
PRODUCT DESCRIPTION

# EuroProt+ Smart Line S24

## IED-EP+S/S24/Variant 5

## TRANSFORMER DIFFERENTIAL PROTECTION RELAY

PROTECTA HUNGARY

# EUROPROT+ SMART LINE S24 VARIANT 5

## TRANSFORMER DIFFERENTIAL PROTECTION RELAY

## OVERVIEW

The **IED EP+ S24** Series is member of the **EuroProt+** numerical protection relay, made by Protecta Co. Ltd. The **EuroProt+** type complex protection in respect of hardware and software is a modular device. The modules are assembled and configured according to the requirements, and then the software determines the functions. The **IED EP+ S24** Series is contained a special selection of the **EuroProt+** modules, bearing in mind the cost effective realization. The **IED EP+ S24** Series is divided into several different variants corresponding to the scope of application.

The **IED EP+ S24 Variant 5** is dedicated transformer protection and control IED for power transformers, unit and step-up transformers including power generator-transformer blocks in utility and industry power distribution systems.

### GENERAL FEATURES

- Native IEC 61850 IED with Edition 1 & 2 compatibility
- Standard module layouts with options 24 HP wide rack size (height: 3U)
- The pre-defined factory configuration can be customized to the user's specification with the powerful EuroCAP tool
- Flexible protection and control functionality to meet special customer requirements
- Different HMI Types: advanced HMI with color touchscreen and black-and-white display with 4 tactile push buttons. An embedded web server and extended measuring, control and monitoring functions are also available for both types
- User configurable LCD user screens, which can display SLDs (Single Line Diagrams) with switchgear position indication and control as well as setting values, measurement values, event and fault information (timestamp, function block, fault phase, fault current...)
- 8 setting groups available as default. The number of setting groups can be up to 20 as user's requirement
- Enhanced breaker monitoring and control
- High capacity disturbance recorder (DRE) and event logging in non-volatile memory:
  - DRE can store more than 64 records
  - Each DRE recording can be configured up to 32 analogue and 64 digital signal channels with duration up to 10s and sampling rate up to 2kHz
  - Event recorder can store more than 10,000 events
  - The records can be read out from IED in the standard COMTRADE file format (IEEE Std C37.111) via exist communication connection (such as IEC61850) or even examined on-line. Every single record stored in 3 files


with the same name and the following extensions: .dat, .cfg, .inf

- Several mounting methods: Rack; Flush mounting; Semi-flush mounting; Wall mounting; Wall-mounting with terminals; Flush mounting with IP54 rated cover.
- Wide range of communication protocols:
  - Ethernet-based communication protocol: IEC61850, DNP3.0 TCP, IEC60870-5-104, Modbus TCP
  - Serial communication protocol: DNP3.0, IEC60870-5-101, IEC60870-5-103, MODBUS, SPA
- Legacy network based protocols via 100Base-FX and 10/100Base-TX (RJ45)
- Optional communication ports: Fiber Ethernet (MM/ST, SM/FC), RJ45, Serial POF, Serial glass fiber, RS-485/422
- Handling of several communication protocols simultaneously
- Built-in self-monitoring to detect internal hardware or software errors
- Time synchronization protocol: NTP/SNTP, Minute pulse, Legacy protocol, IRIG-B
- Integrated advanced cyber security - Conformity with the Cyber Security requirements in accordance with NERC-CIP, IEEE 1686, BDEW Whitepaper and IEC 62351-8 standard and recommendation. Passwords are required when logging into the device for: access, control, setting, manage,...

## APPLICATION

### SCOPE OF APPLICATION

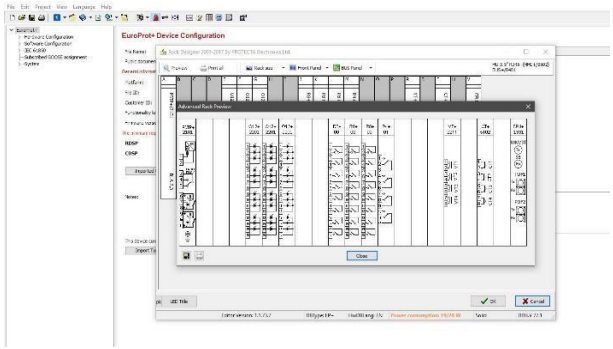
- Transformer differential protection for power transformers, unit and step-up transformers including power generator-transformer blocks in utility and industry power distribution systems
- Restricted earth fault protection
- Three-phase and residual overcurrent protection for both side of the transformer

- Transformer thermal protection
- Breaker failure protection function
- Current unbalance detection of CT's
- Programmable interlocking schemes

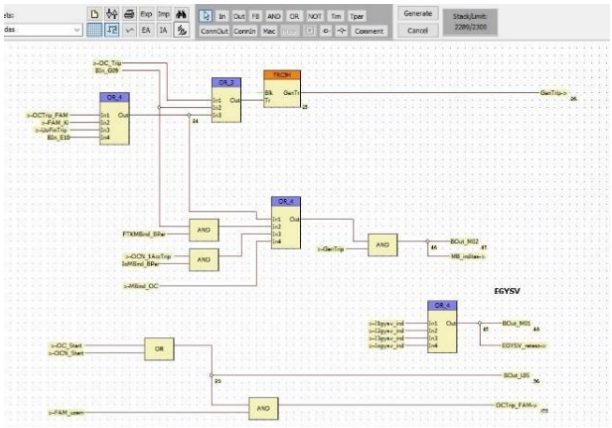
## EUROCAP CONFIGURATION TOOL

The EuroCAP configuration tool, which is available free of charge, offers a user-friendly and flexible application for protection, control and measurement functions to ensure that the IED-EP+ devices are fully customisable.

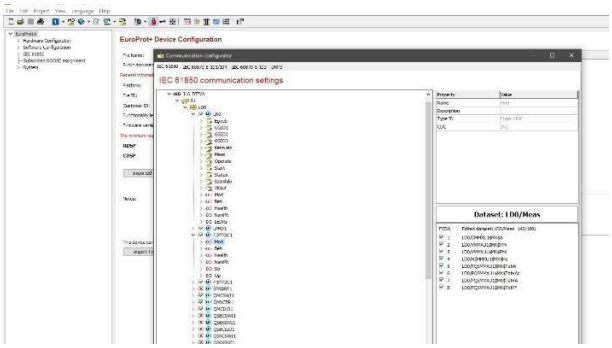
- **HW configuration**
  - View the exciting hardware configuration of the IED including card information and slot position
  - Modify (add or change) certain HW modules
  - Digital and analogue I/O signal definition



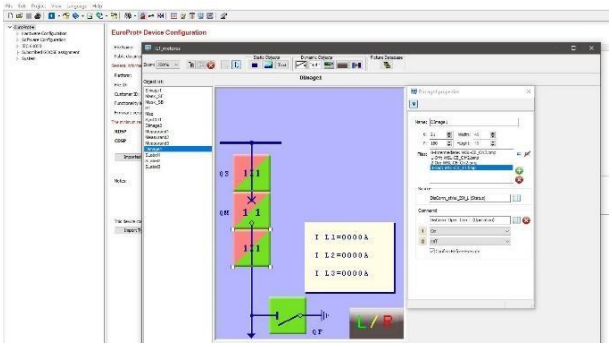
- **Logic editor**
  - Create/manage logical sheets
  - Factory pre-configured logical schemes to speed up the commissioning process



- **Communication configurator**
  - Set up IEC 61850, 101-104, 103, DNP3 communication protocols
  - Configure dataset, report and goose control block properties for IEC 61850 horizontal and vertical communication
  - GOOSE configuration between IEDs



- **LCD configurator (available with color TFT displays)**
  - Create/modify user screens with Single Line Diagrams, measuring or status values
  - Icon library for effective configuration Own, user-defined symbols can be created as well



- **Feedback documentation**

Automatic documentation of the configured IED, which can contain the actual connection assignment, on-line measurements, all recorded event channels, all recorded disturbance channels, LED assignment, Logical sheets and the relevant communication settings and collect the protection, control and monitoring parameters.

