

THYTRONIC

PRO-N



NV021

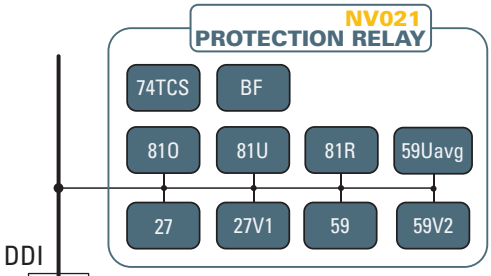
LoM PROTECTION RELAY

THE COMPREHENSIVE SOLUTION FOR VOLTAGE AND FREQUENCY PROTECTION FOR LOW VOLTAGE APPLICATIONS

— Application

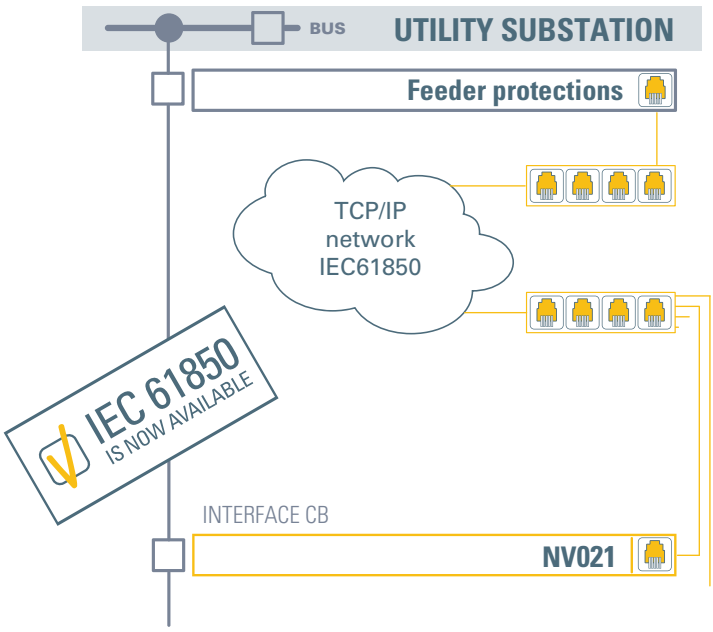
The relay type NV021 can be typically used in LV distribution systems, on transformers or for electrical machines.

It can be used for system decoupling, load shedding and loss of main (islanding) protection.



- Protective & control functions

27	Phase undervoltage
27V1	Positive sequence undervoltage
59	Phase overvoltage
59V2	Negative sequence overvoltage
59N	Residual overvoltage
59Uavg	Average overvoltage
81O	Overfrequency
81U	Underfrequency
81R	Frequency rate of change
BF	Circuit breaker failure
74TCS	Trip circuit supervision



— Construction

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

— Measuring inputs for inductive VTs or direct connection

Three phase voltage inputs with programmable nominal voltages within range 200...520 V (U_R = 400 V).

— 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 in accordance with a matrix (tripping matrix) structure.

— Modular design

In order to extend I/O capability, the NV021 hardware can be customized through external auxiliary modules:

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



— Control and monitoring

Several predefined functions are implemented:

- Trip circuit supervision (74TCS)
- Remote tripping
- Automatic reclosure for photovoltaic plants
- Circuit Breaker commands and diagnostic

User defined logic may be customized according to IEC 61131-3 standard protocol (PLC).

— 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.

— 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.

