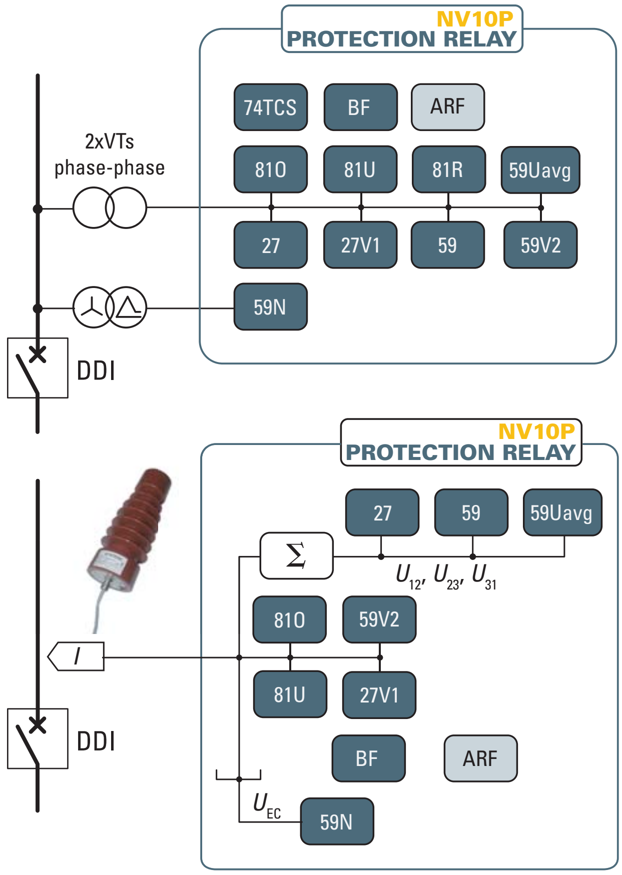
NV10P

LoM PROTECTION RELAY

THE COMPREHENSIVE SOLUTION FOR VOLTAGE AND FREQUENCY PROTECTION

— Application

The relay type NV10P can be typically used in HV, MV and LV distribution systems, on transformers or for electrical machines.
It can be used for system decoupling, load shedding and loss of main (islanding) protection.



IEC 61850
IS NOW AVAILABLE

- 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
DDI-OPEN	Automatisms concerning the VTs positioning
ARF	Automatic reclosure (opzional for pv plants)

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) and with connections to the input signals suitable for inductive VTs (screw terminals) or electronic sensors (RJ45 jacks).

Measuring inputs for inductive VTs or direct connection
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).

Measuring inputs for electronic sensors
Three phase voltages, with 20 / √ 3 kV (primary) rated voltage; the residual voltage is obtained by vector calculation from the phase voltages

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 NV10 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 (optional NV10P-ARF)
- 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, IEC 60870-5-103 or DNP3 protocol,
  - Ethernet port (RJ45 or optical fiber) - 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.
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.

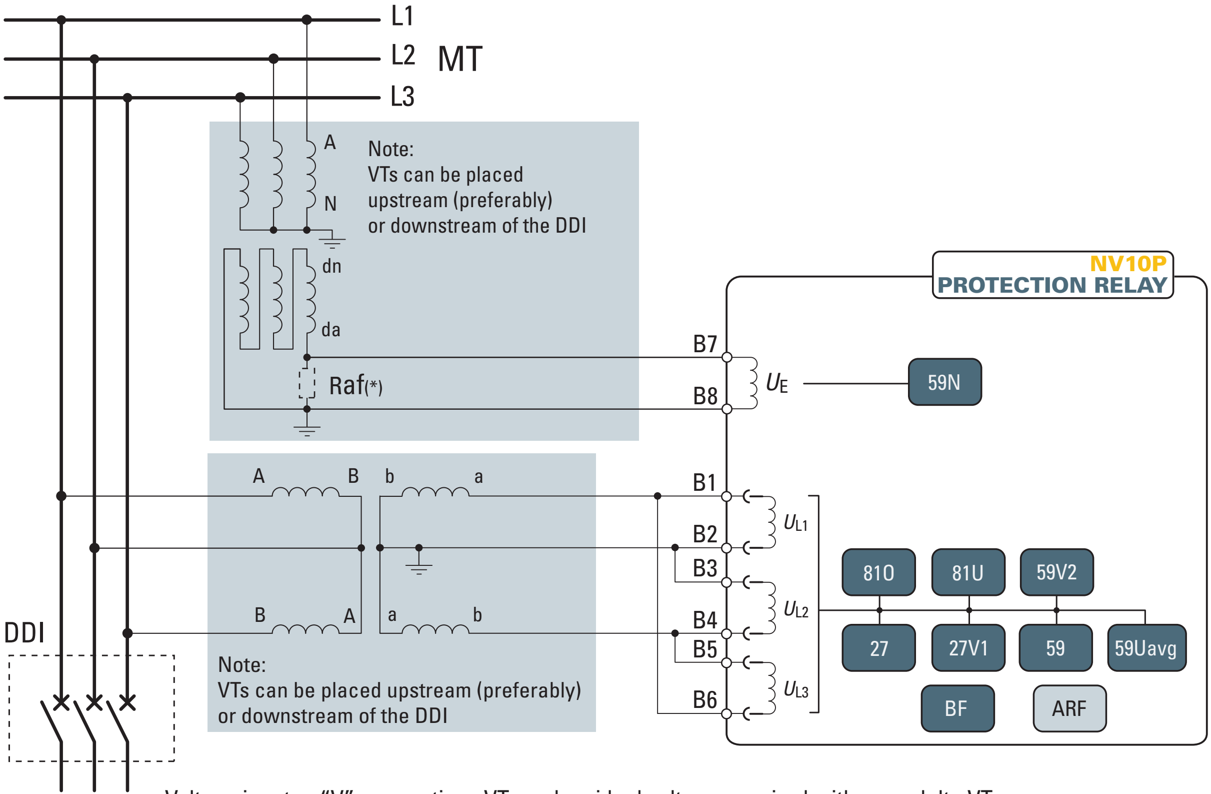
Metering
NV10 provides metering values for phase, residual voltages and frequency, making them available for reading on a display or to communication interfaces. Voltages are sampled 24 times per period and the RMS value of the fundamental component is measured using the DFT (Discrete Fourier Transform) algorithm and digital filtering. The measured voltages can be displayed with reference to nominal values or directly expressed in volts.
With DFT the RMS value some harmonic are also measured.

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.

