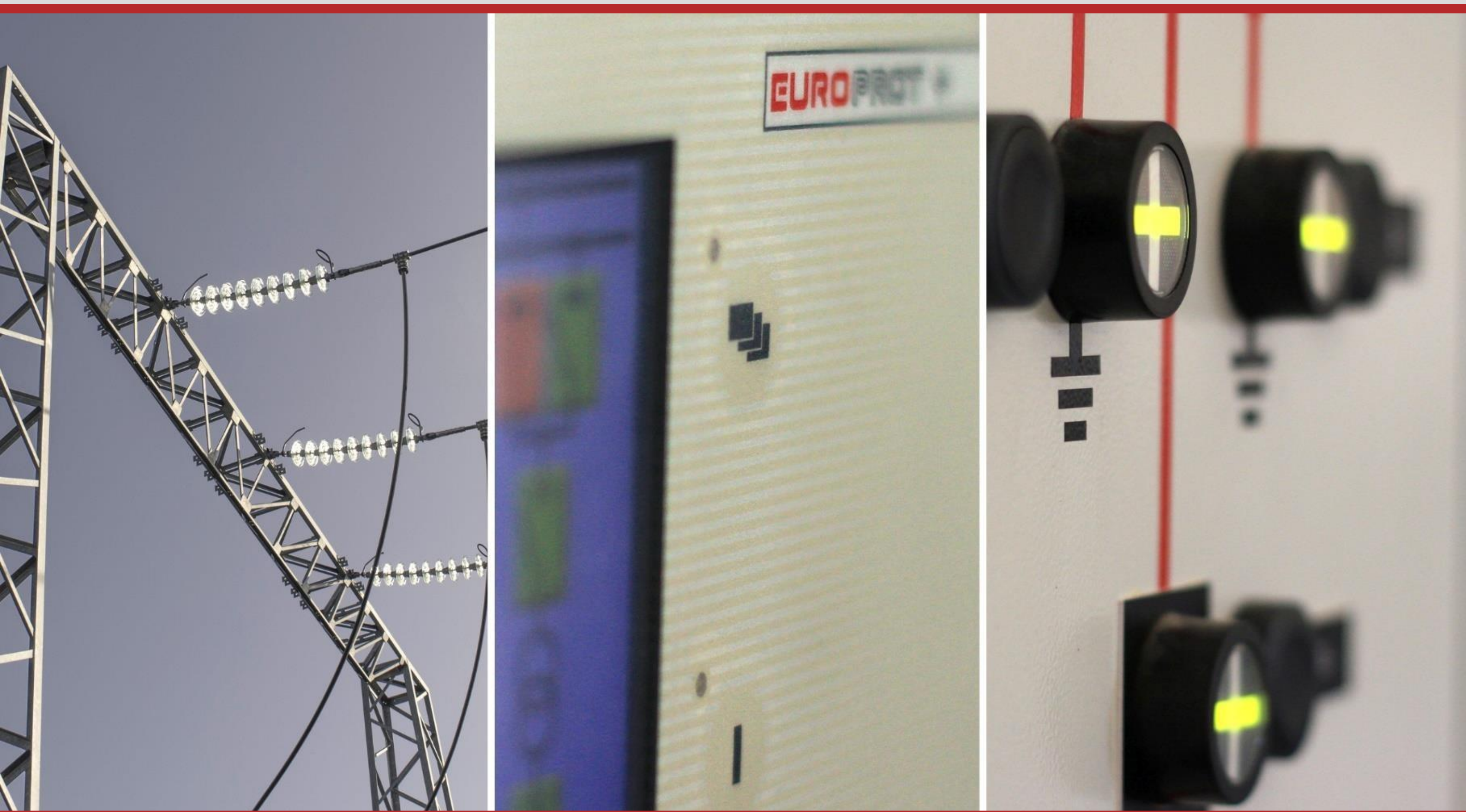


PRODUCT DESCRIPTION

EuroProt+ DTVA

IED-EP+/DTVA

LINE PROTECTION RELAY

PROTECTA HUNGARY

EUROPROT+ DTVA

LINE PROTECTION RELAY

OVERVIEW

The **DTVA** product type is a member of the **EuroProt+** numerical protection relay, made by Protecta Co. Ltd. The **EuroProt+** 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 members of the **DTVA** product type are configured to protect and control transmission line.

GENERAL FEATURES

- Native IEC 61850 IED with Edition 1 & 2 compatibility
- Module layouts with options 42 or 84 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 online. 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 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

The **DTVA** product type is configured to protect, control and supervise the elements of the transmission network, where systems are typically solidly grounded worldwide. In these networks single phase-to-ground faults result in high currents comparable to line-to-line faults; therefore, both types of faults need fast protection functions.

The relay can be used for single- or three-phase tripping and it supports double breaker terminals such as breaker and a half or ring bus topology.

The main protection functions of the **DTVA** type include high-speed distance protection with five independent protection zones and line differential protection. The relays support the general teleprotection schemes (POTT, PUTT etc.).

Additionally, the **DTVA** product type includes a variety of versatile protection functions: directional and non- directional overcurrent protection, voltage-based protection and frequency-based protection.

The HV automatic reclosing function provides multi- shot autoreclosing with a synchro-check feature. The dead times can be set individually for each cycle and separately for single-phase faults and multi-phase faults.

Because of the implemented control, measuring and monitoring function, the IED can also be used as a bay control unit.

SCOPE OF APPLICATION

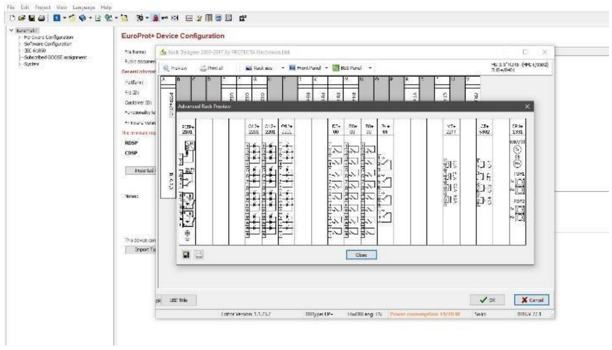
- The main fields of application are transmission overhead lines including series-compensated lines and underground cable protection
- The main protection is phase-selective line differential protection:
  - Optional redundant communication via two physical links in 2-end topology,
  - 3- end topology handling,
  - CT error and CT saturation detection,
  - Optional capacitive charging current compensation,
  - Wide range of communication schemes supported: dedicated fiber optic channel, pilot wire, communication networks using G703.1 (64kbit/s)
  - Transformer can be placed in the protected zone
  - 1-/3-phase tripping and support for double breaker terminals such as breaker and a half or ring bus topologies
- Five independent distance protection zones with polygon-shaped or MHO characteristics:
  - Load encroachment characteristics
  - Analogue input processing is applied to the zero sequence current of the parallel line.
  - The complex earth-fault compensation factor is applied for the correct impedance measurement of single-phase-to-earth faults
  - The power swing detection function can block the distance protection function in case of stable swings, or it can generate a trip command if the system operates out of step
  - Numerous transfer tripping schemes available (PUTT, POTT, DUTT, Directional Compensation or Blocking, etc.)
  - Current reversal and weak-end infeed logic
- Binary signal transmission or teleprotection with remote-end communication via several kinds of communication schemes
- Non-directional impedance protection function or high-speed OC protection function is applied in case of switch-onto-fault conditions
- Autoreclosing up to four shots of reclosing; dead times can be set individually for each reclosing sequence separately for single-phase faults and for multi-phase faults
- Full-scheme faulty phase identification by minimum impedance detection
- VT supervision and dead line detection Current unbalance detection of CT
- Switchgear automation and control with synchro-check/synchro-switch capability
- Programmable interlocking schemes
- Back-up protection for transformers, lines, generators, motors, busbars
- Optional decentralized busbar protection sub-unit application

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.

