THYTRONIC

SMART line
Protection Relays

NC020

FILTER & CAPACITOR BANK PROTECTION RELAY

THE LOW COST SOLUTION
FOR HARMONIC FILTERS AND CAPACITOR BANK

— Application

In recent years the harmonic producing part of total load has increased continuously because of the massive usage of power electronic in all the voltage levels. Thyristor convertors, frequency convertors, thyristor switches and static var compensator, such as thyristor controlled reactors (TCR) and thyristor switched capacitors (TSC), are commonly adopted in industrial applications and power utilities.

Filter capacitor banks consist of capacitor bank and series connected air core. Their task is to absorb the harmonic currents generated by loads and all above mentioned power electronic devices.

The aim of NC020 is to provide a reliable and cost effective solution for such an application granting capacitor bank safe operations.

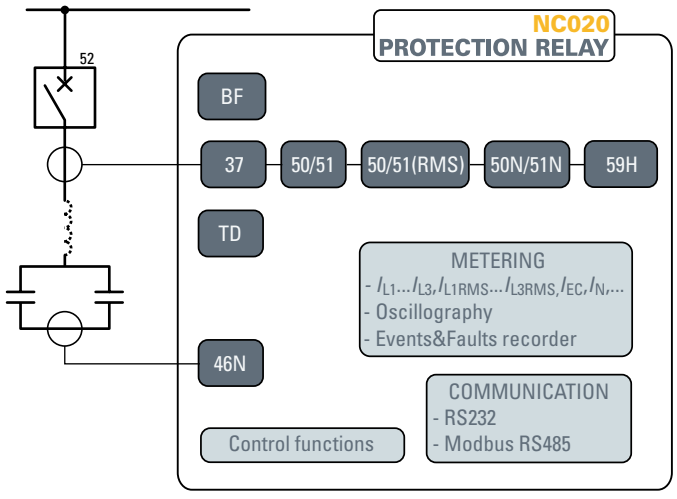
The capacitor banks may have the following configurations:

- 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.

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

Protection 50/51 RMS is based on true RMS value measurement of the three phase currents (fundamental and harmonics up to the 23th).

The peak capacitor voltage is achieved for any phase by means of the sum of the fundamental frequency voltage and its harmonics (up to twenty-third order), calculated from the phase currents. Hence it is an innovative key against the dangerous pick voltages for those applications without VTs for the direct measurement of the capacitor voltages.



Protective & control functions

37	Undercurrent
46N	Neutral unbalance overcurrent with inherent unbalance compensation
50/51	Fundamental frequency phase overcurrent
50/51(RMS)	True RMS phase overcurrent
50N/51N	Computed residual overcurrent
59H	Peak overvoltage
BF	Breaker Failure
TD	Discharge Timer

— 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.

— Output relays

Four output relays are available (two changeover contacts); each relay may be individually programmed as normal state (normally energized or de-energized) 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 in accordance with a matrix (tripping matrix) structure.

— Binary inputs

Three binary inputs are available with predefined functions:

- IN1 acquisition of 52b aux contact for CB position detection
- IN2 acquisition of 52a aux contact for CB position detection
- IN3 Remote Reset.

— Construction

The NC020 protection relay case is suitable for flush or rack mounting.

— 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,
- The yellow LED START, no-latched: Start of any element
- The red LED TRIP, no-latched: Trip of any element
- The red LED 1, latched: Trip of the I>, I>>, I>>> elements (RMS or DFT)
- The red LED 2, no-latched: Trip of the 50N, 46N elements
- The red LED 3, no-latched: Trip of the 59H element
- The red LED 4, no-latched: CB Open (CB position)
- The red LED 5, no-latched: TD state[1].