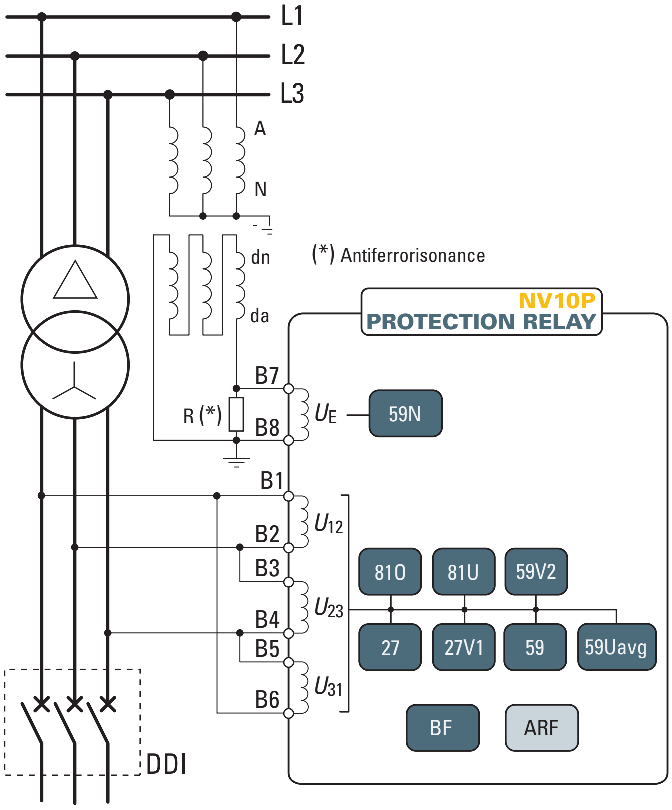
Digital Fault Recorder (Oscillography)
Upon trigger of tripping/starting of each function or external signals, the relay records in COMTRADE format:
- Oscillography with instantaneous values for transient analysis.
- RMS values for long time periods analysis.
- Logic states (binary inputs and output relays).

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

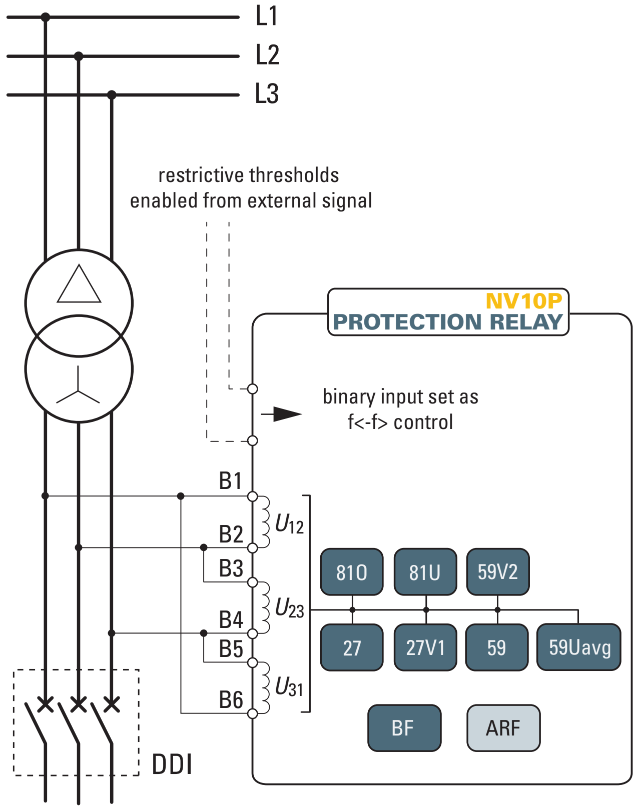
NV10P RELAYS WITH INDUCTIVE VTS INPUTS



Voltage inputs - “V” connections VTs and residual voltage acquired with open delta VT



Direct measure of LV phase-to-phase voltages
and residual voltage acquired with open delta VT in MV



Direct measurement of phase-phase voltage input and
f <-f> control enable by contact indicating the activation
of the 59N from a remote device

Measuring inputs for inductive VTs or direct connection

- Three phase-to-phase voltage inputs (U_R = 100 V) or 200...520 V (U_R = 400 V) from n. 2 VTs for NV10P-J... versions or LV direct connection for NV10P-U...versions)
- One residual voltage input (connected on the secondary star-open delta VT).

Measures

- Three phase-to-phase voltages U_{12}, U_{23}, U_{31}
- Residual voltage U_E
- 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) $U_1=(U_{L1}+e^{+j120°}\cdot U_{L2}+e^{-j120°}\cdot U_{L3})/3$

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)

$U_2=(U_{L1}+e^{-j120°}\cdot U_{L2}+e^{+j120°}\cdot U_{L3})/3$

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

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

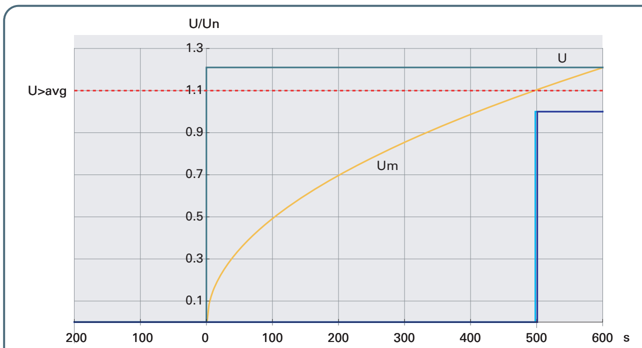
Three-phases undervoltage function with OR logic, based on the RMS value of fundamental component of the three phase-to-phase voltages, two definite time thresholds.

Overvoltage - 59

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

RMS ten minutes overvoltage - 59Uavg

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



Funzione di massima tensione su 10 minuti (59Uavg)

Note - The description of 59Uavg element applies to the NV10P devices with sw version 2.70 and following

Under/over frequency - 81U and 81O

Under and over frequency function with frequency measurement on the three phase voltages, 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:

- starting of the second residual overvoltage threshold of 59N internal protection (*ON* programming of the *f<&UE>>, f>&UE>>* parameter)
- starting of the residual overvoltage threshold 59N acquired from external contact with the binary input programmed as *f<-f> Control* (*ON* programming of the *f <& DIGIN, f> & DIGIN* parameter)
- 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)
- starting of the negative sequence element (59V2) ((*ON* programming of the *f<&59V2, f>&59V2* parameter)
- 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).

Residual overvoltage - 59N

Residual overvoltage, two definite time thresholds.