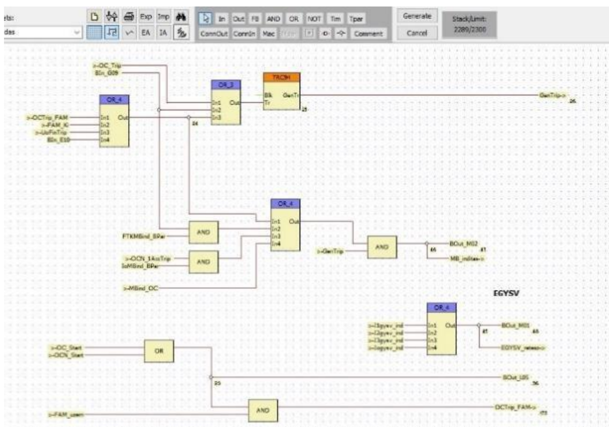
- **HW configuration**

- 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

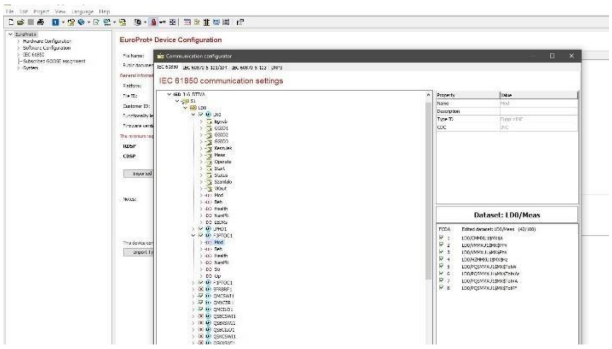


- **Communication configurator**

- Set up IEC 61850, 101-104, 103, DNP3 communication protocols
- Configure dataset, report and goose control block

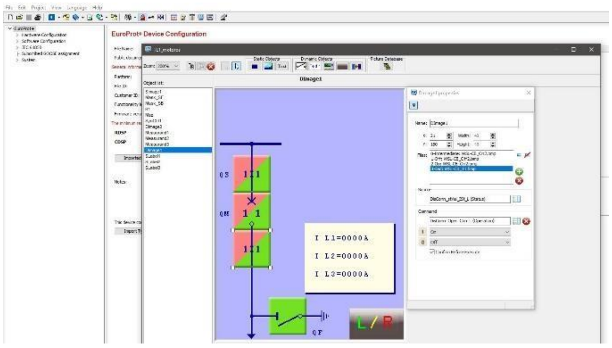
properties for IEC 61850 horizontal and vertical communication

- 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

- **Pre-defined configuration variants**

The **DTVA** configuration measures three phase currents, the zero sequence current component of the parallel line and additionally three phase voltages and the busbar voltage. These measurements allow, in addition to the current- and voltage-based functions, directionality extension of the configured phase overcurrent and residual overcurrent function and also directional overpower or underpower functions.

There are two main protection functions in this application: they are the distance protection function and also the line differential protection function.

The distance protection function can generate three-phase or single phase trip commands, depending on the fault types and the requirements.

The communication hardware module sends and receives phase current vectors to realize the line differential protection function. The choice of the functions is extended with the automatic reclosing function, synchro-check and switch-onto-fault logic.

Based on the voltage measurement also the frequency is evaluated to realize frequency- based protection functions.

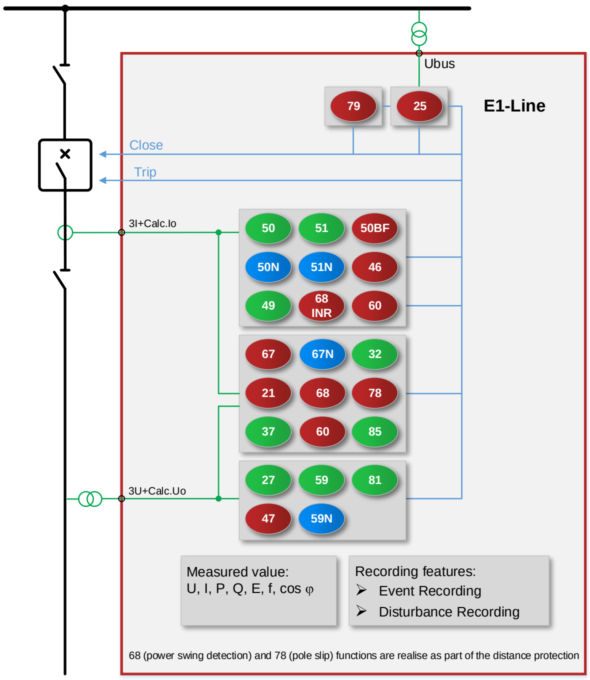
The number and the functionality of the members of each product type is put together according to the application philosophy, keeping in mind the possible main usages. The available configurations of the **DTVA** type are listed in the table below.

VARIANT	MAIN APPLICATION
E1-Line	High-voltage distance protection, control and automation
E2-Line	Combined high-voltage distance and line differential protection, control and automation

- **E1-Line High-voltage distance protection, control and automation**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Distance protection	Z<,FL	21	1
Synchrocheck	SYNC	25	1
Definite time undervoltage protection	U <, U <<	27	2
Directional overpower protection	P >	32	2
Directional underpower protection	P <	37	2
Negative sequence overcurrent protection	I2 >	46	2
Broken conductor protection	I2/I1>	46BC	1
Negative sequence definite time overvoltage protection	U2 >	47	2
Thermal protection	T >	49	1
Three-phase instantaneous overcurrent protection	I >>>	50	1
Residual instantaneous overcurrent protection	Io >>>	50N	1
Breaker failure protection	CBFP	50BF	1
Three-phase time overcurrent protection	I >, I >>	51	3
Residual overcurrent protection	Io >, Io >>	51N	3
Definite time overvoltage protection	U >, U >>	59	2
Residual definite time overvoltage protection	Uo >, Uo >>	59N	2
Current unbalance protection		60	1
Voltage transformer supervision and dead line detection		60	1
Directional three-phase overcurrent protection	I Dir >, I Dir >>	67	4
Directional residual time overcurrent protection	Io Dir >, Io Dir >>	67N	4
Power swing detection		68	1
Inrush current detection	I2h >	68	1
Trip circuit supervision		74	1
Out-of-step	ΔZ/Δt	78	1
Auto-reclose	0 → 1	79	1
Overfrequency protection	f >, f >>	81O	4
Overfrequency protection	f <, f <<	81U	4
Rate of change of frequency protection	df/dt	81R	2
Teleprotection		85	1
Lockout trip logic function		86/94	1
Switch onto fault			1

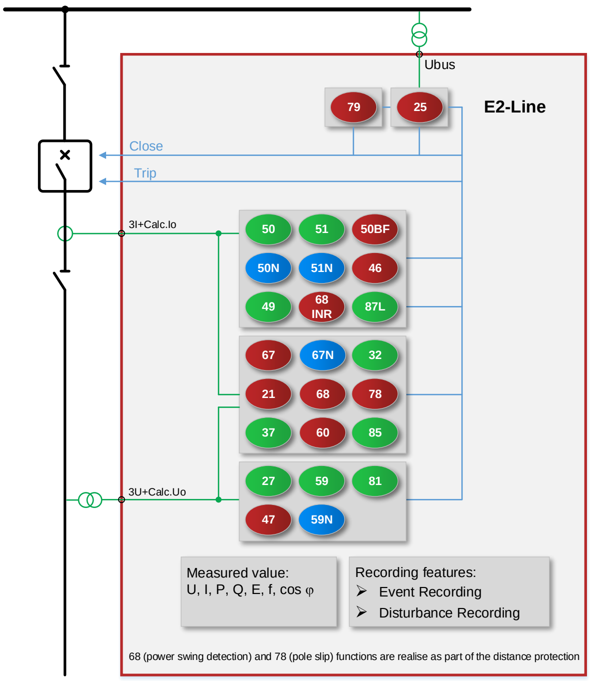
**The Inst. column contains the numbers of the pre-configured function blocks in the factory configuration. These numbers may be different in order to meet the user's requirements.*



- **E2-Line Combined high-voltage distance and line differential protection, control and automation**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Distance protection	Z<,FL	21	1
Synchrocheck	SYNC	25	1
Definite time undervoltage protection	U <, U <<	27	2
Directional overpower protection	P >	32	2
Directional underpower protecton	P <	37	2
Negative sequence overcurrent protection	I2 >	46	2
Broken conductor protection	I2/I1>	46BC	1
Negative sequence definite time overvoltage protection	U2 >	47	2
Thermal protection	T >	49	1
Three-phase instantaneous overcurrent protection	I >>>	50	1
Residual instantaneous overcurrent protection	Io >>>	50N	1
Breaker failure protection	CBFP	50BF	1
Three-phase time overcurrent protection	I >, I >>	51	3
Residual overcurrent protection	Io >, Io >>	51N	3
Definite time overvoltage protection	U >, U >>	59	2
Residual definite time overvoltage protection	Uo >, Uo >>	59N	2
Current unbalance		60	1
Voltage transformer supervision and dead line detection		60	1
Directional three-phase overcurrent protection	I Dir >, I Dir >>	67	4
Directional residual time overcurrent protection	Io Dir >, Io Dir >>	67N	4
Power swing detection		68	1
Inrush current detection	I2h >	68	1
Trip circuit supervision		74	1
Out-of-step	ΔZ/Δt	78	1
Auto-reclose	0 → 1	79	1
Overfrequency protection	f >, f >>	81O	4
Overfrequency protection	f <, f <<	81U	4
Rate of change of frequency protection	df/dt	81R	2
Teleprotection		85	1
Lockout trip logic function		86/94	1
Line differential protection	3IdL >	87L	1
Switch onto fault			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.