By means of the push buttons O and I the commands for CB opening and closing may be activated

Note 1 - OFF=disabled, ON=enabled, blink=count in progress

— Metering

NC020 provides metering values for phase, neutral and residual currents, making them available for reading on a display or to communication interfaces.
Moreover the peak capacitor voltage is calculated (harmonics up to twenty-third order) by means of the measured line currents.
Input signals are sampled 48 times per period and the RMS value of the fundamental component is measured using the DFT (Discrete Fourier Transform) algorithm and digital filtering.
The measured signals can be displayed with reference to nominal values or directly expressed in amperes.

— Cold Load Pickup (CLP)

The Cold Load Pickup feature can operate in two following modes:

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

It is triggered by the circuit breaker closing.

— 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:

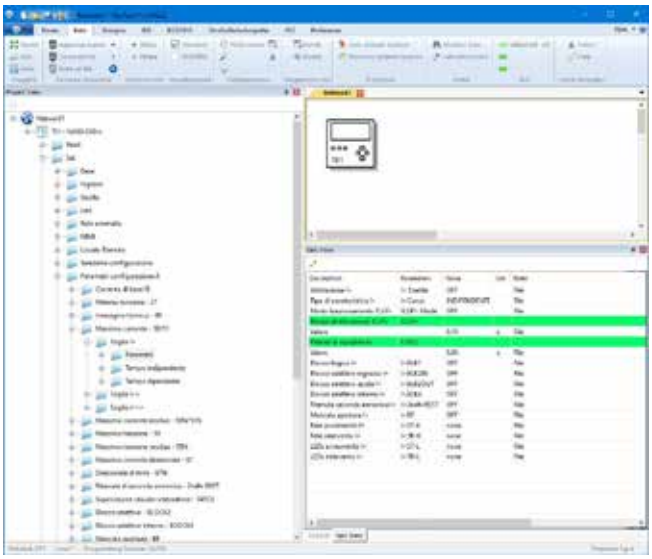
- Hw faults (auxiliary power supply, output relay coil interruptions, ...).
- Sw faults (boot and run time tests for data base, EEPROM memory checksum failure,...).

— Firmware updating

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

— 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 Thytronic devices.



— Data storage

Several useful data are stored into a non volatile memory.

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

— Communication

Two communication interfaces are implemented:

- One RS232 local communication front-end interface for communication with ThyVisor setup software
- One RS485 port using ModBus® RTU for communication with remote monitoring and control systems.

— Digital Fault Recorder (Oscillography)[4]

Upon trigger of tripping/starting of each function, I/O or manual trigger, the relay records in COMTRADE format the oscillography with instantaneous values (i_{L1}, i_{L2}, i_{L3}, i_N) for transient analysis.

Note 4 - A licence for retrieving the digital fault recorder function is required. The oscillographic recordings are stored in non-volatile memory.

SPECIFICATIONS

GENERAL

Mechanical data

Mounting:	flush, rack
Mass (flush mounting case)	1.2 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	2004/108/EC
• Low Voltage Directive	2006/95/EC
Type tests	IEC 60255-6

COMMUNICATION INTERFACES

Local PC RS232	19200 bps
RS485 port	1200...57600 bps
Protocol	ModBus® RTU

INPUT CIRCUITS

Rated frequency

Rated value [1]	50 or 60 Hz

Note 1 - Must be selected at time of order

Auxiliary power supply Uaux

Nominal value (range)	24...230 Vac/dc
Operative range	19...265 Vac / 19...300 Vdc
Power consumption (max)	6 W (9 VA)

Phase current inputs

Nominal current I_n	1 A or 5 A selectable by DIP Switches
Permanent overload	25 A
Thermal overload (1 s)	500 A
Rated consumption (for any phase)	≤ 0.002 VA (I_n = 1 A)
	≤ 0.04 VA (I_n = 5 A)
Connections	4 mm ring lugs suitable for M4 screws

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_{Nn} = 1 A)
	≤ 0.012 VA (I_{Nn} = 5 A)
Connections	4 mm ring lugs suitable for M4 screws