Positive sequence undervoltage - 27V1

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

Negative sequence overvoltage - 59V2

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

Breaker failure - BF

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

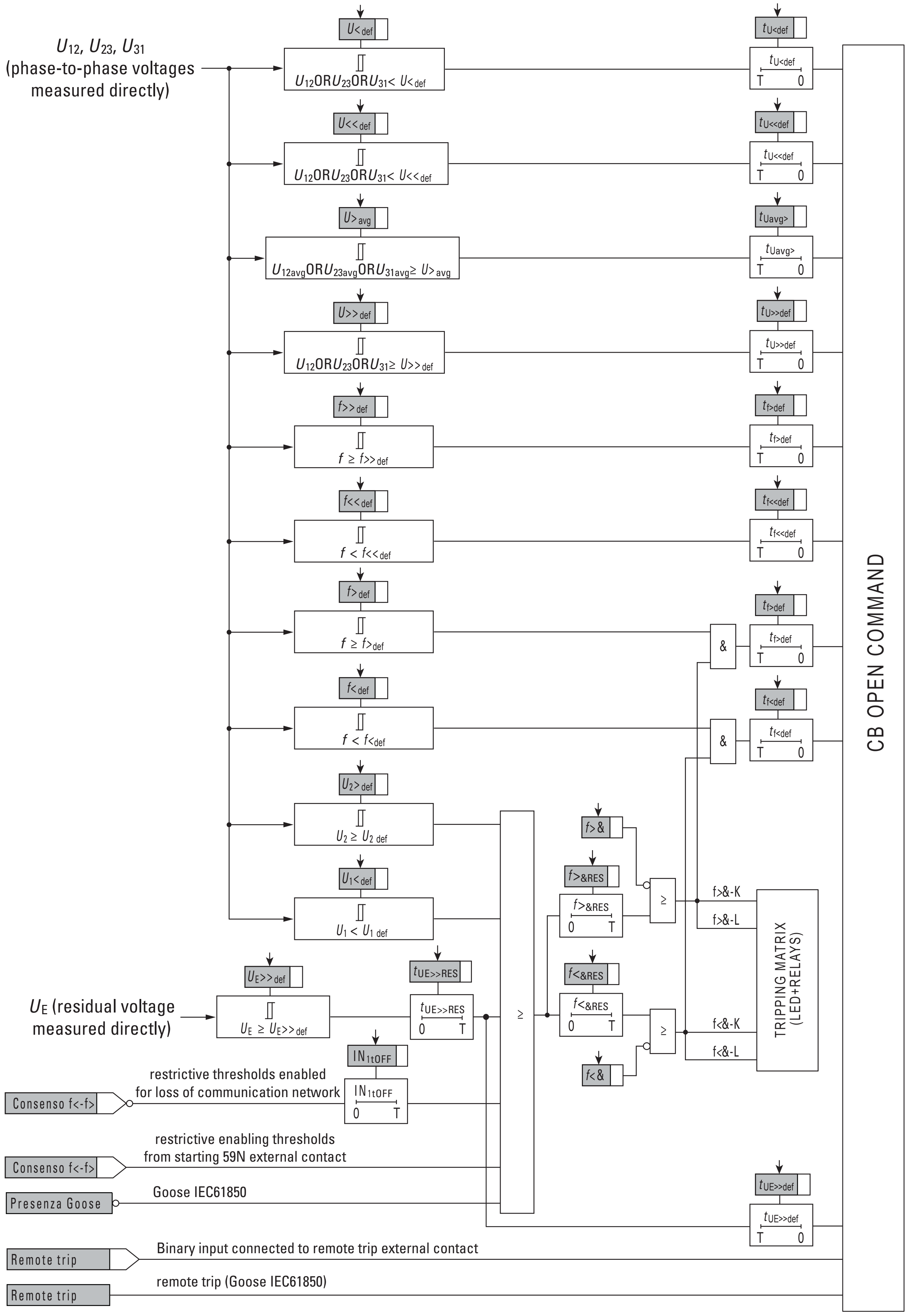
- Start and trip of protective elements internal to the relay (thresholds trip associated with the breaker failure protection) or, if enabled, by the trip of external protections associated with a binary input.
- The state of the 52a and 52b auxiliary contacts of the circuit breaker corresponds to the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

VTs positioning

For static generators only (asynchronous and not self excited), the VTs may be install downstream of the DDI; the protections are disabled with DDI open (to avoid that the relay prevent closing of the DDI) the f >>, f<< and UE >> operate time are reduced for an adjustable time after the closing of the DDI.

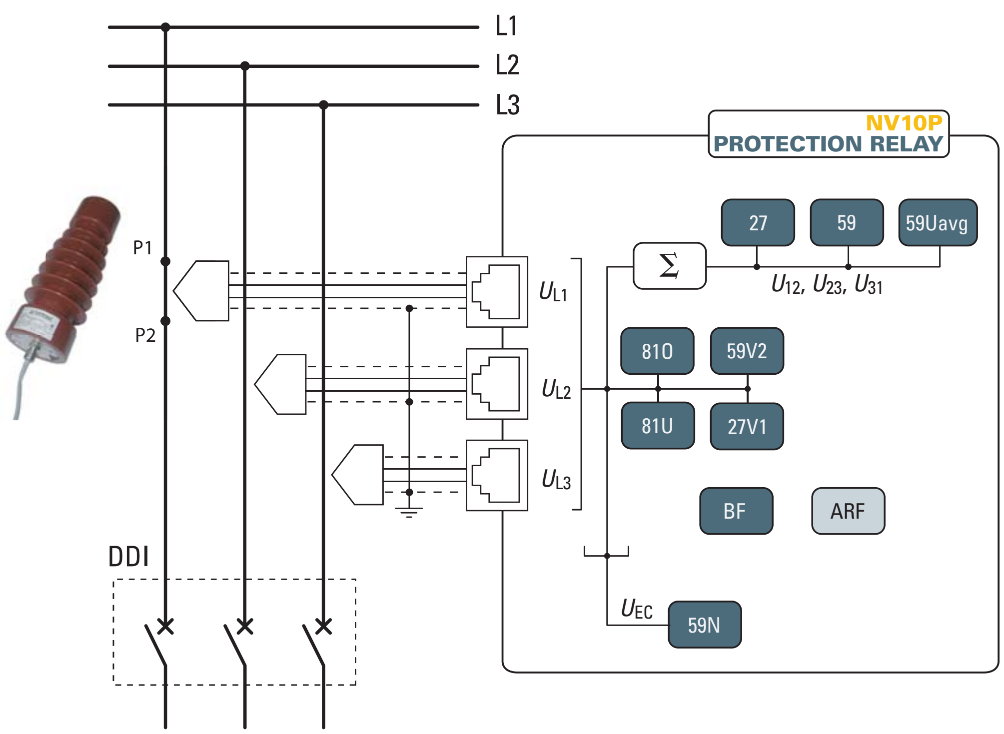
Automatic recloser for photovoltaic plants - ARF

Optional function.