— Firmware updating

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

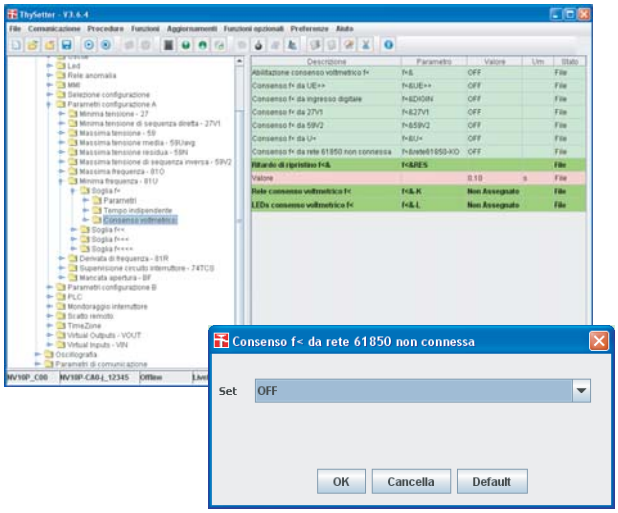
— Communication

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 - ModBus® RTU protocol,
  - Ethernet port - 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 ThySetter software.
The same PC setup software is required to set, monitor and configure all Pro_N devices.
Two session level (User or Administrator) with password for sensible data access are provided.



— 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.

— 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,...)
- Circuit breaker faults.

— 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 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.

— 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).

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

— Measuring inputs

- Three phase-to-phase voltage inputs 200...520 V (U_R = 400 V) with LV direct connection.

— Measures

- Three phase-to-phase voltages U_{12}, U_{23}, U_{31}
- Average value of 3-phase voltages on 10 minutes with updates every three seconds
- Frequency f (measured on phase-to-phase voltages)
- Positive sequence voltage U_1 (measured on phase-to-phase voltages) [1] $U_1=(U_{L1}+e^{+j120°}\cdot U_{L2}+e^{-j120°}\cdot U_{L3})/3$

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

- Negative sequence voltage U_2 (measured on phase-to-phase voltages) [1]

$U_2=(U_{L1}+e^{-j120°}\cdot U_{L2}+e^{+j120°}\cdot U_{L3})/3$
where $e^{-j120°}=-1/2-j\sqrt{3}/2$, $e^{j120°}=-1/2+j\sqrt{3}/2$.

Note 1: the element is meaningful in three-phase applications only

— Binary inputs

The two binary inputs, in addition to traditional assignments, can be programmed to:

- Acquisition of CB state 52a or 52b (for Breaker Failure protection (BF) and ARF automatic reclosure function for photovoltaic plants)
- *f<-f> voltage enable*, indicating activation by external contact function of 59N external device, or, with inverted logic for future use contact indicating the presence / absence status of the communication network).
- *Remote trip* (external command)

PROTECTIVE FUNCTIONS

— Undervoltage - 27

The undervoltage protection can be programmed for unipolar or three-phase application with two thresholds.

- When applying on the three-phase network you must select the logical OR; the element is based on the RMS value of fundamental component of the three phase-to-phase voltages,
- For application on single-phase you must select the logical AND, the element is based on the RMS value of fundamental component of the phase-neutral voltage.

The *Logic27* parameter is available inside the **Set \ Profile A (or B) \ Undervoltage-27 \ Common configuration**.

— Positive sequence undervoltage - 27V1

Positive sequence undervoltage, with voltage measurement on the three phase-to-phase voltages[2], one definite time threshold.

Note 2: the element is meaningful in three-phase applications only

— Overvoltage - 59

Three-phases overvoltage function with OR logic, based on the RMS value of fundamental component of the three phase-to-phase voltages (three phase applications) or phase-to-neutral (one phase applications), two definite time thresholds.

— Average overvoltage - 59Uavg

Three-phases overvoltage function with OR logic, based on the average value of the three phase-to-phase voltages (three phase applications) or phase-to-neutral (one phase applications) on 10 minutes with refresh every 3 seconds, one definite time threshold.

— Negative sequence overvoltage - 59V2

Negative sequence overvoltage, with voltage measurement on the three phase-to-phase voltages [3], one definite time threshold.

Note 3: the element is meaningful in three-phase applications only

— Under/over frequency - 81U and 81O

Under and over frequency function with frequency measurement on the three phase voltages (three phase applications) or phase-to-neutral (one phase applications), two definite time thresholds.

- Insensitivity to transient frequency less than or equal to 40 ms.
- Operation in the 0,2 U_n...1,15 U_n input voltage and inhibition for input voltages lower than 0,2 U_n.
- The second threshold of each protection is always active.
- The first threshold may be disabled by local control (enable / disable threshold by means of keyboard or communications program).