Binary inputs

Quantity	*3*
• IN1	52b
• IN2	52a
• IN3	Remote Reset
Type	dry inputs
Max permissible voltage	19...265 Vac/19...300 Vdc
Max consumption, energized	3 mA

OUTPUT CIRCUITS

Output relays K1...K4

Quantity	4
Command relays K1, K2, K4	
Type of contacts	changeover (SPDT, type C)
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
Signalling relays K3	
Type of contacts	changeover (SPDT, type C)
Nominal current	8 A
Nominal voltage/max switching voltage	250 Vac/400 Vac

LEDs

Quantity	8
• ON/fail (green)	1
• Start (yellow)	1
• Trip (red)	1
• Trip I>, I>>, I>>> RMS or DFT (red)	1
• Trip 46N, 50N (red)	1
• Trip 59H (red)	1
• CB position (red)	1
• TD state (red)	1

GENERAL SETTINGS

Rated values

Phase CT nominal primary current (I_{np})	1 A...5000 A
Neutral CT nominal primary current (I_{Nnp})	1 A...5000 A
Reading	Direct / Relative

Relay output timers

Minimum pulse width (t_{TR})	0.01...0.50 s

PROTECTIVE FUNCTIONS

— Discharge time (TD)

TD discharge time (t_D) 6...6000 s

Note - When enabled it is started by the internal threshold of the undercurrent protection (37). The discharge time counter may be manually cleared by MMI command and by ThyVisor

— Compensation - 46N

Compensation current ($I_{NC\ MOD\ calib}$) - I_{Nn}
Compensation angle ($I_{NC\ PHI\ calib}$) -°

Note - The compensation parameters are determined by the device as a result of the command "INC Comp exe" that must be activated in the Commands\Compensation\Set compensation menu

— Undercurrent - 37

I< Element
Definite time
- First threshold definite time ($I<_{def}$) 0.1 I_n
- $I<_{def}$ Operating time ($t<_{def}$) 0.100 s

I<< Element
Definite time
- second threshold definite time ($I<<_{def}$) 0.05...1.00 I_n
- $I<<_{def}$ Operating time ($t<<_{def}$) 0.03...600 s

Note - The 37 element is based on RMS measurement of three phase currents (the computed RMS value takes into account the contribution of fundamental and harmonics). It is an internal element servicing the Timer Discharge (TD) function.

— Neutral unbalance overcurrent - 46N

$I_{N>AL}$ *Element*
- $I_{NCLP>AL}$ CLP activation time 0.00...100.0 s

Definite time
- 46N Alarm threshold definite time ($I_{N>ALdef}$) 0.01...2.00 I_{Nn}
- $I_{N>ALdef}$ within CLP ($I_{NCLP>ALdef}$) 0.01...2.00 I_{Nn}
- $I_{N>ALdef}$ Operating time ($t_{IN>ALdef}$) 0.03...600 s

$I_N>$ *Element*
- $I_N>$ CLP 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 ($t_{IN>def}$) 0.03...600 s

$I_N>>$ *Element*
- $I_N>>$ CLP 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 ($t_{IN>>def}$) 0.03...60.0 s

— Phase overcurrent - 50/51 RMS [1]

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 ($t_{I>RES}$) 0.00...100.0 s

Definite time
- 50/51 RMS First threshold definite time ($I>_{def}$) 0.100...20.0 I_n
- $I>_{def}$ within CLP ($I_{CLP>def}$) 0.100...20.0 I_n
- $I>_{def}$ Operating time ($t>_{def}$) 0.03...600 s

Inverse time
- 50/51 First threshold inverse time ($I>_{inv}$) 0.100...2.50 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 twenty-third 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*

— Phase overcurrent - 50/51 Fundamental

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

Definite time
- 50/51 Second threshold definite time ($I>>_{def}$) 0.100...20.0 I_n
- $I>>_{def}$ within CLP ($I_{CLP>>def}$) 0.100...20.0 I_n
- $I>>_{def}$ Operating time ($t_{I>>def}$) 0.03...600 s