- **Offline Parameter Set Editor**
  - View, set, compare and save the setting of the IED parameters
  - Import existing parameter settings into the Offline parameter set editor from the IED
  - Import/Export parameters in xlsx format
  - Generate and save parameters in RIO/XRIO format for relay tester

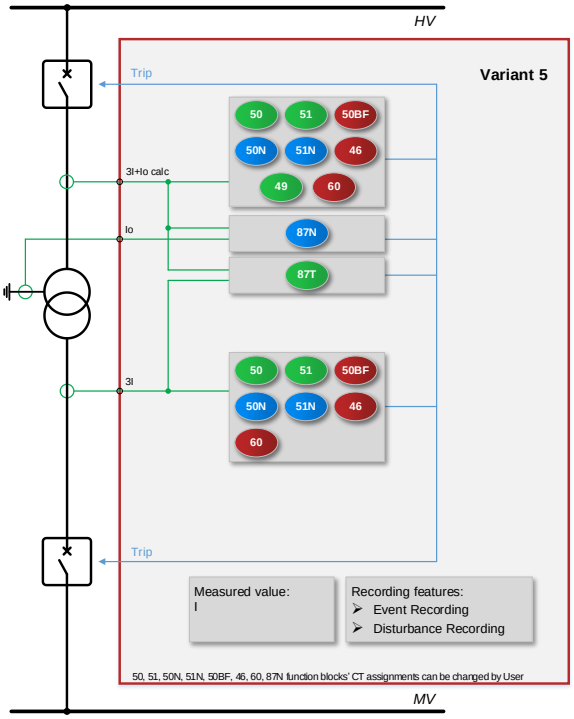
## PROTECTION & CONTROL FUNCTIONS

The **Variant 5** configuration measures three phase currents and the zero sequence current component from both sides of a two winding, three-phase transformer. The main protection functions are transformer differential protection and restricted earth-fault protection functions.

The realized current-based protection functions, including thermal replica protection functionand differential functions, are listed in the Table below.

| THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS | IEC | ANSI | *Inst. |
|---|---|---|---|
| Circuit breaker control (included interlocking function) | | | |
| Disconnector control (included interlocking function) | | | |
| Negative sequence overcurrent protection | I2 > | 46 | 1 |
| Thermal protection | T > | 49 | 1 |
| Three-phase instantaneous overcurrent protection | I >>> | 50 | 2 |
| Breaker failure protection | CBFP | 50BF | 2 |
| Residual instantaneous overcurrent protection | Io >>> | 50N/50Ns | 2 |
| Three-phase time overcurrent protection | I >, I >> | 51 | 6 |
| Residual overcurrent protection | Io >, Io >> | 51N/51Ns | 6 |
| Current unbalance | | 60 | 1 |
| Inrush detection | I2h > | 68 | 1 |
| Trip circuit supervision | | 74 | 2 |
| Lockout trip logic function | | 86/94 | 1 |
| Generator/Motor differential protection | 3IdG >, 3IdM | 87G / 87M | 1 |
| Restricted earth-fault protection | REF | 87N | 2 |
| Transformer differential protection (2W) | 3IdT > | 87T | 1 |

**The Inst. column contains the numbers of the pre-configured function blocks in the factory configuration. These numbers may be different in order to meet the user's requirements*



- **Circuit breaker control function block (CB1Pol)**

The Circuit breaker control function block can be used to integrate the circuit breaker control of the EuroProt+ device into the station control system and to apply active scheme screens of the local LCD of the device. Up to 32 Circuit breaker control function blocks can be configured.

The Circuit breaker control function block receives remote commands from the SCADA system and local commands from the local LCD of the device, performs the prescribed checking and transmits the commands to the circuit breaker. It processes the status signals received from the circuit breaker and offers them to the status display of the local LCD and to the SCADA system.

**Main features:**

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- The signals and commands of the synchro check/synchro switch function block can be integrated into the operation of the function block.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” (enabled trip command) and “EnaOn” (enabled close command), using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
  - Time limitation to execute a command
  - Command pulse duration
  - Filtering the intermediate state of the circuit breaker
  - Checking the synchro check and synchro switch times
  - Controlling the individual steps of the manual commands
- Sending trip and close commands to the circuit breaker (to be combined with the trip commands of the protection functions and with the close command of the automatic reclosing function; the protection functions and the automatic reclosing function directly give commands to the CB). The combination is made graphically using the graphic equation editor
- Operation counter
- Event reporting

The Circuit breaker control function block has binary input signals. The conditions are defined by the user applying the graphic equation editor. The signals of the circuit breaker control are seen in the binary input status list.

- **Disconnector control function (DisConn)**

The Disconnector control function block can be used to integrate the disconnector or earthing switch control of the EuroProt+ device into the station control system and to apply active scheme screens of the local LCD of the device. Up to 32 Disconnector control function blocks can be configured.

The disconnector control function block receives remote commands from the SCADA system and local commands from the local LCD of the device, performs the prescribed checking and transmits the commands to the disconnector. It processes the status signals received from the disconnector and offers them to the status display of the local LCD and to the SCADA system.

**Main features:**

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” (enabled trip command) and “EnaOn” (enabled close command), using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
  - Time limitation to execute a command
  - Command pulse duration
  - Filtering the intermediate state of the disconnector
  - Controlling the individual steps of the manual commands
- Sending trip and close commands to the disconnector
- Operation counter
- Event reporting

The Disconnector control function block has binary input signals. The conditions are defined by the user applying the graphic equation editor. The signals of the disconnector control are seen in the binary input status list.

- **Negative sequence overcurrent protection (46)**

The negative sequence overcurrent protection function (46) block operates if the negative sequence current is higher than the preset starting value. In the negative sequence overcurrent protection function, definite-time or inverse-time characteristics are implemented, according to IEC or IEEE standards. The function evaluates a single measured current, which is the RMS value of the fundamental Fourier component of the negative sequence current. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08. The definite (independent) time characteristic has a fixed delaying time when the current is above the starting current Gs previously set as a parameter. The negative phase sequence components calculation is based on the Fourier components of the phase currents.

The binary output status signals of the negative sequence overcurrent protection function are the general starting and the general trip command of the function.

The negative sequence overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

- **Thermal protection (49)**

Basically, thermal protection measures the three sampled phase currents. RMS values are calculated and the temperature calculation is based on the highest RMS value of the phase currents. The temperature calculation is based on the step-by-step solution of the thermal differential equation. This method yields “over temperature”, meaning the temperature above the ambient temperature. Accordingly, the temperature of the protected object is the sum of the calculated “over temperature” and the ambient temperature.

If the calculated temperature (calculated “over temperature” + ambient temperature) is above the threshold values, alarm, trip and restart blocking status signals are generated.

- **Three-phase instantaneous overcurrent protection (50)**

The three-phase instantaneous overcurrent protection function (50) operates immediately if the phase currents are higher than the setting value. The setting value is a parameter, and it can be doubled by graphic programming of the dedicated input binary signal defined by the user. The function is based on peak value selection or on the RMS values of the Fourier basic harmonic calculation, according to the parameter setting. The fundamental Fourier components are results of an external function block.

Parameter for type selection has selection range of Off, Peak value and Fundamental value. When Fourier calculation is selected then the accuracy of the operation is high, the operation time however is above one period of the network frequency. If the operation is based on peak values then fast sub-cycle operation can be expected, but the transient overreach can be high.

The function generates trip commands without additional time delay if the detected values are above the current setting value. The function generates trip commands for the three phases individually and a general trip command as well.

The instantaneous overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

- **Breaker failure protection (50BF)**

After a protection function generates a trip command, it is expected that the circuit breaker opens and the fault current drops below the pre-defined normal level. If not, then an additional trip command must be generated for all backup circuit breakers to clear the fault. At the same time, if required, a repeated trip command can be generated to the circuit breakers which are a priori expected to open. The breaker failure protection function can be applied to perform this task.

The starting signal of the breaker failure protection function is usually the trip command of any other protection function. Dedicated timer starts at the rising edge of the general start signal for the backup trip command. During the running time of the timer the function optionally monitors the currents, the closed state of the circuit breakers or both, according to the user’s choice. The selection is made using an enumerated parameter.

If current supervision is selected by the user then the current limit values must be set correctly. The binary input indicating the status of the circuit breaker has no meaning.

If contact supervision is selected by the user then the current limit values have no meaning. The binary input indicating the status of the circuit breaker must be programmed correctly using the graphic equation editor.

If the parameter selection is “Current/Contact”, the current parameters and the status signal must be set correctly. The breaker failure protection function resets only if all conditions for faultless state are fulfilled.