The first threshold is enabled / disabled, respectively, in the absence / presence of the integrity of the communication network (digital input set with inverted logic and *f<-f> control enable* function or by means of IEC 61850 communication protocol).
For the trip of the first threshold of each element one or more of the following consensus can be enabled:

- loss of communication network from external contact acquired by a binary input programmed as *f<-f> Control* and inverted logic (*ON* programming of the *f <& DIGIN, f> & DIGIN* parameter)
- starting of the positive sequence element (27V1) (*ON* programming of the *f<&27V1, f>&27V1* parameter) [4]
- starting of the negative sequence element (59V2) ((*ON* programming of the *f<&59V2, f>&59V2* parameter) [4]
- starting of the undervoltage element (27) (*ON* programming of the *f<&U<, f>&U<* parameter)
- loss of communication network from Goose IEC 61850 message (*ON* programming of the *f<&rete61850-KO, f>&rete61850-KO* parameter).

Note 4: the element is meaningful in three-phase applications only

— Breaker failure - BF

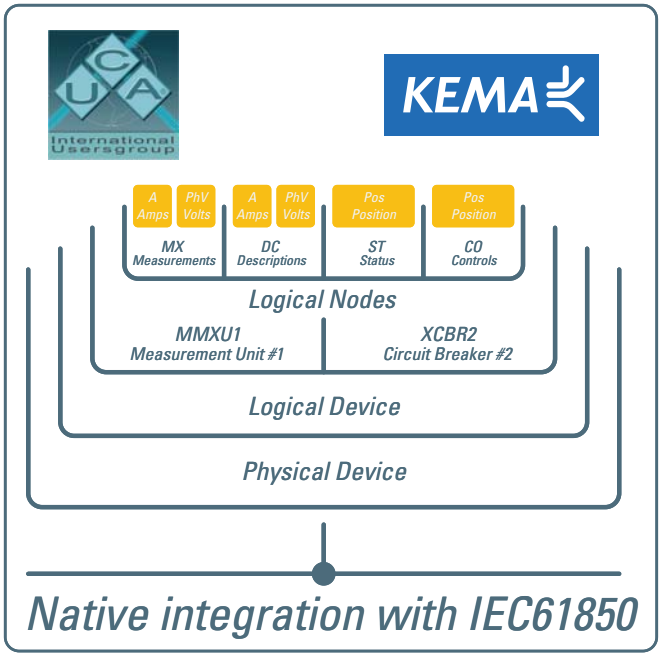
The starting of the circuit breaker failure protection occurs if both the following conditions are active:

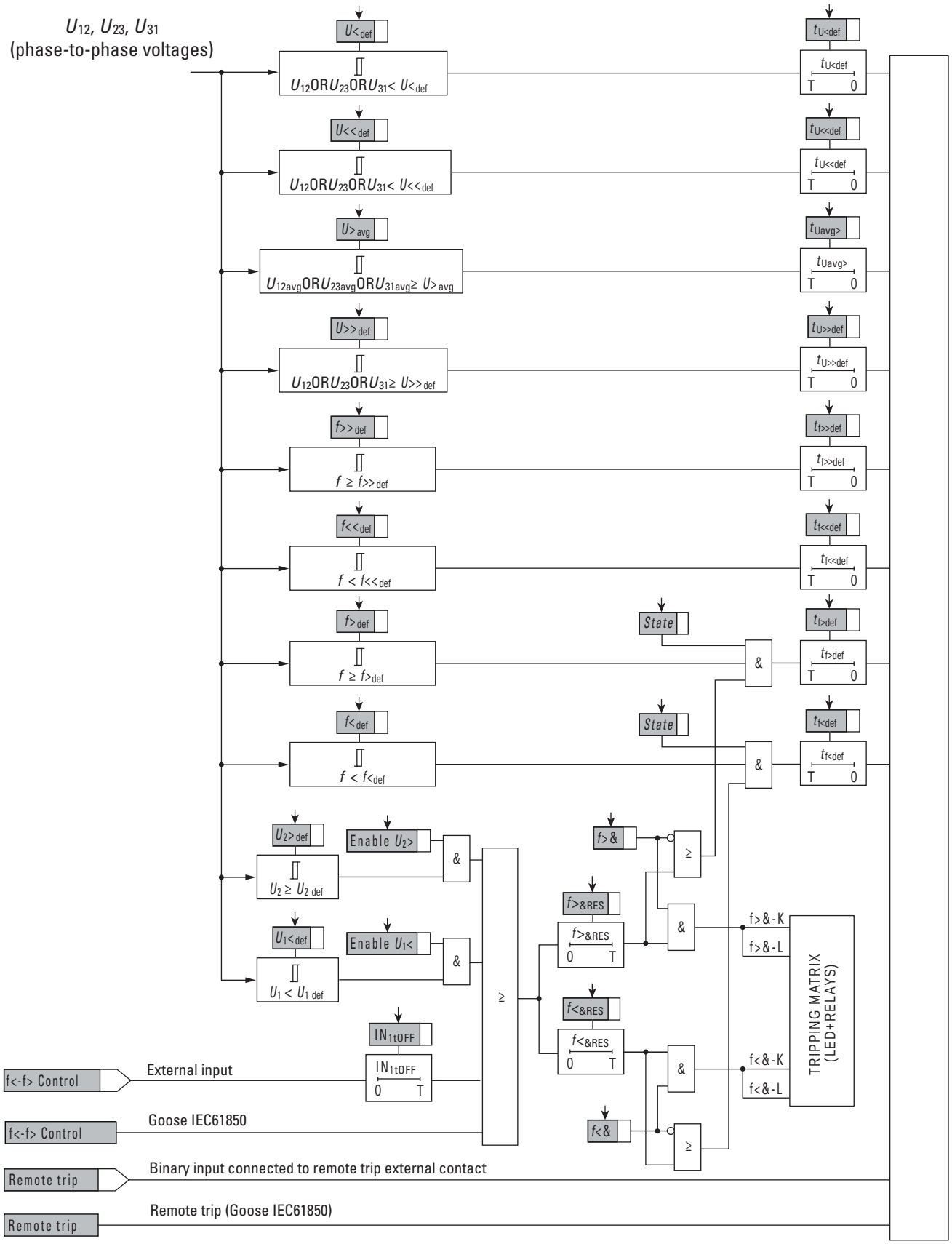
- Start and trip of protective elements internal to the relay (thresholds trip associated with the breaker failure protection) or, if enabled, by the trip of external protections associated with a binary input.
- The state of the 52a and 52b auxiliary contacts of the circuit breaker corresponds to the closed state.

— Capability of receiving signals on the IEC 61850 protocol

A set of signals aimed at the Government of the distribution network in the presence of Diffuse Generation (GD) is defined, so as to allow detaching of generators in case of reception of the remote trip signal and enable / inhibit the restrictive frequency thresholds (81 <. S1 and 81>. S1).
These signals are transmitted by the Utlility and the same for all active users can be used directly by the Protection Interface thanks to the embedded protocol or can be acquired by logic inputs after being "converted" by a dry contact device external:

- control the opening of the interface device (DDI) in case of reception of the signal relating to an input remote trip by assigning the *Remote Trip* function,
- enable / inhibit the frequency thresholds giving consent to a binary input *f<-f> control enable* function.





Functional diagram for the NV021 protection interface

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	2004/108/EC
• Low Voltage Directive	2006/95/EC
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 61850

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)

— Voltage inputs

Reference voltage U_R	400 V
Nominal voltage U_n	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

— Binary inputs

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

— 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 nominal voltage (U_n)	200...520 V
Line VT primary nominal voltage (U_{np})	50 V..500 kV

— Binary input timers

ON delay time (IN1 t_{ON}, IN2 t_{ON})	0.00...100.0 s
OFF delay time (IN1 t_{OFF}, IN2 t_{OFF})	0.00...100.0 s
Logic	Active-ON/Active-OFF

— Relay output timers

Minimum pulse width	0.000...0.500 s

PROTECTIVE FUNCTIONS

— Undervoltage - 27

Common configuration:	
• 27 Operating logic (*Logic*27)	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*