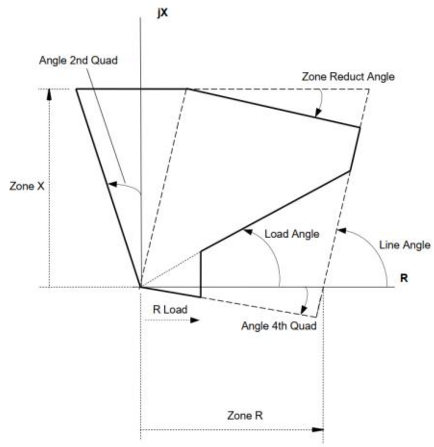
- **Distance protection (21)**

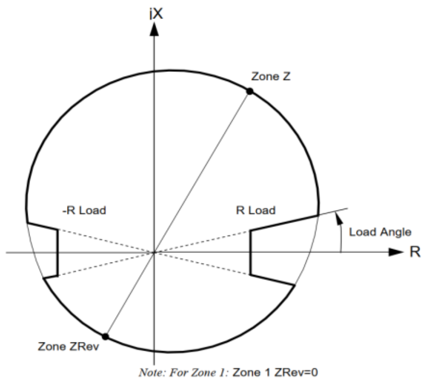
The distance protection function provides main protection for overhead lines and cables of solidly grounded networks. Its main features are as follows:

- A full-scheme system provides continuous measurement of impedance separately in three independent phase-to-phase measuring loops as well as in three independent phase-to-earth measuring loops.
- The complex earth fault compensation factor is applied for correct impedance measuring on single-phase-to-earth fault.
- Analogue input processing is applied to the zero sequence current of the parallel line.
- Impedance calculation is conditional of the values of phase currents being sufficient. The current is considered to be sufficient for impedance calculation if it is above the level

set by parameter.

- To decide the presence or absence of the zero sequence current, biased characteristics are applied.
- Full-scheme faulty phase identification by minimum impedance detection.
- Five independent distance protection zones are configured.
- The operating decision is based on polygon-shaped or Mho characteristics





- Load encroachment characteristics can be selected (see Figure) determined by two parameters.
- The directional decision is dynamically based on:
  - measured loop voltages if they are sufficient for decision,
  - healthy phase voltages if they are available for asymmetrical faults,
  - voltages stored in the memory if they are available,
- Directional decision of any zones can be reversed.
- The operation of any zones is non-directional if it is optionally selected.
- The distance protection function can operate properly if CVT is applied as well.
- Non-directional impedance protection function or high speed OC protection function is applied in case of switch-onto-fault.
- Distance-to-fault evaluation is implemented (fault locator function).
- Binary input signals and conditions can influence the operation:
  - blocking/enabling
  - VT failure signal
- Integrated high-speed overcurrent back-up function is also implemented.
- The power swing detection function can block the distance protection function in case of stable swings, or it can generate a trip command if the system operates out of step.

▪ **Synchro check, synchro switch (25)**

Several problems can occur in the electric power system if the circuit breaker closes and connects two systems operating asynchronously. The high current surge can cause damage in the interconnecting elements, the accelerating forces can overstress the shafts of rotating machines or, at last, the actions taken by the protective system can result in the unwanted separation of parts of the electric power system. To prevent such problems, this function checks whether the systems to be interconnected are operating synchronously. If yes, then the close command is transmitted to the circuit breaker. In case of asynchronous operation, the close command is delayed to wait for the appropriate vector position of the voltage vectors on both sides of the circuit breaker. If the conditions for safe closing cannot be fulfilled within an expected time, then closing is declined.

There are three modes of operation:

- Energizing check:
  - Dead bus, live line,
  - Live bus, dead line,
  - Any Energizing Case (including Dead bus, dead line).
- Synchro check (Live line, live bus)
- Synchro switch (Live line, live bus)

The function can be started by the switching request signals initiated both the automatic reclosing and the manual closing. The binary input signals are defined by the user, applying the graphic equation editor.

Blocking signal of the function are defined by the user, applying the graphic equation editor. Blocking signal of the voltage transformer supervision function for all voltage sources are defined by the user, applying the graphic equation editor.

Signal to interrupt (cancel) the automatic or the manual switching procedure are defined by the user, applying the graphic equation editor.

▪ **Definite time undervoltage protection (27)**

The definite time undervoltage protection function measures the RMS values of the fundamental Fourier component of three phase voltages. The Fourier calculation inputs are the sampled values of the three phase voltages (UL1, UL2, UL3), and the outputs are the basic Fourier components of the analyzed voltages (UL1Four, UL2Four, UL3Four). They are not part of the TUV27 function; they belong to the preparatory phase.

The function generates start signals for the phases individually. The general start signal is generated if the voltage is below the preset starting level parameter setting value and above the defined blocking level. The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The operation mode can be chosen by the type selection parameter. The function can be disabled, and can be set to “1 out of 3”, “2 out of 3”, and “All”.

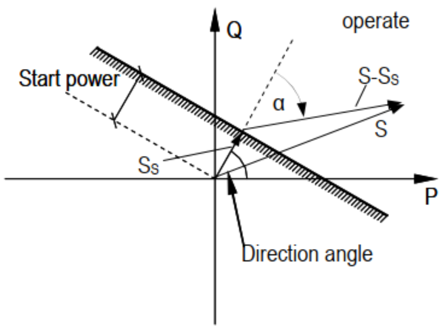
The overvoltage protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

- **Directional over-power protection (32)**

The directional over-power protection function can be applied to protect any elements of the electric power system mainly generators if the active and/or reactive power has to be limited.

The inputs of the function are the Fourier basic harmonic components of the three phase currents and those of the three phase voltages. Based on the measured voltages and currents, the block calculates the three-phase activeand reactive power (point S) and compares the P-Q coordinates with the defined characteristics on the power plane. The characteristic is defined as a line laying on the point SS and perpendicular to the direction of SS. The SS point is defined by the “Start power” magnitude and the “Direction angle”. The over-power function operates if the angle of the S-SS vector related to the directional line is below 90 degrees and above -90 degrees.

At operation, the “Start power” value is decreased by a hysteresis value.

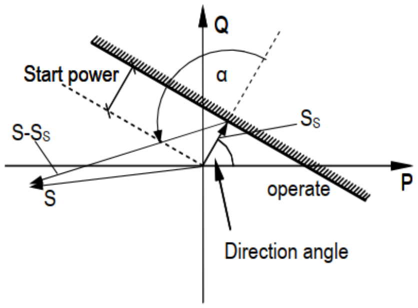


- **Directional under-power protection (37)**

The directional under-power protection function can be applied mainly to protect any elements of the electric power system, mainly generators, if the active and/or reactive power has to be limited in respect of the allowed minimum power.

The inputs of the function are the Fourier basic harmonic components of the three phase currents and those of the three phase voltages. Based on the measured voltages and currents, the block calculates the three-phase active and reactive power (point S) and compares the P-Q coordinates with the defined characteristics on the power plane. The characteristic is defined as a line laying on the point SS and perpendicular to the direction of SS. The SS point is defined by the “Start power” magnitude and the “Direction angle”. The under-power function operates if the angle of the S-SS vector related to the directional line is above 90 degrees or below -90 degrees, i.e. if the point S is on the “Operate” side of the P-Q plane.

At operation, the “Start power” value is increased by a hysteresis value.



- **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.

- **Broken conductor protection (46BC)**

The broken conductor protection function can be applied to detect a power lines and cables broken conductor condition or a single-pole breaker malfunction condition.

By measuring the phase current input signals and compares the ratio of negative phase sequence current (I2) to positive phase sequence current (I1). If the I2/I1 ratio is above the setting limit, the function generates a start signal. It is a necessary precondition of start signal generation that the positive phase sequence current (I1) must be between 6.67% and 100% of the rated current.

The function can be disabled by parameter setting, and by an input signal programmed by the user with the graphic programming tool. The trip command is generated after the defined time delay if trip command is enabled by parameter setting.

- **Negative sequence definite time overvoltage protection (47)**

The definite time negative sequence overvoltage protection function measures three voltages and calculates the negative sequence component. If the negative sequence component is above the level defined by parameter setting, then a start signal is generated. The function generates a start signal. The general start signal is generated if the negative sequence voltage component is above the level defined by parameter setting value. The function generates a trip command only if the time delay has expired and the parameter selection requires a trip command as well.

The function can be disabled by parameter setting or by an external signal, edited by the graphic logic 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.

- **Definite time overvoltage protection (59)**

The definite time overvoltage protection function measures three voltages. The measured values of the characteristic quantity are the RMS values of the basic Fourier components of the phase voltages. The Fourier calculation inputs are the sampled values of the three phase voltages (UL1, UL2, UL3), and the outputs are the basic Fourier components of the analyzed voltages (UL1Four, UL2Four, UL3Four). They are not part of the 59 function; they belong to the preparatory phase.