If at the end of the running time of the backup timer the currents do not drop below the pre- defined level, and/or the monitored circuit breaker is still in closed position, then a backup trip command is generated.

The pulse duration of the trip command is not shorter than the time defined by setting the parameter Pulse length.

The breaker failure protection function can be disabled by setting the enabling parameter to “Off”.

Dynamic blocking (inhibition) is possible using the binary input Block. The conditions are to be programmed by the user, using the graphic equation editor.

- **Residual instantaneous overcurrent protection (50N/50Ns)**

The residual instantaneous overcurrent protection function operates immediately if the residual current (3Io) is above the setting value. The setting value is a parameter, and it can be doubled by a dedicated binary input signal defined by the user applying the graphic programming. The function is based on peak value selection or on the RMS values of the Fourier basic harmonic component of the residual current, according to the parameter setting. The fundamental Fourier component calculation is not part of the 50N/50Ns function. Parameter for type selection has selection range of Off, Peak value and Fundamental value.

The function generates a trip commands without additional time delay if the detected values are above the current setting value.

If the relay is equipped with the current transformer module with a sensitive channel (4th channel), the function will be considered as sensitive residual instantaneous overcurrent protection for use in applications where the fault current magnitude may be very low.

The residual instantaneous overcurrent protection function has a binary input signal, which serves the purpose of disabling

the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

- **Three-phase time overcurrent protection (51)**

The overcurrent protection function realizes definite time or inverse time characteristics according to IEC or IEEE standards, based on three phase currents. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08. This function can be applied as main protection for medium-voltage applications or backup or overload protection for high-voltage network elements. The definite (independent) time characteristic has a fixed time delay when the current is above the starting current is previously set as a parameter.

The binary output status signals of the three-phase overcurrent protection function are starting signals of the three phases individually, a general starting signal and a general trip command.

The overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

- **Residual overcurrent protection (51N/51Ns)**

The residual delayed overcurrent protection function can realize definite time or inverse time characteristics according to IEC or IEEE standards, based on the RMS value of the fundamental Fourier component of a single measured current, which can be the measured residual current at the neutral point (3Io) or the calculated zero sequence current component. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08. The definite (independent) time characteristic has a fixed time delay when the current is above the starting current Is previously set as a parameter.

The binary output status signals of the residual overcurrent protection function are the general starting signal and the general trip command if the time delay determined by the characteristics expired.

If the relay is equipped with the current transformer module with a sensitive channel (4th channel), the function will be considered as sensitive residual overcurrent protection (51Ns) for use in applications where the fault current magnitude may be very low.

The residual overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

- **Current unbalance function (60)**

The current unbalance protection function (60) can be applied to detect unexpected asymmetry in current measurement. The applied method selects maximum and minimum phase currents (RMS value of the fundamental Fourier components). If the difference between them is above the setting limit, the function generates a start signal. It is a necessary precondition of start signal generation that the maximum of the currents be above 10 % of the rated current and below 150% of the rated current. The Fourier calculation modules calculate the RMS value of the basic Fourier current components of the phase currents individually. They are not part of the VCB60 function; they belong to the preparatory phase.

The decision logic module combines the status signals to generate the starting signal and the trip command of the function. The trip command is generated after the defined time delay if trip command is enabled by the Boolean parameter setting.

The function can be disabled by parameter setting, and by an input signal programmed by the user with the graphic programming tool.

- **Inrush detection (68)**

When an inductive element with an iron core (transformer, reactor, etc.) is energized, high current peak values can be detected. This is caused by the transient asymmetric saturation of the iron core as a nonlinear element in the power network. The sizing of the iron core is usually sufficient to keep the steady state magnetic flux values below the saturation point of the iron core, so the inrush transient slowly dies out. These current peaks depend also on random factors such as the phase angle at energizing. Depending on the shape of the magnetization curve of the iron core, the detected peaks can be several times above the rated current peaks. Additionally, in medium or high voltage networks, where losses and damping are low, the indicated high current values may be sustained at length. The function operates independently using all three phase currents individually, and additionally, a general inrush detection signal is generated if any of the phases detects inrush current.

The function can be disabled by the binary input Disable. This signal is the result of logic equations graphically edited by the user. Using the inrush detection binary signals, other protection functions can be blocked during the transient period so as to avoid the unwanted trip.

- **Trip circuit supervision (74)**

The trip circuit supervision is utilized for checking the integrity of the circuit between the trip coil and the tripping output of the protection device.

This is realized by injecting a small DC current (around 1-5 mA) into the trip circuit. If the circuit is intact, the current flows, causing an active signal to the opto coupler input of the trip contact.

The state of the input is shown on the devices' binary input listing among the other binary inputs, and it can be handled like any other of them (it can be added to the user logic, etc.)

- **Lockout trip logic (86/94)**

The lockout version of the simplified trip logic function

operates according to the functionality required by the IEC 61850 standard for the “Trip logic logical node”. Its output can be set to lockout and be reset externally.

This simplified software module can be applied if only three-phase trip commands are required, that is, phase selectivity is not applied.

The function receives the trip requirements of the protective functions implemented in the device and combines the binary signals and parameters to the outputs of the device.

The operation can be normal or lockout. In normal mode, the output remains energized at least for a given pulse time and drops off as soon as the trip input drops off. The aim of this decision logic is to define a minimal impulse duration even if the protection functions detect a very shorttime fault.

In lockout mode the output stays active until the function gets a reset signal on its reset input.

The trip requirements and the reset signal are programmed by the user, using the graphic equation editor.

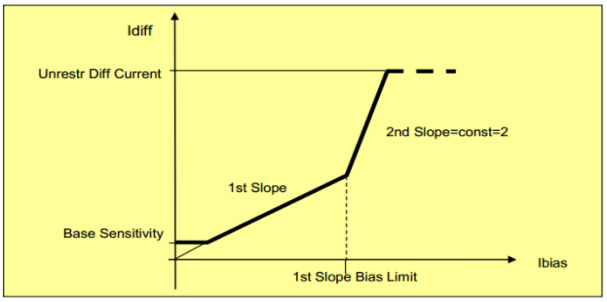
- **Generator/Motor differential protection (87G/87M)**

The generator differential protection function provides main protection for generators or large motors. The application needs current transformers in all three phases both on the network side and on the neutral side. It is a simplified version, based on the Protecta general differential protection function, using less parameter values to be set.

The differential currents in the phases are calculated as the difference between the currents measured on the network side and those on the neutral side.

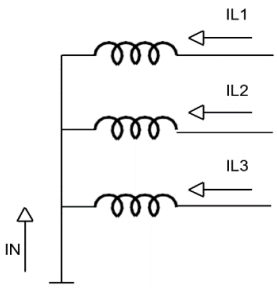
This module calculates the basic Fourier components of three differential currents. These results are needed also for the high-speed differential current decision.

The generator/motor differential protection characteristics:

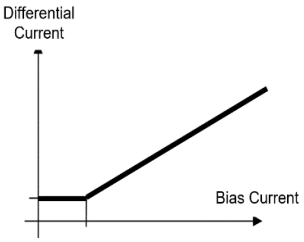



- **Restricted earth fault protection (87N)**

The restricted earth-fault protection function is basically a low-impedance differential protection function based on zero sequence current components. It can be applied to protect one side winding of transformers with grounded neutral against single-phase-to-earth fault (see Figure).




The function compares the measured neutral current at the star point (IN) and the calculated zero sequence current component of the phase currents (IL1, IL2, IL3) and generates a trip command if the difference of these currents is above the characteristics.




The function performs the necessary calculations for the evaluation of the “percentage differential characteristics”, and decides to trip if the differential current is above the characteristic curve of the zero sequence differential protection function. This curve is the function of the restraint (Bias) current, which is the maximum of the phase currents and the current of the neutral point.

Additionally, the function compares the direction of the neutral current and that of the calculated zero sequence current. In case of small zero sequence component of the high fault currents in the phases, this decision improves the stability of the function.

A Boolean parameter of the restricted earth-fault protection function serves to enable the directional checking of the measured and calculated zero sequence currents. The restricted earth-fault protection function generates a trip signal if the differential current as the function of the bias current is above the differential characteristic lines and the function is not blocked by the directional decision. Additionally, the operation of the function is enabled by parameter setting. The conditions of enabling are defined by the user applying the graphic equation editor.