— Positive sequence undervoltage - 27V1

U_1< Element
- 27V1 First threshold definite time ($U_{1<def}$) 0.05...1.10 U_n
- 27V1 Operating time ($t_{U1<def}$) 0.07...100.0 s

— Overvoltage - 59

Common configuration:
- 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:
$t = 0.5 \cdot t_{U>inv} / [(U/U>_{inv})-1]$ *where:*
t = trip time (in seconds)
$t_{U>inv}$ *= operating time setting (in seconds)*
U = input voltage
$U>_{inv}$ *= threshold*

— Average overvoltage - 59Uavg [1]

Common configuration:
- 59Uavg Operating logic (*Logic59Uavg*) AND/OR

Uavg> Element
Definite time
- 59Uavg First threshold definite time ($U_{avg>def}$) 0.50...1.50 U_n
- Time delay ($t_{Uavg>def}$) 0...1000 s

Note [1] - based on the average value of the three phase-to-phase voltages on 10 minutes with refresh every 3 seconds.

— 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

— Underfrequency - 81U

f< Element
Definite time
- 81U First threshold definite time ($f<_{def}$) 0.800...1.000 f_n
- $f<_{def}$ Operating time ($t_{f<def}$) 0.05...100.0 s

Voltage control
- f< Control enable (*f<&*) ON/OFF
- f< Controlled by binary input (*f<&DIGIN*) ON/OFF
- f< Controlled by 27V1 start (*f<&27V1*) ON/OFF
- f< Controlled by 59V2 start (*f<&59V2*) ON/OFF
- f< Controlled by *U*< start (*f<&U<*) ON/OFF
- f< Controlled by 61850 no link (*f<&rete61850-KO*) ON/OFF
- f<& Reset time delay (*f<&RES*) 0.00...200.0 s

f<< Element
Definite time
- 81U Second threshold definite time ($f<<_{def}$) 0.800...1.000 f_n
- $f<<_{def}$ Operating time ($t_{f<<def}$) 0.05...100.0 s

f<<< Element
Definite time
- 81U Third threshold definite time ($f<<<_{def}$) 0.800...1.000 f_n
- $f<<<_{def}$ Operating time ($t_{f<<<def}$) 0.05...100.0 s

f<<<< Element
Definite time
- 81U Fourth threshold definite time ($f<<<<_{def}$) 0.800...1.000 f_n
- $f<<<<_{def}$ Operating time ($t_{f<<<<def}$) 0.05...100.0 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...100.0 s

Voltage control
- f> Control enable (*f>&*) ON/OFF
- f> Controlled by binary input (*f>&DIGIN*) ON/OFF
- f> Controlled by 27V1 start (*f>&27V1*) ON/OFF
- f> Controlled by 59V2 start (*f>&59V2*) ON/OFF
- f> Controlled by *U*< start (*f>&U<*) ON/OFF
- f> Controlled by 61850 no link (*f>&rete61850-KO*) ON/OFF
- f>& Reset time delay (*f>&RES*) 0.00...200.0 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...100.0 s

— Frequency rate of change - 81R

df> Element
- Operating mode (*df*>mode) Module/Positive/Negative

Definite time
- 81R First threshold definite time ($df>_{def}$) 0.1...10.0 Hz/s
- $df>_{def}$ Operating time ($tdf>_{def}$) 0.00...100.0 s

df>> Element
- Operating mode (*df*>>mode) Module/Positive/Negative

Definite time
- 81R Second threshold definite time ($df>>_{def}$) 0.1...10.0 Hz/s
- $df>>_{def}$ Operating time ($tdf>>_{def}$) 0.00...100.0 s

df>>> Element
- Operating mode (*df*>>>mode) Module/Positive/Negative

Definite time
- 81R Third threshold definite time ($df>>>_{def}$) 0.1...10.0 Hz/s
- $df>>>_{def}$ Operating time ($tdf>>>_{def}$) 0.00...100.0 s

df>>>> Element
- Operating mode (*df*>>>>mode) Module/Positive/Negative

Definite time
- 81R Fourth threshold definite time ($df>>>>_{def}$) 0.1...10.0 Hz/s
- $df>>>>_{def}$ Operating time ($tdf>>>>_{def}$) 0.00...100.0 s