Inverse time
- 50/51 Second threshold inverse time ($I>>_{inv}$) 0.100...2.50 I_n
- $I>>_{inv}$ within CLP ($I_{CLP>>inv}$) 0.100...10.00 I_n
- $I>>_{inv}$ Operating time ($t_{I>>inv}$) 0.02...60.0 s

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

Definite time
- 50/51 Third threshold definite time ($I>>>_{def}$) 0.100...20.0 I_n
- $I>>>_{def}$ within CLP ($I_{CLP>>>def}$) 0.100...20.0 I_n
- $I>>>_{def}$ Operating time ($t_{I>>>def}$) 0.03...60.0 s

— Residual overcurrent - 50N/51N

$I_E>$ *Element*
- $I_E>$ CLP activation time ($t_{IECLP>}$) 0.00...100.0 s
- $I_E>$ Reset time delay ($t_{IE>RES}$) 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 ($t_{IE>def}$) 0.03...200 s

$I_E>>$ *Element*
- $I_E>>$ CLP activation time ($t_{IECLP>>}$) 0.00...100.0 s
- $I_E>$ Reset time delay ($t_{IE>>RES}$) 0.00...100.0 s

Definite time
- 50N/51N Second 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 ($t_{IE>>def}$) 0.03...60.0 s

Note: The computed residual current I_{EC} (vectorial sum of the phase currents) is employed

— Peak overvoltage - 59H

U> Element
- *U*> CLP activation time ($t_{UCLP>}$) 0.00...100.0 s
- *U*> Reset time delay ($t_{U>RES}$) 0...600 s

Definite time
- 59 First threshold definite time ($U>_{def}$) 0.20...10.00 U_n
- $U>_{def}$ within CLP ($U_{CLP>def}$) 0.20...10.00 U_n
- $U>_{def}$ Operating time ($t_{U>def}$) 0.03...600 s

U>> Element
- *U*>> CLP activation time ($t_{UCLP>>}$) 0.00...100.0 s
- *U*>> Reset time delay ($t_{U>>RES}$) 0...600 s

Definite time
- 59 Second threshold definite time ($U>>_{def}$) 0.20...10.00 U_n
- $U>>_{def}$ within CLP ($U_{CLP>>def}$) 0.20...10.00 U_n
- $U>>_{def}$ Operating time ($t_{U>>def}$) 0.03...200 s

U>>> Element
- *U*>>> CLP activation time ($t_{UCLP>>>}$) 0.00...100.0 s
- *U*>>> Reset time delay ($t_{U>>>RES}$) 0...600 s

Definite time
- 59 Third threshold definite time ($U>>>_{def}$) 0.20...10.00 U_n
- $U>>>_{def}$ within CLP ($U_{CLP>>>def}$) 0.20...10.00 U_n
- $U>>>_{def}$ Operating time ($t_{U>>>def}$) 0.03...60.0 s

Note - The 59H element is based on calculation of peak voltages (the computed value is obtained from currents taking into account the contribution of fundamental and harmonic up to twenty-third order)

— Circuit Breaker supervision

CB check 52a, 52b, 52a/52b

— Breaker failure - BF

BF Enable Trip I>, I>>, I>>>, IE>, IE>>,IN>AL, IN>, IN>>, U>,..
Time delay (t_{BF}) 0.10...10.00 s

METERING & RECORDING

— Measures

• Fundamental RMS phase currents	I_{L1}, I_{L2}, I_{L3}
• RMS phase currents	$I_{L1\ RMS}$, $I_{L2\ RMS}$, $I_{L3\ RMS}$
• Fundamental RMS calculated residual current	I_{EC}
• Fundamental RMS of neutral current	I_N
• Displacement angle of neutral current	$I_{N\ PHI}$
• Fundamental RMS of compensated neutral current	I_{NC}
• Displacement angle of calibrated neutral current	$I_{N\ PHI\ calib}$
• Fundamental RMS of calibrated neutral current	$I_{NC\ MOD\ calib}$
• Capacitor calculated peak voltages (p.u.)	V_1, V_2, V_3
• Discharge timer	T_D