- **Transformer differential protection (87T)**

The differential protection function provides main protection for transformers, generators or large motors, but it can also be applied for overhead lines and cables of solidly grounded networks or for the protection of any combination of the aforementioned objects.

The three-phase power transformers transform the primary current to the secondary side according to the turns ratio and the vector group of the transformers. The Y (star), D (delta) or Z (zig-zag) connection of the three phase coils on the primary and secondary sides causes the vector shift of the currents. The numerical differential protection function applies matrix transformation of the directly measured currents of one side of the transformer to match them with the currents of the other side.

In Protecta’s transformer differential protection the target of the matrix transformation is the delta (D) side. Thus the problem of zero sequence current elimination in case of an external ground fault is also solved.

The method of the matrix transformation is defined by the “Code” parameter identifying the transformer vector group connection.

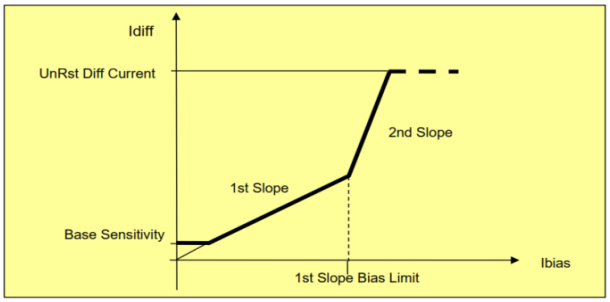
The differential current can be high during the transients of transformer energizing (inrush current) due to the current distortion caused by the transformer iron core asymmetrical saturation. In this case, the second harmonic content of the differential current is applied to disable the false operation of the differential protection function.

The differential current can be high in case of the over-excitation of the transformer due to the current distortion caused by the transformer iron core symmetrical saturation. In this case, the fifth harmonic content of the differential current is applied to disable the false operation of the differential protection function.

The harmonic analysis calculates the basic Fourier components of the three differential currents. These results are needed for the high-speed differential current decision and for the second and fifth harmonic restraint calculation. Third harmonic is eliminated in the algorithm's transformation matrix without individual settings like 2nd or 5th harmonics

The software modules evaluate and compare the result with the parameter values set for the second and fifth harmonic. If the harmonic content relative to the basic harmonic component of the differential currents is high, a restraint signal is generated immediately and a timer is started at the same time. If the duration of the active status is at least 25 ms, then the resetting of the restraint signal is delayed by an additional 15 ms.

The decision logic module decides if the differential current of the individual phases is above the characteristic curve of the differential protection function. It compares the magnitudes of the differential currents and those of the restraint currents for evaluation of the "percentage differential characteristics". This curve is the function of the restraint current, which is calculated based on the sum of the magnitude of the phase-shifted phase currents (see Figure below).




The characteristic curve has four sections. The first section is the base sensitivity, the second one serves to compensate the turns ratio deviation e.g. due to the operation of the on-load tap changer, the third is to eliminate false operation caused by the CT saturation and the fourth one is the unrestricted differential function.

The differential protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user applying the graphic equation editor.

## MEASUREMENT FUNCTIONS

- **Measurement functions**

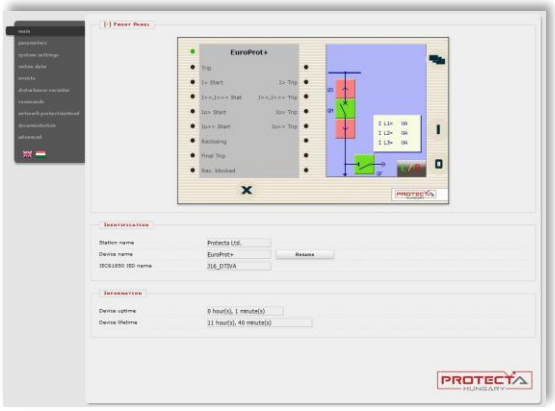
Based on the hardware inputs the measurements listed in Table below are available.

| Measurement functions | Variant 5 |
|---|---|
| Current (I1, I2, I3, Io) | X |
| Supervised trip contacts (TCS) | X |

*The measurement functions of the Variant 5 configuration*

## HMI AND COMMUNICATION TASKS

- **Embedded WEB-server:** Allows remote access via Ethernet port of device
  - Firmware upgrade possibility
  - Modification of user parameters
  - Events list and disturbance record
  - Password management
  - Online data measurement
  - Commands
  - Administrative tasks




*Embedded WEB-server*

- **Front panel HMI:**

There are two type of front panel HMI:

- **HMI+2504**:
  - 128x64pixels, black and white
  - 4 x tactile user keys
  - RJ45 10/100Mbit/s
- **HMI+2404** (optional):
  - 320 × 240 pixel TFT display with Resistive touchscreen interface
  - 4 x tactile user keys
  - RJ-45 10/100Mbit/s


*IED EP+S24 B&W HMI front panel*


*IED EP+S24 True color HMI front panel*

- **Communication:**
  - The built-in 5-port Ethernet switch allows EuroProt+ to connect to IP/Ethernet-based network. The following Ethernet ports are available:
    - Station bus (100Base-FX Ethernet) SBW
    - Redundant station bus (100Base-FX Ethernet) SBR
    - Proprietary process bus (100Base-FX Ethernet)
    - RJ-45 Ethernet user interface
    - Optional 10/100Base-T port via RJ-45 connector
  - PRP/HSR seamless redundancy for Ethernet networking (100Base-FX Ethernet; 10/100Base-TX Ethernet)
  - Redundancy RJ-45 for Ethernet networking (10/100Base-TX Ethernet)
  - Other communication:
    - RS422/RS485 interfaces (galvanic interface to support legacy or other serial protocols, ASIF)
    - Plastic or glass fiber interfaces to support legacy protocols, ASIF

## FUNCTIONAL PARAMETERS

| | |
|---|---|
| **Circuit breaker control function block (CB1Pol)** | |
| ControlModel | Direct normal, Direct enhanced, SBO enhanced |
| Forced check | If true, then the check function cannot be neglected by the check attribute defined by the IEC 61850 standard |
| Max.Operating time | 10-1000ms in 1ms steps |
| Pulse length | 50-500ms in 1ms steps |
| Max.Intermediate time | 20-30000ms in 1ms steps |
| Max.SynChk time | 10-5000ms in 1ms steps |
| Max.SynSW time | 0-60000ms in 1ms steps |
| SBO Timeout | 1000-20000ms in 1ms steps |
| **Disconnector control function (DisConn)** | |
| ControlModel | Direct normal, Direct enhanced, SBO enhanced |
| Type of switch | N/A, Load break, Disconnector, Earthing Switch, HS Earthing Switch |
| Forced check | If true, then the check function cannot be neglected by the check attribute defined by the IEC 61850 standard |
| Max.Operating time | 10-20000ms in 1ms steps |
| Pulse length | 50-30000ms in 1ms steps |
| Max.Intermediate time | 20-30000ms in 1ms steps |
| SBO Timeout | 1000-20000ms in 1ms steps |
| **Negative sequence overcurrent protection (46)** | |
| Operation | Off, DefiniteTime, IEC Inv,IEC VeryInv, IEC ExtInv,IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv |
| Start Current | 5-3000% in 1% steps |
| Time Multiplier | 0.05-999 in 0.01 steps |
| Minimal time delay for the inverse char. | 0-60000ms in 1ms steps |
| Definite time delay | 0-60000ms in 1ms steps |
| Reset time delay for the inverse char | 0-60000ms in 1ms steps |
| **Thermal protection (49)** | |
| Operation | Off, Pulsed, Locked |
| Alarm Temperature | 60-200deg in 1deg steps |
| Trip Temperature | 60-200deg in 1deg steps |
| Rated Temperature | 60-200deg in 1deg steps |
| Base Temperature | 0-40deg in 1deg steps |
| Unlock Temperature | 20-200deg in 1deg steps |
| Ambient Temperature | 0-40deg in 1deg steps |
| Startup Term | 0-60% in 1% steps |
| Rated Load Current | 20-150% in 1% steps |
| Time Constan | 1-999min in 1min step |
| **Three-phase instantaneous overcurrent protection (50)** | |
| Operation | Off, Peak value, Fundamental value |
| Start current | 5-3000% in 1% steps |
| **Breaker failure protection (50BF)** | |