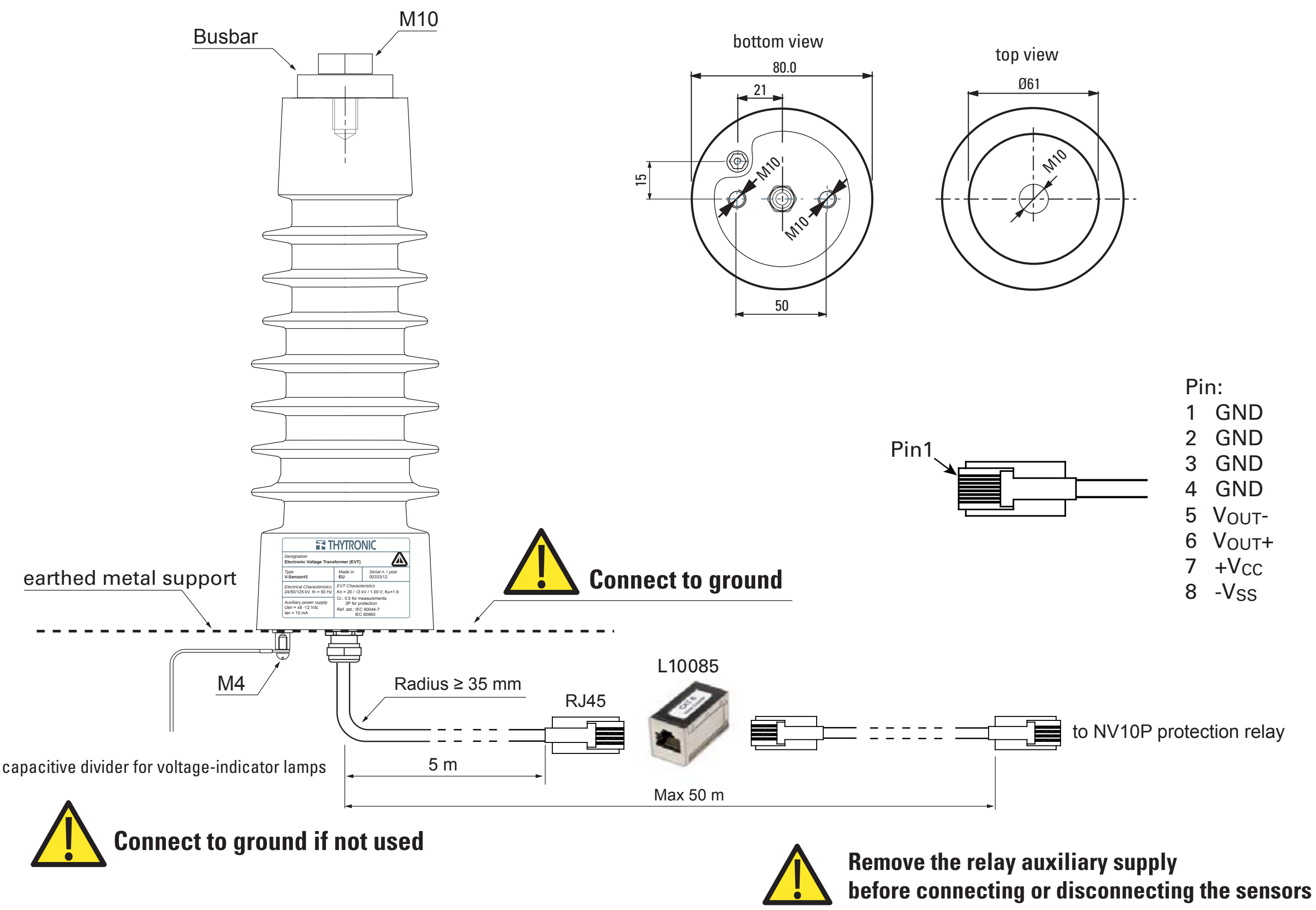
Functional diagram for the NV10P protection interface with inductive VTs

NV10P RELAYS WITH ELECTRONIC SENSOR INPUTS



Voltage inputs - “V-sensor” connections and residual voltage calculated by means of vector sum

V-Sensor



Measuring inputs for electronic sensors connection
Three phase-to-ground voltage inputs for V-Sensor or ThySensor.

Measures
- Three phase-to-ground voltages U_{L1}, U_{L2}, U_{L3}
- Three phase-to-phase voltage U_{12}, U_{23}, U_{31} (calculated)

$$U_{12}=|\vec{U}_{L1}-\vec{U}_{L2}|,\ U_{23}=|\vec{U}_{L2}-\vec{U}_{L3}|,\ U_{31}=|\vec{U}_{L3}-\vec{U}_{L1}|$$

- Residual voltage U_{EC} (calculated)

$$U_{EC}=|\vec{U}_{L1}+\vec{U}_{L2}+\vec{U}_{L3}|$$

- 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-ground voltages) $U_1=(U_{L1}+e^{+j120°}\cdot U_{L2}+e^{-j120°}\cdot U_{L3})/3$

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-ground voltages)

$U_2=(U_{L1}+e^{-j120°}\cdot U_{L2}+e^{+j120°}\cdot U_{L3})/3$

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

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
Three-phases undervoltage function with OR logic, based on the RMS value of fundamental component of the three phase-to-phase voltages, two definite time thresholds.

Overvoltage - 59
Three-phases overvoltage function with OR logic, based on the RMS value of fundamental component of the three phase-to-phase voltages, two definite time thresholds.

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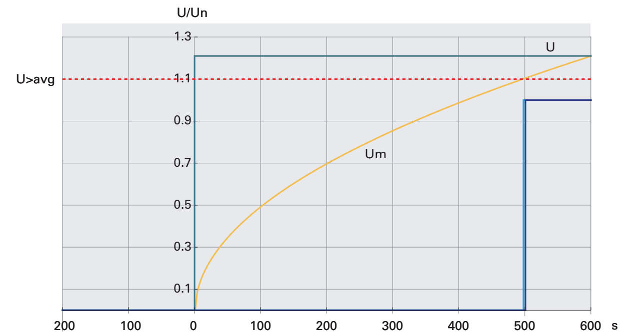

Funzione di massima tensione su 10 minuti (59Uavg)

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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).
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For the trip of the first threshold of each element one or more of the following consensus can be enabled:
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- starting of the positive sequence element (27V1) (*ON* programming of the *f<&27V1, f>&27V1* parameter)
- starting of the negative sequence element (59V2) ((*ON* programming of the *f<&59V2, f>&59V2* parameter)
- 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).

Residual overvoltage - 59N
Residual overvoltage, two definite time thresholds.

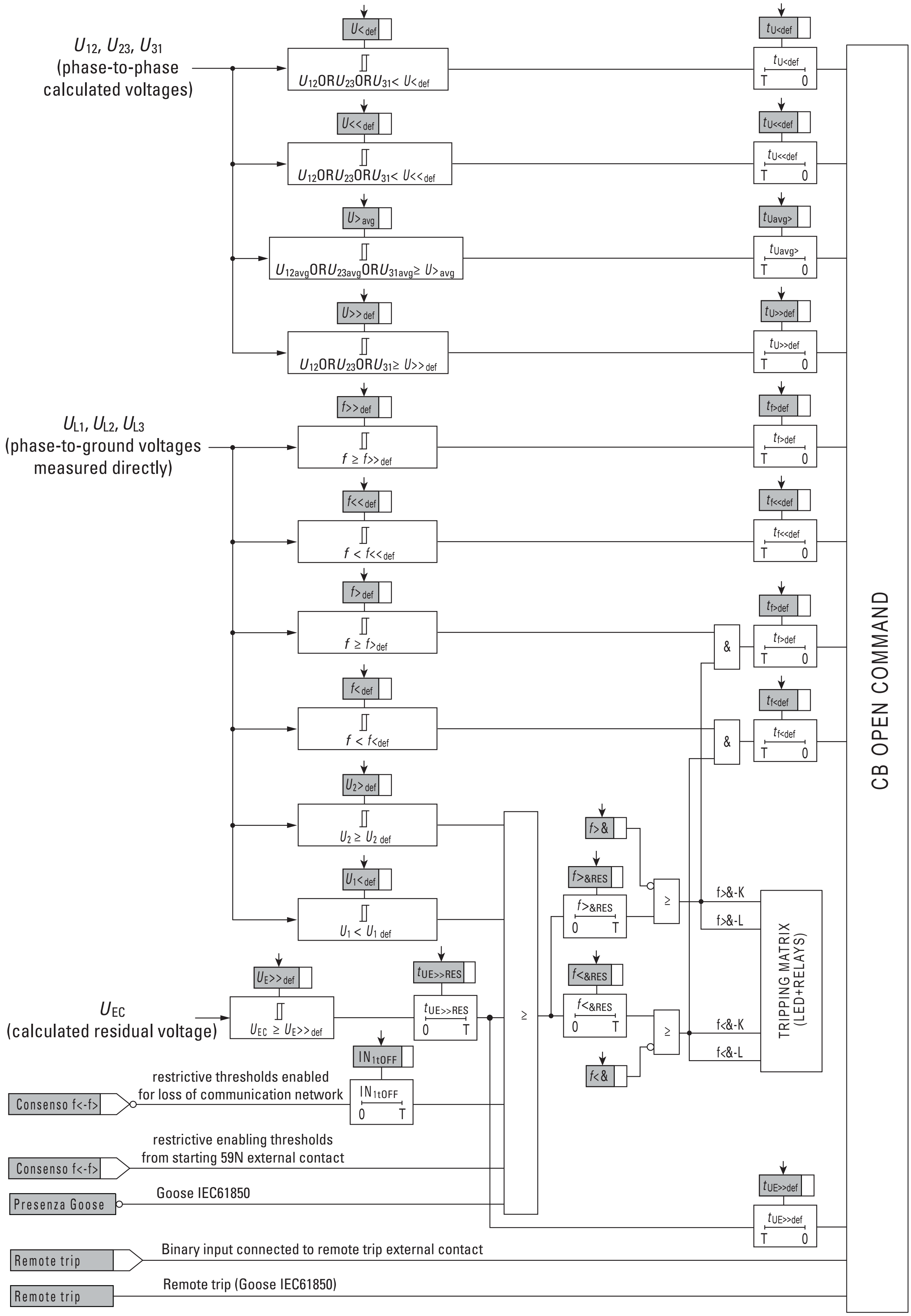
Positive sequence undervoltage - 27V1
Positive sequence undervoltage, with voltage measurement on the three phase-to-ground voltages, one definite time threshold.