The function generates start signals for the phases individually. The general start signal is generated if the voltage in any of the three measured voltages is above the level defined by parameter setting value. The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The overvoltage 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 definite time overvoltage protection (59N)**

The residual definite time overvoltage protection function operates according to definite time characteristics, using the RMS values of the fundamental Fourier component of the zero sequence voltage (UN=3Uo). The Fourier calculation inputs are the sampled values of the residual or neutral voltage (UN=3Uo) and the outputs are the RMS value of the basic Fourier components of those.

The function generates start signal if the residual voltage is above the level defined by parameter setting value. The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The residual overvoltage 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.

- **Voltage transformer supervision (VTS60)**

The voltage transformer supervision function generates a signal to indicate an error in the voltage transformer secondary circuit. This signal can serve, for example, as a warning, indicating disturbances in the measurement, or it can disable the operation of the distance protection function if appropriate measured voltage signals are not available for a distance decision.

The voltage transformer supervision function is designed to detect faulty asymmetrical states of the voltage transformer circuit caused, for example, by a broken conductor in the secondary circuit. The user has to generate graphic equations for the application of the signal of this voltage transformer supervision function.

The voltage transformer supervision function can be used in three different modes of application:

- Zero sequence detection (for typical applications in systems with grounded neutral): “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) is below the preset current value.
- Negative sequence detection (for typical applications in systems with isolated or resonant grounded (Petersen) neutral): “VT failure” signal is generated if the negative sequence voltage component (U2) is above the preset voltage value AND the negative sequence current component (I2) is below the preset current value.
- Special application: “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) AND the negative sequence current component (I2) are below the preset current values.

The voltage transformer supervision function can be activated if “Live line” status is detected for at least 200 ms. This delay avoids mal-operation at line energizing if the poles of the circuit breaker make contact with a time delay. The function is set to be inactive if “Dead line” status is detected.

If the conditions specified by the selected mode of operation are fulfilled (for at least 4 milliseconds) then the voltage transformer supervision function is activated and the operation signal is generated. (When evaluating this time delay, the natural operating time of the applied Fourier algorithm must also be considered.

- **Three-phase directional overcurrent protection (67)**

The directional three-phase overcurrent protection function can be applied on solidly grounded, compensated or isolated networks, where the overcurrent protection must be supplemented with a directional decision.

The direction can be selected as forward or backward. The overcurrent decision can be set also without considering the decision.

The overcurrent decision can be based on current RMS values or on Fourier fundamental harmonic values.

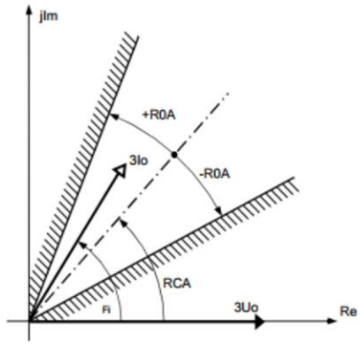
The time overcurrent characteristic can be definite time or several types of standard IEC or ANSI characteristics.

The function can be enabled or disabled by a parameter. The status signal of the VTS (voltage transformer supervision) function can also disable the directional operation.

- **Residual directional overcurrent protection (67N/67Ns)**

The main application area of the directional residual delayed overcurrent protection function is an earth-fault protection.

The inputs of the function are the RMS value of the Fourier basic harmonic components of the zero sequence current (IN=3Io) and those of the zero sequence voltage (UN=3Uo).



The block of the directional decision generates a signal of TRUE value if the $U_N=3U_o$ zero sequence voltage and the $I_N=3I_o$ zero sequence current are above the limits needed for correct directional decision, and the angle difference between the vectors is within the preset range. The decision enables the output start and trip signal of an overcurrent protection function block (51N/51Ns). This non- directional residual overcurrent protection function block is described in a separate document. The directional decision module calculates the phase angle between the residual voltage and the residual current. The reference signal is the residual voltage according to the Figure.

The output of the directional decision module is OK, namely it is TRUE if the phase angle between the residual voltage and the residual current is within the limit range defined by the preset parameter OR if non-directional operation is selected by the preset parameter (Direction=NonDir).

If the relay is equipped with the current transformer module with a sensitive channel (4th channel), the function will be considered as sensitive residual directional overcurrent protection (67Ns) for use in applications where the fault current magnitude may be very low.

- **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.)

- **Out-of-step protection (78)**

The pole slipping protection function can be applied mainly for synchronous generators. If a generator falls out of synchronism, then the voltage vector induced by the generator rotates slower or with a higher speed as compared to voltage vectors of the network. The result is that according to the frequency difference of the two vector systems, the cyclical voltage difference on the current carrying elements of the network are overloaded cyclically. To protect the stator coils from the harmful effects of the high currents and to protect the network elements, a disconnection is required.

The pole slipping protection function is designed for this purpose.

Main features

The main features of the pole slipping protection function are as follows:

- A full-scheme system provides continuous measurement of impedances separately in three independent phase-to-phase measuring loops.
- Impedance calculation is conditional on the values of the positive sequence currents being above a defined value.
- A further condition of the operation is that the negative sequence current component is less than 1/6 of the value defined for the positive sequence component.
- The operate decision is based on quadrilateral characteristics on the impedance plane using four setting parameters.
- The number of vector revolutions can be set by a parameter.
- The duration of the trip signal is set by a parameter.
- Blocking/enabling binary input signal can influence the operation.

- **Auto-reclose (79)**

The automatic reclosing function can realize up to four shots of reclosing. The dead time can be set individually for each reclosing and separately for earth faults and for multi-phase faults. All shots are of three phase reclosing. The starting signal of the cycles can be generated by any combination of the protection functions or external signals of the binary inputs.

The automatic reclosing function is triggered if as a consequence of a fault a protection function generates a trip command to the circuit breaker and the protection function resets because the fault current drops to zero or the circuit breaker's auxiliary contact signals open state. According to the preset parameter values, either of these two conditions starts counting the dead time, at the end of which the automatic reclosing function generates a close command automatically. If the fault still exits or reappears, then within the "Reclaim time" the protection functions picks up again and the subsequent cycle is started. If the fault still exists at the end of the last cycle, the automatic reclosing function trips and generates the signal for final trip. If no pickup is detected within this time, then the automatic reclosing cycle resets and a new fault will start the procedure with the first cycle again.

At the moment of generating the close command, the circuit breaker must be ready for operation, which is signaled via the binary input "CB Ready". The preset parameter value "CB Supervision time" decides how long the automatic reclosing function is allowed to wait at the end of the dead time for this signal. If the signal is not received during this dead time extension, then the automatic reclosing function terminates.

Depending on binary parameter settings, the automatic reclosing function block can accelerate trip commands of the individual reclosing cycles. This function needs user-programmed graphic equations to generate the accelerated trip command. The automatic reclosing function can be blocked by a binary input. The conditions are defined by the user applying the graphic equation editor.

- **Over-frequency protection (81O)**

The deviation of the frequency from the rated system frequency indicates unbalance between the generated power and the load demand. If the available generation is large compared to the consumption by the load connected to the power system, then the system frequency is above the rated value. The over-frequency protection function is usually applied to decrease generation to control the system frequency. Another possible application is the detection of unintended island operation of distributed generation and some consumers. In the island, there is low probability that the power generated is the same as consumption; accordingly, the detection of high frequency can be one of the indication of island operation.

The over-frequency protection function generates a start signal if at least five measured frequency values are above the preset level. Time delay can also be set.

The function can be enabled/disabled by a parameter.

The over-frequency protection function has a binary input signal. The conditions of the input signal are defined by the user, applying the graphic equation editor. The signal can block the under-frequency protection function.

- **Underfrequency protection (81U)**

The deviation of the frequency from the rated system frequency indicates unbalance between the generated power and the load demand. If the available generation is small compared to the consumption by the load connected to the power system, then the system frequency is below the rated value. The under-frequency protection function is usually applied to increase generation or for load shedding to control the system frequency. Another possible application is the detection of unintended island operation of distributed generation and some consumers. In the island, there is low probability that the power generated is the same as consumption; accordingly, the detection of low frequency can be one of the indications of island operation. Accurate frequency measurement is also the criterion for the synchro-check and synchro- switch functions.

The under-frequency protection function generates a start signal if at least five measured frequency values are below the setting value.Time delay can also be set.

The function can be enabled/disabled by a parameter.

The under-frequency protection function has a binary input signal. The conditions of the input signal are defined by the user, applying the graphic equation editor. The signal can block the under-frequency protection function.

- **Rate of change of frequency protection (81R)**

The deviation of the frequency from the rated system frequency indicates unbalance between the generated power and the load demand. If the available generation is large compared to the consumption by the load connected to the power system, then the system frequency is above the rated value, and if it is small, the frequency is below the rated value. If the unbalance is large, then the frequency changes rapidly. The rate of change of frequency protection function is usually applied to reset the balance between generation and consumption to control the system frequency. Another possible application is the detection of unintended island operation of distributed generation and some consumers. In the island, there is low probability that the power generated is the same as consumption; accordingly, the detection of a high rate of change of frequency can be an indication of island operation.