| | |
|---|---|
| Operation | Off, Current, Contact, Current/Contact |
| Retrip | Off, On |
| Start Ph Current | 20-200% in 1% steps |
| Start Res Current | 10-200% in 1% steps |
| Retrip Time Delay | 0-1000ms in 1ms steps |
| Backup Time Delay | 100-60000ms in 1ms steps |
| Pulse Duration | 0-60000ms in 1ms steps |
| **Residual instantaneous overcurrent protection (50N/50Ns)** | |
| Operation | Off, Peak value, Fundamental value |
| Start Current | 5-3000% in 1% steps |
| **Three-phase time overcurrent protection (51)** | |
| Operation | Off, Definite Time, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI0.95 Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv |
| Start current | 5-3000% in 1% steps |
| Time Multiplier | 0.05-999 in 0.01 steps |
| Minimum time delay for the inverse char. | 40-60000ms in 1ms steps |
| Definite time delay for definite type char. | 40-60000ms in 1ms steps |
| Reset time delay for the IEC type inverse char. | 60-60000ms in 1ms steps |
| **Residual time overcurrent protection (51N/51Ns)** | |
| Operation | Off, DefiniteTime, IEC Inv,IEC VeryInv, IEC ExtInv,IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv |
| Start current | |
| In = 1A or 5A | 5-3000% in 1% steps |
| In = 200mA or 1A | 5-3000% in 1% steps |
| Time Multiplier | 0.05-999 in 0.01 steps |
| Minimum time delay for the inverse char. | 40-60000ms in 1ms steps |
| Definite time delay for definite type char. | 40-60000ms in 1ms steps |
| Reset time delay for the inverse char. | 60-60000ms in 1ms steps |
| **Current transformer supervision (60)** | |
| Operation | Off, On |
| Start Signal Only | False, True |
| Start Current Diff | 10-90% in 1% steps |
| Time Delay | 100-60000ms in 1ms steps |
| **Inrush detection (68)** | |
| Operation | Off, On |
| 2nd Harm Ratio | 5-50% in 1% steps |
| Basic sensitivity of the function | 20-100% in 1% steps |
| **Lockout trip logic (86/94)** | |
| Operation | Off, On, Lockout |
| Min pulse duration | 50-60000ms in 1ms steps |
| **Generator/Motor differential protection (87G/87M)** | |
| Operation | Off, On |

| | |
|---|---|
| Base Sensitivity | 10-50% in 1% step |
| 1st Slope | 10-50% in 1% step |
| 1st Slope Bias Limit | 200-2000% in 1% step |
| UnRst Diff Current | 800-2500% in 1% step |
| **Rectricted earth fault protection (87N)** | |
| Operation | Off, On |
| Directional check | False, True |
| Io Primary Match | 20-500% in 1% steps |
| Neutral Match | 100-1000% in 1% steps |
| Base Sensitivity | 10-50% in 1% steps |
| Slope | 50-100% in 1% steps |
| Base Sens Bias Limit | 100-200% in 1% steps |
| **Transformer differential protection (87T)** | |
| Operation | Off, On |
| Pri-Sec VGroup | Dy1, Dy5, Dy7, Dy11, Dd0, Dd6, Dz0, Dz2, Dz4, Dz6, Dz8, Dz10, Yy0, Yy6, Yd1, Yd5, Yd7, Yd11, Yz1, Yz5, Yz7, Yz11 |
| Pri-Ter VGroup* | Dy1, Dy5, Dy7, Dy11, Dd0, Dd6, Dz0, Dz2, Dz4, Dz6, Dz8, Dz10, Yy0, Yy6, Yd1, Yd5, Yd7, Yd11, Yz1, Yz5, Yz7, Yz11 |
| Zero Seq Elimination | False, True |
| TR Primary Comp | 20-500% in 1% step |
| TR Secondary Comp | 20-500% in 1% step |
| TR Tertiary Comp | 20-200% in 1% step |
| 2nd Harm Ratio | 5-50% in 1% step |
| 5th Harm Ratio | 5-50% in 1% step |
| Base Sensitivity | 10-50% in 1% step |
| 1st Slope | 10-50% in 1% step |
| 1st Slope Bias Limit | 200-2000% in 1% step |
| UnRst Diff Current | 800-2500% in 1% step |
| **Disturbance recorder** | |
| Operation | Off, On |
| Resolution | 1/1.2 kHz; 2/2.4kHz |
| Prefault | 100-1000ms in 1ms steps |
| PostFault | 100-10000ms in 1ms steps |
| Max Recording Time | 500-10000ms in 1ms steps |

## TECHNICAL DATA

| HARDWARE | |
|---|---|
| **Analog Inputs (Current & Voltage Input Modules)** | |
| Rated current In | 1A or 5A (selectable) |
| Rated voltage Vn | 110V (± 10%) |
| Rated frequency | 50Hz or 60Hz |
| Overload rating | |
| Current inputs | 20A continuous, 175A for 10s, 500A for 1s, 1200A for 10ms |
| Voltage inputs | 250V continuous, 275V for 1s |
| Burden | |
| Phase current inputs | 0.01VA at In = 1A, 0.25VA at In = 5A |
| Voltage inputs | 0.61VA at 200V, 0.2VA at 100V |
| **Power Supply** | |
| Rated auxiliary voltage | 24/48/60VD (Operative range: 19.2 - 72VDC)<br>110/220VDC (Operative range: 88 - 264VDC or 80-250VAC) |
| Power consumption | 20W |
| **Binary Inputs** | |
| Input circuit DC voltage | 24VDC (Thermal withstand voltage: 72VDC)<br>48VDC (Thermal withstand voltage: 100VDC)<br>110VDC (Thermal withstand voltage: 250VDC)<br>220VDC (Thermal withstand voltage: 320VDC) |
| Pickup voltage | 0.8Un |
| Drop voltage | 0.64Un |
| Power consumption | max. 1.6 mA per channel at 220VDC<br>max. 1.8 mA per channel at 110VDC<br>max. 2 mA per channel at 48VDC<br>max. 3 mA per channel at 24VDC |
| **Binary Outputs** | |
| Rated voltage | 250VAC/DC |
| Continuous carry | 8A |
| Maximum switching voltage | 400VAC |
| Breaking capacity | 0.2A at 220VDC, 0.3A at 110VDC (L/R=40ms)<br>2000VA max |
| Short time carrying capacity | 35A for 1s |
| Operating time | Typically 10ms |
| **Trip Contacts** | |
| Rated voltage | 24VDC/48VDC/110VDC/220VDC |
| Continuous carry | 8A |
| Thermal withstand voltage | 72VDC (Rated voltage: 24VDC or 48VDC)<br>150VDC (Rated voltage: 110VDC)<br>242VDC (Rated voltage: 220VDC) |
| Breaking capacity | 4A (L/R=40ms) |
| Making capacity | 30A for 0.5s |
| Operating time | With pre-trip 0.5 ms, without pre-trip typically 10 ms |
| **Mechanical Design** | |

| | |
|---|---|
| Installation<br>Case<br>Protection class | Flush mounting<br>42 or 84 HP (height:3U)<br>IP41 from front side, IP2x from rear side<br>IP54 Rated mounting kit |
| **Key & LED** | |
| Device keys<br>Capacitive touch key LEDS<br>Number of configurable LED<br>Device status LED | Capacitive touch keys<br>4 pcs yellow, 3 mm circular LEDs indicating touch key actions<br>16<br>1 piece three-color, 3 mm circular LED<br>Green: normal device operation<br>Yellow: device is in warning state<br>Red: device is in error state |
| **Local Interface** | |
| Service port on front panel | 10/100-Base-T interface with RJ-45 type connector |
| **System Interface** | |
| 10/100-Base-TX<br>100Base-FX<br><br><br><br><br>Serial Interface | IP56 rated with RJ-45 connector<br>MM/ST 1300 nm, 50/62.5/125 µm connector, (up to 2 km) fiber<br>MM/LC 1300 nm, 50/62.5/125 µm connector, (up to 2 km) fiber<br>SM/FC 1550 nm, 9/125 µm connector, (up to 120 km), with max. 32 dB link attenuation<br>SM/FC 1550 nm, 9/125 µm connector, (up to 50 km), with max. 27 dB link attenuation<br><br>Plastic optical fiber (ASIF-POF)<br>Glass with ST connector (ASIF-GS)<br>Galvanic RS485/422 (ASIF-G) |
| **PROTECTION & CONTROL FUNCTIONS** | |
| **Circuit breaker control function block (CB1Pol)** | |
| Operate time accuracy | ±5% or ±15 ms, whichever is greater |
| **Disconnector control function (DisConn)** | |
| Operate time accuracy | ±5% or ±15 ms, whichever is greater |
| **Negative sequence overcurrent protection (46)** | |
| Operating accuracy<br>Operate time accuracy<br>Reset ratio<br>Reset time<br>Dependent time char.<br>Definite time char.<br>Reset accuracy time<br>Transient overreach<br>Pickup time *<br>Overshot time<br>Dependent time char.<br>Definite time char.<br>Influence of time varying value of the input current (IEC 60255-151) accuracy | <2% (when 20 ≤ $G_S$ ≤ 1000)<br>±5% or ±15 ms, whichever is greater<br>0.95<br><br>Dependent time char.<br>Approx 60 ms<br>< 2% or ±35 ms, whichever is greater<br>< 2 %<br>< 40 ms<br><br>25 ms<br>45 ms<br>< 4 % |