— Circuit Breaker

• Position	Open - Close - Unknown

— Digital inputs

• IN1 - 52b state	On/Off
• IN2 - 52a state	On/Off
• IN3 - Remote Reset	On/Off

— Counters

• Start I> element	On/Off
• Start I>> element	On/Off
• Start I>>> element	On/Off
• Start IE> element	On/Off
• Start IE>> element	On/Off
• Start IN>AL element	On/Off
• Start IN> element	On/Off
• Start IN>> element	On/Off
• Start U> element	On/Off
• Start U>> element	On/Off
• Start U>>> element	On/Off
• Start I<< element	On/Off
• Trip > element	On/Off
• Trip I>> element	On/Off
• Trip I>>> element	On/Off
• Trip IE> element	On/Off
• Trip IE>> element	On/Off
• Trip IN>AL element	On/Off
• Trip IN> element	On/Off
• Trip IN>> element	On/Off
• Trip U> element	On/Off
• Trip U>> element	On/Off
• Trip U>>> element	On/Off
• Trip I<< element	On/Off

— Event recorder

Number of events	50
Recording mode	circular

Trigger:

• Output relays switching	K1...K4
• Binary inputs switching	IN1, IN2, IN3

Data recorded:

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

— Fault recorder

Number of events	20
Recording mode	circular

Trigger:

• Output relays activation (OFF-ON transition)	K1...K4
• External trigger (binary inputs)	IN1, IN2, IN3
• Element pickup (OFF-ON transition)	Start/Trip

Data recorded:

• Event counter (resettable by ThyVisor)	$0...10^9$
• Fundamental RMS phase currents	I_{L1}, I_{L2}, I_{L3}
• RMS phase currents	$I_{L1\ RMS}$, $I_{L2\ RMS}$, $I_{L3\ RMS}$
• Fundamental RMS calculated residual current	I_{EC}
• Fundamental RMS of compensated current	I_{NC}
• Capacitor peak voltages	V_1, V_2, V_3
• Fault cause	start, trip
• Fault cause info (operating phase)	L1, L2, L3
• Time stamp	Date and time

— Digital Fault Recorder (Oscillography)[1]

File format	COMTRADE
Records	2 [2]
Recording mode	circular
Sampling rate	24 per power frequency cycle

Trigger setup

• Pre-trigger time	0...63 T [3]
• Trigger from inputs	IN1, IN2, IN3
• Trigger from outputs	K1...K4
• General trigger from start / trip	Start, Trip
• Manual trigger	ThyVisor
• Trigger from start / trip	Start I>, I>>, ...Trip I>...
• Manual trigger	

• Data recorded on analog channels (Analog 1...4)