— Breaker failure - BF

BF Time delay (t_{BF}) 0.06...10.00 s

— Circuit Breaker supervision

Number of CB trips (*N.Open*) 0...10000
CB max allowed opening time ($t_{break>}$) 0.05...1.00 s

METERING & RECORDING

— Measured parameters

Direct:
- Frequency *f*
- Input voltages U_{L1}, U_{L2}, U_{L3}

Calculated:
- Maximum voltage between U_{L1}-U_{L2}-U_{L3} U_{Lmax}
- Average voltage between U_{L1}-U_{L2}-U_{L3} U_L
- Average voltage between U_{12}, U_{23}, U_{31} U_{Lavg}
- Positive sequence voltage U_1
- Negative sequence voltage U_2
- Frequency rate of change *df/dt*

Averages:
- Voltage averages (refresh 3 s) U_{L1avg}, U_{L2avg}, U_{L3avg}
- Maximum voltage between U_{L1avg}, U_{L2avg}, U_{L3avg} $U_{Lavgmax}$

— 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 ThySetter) $0...10^9$
- 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 ThySetter) $0...10^9$
- Time stamp Date and time
- Cause tripped element
- Input voltages U_{L1r}, U_{L2r}, U_{L3r}
- Average voltages U_{L1avgr}, U_{L2avgr}, U_{L3avgr}
- Positive and negative sequence voltage U_{1r}, U_{2r}
- Frequency and Frequency rate of change f_r, df_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)

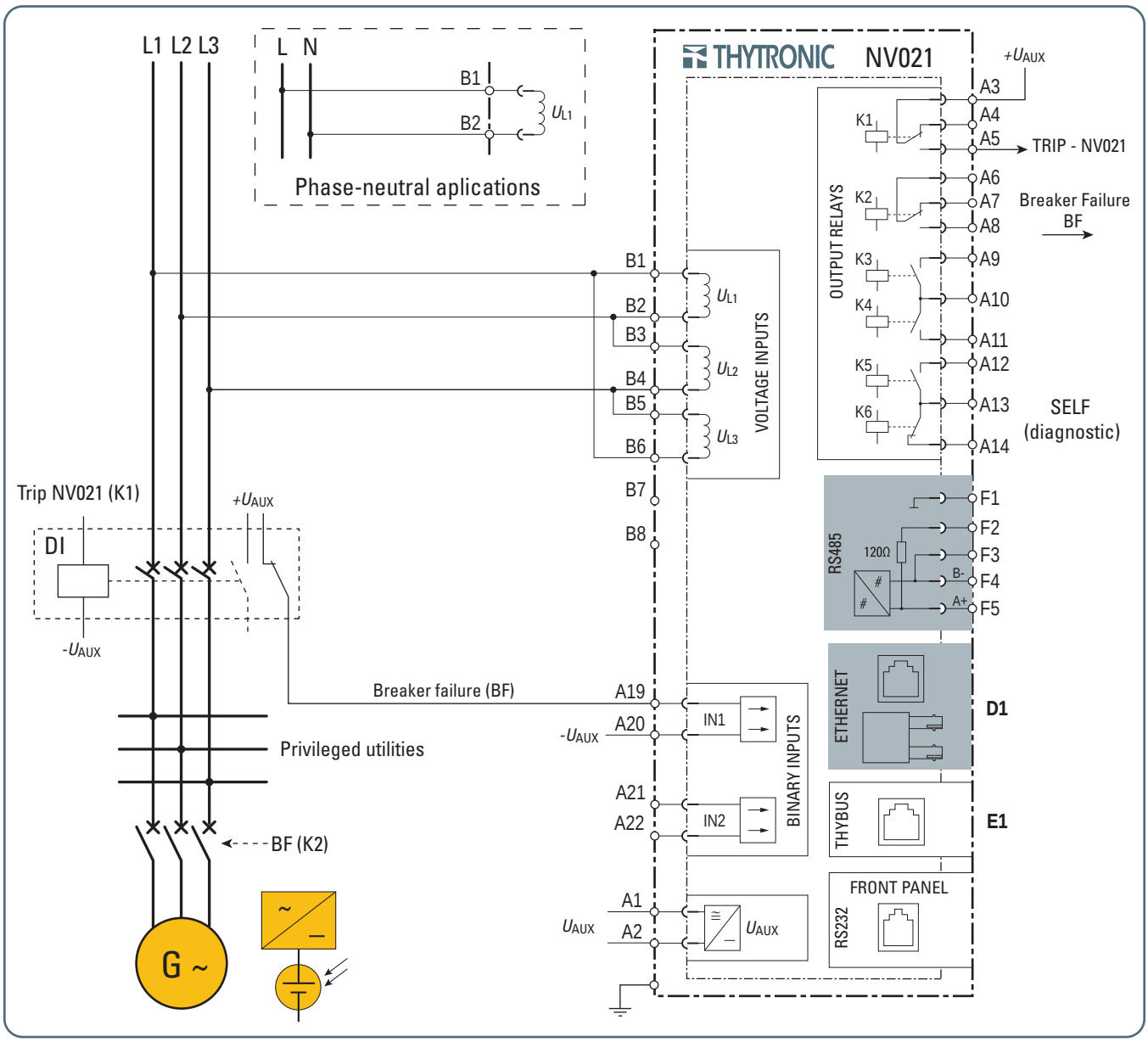
File format	COMTRADE
Records	depending on setting [1]
Recording mode	circular
Sampling rate	24 samples per cycle