| | |
|---|---|
| **Thermal protection (49)** | |
| Operate time at I>1.2*Itrip accuracy | <3 % or <+ 20 ms |
| **Three-phase instantaneous overcurrent protection (50)** | |
| **Using peak value calculation** | |
| Operating characteristic | Instantaneous, accuracy < 6 % |
| Reset ratio | 0.85 |
| Operate time at 2*$I_S$ | <15 ms |
| Reset time | <40 ms |
| Transient overreach | 90% |
| **Using Fourier basic harmonic calculation** | |
| Operating characteristic | Instantaneous, accuracy < 2 % |
| Reset ratio | 0.85 |
| Operate time at 2*$I_S$ | <25 ms |
| Reset time | <60 ms |
| Transient overreach | 15% |
| **Breaker failure protection (50BF)** | |
| Pick-up starting accuracy | <2 % |
| Operating time accuracy | ±5% or ±15 ms, whichever is greater |
| Retrip time | approx. 15 ms |
| Reset ratio | 0.9 |
| Current reset time | 16-25ms |
| **Residual instantaneous overcurrent protection (50N/50Ns)** | |
| **Using peak value calculation** | |
| Operating characteristic (I>0.1 In) | Instantaneous, accuracy <6% |
| Reset ratio | 0.85 |
| Operate time at 2*$I_S$ | < 15 ms |
| Reset time * | < 35 ms |
| Transient overreach | 85 % |
| **Using Fourier basic harmonic calculation** | |
| Operating characteristic (I>0.1 In) | Instantaneous, accuracy <6% |
| Reset ratio | 0.85 |
| Operate time at 2*$I_S$ | < 25 ms |
| Reset time * | < 60 ms |
| Transient overreach | 15 % |
| **Three-phase time overcurrent protection (51)** | |
| Operating accuracy | <2% (when 20 ≤ $G_S$ ≤ 1000) |
| Operate time accuracy | ±5% or ±15 ms, whichever is greater |
| Reset ratio | 0.95 |
| Reset time | |
| Dependent time char. | Dependent time char. |
| Definite time char. | Approx 60 ms |
| Reset time accuracy | < 2% or ±35 ms, whichever is greater |
| Transient overreach | < 2 % |
| Pickup time * | < 40 ms |
| Overshot time | |
| Dependent time char. | 30 ms |

| | |
|---|---|
| Definite time char. | 50 ms |
| Influence of time varying value of the input current (IEC 60255-151) | < 4 % |
| **Residual time overcurrent protection (51N/51Ns)** | |
| Operating accuracy | <3% (when 20 ≤ $G_S$ ≤ 1000) |
| Operate time accuracy | ±5% or ±15 ms, whichever is greater |
| Reset ratio | 0.95 |
| Reset time | |
| Dependent time char. | Dependent time char. |
| Definite time char. | Approx 60 ms |
| Reset accuracy time | < 2% or ±35 ms, whichever is greater |
| Transient overreach | < 2 % |
| Pickup time * | ≤ 40 ms |
| Overshot time | |
| Dependent time char. | 30 ms |
| Definite time char. | 50 ms |
| Influence of time varying value of the input current (IEC 60255-151) accuracy | < 4 % |
| **Current unbalance protection (60)** | |
| Pick-up starting accuracy at In | Pick-up starting accuracy at In |
| Reset ratio | 0.95 |
| Operate time | 70 ms |
| **Inrush detection (68)** | |
| Range | 20 – 2000% of In |
| Current accuracy | ±1% of In |
| **Lockout trip logic (86/94)** | |
| Pulse time | <3 ms |
| **Generator/Motor differential protection (87G/87M)** | |
| Operating characteristic | 2 breakpoints |
| Reset ratio | 0.95 |
| Characteristic accuracy | <2% |
| Operate time, unrestrained | Typically 20 ms |
| Reset time, unrestrained | Typically 25 ms |
| Operate time, restrained | Typically 30 ms |
| Reset time, restrained | Typically 25 ms |
| **Rectricted earth fault protection (87N)** | |
| Operating characteristic | 1 breakpoint |
| Reset ratio | 0.95 |
| Characteristic accuracy | <2% |
| Opera time, restrained | Typically 20ms |
| Reset time, restrained | Typically 25ms |
| **Transformer differential protection (87T)** | |
| Operating characteristic | 2 breakpoints |
| Reset ratio | 0.95 |
| Characteristic accuracy | <2% |

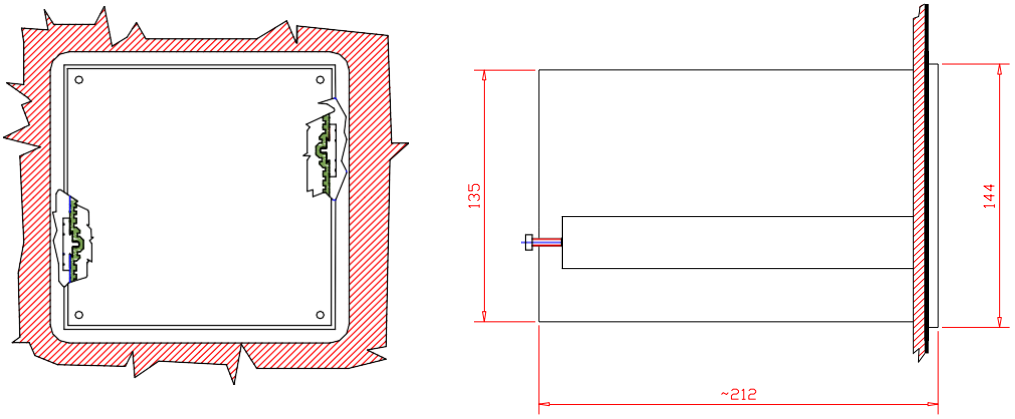
| | |
|---|---|
| Operate time, unrestrained | Typically 20 ms |
| Reset time, unrestrained | Typically 25 ms |
| Operate time, restrained | Typically 30 ms |
| Reset time, restrained | Typically 25 ms |
| **MEASUREMENT FUNCTION** | |
| **Current** | |
| With CT+/5151; CT+/5153 (Channel 1-3) | Range: 0.05 – 20 In, accuracy: ±0.5%, ±1 digit |
| With CT+/1500 | Range: 0.02 – 2 In, accuracy: ±0.2%, ±1 digit |
| **Voltage** | |
| With VT+/2211 | Range: 0.05 – 1.5 Un, accuracy: ±0.5%, ±1 digit |
| **Power (P,Q,S, PF)** | |
| With CT+/5151; CT+/5153 (Channel 1-3) | Range: 0.05 – 20 In, accuracy: ±0.5%, ±1 digit |
| With CT+/1500 | Range: 0.02 – 2 In, accuracy: ±0.2%, ±1 digit |
| **Frequency** | Range: 40 – 60 Hz (50Hz system); accuracy: ±2mHz<br>Range: 50 – 70 Hz (60Hz system); accuracy: ±2mHz |