• Instantaneous currents	i_{L1}, i_{L2}, i_{L3}, i_N

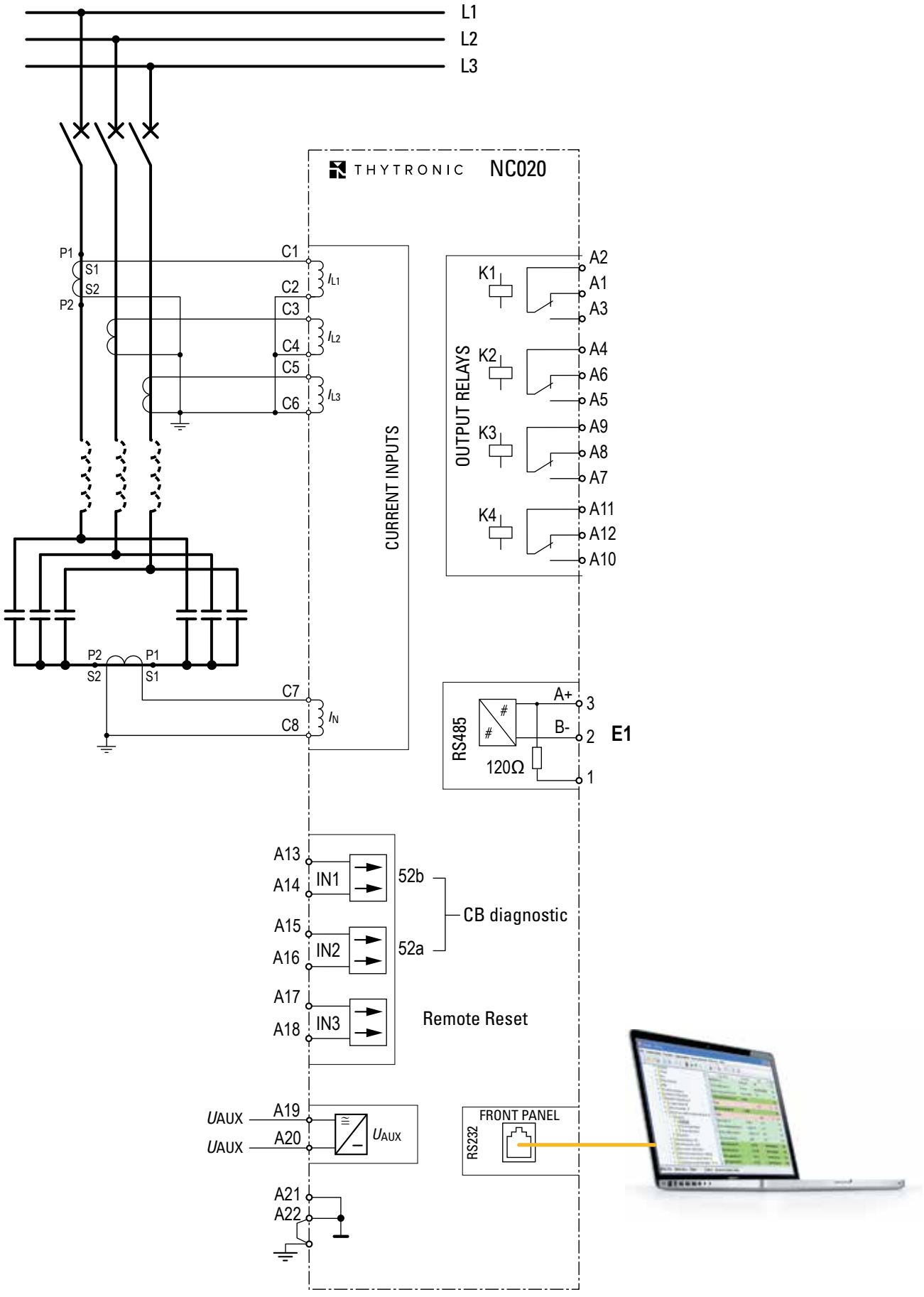
Data recorded on digital channels (Digital 1...4)

• Binary inputs state	IN1, IN2, IN3
• Output relays state	K1...K4
• General trigger from start / trip	Start, Trip

Note 1 - The oscillographic records are stored in non-volatile memory

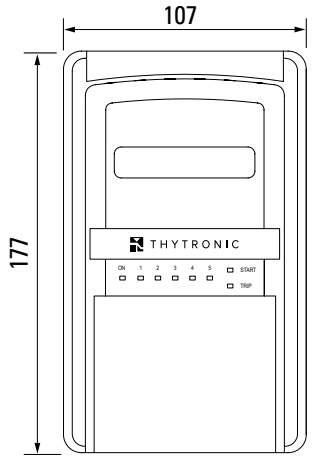
Note 2 - the time duration of the two records is dependent of settings