Negative sequence overvoltage - 59V2
Negative sequence overvoltage, with voltage measurement on the three phase-to-ground voltages, one definite time threshold.

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.

VTs positioning
For static generators only (asynchronous and not self excited), the VTs may be install downstream of the DDI; the protections are disabled with DDI open (to avoid that the relay prevent closing of the DDI) the f >>, f<< and UE >> operate time are reduced for an adjustable time after the closing of the DDI.

Automatic recloser for photovoltaic plants - ARF
Optional function.



Functional diagram for the NV10P protection interface with electronic sensors

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)

Voltage inputs (inductive VTs or direct)

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 (inductive VTs)

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

Voltage inputs (electronic sensors)

Rated secondary voltage (with U_{np} = 20/√3 kV)	1.0 V
Connections	RJ45 socket

Rated primary voltage (electronic sensors)

Rated primary voltage U_{np}	20/√3 kV
Permanent overload	1.8

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)	50...130 V or 200...520 V
Relay nominal voltage phase-to-ground (E_n)[1]	$E_n = U_n/\sqrt{3}$
Relay residual nominal voltage (direct measure) (U_{En})	50...130 V
Relay residual nominal voltage (calculated) (U_{ECN})=$U_n \cdot \sqrt{3}$	50...130 V
Line VT primary nominal voltage (U_{np})	50 V..500 kV
Residual primary nominal voltage (phase-to-phase) · √3 (U_{Enp})	50 V...500 kV

Note [1] Electronic sensor version only

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 (inductive VTs)

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

Undervoltage - 27 (electronic sensors)

Common configuration:

• Voltage measurement type for 27 (*U*type27) [1]	$U_{ph\text{-}ph}/U_{ph\text{-}n}$
• 27 Operating logic (*Logic*27)	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 $U_{ph\text{-}ph}$ setting all threshold are in p.u. U_n
With $U_{ph\text{-}n}$ 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

Positive sequence undervoltage - 27V1 (inductive VTs)

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

Positive sequence undervoltage - 27V1 (electronic sensor)

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

Overvoltage - 59 (inductive VTs)

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

Overvoltage - 59 (electronic sensors)

Common configuration:

• Voltage measurement type for 59 (*U*type59) [1]	$U_{ph\text{-}ph}/U_{ph\text{-}n}$
• 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/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 $U_{ph\text{-}ph}$ setting all threshold are in p.u. U_n
With $U_{ph\text{-}n}$ setting all threshold are in p.u. E_n

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

RMS ten minutes overvoltage - 59Uavg [1] (inductive VTs)

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.

RMS ten minutes overvoltage - 59Uavg [1] (electronic sensors)

Common configuration:

• Voltage measurement type (*Utype59Uavg*)	$U_{ph\text{-}ph}/U_{ph\text{-}n}$
• 59Uavg Operating logic (*Logic59Uavg*)	AND/OR
Uavg> Element	
Definite time	
• 59Uavg First threshold definite time ($U_{avg>def}$)	0.50...1.50 U_n/E_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.

— Residual overvoltage - 59N (inductive VTs)

Common configuration:
- Residual voltage measurement for 59N - direct/calculated (*3V0Type*59N) U_E / U_{EC}
- 59N Operation from 74VT external (*74VText*59N) *OFF / Block*

U_E> Element
- U_E> Curve type (U_E>Curve) DEFINITE / 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
- U_E>>def reduced operating time ($t_{cUE>>def}$) 0.07...10.00 s
- $t_{cUE>>def}$ activation time ($t_{atcUE>>def}$) 1...60 s

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

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

where:

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

— Residual overvoltage - 59N (electronic sensor)

Common configuration:
- Residual voltage measurement for 59N - (*3V0Type*59N) U_{EC}
- 59N Operation from 74VT external (*74VText*59N) *OFF / Block*

U_E> Element
- U_E> Curve type (U_E>Curve) DEFINITE / 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
- U_E>>def reduced operating time ($t_{cUE>>def}$) 0.07...10.00 s
- $t_{cUE>>def}$ activation time ($t_{atcUE>>def}$) 1...60 s

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

$$t = 0.5 \cdot t_{UE>inv} / [(U_{EC}/U_{E>inv})-1]$$ *where:*

t = trip time (in seconds)
$t_{UE>inv}$ = operating time setting (in seconds)
U_{EC} = calculated residual input voltage
$U_{E>inv}$ = threshold

— Negative sequence overvoltage - 59V2 (inductive VTs)

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

— Negative sequence overvoltage - 59V2 (electronic sensor)

U_2> Element
Definite time
- 59V2 First threshold definite time (U_2>def) 0.01...0.50 E_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 U_E>> start (*f<&UE>>*) 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<<def reduced operating time ($t_{cf<<def}$) 0.07...10.00 s
- $t_{cf<<def}$ activation time ($t_{atc<<def}$) 1...60 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 U_E>> start (*f>&UE>>*) 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
- f>>def reduced operating time ($t_{cf>>def}$) 0.07...10.00 s
- $t_{cf>>def}$ activation time ($t_{atcf>>def}$) 1...60 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}
- Residual voltage U_E

Calculated:

- Phase-to-phase voltages U_{12}, U_{23}, U_{31}
- Calculated residual voltage U_{EC}
- 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
- Third harmonic residual voltage U_{E-3rd}
- 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}
- Residual voltages (measured and calculated) U_{Er}, U_{ECr}
- Positive sequence voltage U_{1r}
- Negative sequence voltage U_{2r}
- Frequency f_r
- Frequency rate of change 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:

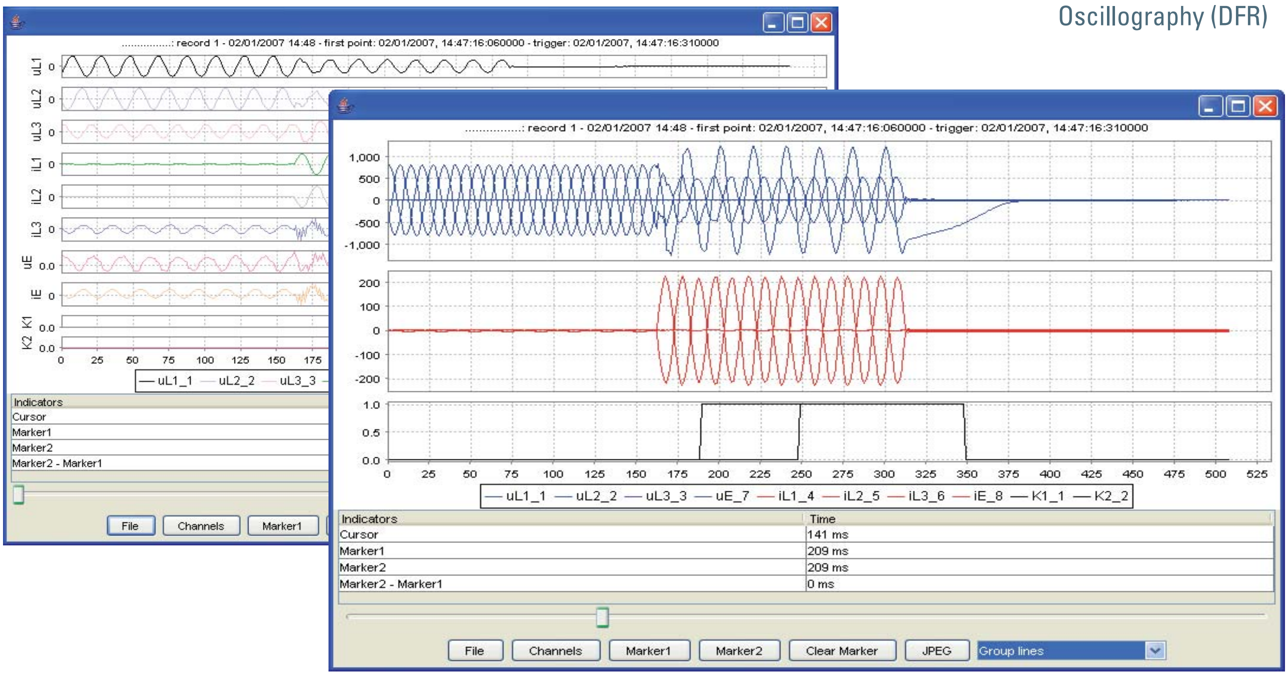
- Instantaneous voltages u_{L1}, u_{L2}, u_{L3}, u_E

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

- Frequency f
- Input voltages U_{L1}, U_{L2}, U_{L3}
- Residual voltage (measured and calculated) U_E, U_{EC}
- Positive sequence voltage U_1
- Negative sequence voltage U_2
- Frequency rate of change df/dt

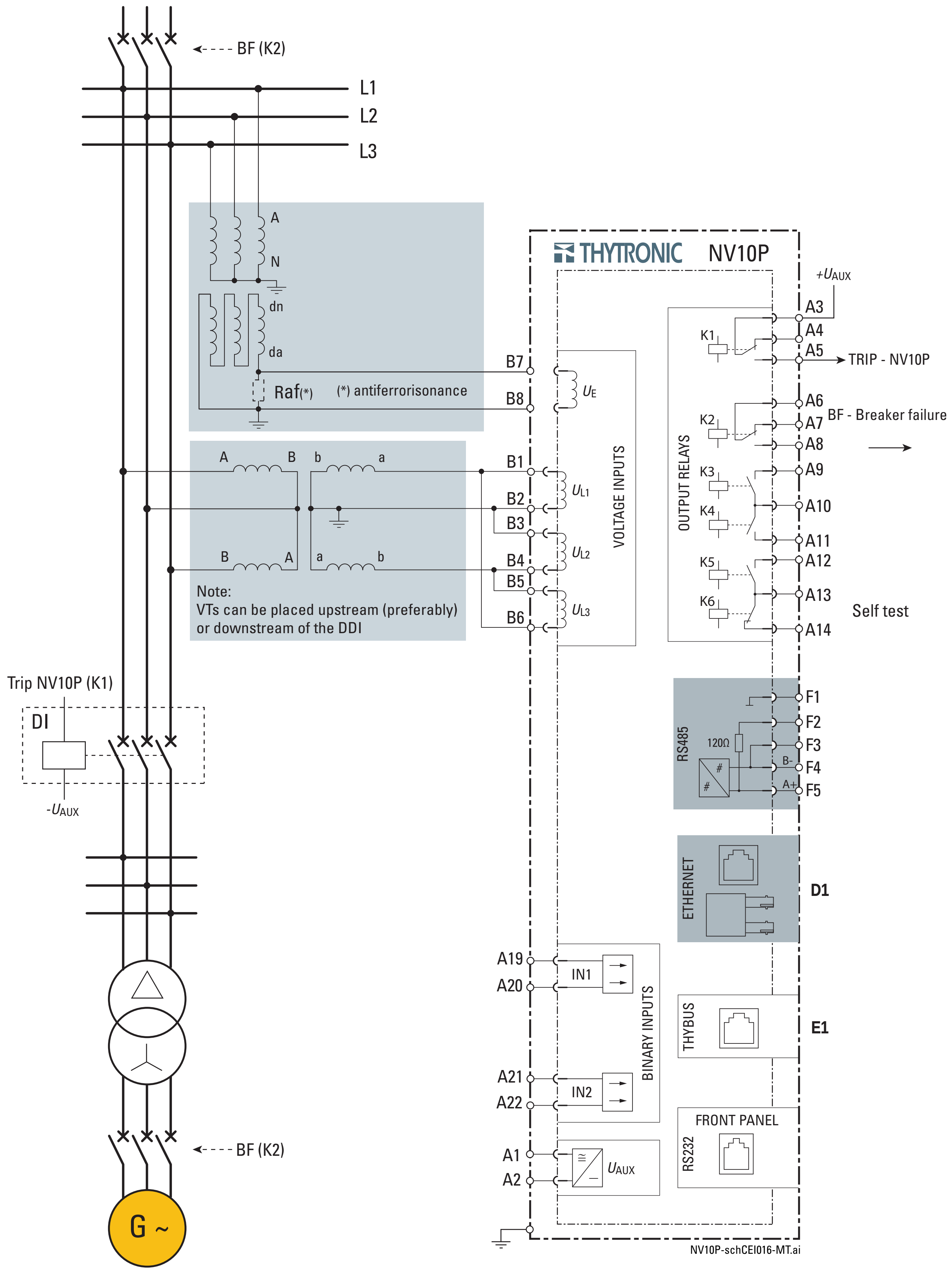
Set digital channels (Digital 1...12):