The rate of change of frequency protection function generates a start signal if the df/dt value is above the setting value. The rate of change of frequency is calculated as the difference of the frequency at the present sampling and at three periods earlier. Time delay can also be set.

The function can be enabled/disabled by a parameter.

The rate of change of frequency protection function has a binary input signal. The conditions of the input signal are defined by the user, applying the graphic equation editor. The signal can block the rate of change of frequency protection function.

- **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.

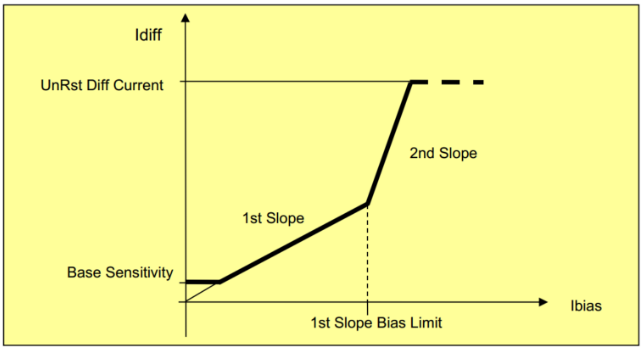
The trip requirements and the reset signal are programmed by the user, using the graphic equation editor.

- **Line differential protection (87L)**

The line differential protection function provides main protection for two terminal transmission lines. The line differential protection function does not apply vector shift compensation, thus transformers must be excluded from the protected section.

The operating principle is based on synchronized Fourier basic harmonic comparison between the line ends.

The devices at both line ends sample the phase currents and calculate the Fourier basic harmonic components. These components are exchanged between the devices synchronized via communication channels. The differential characteristic is a biased characteristic with two break points. Additionally, an unbiased overcurrent stage is applied, based on the calculated differential current.



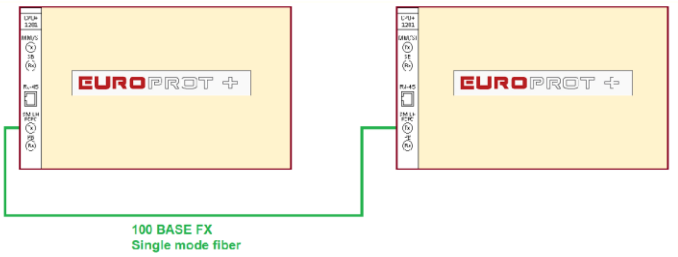
Line differential communication

Basically, the line differential protection is carried out either on **100Base-Fx fiber channel** or on a serial HDLC-based channel. The communication protocol and the frame structure in Ethernet case is relies on the **IEC61850-9-2LE** specification but the required bandwidth is approximately 1.5Mbit/s and some proprietary frame fields were introduced. The data communication layer utilizes VLANs as identification

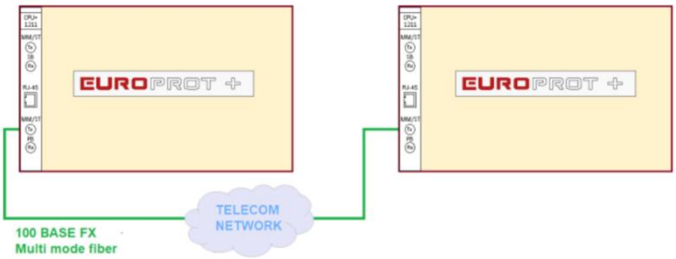
Direct link (peer-to-peer communication):

In case optical fiber is available between two substations, peer-to-peer communication mode is recommended with the following properties:

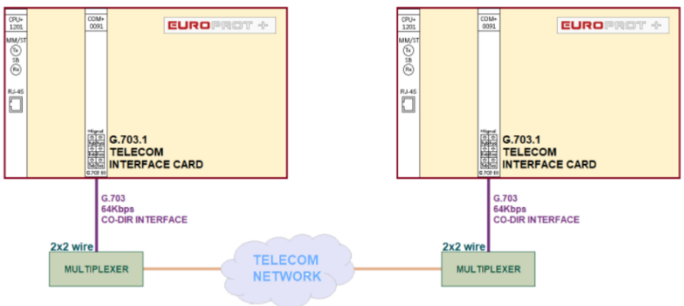
- Short-haul applications limited to 2km: multimode fiber
- Short-haul application up to 27dB line attenuation (50km in practice): single mode fiber 1550nm fiber
- Long-haul applications up to 35dB line attenuation (100-120km in practice): single mode 1550nm fiber.



Via LAN/Telecom network (peer-to-peer communication):

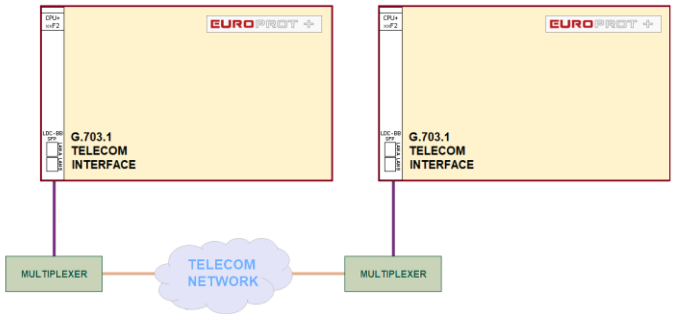


Communication via G.703 64kbit/s co-directional interface (E0)



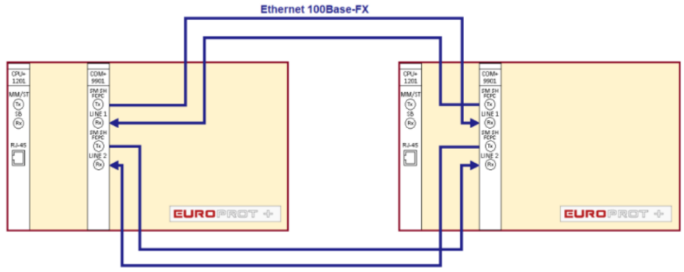
Communication via 2.048Mbit/s (E1/T1) Nx64kbit/s interface

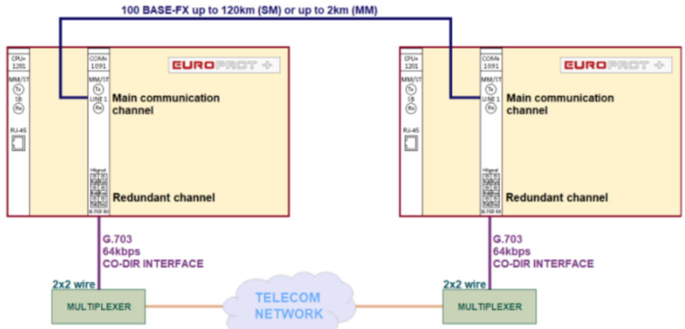
EuroProt+ devices support line differential communication via telecom networks with G703/704 2.048Mbit/s interface (E1). Besides, E1 in European networks the T1 interface (1.54Mbit/s) in America also available.



Redundant line differential communication:

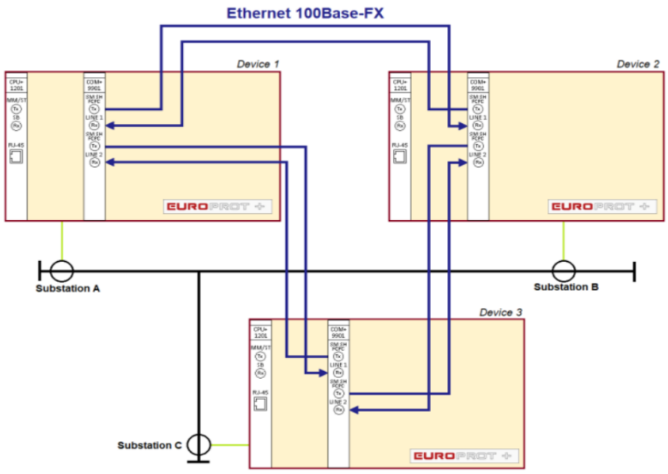
The data interchange over the two communication channels is carried out in parallel way which enables hot standby operation. In case of single point of failure in one of the links, the algorithm processes the data from the other link without switchover time





Three terminal line differential communication:

With an additional communication card, the EuroProt+ device allows three terminal line differential communication between protections. The communication channel in this case is Ethernet 100Base-Fx



- **Switch-onto-fault (SOFT)**

Some protection functions, e.g. distance protection, directional overcurrent protection, etc. need to decide the direction of the fault. This decision is based on the angle between the voltage and the current. In case of close-up faults, however, the voltage of the faulty loop is near zero: it is not sufficient for a directional decision. If there are no healthy phases, then the voltage samples stored in the memory are applied to decide if the fault is forward or reverse.