## ENVIRONMENTAL PERFORMANCE

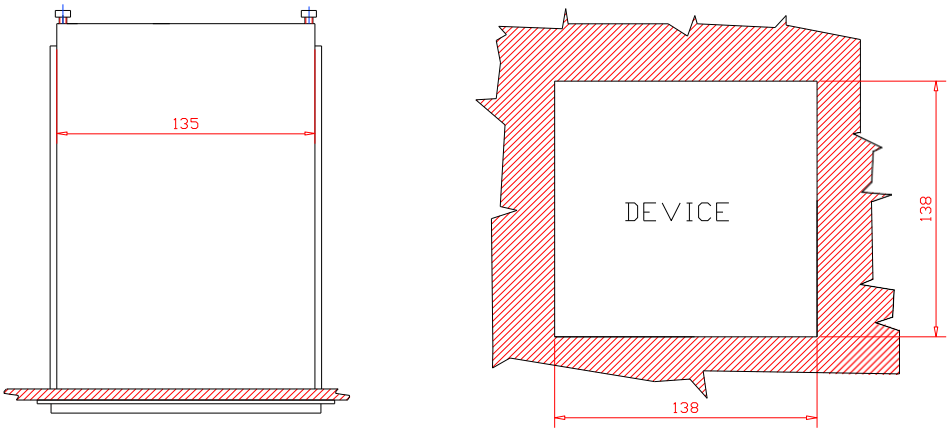
| | | |
|---|---|---|
| **Atmospheric Environment** | | |
| Temperature | IEC 60068-2-1<br>IEC 60068-2-2<br>IEC 60068-2-14 | Storage temperature: - 40 ºC … + 70 ºC<br>Operation temperature: - 20 ºC … + 55 ºC |
| Humidity | IEC 60255-1<br>IEC 60068-2-78<br>IEC 60068-2-30 | Humidity: 10 % ... 93 % |
| Enclosure protection | IEC 60529 | IP41 from front side, IP2x from rear side<br>IP54 Rated mounting kit |
| **Mechanical Environment** | | |
| Vibration | IEC 60255-21-1 | Class I |
| Shock and bump | IEC 60255-21-2 | Class I |
| Seismic | IEC 60255-21-3 | Class I |
| **Electrical Environment** | | |
| Dielectric withstand | IEC 60255-27 | Test levels: 2 kV AC 50 Hz (0.705 kV DC for transducer inputs) |
| High voltage impulse | IEC 60255-27 | Test levels: 5 kV (1 kV for transducer and temperature measuring inputs) |
| Insulation resistance | IEC 60255-27 | Insulation resistance > 15 GΩ |
| Voltage dips, interruptions, variations and ripple on dc supply | IEC 60255-26 | Voltage dips: 40 % (200 ms), 70 % (500ms), 80 % (5000 ms) |
| Thermal short time | IEC 60255-27 | |
| **Electromagnetic Environment** | | |
| Electrostatic discharge | IEC 61000-4-2<br>IEC 60255-26 | Test voltages: 15 kV air discharge, 8 kV contact discharge |
| Radiated radio frequency electromagnetic field immunity | IEC 61000-4-3<br>IEC 60255-26 | Test field strength: 10 V/m |
| Electrical fast transient | IEC 61000-4-4<br>IEC 60255-26 | Test voltage: 4 kV, 5kHz |
| Surge immunity | IEC 61000-4-5<br>IEC 60255-26 | Test voltages: 4 kV line-to-earth, 2 kV line-to-line |
| Immunity to conducted disturbances, induced by radio-frequency fields | IEC 61000-4-6<br>IEC 60255-26 | Frequency sweep: 150kHz…80 MHz<br>Spot frequencies: 27 MHz, 68 MHz<br>Test voltage: 10 V |
| Power frequency magnetic field immunity | IEC 61000-4-8<br>IEC 60255-26 | Test field field strength: 100 A/m continuous, 1000 A/m for 3 s |
| Damped oscillatory wave immunity | IEC 61000-4-18<br>IEC 60255-26 | Test frequency: 100 kHz, 1 MHz<br>Test voltage: 2.5 kV in common mode, 1 kV in differential mode |

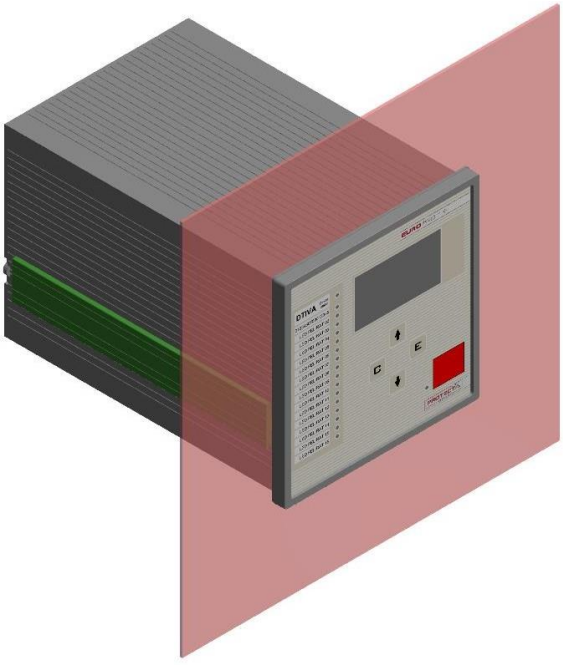
## DIMENSION AND PANEL CUT-OUT

- **Flush mounting of 24HP panel instrument case**



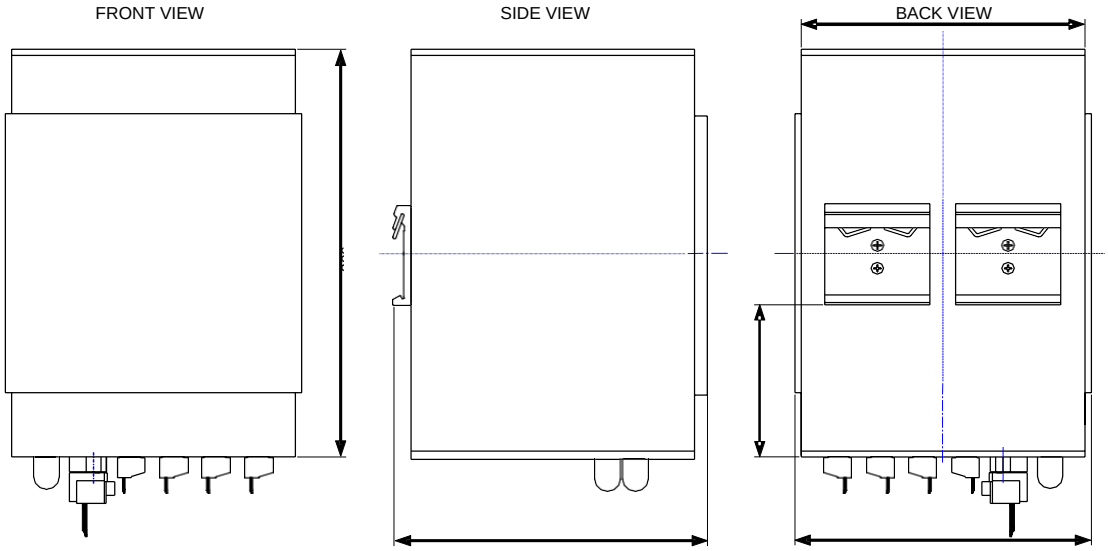

PANEL CUT-OUT



*S24 Series flush mounting method*

- **Din rail mounting of 24HP panel instrument case**





*S24 Series din rail mounting method*

## HARDWARE CONFIGURATION

- **I/O configuration**

The standard number of inputs and outputs of each variant are listed in the table below.