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 voltages u_{L1}, u_{L2}, u_{L3}, u_E

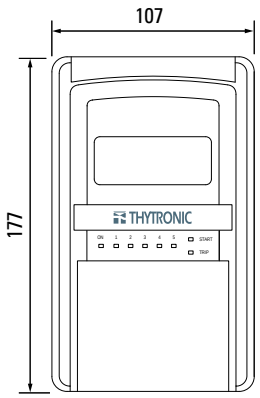
Set analog channels (Analog 1...12):
- Frequency f
- Input voltages U_{L1}, U_{L2}, U_{L3}
- Positive sequence voltage U_1
- Negative sequence voltage U_2
- Frequency rate of change df/dt

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

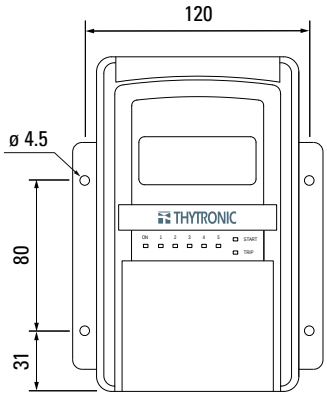


DIMENSIONS

FRONT VIEW

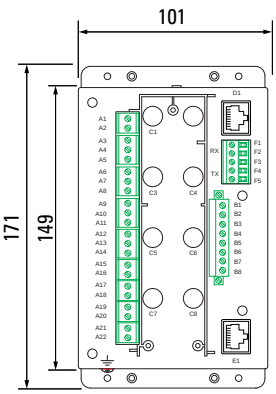


FLUSH MOUNTING

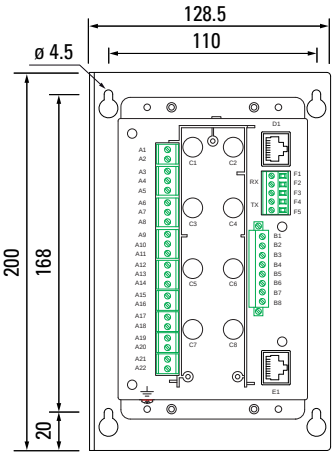


PROJECTING MOUNTING