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



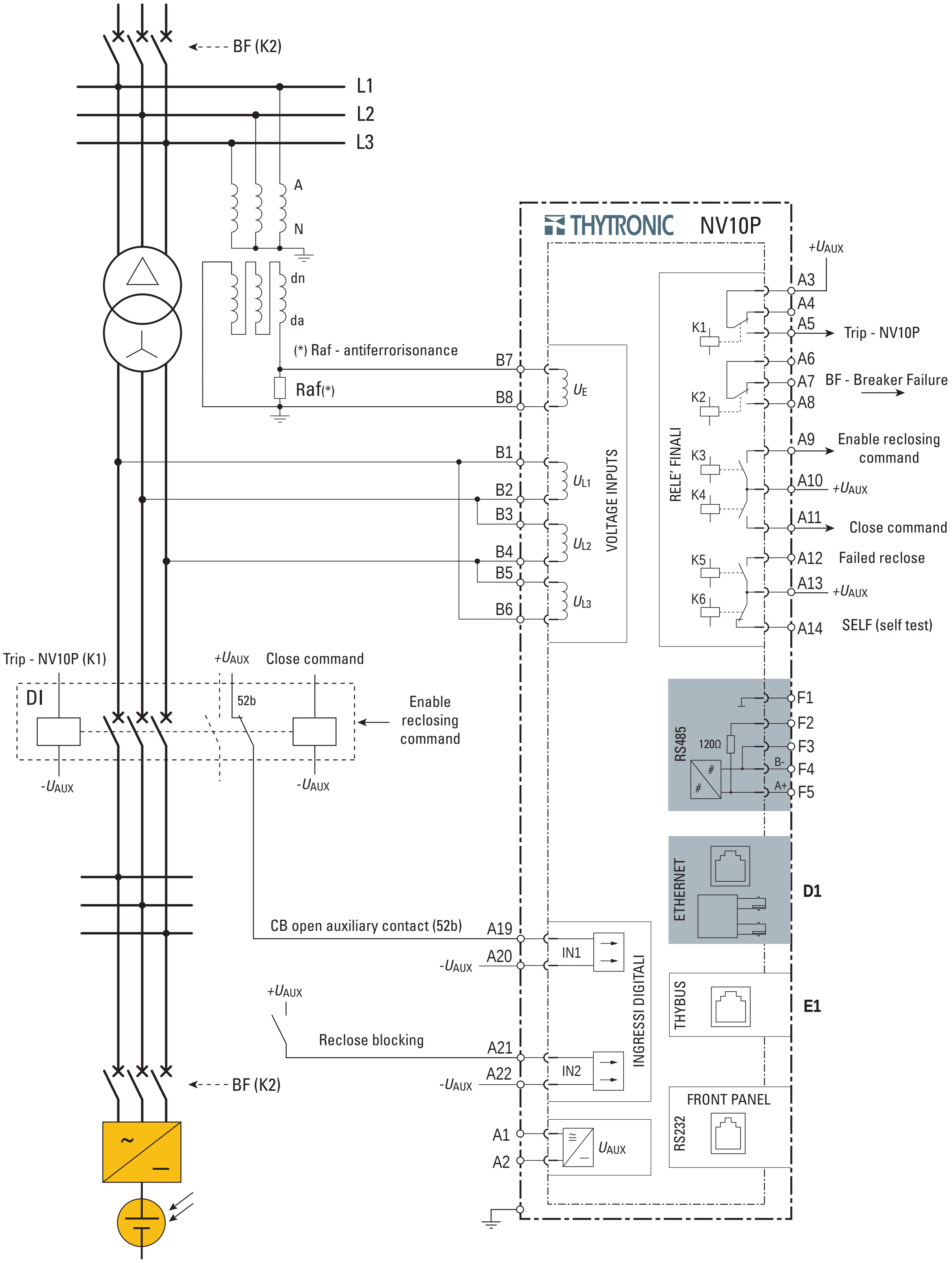
Oscillography (DFR)

Connection diagram example



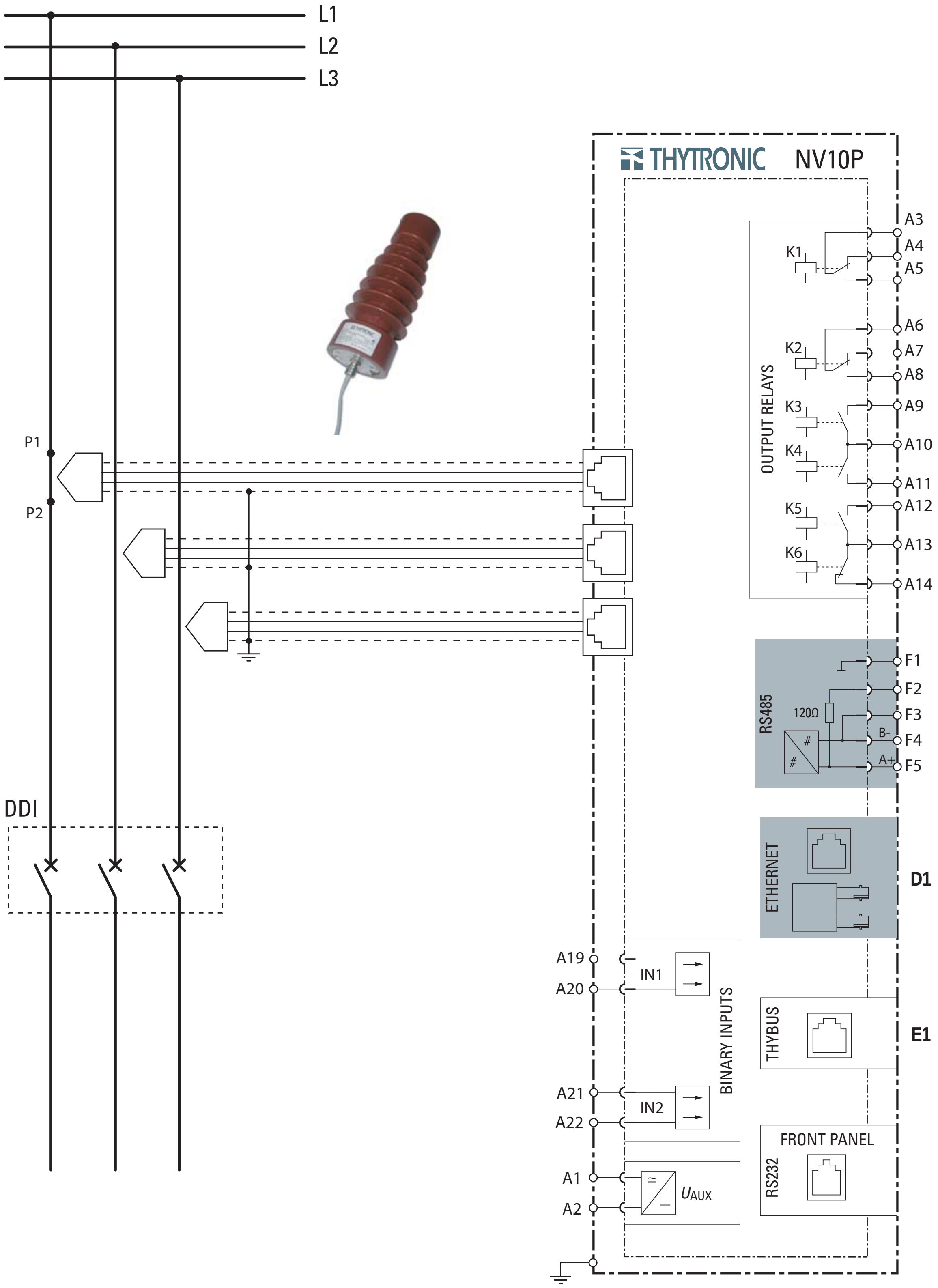
“V” connections VTs or direct measure of LV phase-to-phase voltages and residual voltage acquired with open delta VT in MV