If the protected object is energized, the close command for the circuit breaker is received in “dead” condition. This means that the voltage samples stored in the memory have zero values. In this case the decision on the trip command is based on the programming of the protection function for the “switch-onto-fault” condition.

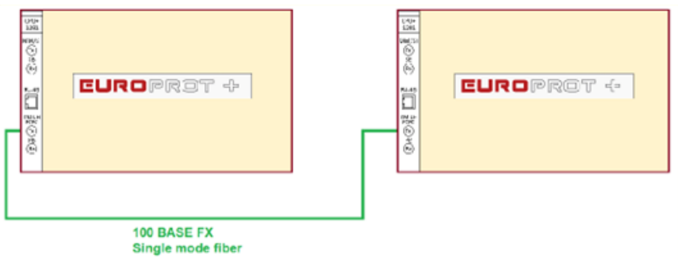
This “switch-onto-fault” detection function prepares the conditions for the subsequent decision. The function can handle both automatic and manual close commands.

- **Teleprotection (85)**

The non-unit protection functions, generally distance protection, can have two, three or even more zones available. These are usually arranged so that the shortest zone corresponds to an impedance slightly smaller than that of the protected section (underreach) and is normally instantaneous in operation. Zones with longer reach settings are normally time-delayed to achieve selectivity. As a consequence of the underreach setting, faults near the ends of the line are cleared with a considerable time delay. To accelerate this kind of operation, protective devices at the line ends exchange logic signals (teleprotection). These signals can be direct trip command, permissive or blocking signals.

The simple binary signal sent and received via a communication channel or via optically isolated inputs.

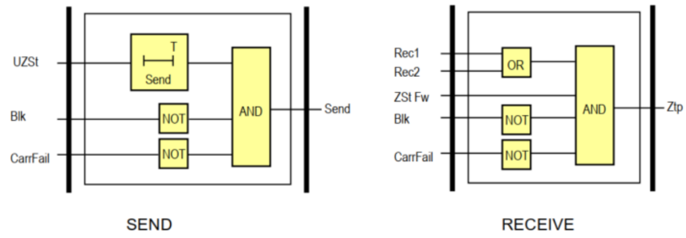
In the case of a direct fiber optic cable connection between two substations, directly connecting the two relays at both ends with a fiber optic cable is the solution used to send/receive teleprotection signals.



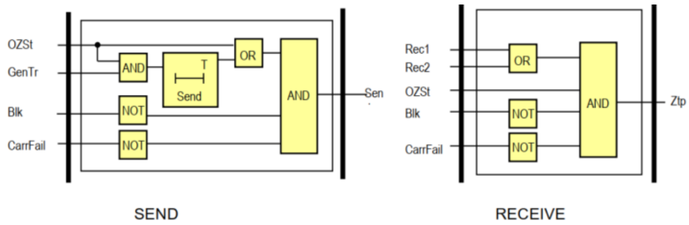
Transmission distance up to 2km if using multimode (short-haul) fiber optic cable; and up to 120km if using single mode fiber optic cable (Long-haul, 1550nm)

For the selection of one of the standard modes of operation, the function offers two enumerated parameters, Operation and PUTT Trip. With the parameter Operation, the following options are available: PUTT, POTT, Dir. Comparison, Dir. Blocking, DUTT while with the parameter PUTT Trip: with Start,with Overreach can be set.

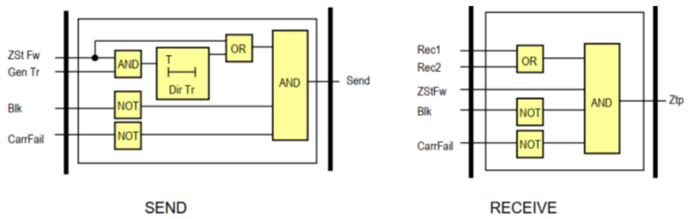
Permissive Underreach Transfer Trip (PUTT)



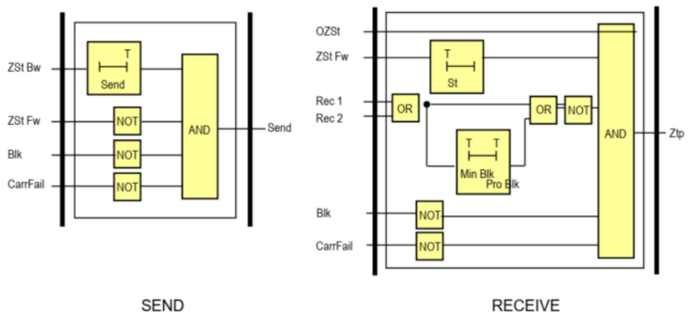
Permissive Overreach Transfer Trip (POTT)



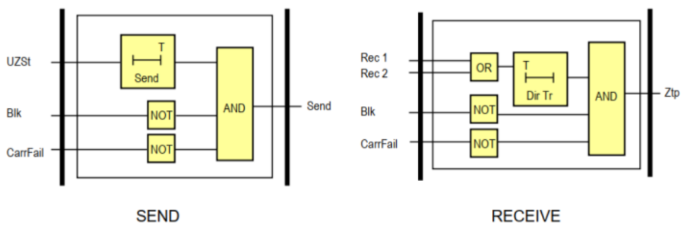
Directional comparison (Dir.Comparison)



Blocking directional comparison (Dir.Blocking)



Direct underreaching transfer trip (DUTT)



MEASUREMENT FUNCTIONS

- **Measurement functions**

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

Measurement functions	E1-Line	E2-Line
Current (I1, I2, I3, I4, Iseq (I0, I1, I2))	X	X
Voltage (U1, U2, U3, U4, U12, U23, U31, Useq (U0, U1, U2)) and frequency	X	X
Power (P, Q, S, pf) and Energy (E+, E-, Eq+, Eq-)	X	X
Circuit breaker wear	X	X
Supervised trip contacts (TCS)	X	X

The measurement functions of the DTVA configuration

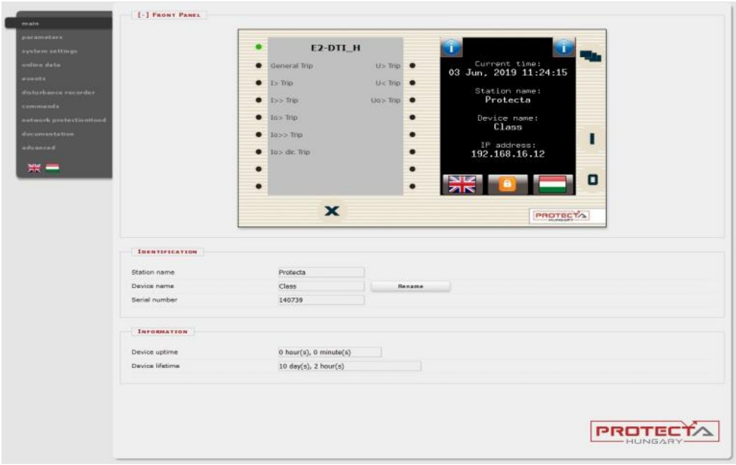
- **Monitoring functions**

The **DTVA** product type can monitor andetect current and voltage harmonics and short duration system disturbances such as:

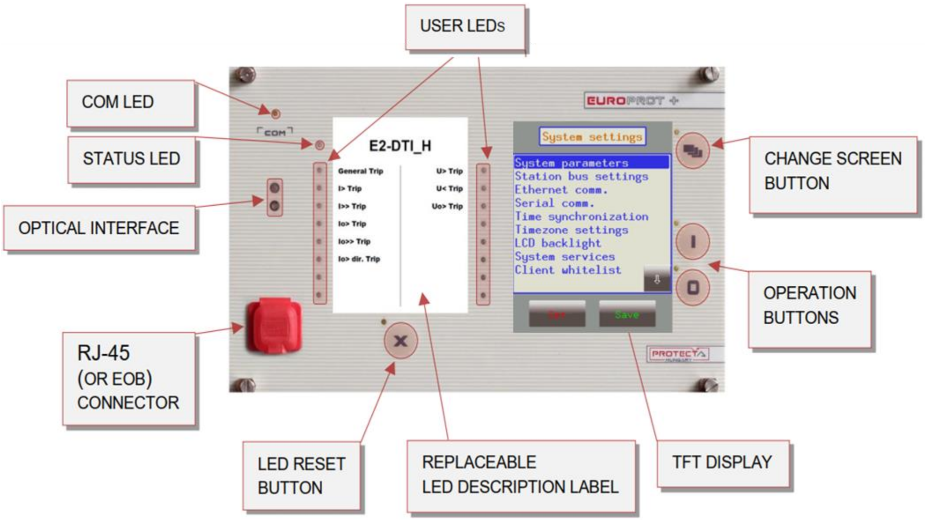
- Harmonics contents of each voltage and current channel (order 1st to order 19th)
- Current total demand distortion (TDD)
- Voltage total harmonic distortion (THD)
- Sags (Dips), Swells and Interrupts

