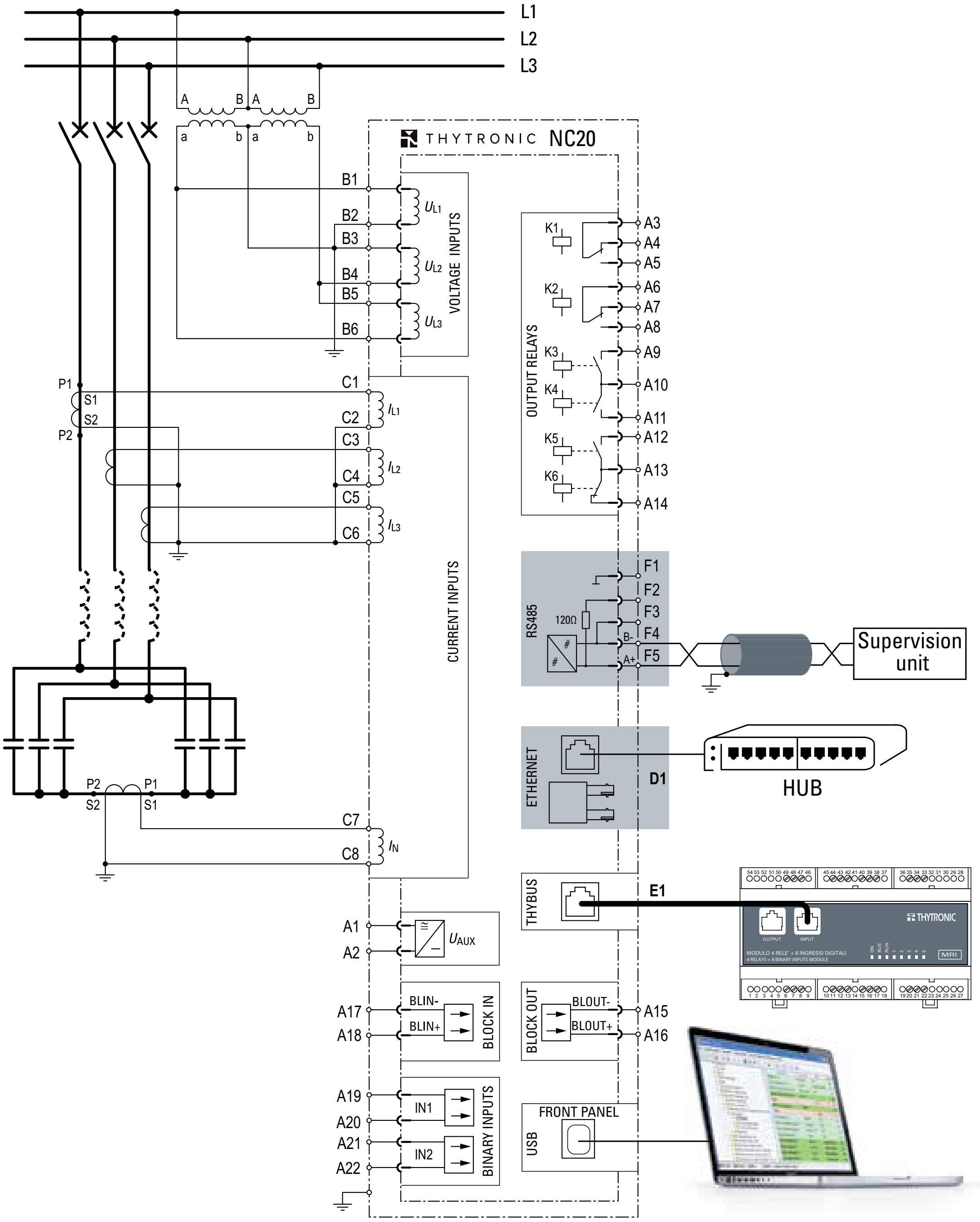
Set analog channels (Analog 1...12):
- Frequency f
- Fundamental frequency currents I_{L1}, I_{L2}, I_{L3}, I_N, I_{NC}, I_{EC}
- RMS phase currents I_{L1RMS}, I_{L2RMS}, I_{L3RMS}
- Displacement angles Phi_N, Phi_{NC}
- Fundamental frequency voltages U_{L1}, U_{L2}, U_{L3}

Set digital channels (Digital 1...12):
- Output relays state K1...K6...K10
- Binary inputs state IN1, IN2...INx

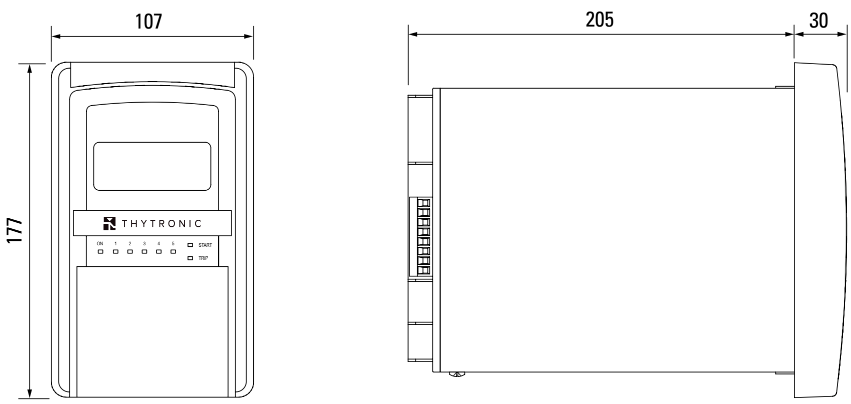
Note [1] - For instance, with following settings:
- Pre-trigger time 0.25 s
- Post-trigger time 0.25 s
- Sampled channels i_{L1}, i_{L2}, i_{L3}, i_N, u_{L1}, u_{L2}, u_{L3}
- Analog channels I_{L1}, I_{L2}, I_{L3}, I_{L1RMS}, I_{L2RMS}, I_{L3RMS}, I_N
- Digital channels K1, K2, K3, K4, K5, K6, IN1, IN2

up to 115 records can be stored when f = 50 Hz

— Connection diagram example



DIMENSIONS



FLUSH MOUNTING CUTOUT