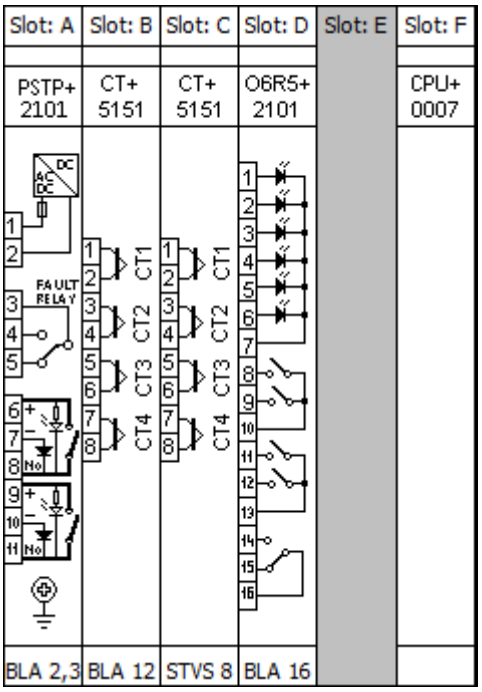
| Hardware configuration | Variant 5 |
|---|---|
| Current inputs (4th channel can be sensitive) | 8 |
| Voltage inputs | 0 |
| Binary inputs (BI) | 6* |
| Binary outputs (BO) | 5* |
| IRF( Internal fault relay) contact | 1 |
| Fast trip outputs | 2* |

*: as standard I/O card hardware configuration. The number of binary inputs, binary outputs, and fast trip outputs can be selected as optional (I/O card option)

The maximum available number of binary inputs and outputs of each variant are listed in the table below.

| Hardware configuration | Variant 5 |
|---|---|
| Current inputs (4th channel can be sensitive) | 8 |
| Voltage inputs | 0 |
| Binary inputs (BI) | 33 |
| Binary outputs (BO) | 24 |
| IRF( Internal fault relay) contact | 1 |
| Fast trip outputs | 2 |

- **Module arrangement**



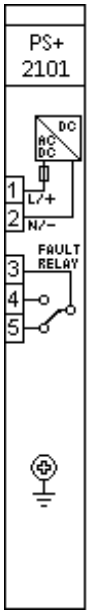
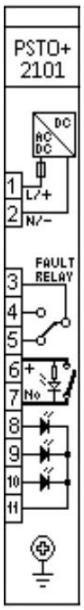
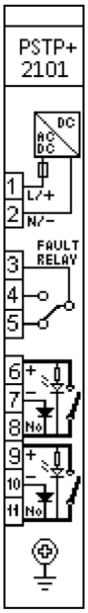
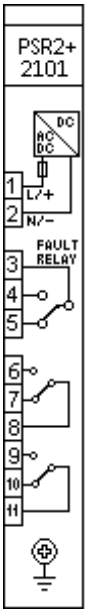
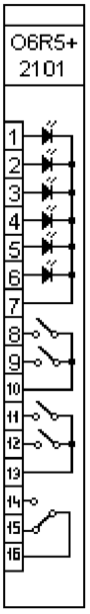
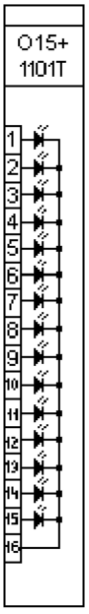
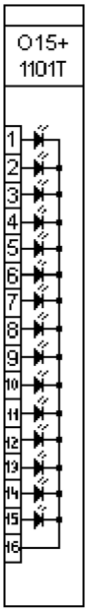
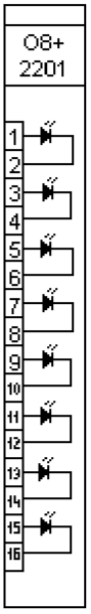
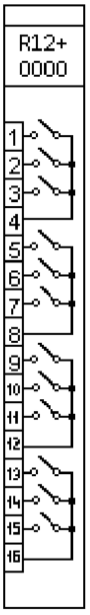
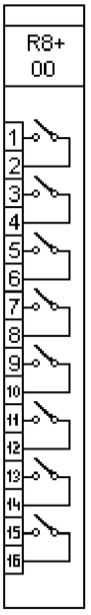

S24 *Variant 5 default hardware layout*

- **I/O module options**

| IO card type | Slot A | Slot B | Slot C | Slot D | Slot E |
|---|---|---|---|---|---|
| PS | Option | N/A | N/A | N/A | N/A |
| PSTO | Option | N/A | N/A | N/A | N/A |
| PSTP | Option | N/A | N/A | N/A | N/A |
| PSR2 | Option | N/A | N/A | N/A | N/A |
| O6R5 | N/A | N/A | N/A | Standard | Option |
| O15 | N/A | N/A | N/A | Option | Option |
| O12 | N/A | N/A | N/A | Option | Option |
| O8 | N/A | N/A | N/A | Option | Option |
| R12 | N/A | N/A | N/A | Option | Option |
| R8 | N/A | N/A | N/A | Option | Option |

*I/O module options*

- **I/O module types**

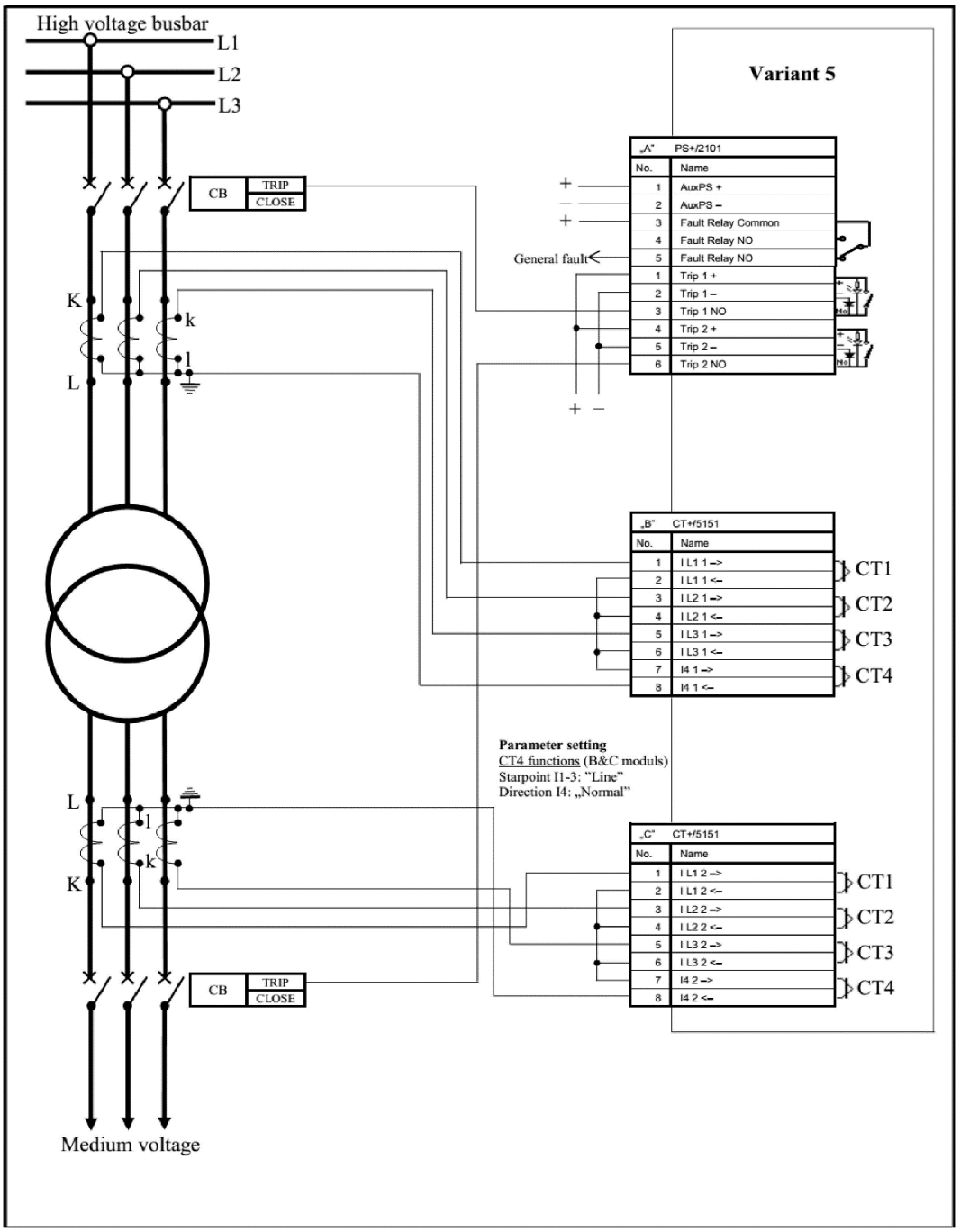
| PS (IRF) | PSTO (3BI/1BO) | PSTP (2BO) | PSR2 (2BO) | O6R5 (6BI/5BO) | O15 (15BI) | O12 (12BI) | O8 (8BI) | R12 (12BO) | R8 (8BI) |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |



*I/O module types*

## EXTERNAL CONNECTION DIAGRAM

- **S24 – Variant 5**




*Typical connection diagram for the S24 – Variant 5*

## CONTACT

For more information, please refer to the **S24 Series Variant 5** configuration description document or contact us:

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