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 records
  - Password management
  - Online data measurement
  - Commands
  - Administrative tasks



- **Front panel TFT display handling:** the interactive menu set is available through the TFT and the touchscreen interface.
- **User keys:** capacitive touch keys on 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
    - Process bus (100Base-FX Ethernet)
    - EOB or EOB2 (Ethernet Over Board) or RJ-4 Ethernet user interface on front panel
    - 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
    - Proprietary process bus communication controller on COM+ module

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
Distance protection function (21)	
Operation Zone1	Off, Forward, Backward
Operation Zone2	Off, Forward, Backward, NonDirectional
Operation Zone3	Off, Forward, Backward, NonDirectional
Operation Zone4	Off, Forward, Backward, NonDirectional
Operation Zone5	Off, Forward, Backward, NonDirectional
Operation power swing detection (PSD)	Off,1 out of 3, 2 out of 3, 3 out of 3
Operation Out-Of-Step	Off, On
SOTF Zone	Off, Zone1, Zone2, Zone3, Zone4, Zone5, HSOC
IPh Base Sens	10-30% in 1% steps
IRes Base Sens	10-50% in 1% steps
IRes Bias	5-30% in 1% steps
Angle 4th Quad	0-30deg in 1deg steps
Angle 2nd Quad	0-30deg in 1deg steps
Zone Reduct Angle	0-40deg in 1deg steps
Load Angle	0-45deg in 1deg steps
Line Angle	45-90deg in 1deg steps
PSD R_out/R_in	120-160% in 1% steps
PSD X_out/X_in	120-160% in 1% steps
SOTF Current	10-1000% in 1% steps
R and X setting values for the five zones individually:	
Zone1 R	0.1-320Ohm in 0.01Ohm steps
Zone2 R	0.1-320Ohm in 0.01Ohm steps
Zone3 R	0.1-320Ohm in 0.01Ohm steps
Zone4 R	0.1-320Ohm in 0.01Ohm steps
Zone5 R	0.1-320Ohm in 0.01Ohm steps
Zone1 X	0.1-320Ohm in 0.01Ohm steps

Zone2 X	0.1-320Ohm in 0.01Ohm steps
Zone3 X	0.1-320Ohm in 0.01Ohm steps
Zone4 X	0.1-320Ohm in 0.01Ohm steps
Zone5 X	0.1-320Ohm in 0.01Ohm steps
R Load	0.1-320Ohm in 0.01Ohm steps
Zero sequence current compensation factors:	
Zone1 (Xo-X1)/3X1	0-5 in 0.01 steps
Zone1 (Ro-R1)/3R1	0-5 in 0.01 steps
Zone2 (Xo-X1)/3X1	0-5 in 0.01 steps
Zone2 (Ro-R1)/3R1	0-5 in 0.01 steps
Zone3 (Xo-X1)/3X1	0-5 in 0.01 steps
Zone3 (Ro-R1)/3R1	0-5 in 0.01 steps
Zone4 (Xo-X1)/3X1	0-5 in 0.01 steps
Zone4 (Ro-R1)/3R1	0-5 in 0.01 steps
Zone5 (Xo-X1)/3X1	0-5 in 0.01 steps
Zone5 (Ro-R1)/3R1	0-5 in 0.01 steps
Parallel line coupling factor:	
Par Line Xm/3X1	0-5 in 0.01 steps
Par Line Rm/3X1	0-5 in 0.01 steps
Data of the for displaying distance:	
Line Length	0.1-1000km in 0.01km steps
Line Reactance	0.1-1000km in 0.01km steps
Characteristics for the PSD function:	
PSD Xinner	0.1-200Ohm in 0.01Ohm steps
PSD Xinner	0.1-200Ohm in 0.01Ohm steps
Time delay for the zones individually:	
Zone1 Time Delay	0-60000ms in 1ms steps
Zone2 Time Delay	0-60000ms in 1ms steps
Zone3 Time Delay	0-60000ms in 1ms steps
Zone4 Time Delay	0-60000ms in 1ms steps
Zone5 Time Delay	0-60000ms in 1ms steps
Parameters for the PSD function:	
PSD Time Delay	10-1000ms in 1ms steps
Very Slow Swing	100-10000ms in 1ms steps
PSD Reset	100-10000ms in 1ms steps
OutOfStep Pulse	50-1000ms in 1ms steps
Synchro check (25)	
Voltage Select	L1-N, L2-N, L3-N, L1-L2, L2-L3, L3-L1
Voltage Select	Off, On, ByPass
SynSW Auto	Off, On
Energizing Auto	Off, DeadBus LiveLine, LiveBus DeadLine, Any energ case
Operation Man	Off, On, ByPass
SynSW Man	Off, On
Energizing Man	Off,DeadBus LiveLine, LiveBus DeadLine, Any energ case
U Live	60-110% in 1% steps
U Dead	10-60% in 1% steps
Udiff Syncheck auto	5-30% in 1% steps
Udiff SynSW auto	5-30% in 1% steps
MaxPhaseDiff auto	5-80º in 1º steps
Udiff SynCheck Man	5-30% in 1% steps
Udiff SynSW Man	5-30% in 1% steps
MaxPhaseDiff Man	5-80º in 1º steps

FrDiff SynCheck Auto FrDiff SynSW Auto FrDiff SynCheck Man FrDiff SynSW Man Breaker Time Close Pulse Max Switch Time	0.02-0.5Hz in 0.02Hz steps 0.10-1.00Hz in 0.2Hz steps 0.02-0.5Hz in 0.02Hz steps 0.10-1.00Hz in 0.2Hz steps 0-500ms in 1ms steps 10-60000ms in 1ms steps 100-60000ms in 1ms steps
Definite time undervoltage protection (27)	
Operation Start Voltage Block Voltage Reset Ratio Time Delay	Off, 1 out of 3, 2 out of 3, All 30-130% in 1% steps 0-20% in 1% steps 1-10% in 1% steps 50-60000ms in 1ms steps
Directional overpower protection (32)	
Operation Direction Angle Start Power Time Delay	Off, On -179-180deg in 1deg steps 1-200% in 0.1% steps 0-60000ms in 1ms steps
Directional underpower protection (37)	
Operation Direction Angle Start Power Time Delay	Off, On -179-180deg in 1deg steps 1-200% in 0.1% steps 0-60000ms 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 Time Multiplier Minimal time delay for the inverse char. Definite time delay Reset time delay for the inverse char	5-3000% in 1% steps 0.05-999 in 0.01 steps 0-60000ms in 1ms steps 0-60000ms in 1ms steps 0-60000ms in 1ms steps
Broken conductor protection (46BC)	
Operation Start signal only Start current Time Delay	Off, On False, True 10-90% in 1% steps 100-60000ms in 1ms steps
Negative sequence overvoltage protection (47)	
Operation Start Voltage Time Delay	Off, On 2-40% in 1% steps 50-60000ms in 1ms steps
Thermal protection (49)	
Operation Alarm Temperature Trip Temperature	Off, Pulsed, Locked 60-200deg in 1deg steps 60-200deg in 1deg steps

Rated Temperature Base Temperature Unlock Temperature Ambient Temperature Startup Term Rated Load Current Time Constan	60-200deg in 1deg steps 0-40deg in 1deg steps 20-200deg in 1deg steps 0-40deg in 1deg steps 0-60% in 1% steps 20-150% in 1% steps 1-999min in 1min step
Three-phase instantaneous overcurrent protection (50)	
Operation Start current	Off, Peak value, Fundamental value 5-3000% in 1% steps
Breaker failure protection (50BF)	
Operation Retrip Start Ph Current Start Res Current Retrip Time Delay Backup Time Delay Pulse Duration	Off, Current, Contact, Current/Contact Off, On 20-200% in 1% steps 10-200% in 1% steps 0-1000ms in 1ms steps 100-60000ms in 1ms steps 0-60000ms in 1ms steps
Residual instantaneous overcurrent protection (50N/50Ns)	
Operation Start Current	Off, Peak value, Fundamental value 5-3000% in 1% steps
Three-phase time overcurrent protection (51)	
Operation Start current Time Multiplier Minimum time delay for the inverse char. Definite time delay for definite type char. Reset time delay for the IEC type inverse char.	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 5-3000% in 1% steps 0.05-999 in 0.01 steps 40-60000ms in 1ms steps 40-60000ms in 1ms steps 60-60000ms in 1ms steps
Residual time overcurrent protection (51N/51Ns)	
Operation Start current In = 1A or 5A In = 200mA or 1A Time Multiplier Minimum time delay for the inverse char. Definite time delay for definite type char. Reset time delay for the inverse char.	Off, DefiniteTime, IEC Inv,IEC VeryInv, IEC ExtInv,IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv 5-3000% in 1% steps 5-3000% in 1% steps 0.05-999 in 0.01 steps 40-60000ms in 1ms steps 40-60000ms in 1ms steps 60-60000ms in 1ms steps
Definite time overvoltage protection (59)	
Operation Start Voltage Reset Ratio	Off, On 30-130% in 1% steps 1-10% in 1% steps