REAR VIEW

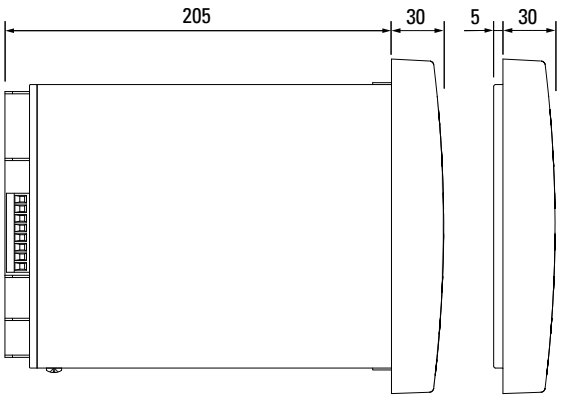


FLUSH MOUNTING



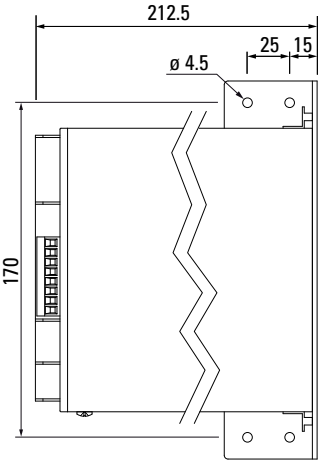
PROJECTING MOUNTING
(Separate operate panel)

SIDE VIEW

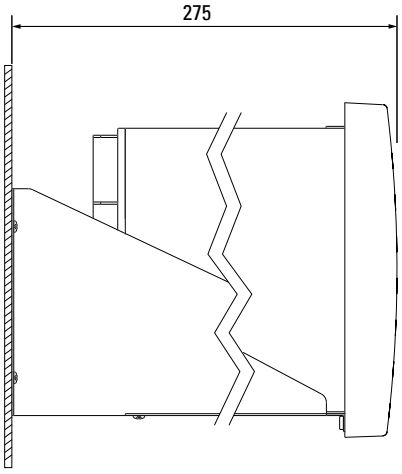


FLUSH MOUNTING

SEPARATE
OPERATOR PANEL

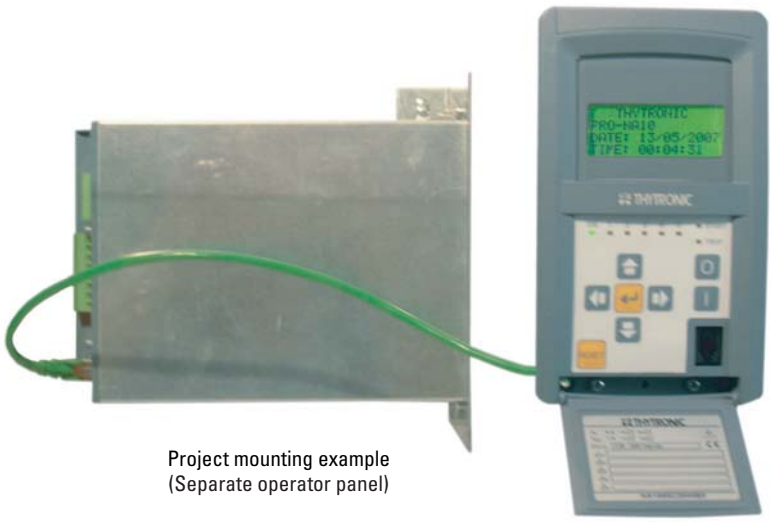


PROJECTING MOUNTING
(Separate operator panel)



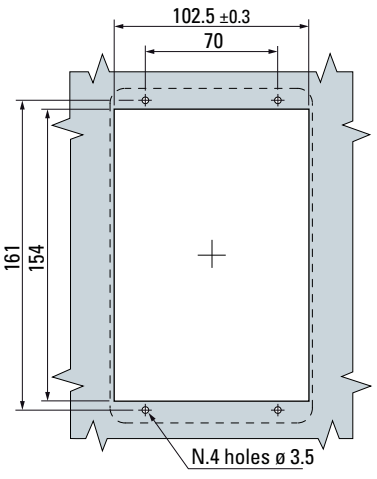
PROJECTING MOUNTING
(Stand alone)

PHOTO



Project mounting example
(Separate operator panel)

FLUSH MOUNTING CUTOUT



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