Connection diagram example for active users (photovoltaic plant with low voltage interface) with reclosing function



Digital input and output relays connections for automatic reclosing function (ARF)
Phase-phase input voltages with direct connection to the LV side (U_R = 400 V versions)

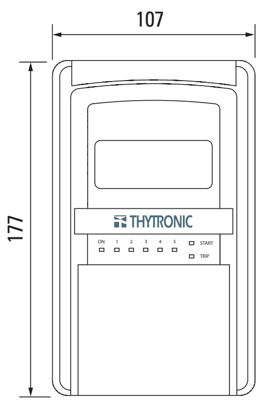
— Connection diagram example for active users with V-Sensor voltage sensors



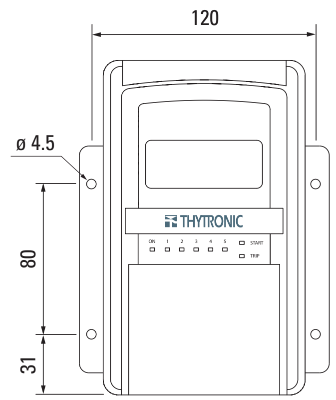
Voltage inputs - “V-sensor” connections and residual voltage calculated by means of vector sum

DIMENSIONS

FRONT VIEW

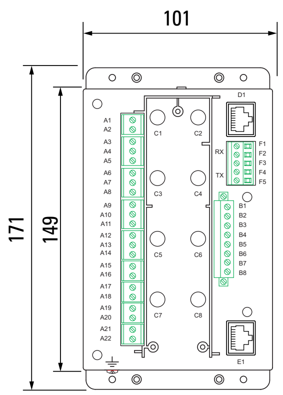


FLUSH MOUNTING

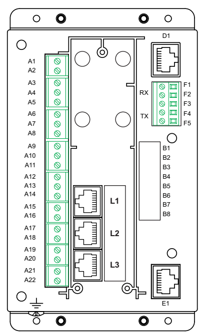


PROJECTING MOUNTING

REAR VIEW

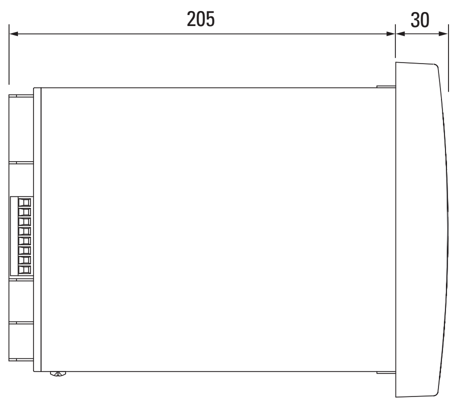


FLUSH MOUNTING
(inductive VT inputs)

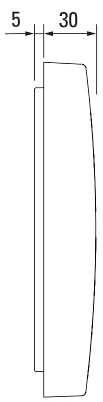


FLUSH MOUNTING
(electronic sensor inputs)

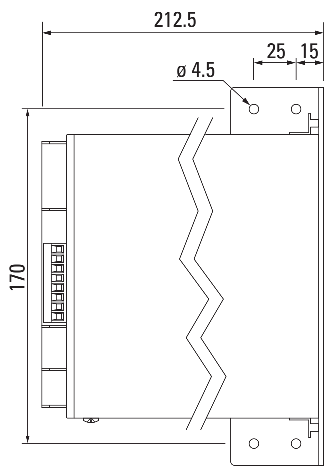
SIDE VIEW



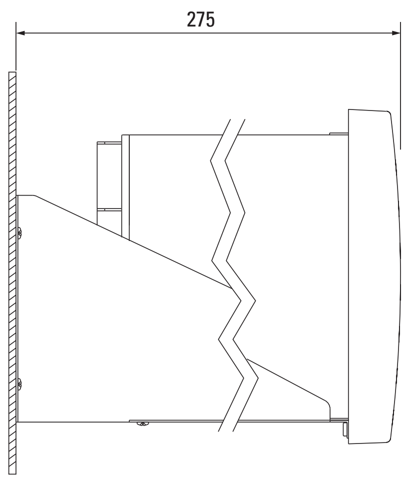
FLUSH MOUNTING



SEPARATE
OPERATOR PANEL

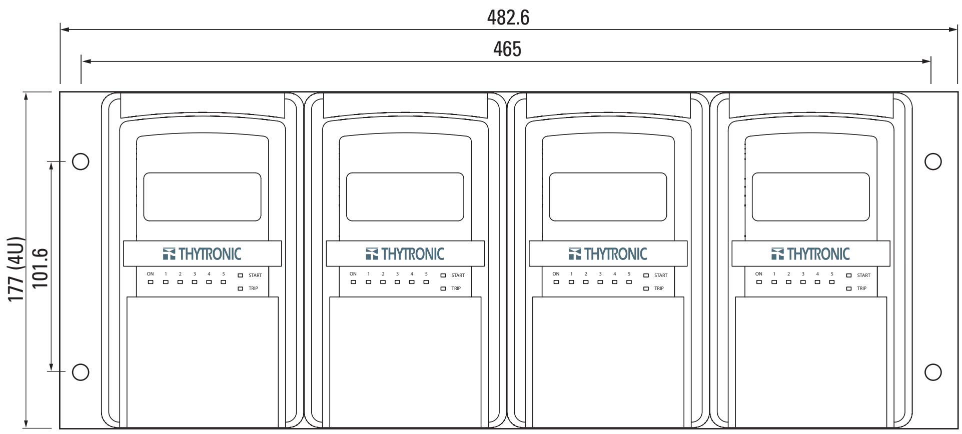


PROJECTING MOUNTING
(Separate operator panel)

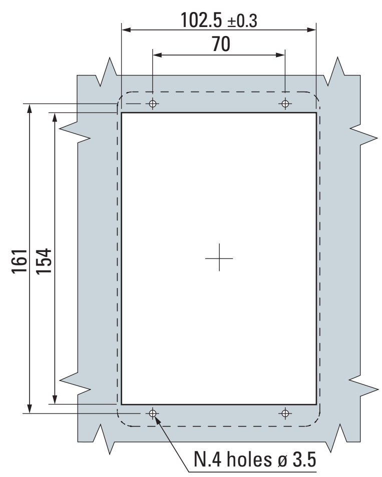


PROJECTING MOUNTING
(Stand alone)

RACK MOUNTING



FLUSH MOUNTING CUTOUT



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