— Example of connection diagram

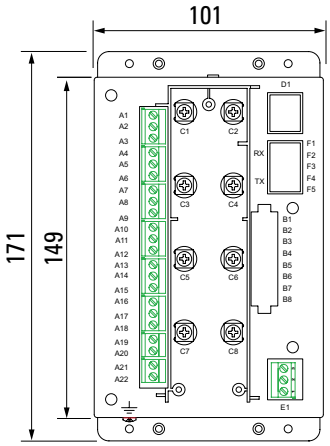


DIMENSIONS

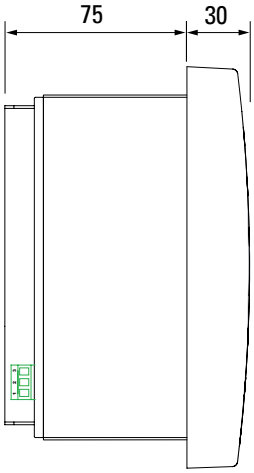
FRONT VIEW



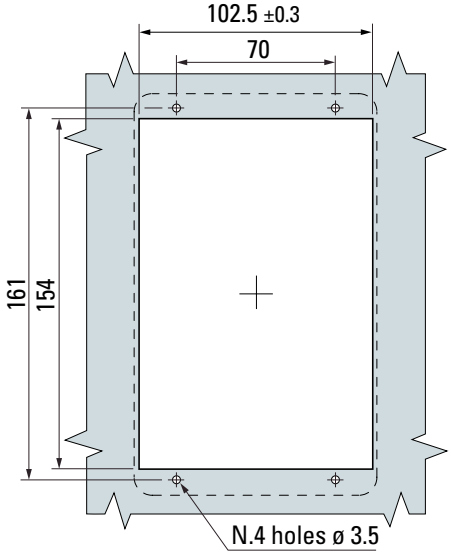
REAR VIEW



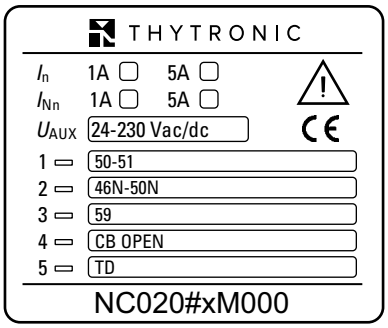
SIDE VIEW



FLUSH MOUNTING CUTOUT



IDENTIFICATION LABEL



LEDs

ON: powered device and diagnostics OK
START: start of any element
TRIP: trip of any element
LED 1: Trip of the I>, I>>, I>>> elements (RMS or DFT)
LED 2: Trip of the 50N, 46N elements
LED 3: Trip of the 59H element
LED 4: CB Open (CB position)
LED 5: TD state

THYTRONIC

ENERGY FOR A SAFER FUTURE

A PERSONALISED SERVICE OF THE PRODUCTION, A RAPID DELIVERY, A COMPETITIVE PRICE AND AN ATTENTIVE EVALUATION OF OUR CUSTOMERS NEEDS, HAVE ALL CONTRIBUTED IN MAKING US ONE OF THE BEST AND MOST RELIABLE PRODUCERS OF PROTECTIVE RELAYS. FORTY YEARS OF EXPERIENCE HAS MADE STANDARD THESE ADVANTAGES THAT ARE GREATLY APPRECIATED BY LARGE COMPANIES THAT DEAL ON THE INTERNATIONAL MARKET. A HIGHLY QUALIFIED AND MOTIVATED STAFF PERMITS US TO OFFER AN AVANT-GARDE PRODUCT AND SERVICE WHICH MEET ALL SAFETY AND CONTINUITY DEMANDS, VITAL IN THE GENERATION OF ELECTRIC POWER. OUR COMPANY PHILOSOPHY HAS HAD A POSITIVE REACTION FROM THE MARKET BY BACKING OUR COMMITMENT AND HENCE STIMULATING OUR GROWTH.

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