Time Delay	0-60000ms in 1ms steps
Residual overvoltage protection (59N)	
Operation Start Voltage Time Delay	Off, On 2-60% in 1% steps 0-60000ms in 1ms steps
Current transformer supervision (60)	
Operation Start Signal Only Start Current Diff Time Delay	Off, On False, True 10-90% in 1% steps 100-60000ms in 1ms steps
Voltage transformer supervision (60)	
Operation Min Operate Voltage Min Operate Current Start URes Start IRes Start UNeg Start INeg	Off, Zero sequence, Negative sequence, Special 10-100% in 1% steps 2-100% in 1% steps 5-50% in 1% steps 10-50% in 1% steps 5-50% in 1% steps 10-50% in 1% steps
Three-phase directional overcurrent protection (67)	
Direction Operation Operating Angle Characteristic Angle Start Current Time Multiplier Minimum time delay for the inverse char. Definite time delay Reset time	NonDir, Forward, Backward Off, DefiniteTime, IEC Inv,IEC VeryInv, IEC ExtInv,IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv 30-80º in 1º steps 40-90º in 1º steps 5-3000% in 1% steps 0.05-999 in 0.01 steps 30-60000ms in 1ms steps 30-60000ms in 1ms steps 60-60000ms in 1ms steps
Residual directional overcurrent protection (67N/67Ns)	
Direction Operation Start Current URes Min IRes Min Operating Angle Characteristic Angle Time Multiplier Minimal time delay for the inverse char. Definite time delay Reset time delay for the inverse char.	NonDir, Forward - Angle, Backward Angle, Forward I*cos(fi), Backward- Angle, Forward-I*cos(fi), Backward - I*sin(fi), Forward-I*sin(fi+45), Backward - I*sin(fi+45) Off, DefiniteTime, IEC Inv,IEC VeryInv, IEC ExtInv,IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv 5-3000% in 1% steps 1-20% in 1% steps 1-50% in 1% steps 30-85º in 1º steps -180-180º in 1º steps 0.05-999 in 0.01 step 30-60000ms in 1ms steps 30-60000ms in 1ms steps 30-60000ms in 1ms steps
Inrush detection (68)	

Operation 2nd Harm Ratio Basic sensitivity of the function	Off, On 5-50% in 1% steps 20-100% in 1% steps
Out-of-step (78)	
Operation Max. cycle number I1LowLimit R forward X forward R backward X backward Dead time Trip pulse duration	Off, On 1-10cycle in 1cycle steps 50-200% in 1% steps 0.10-150.00Ohm in 0.01Ohm steps 0.10-150.00Ohm in 0.01Ohm steps 0.10-150.00Ohm in 0.01Ohm steps 0.10-150.00Ohm in 0.01Ohm steps 1000-60000ms in 1ms steps 50-10000ms in 1ms steps
Auto-reclose (79)	
Operation EarthFault RecCycle PhaseFault RecCycle Reclosing Started by 1. Dead Time Ph 2. Dead Time Ph 3. Dead Time Ph 4. Dead Time Ph 1. Dead Time EF 2. Dead Time EF 3. Dead Time EF 4. Dead Time EF Reclaim Time Close Command Time Dynamic Blocking Time Block after Man Close Action Time Start Signal Max Time DeadTime Max Delay CB Supervision Time SynCheck Max Time SynCheck Max Time CB State Monitoring Accelerate 1.Trip Accelerate 2.Trip Accelerate 3.Trip Accelerate 4.Trip	Off, On Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4. Enabled Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4. Enabled Trip reset, CB open 0-100000ms in 10ms steps 10-100000ms in 10ms steps 10-100000ms in 10ms steps 10-100000ms in 10ms steps 0-100000ms in 10ms steps 10-100000ms in 10ms steps 10-100000ms in 10ms steps 10-100000ms in 10ms steps 100-300000ms in 10ms steps 10-10000ms in 10ms steps 10-100000ms in 10ms steps 0-100000ms in 10ms steps 0-20000ms in 10ms steps 0-10000ms in 10ms steps 0-100000ms in 10ms steps 10-100000ms in 10ms steps 500-100000ms in 10ms steps 500-100000ms in 10ms steps False, True False, True False, True False, True False, True
Overfrequency protection (81O) Undefrequency protection (81U)	
Operation Start signal only Start frequency Time Delay Voltage limit	Off, On False, True 40-70Hz in 0.01Hz steps 0-60000ms in 1ms steps 0.3-1.0 Un

Rate of change of frequency protection (81R)	
Operation Start signal only Start df/dt Time Delay	Off, On False, True -5.00-5.00Hz/s in 0.01Hz/s steps 0-60000ms in 1ms steps
Lockout trip logic (86/94)	
Operation Min pulse duration	Off, On, Lockout 50-60000ms in 1ms steps
Line differential protection (87L)	
Operation Base Sensitivity 1st Slope 2nd Slope 1st Slope Bias Limit UnRst Diff Current Local Ratio Remote Ratio	Off, On 10-50% in 1% steps 10-50% in 1% steps 50-100% in 1% steps 100-400% in 1% steps 500-1000% in 1% steps 0.10-2.00 in 0.01 steps 0.10-2.00 in 0.01 steps
Switch-onto-fault (SOTF)	
Operation SOTF Drop Delay	Off, On 10-10000ms in 1ms steps
Teleprotection (85)	
Operation PUTT Trip Send Prolong time Direct Trip delay Z Start delay (block) Min. Block time Prolong Block time	Off, PUTT, POTT, Dir. comparison, Dir. blocking, DUTT with Pickup, with Z Overreach 1-10000ms in 1ms steps 1-10000ms in 1ms steps 1-10000ms in 1ms steps 1-10000ms in 1ms steps 1-10000ms in 1ms steps
Disturbance recorder	
Operation Resolution Prefault PostFault Max Recording Time	Off, On 1/1.2 kHz; 2/2.4kHz 100-1000ms in 1ms steps 100-10000ms in 1ms steps 500-10000ms in 1ms steps

TECHNICAL DATA

HARDWARE	
Analog Inputs (Current & Voltage Input Modules)	
Rated current In Rated voltage Vn Rated frequency Overload rating Current inputs Voltage inputs Burden Phase current inputs Voltage inputs	1A or 5A (selectable) 110V (± 10%) 50Hz or 60Hz 20A continuous, 175A for 10s, 500A for 1s, 1200A for 10ms 250V continuous, 275V for 1s 0.01VA at In = 1A, 0.25VA at In = 5A 0.61VA at 200V, 0.2VA at 100V
Power Supply	
Rated auxiliary voltage Power consumption	24/48/60VDC (Operative range: 19.2 - 72VDC) 110/220VDC (Operative range: 88 - 264VDC or 80-250VAC) 20W, 25W, 30W, 60W (Depend on type of power supply module)
Binary Inputs	
Input circuit DC voltage Pickup voltage Drop voltage Power consumption	24VDC (Thermal withstand voltage: 72VDC) 48VDC (Thermal withstand voltage: 100VDC) 110VDC (Thermal withstand voltage: 250VDC) 220VDC (Thermal withstand voltage: 320VDC) 0.8Un 0.64Un max. 1.6 mA per channel at 220VDC max. 1.8 mA per channel at 110VDC max. 2 mA per channel at 48VDC max. 3 mA per channel at 24VDC
Binary Outputs	
Rated voltage Continuous carry Maximum switching voltage Breaking capacity Short time carrying capacity Operating time	250VAC/DC 8A 400VAC 0.2A at 220VDC, 0.3A at 110VDC (L/R=40ms) 2000VA max 35A for 1s Typically 10ms
Trip Contacts	
Rated voltage Continuous carry Thermal withstand voltage Breaking capacity Making capacity Operating time	24VDC/48VDC/110VDC/220VDC 8A 72VDC (Rated voltage: 24VDC or 48VDC) 150VDC (Rated voltage: 110VDC) 242VDC (Rated voltage: 220VDC) 4A (L/R=40ms) 30A for 0.5s With pre-trip 0.5 ms, without pre-trip typically 10 ms
Mechanical Design	

Installation Case Protection class	Flush mounting/Rack mounting 42 or 84 HP (height:3U) IP41 from front side, IP2x from rear side IP54 Rated mounting kit
Key & LED	
Device keys Capacitive touch key LEDS Number of configurable LED Device status LED	Capacitive touch keys 4 pcs yellow, 3 mm circular LEDs indicating touch key actions 16 1 piece three-color, 3 mm circular LED Green: normal device operation Yellow: device is in warning state 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 100Base-FX	IP56 rated with RJ-45 connector MM/ST 1300 nm, 50/62.5/125 µm connector, (up to 2 km) fiber MM/LC 1300 nm, 50/62.5/125 µm connector, (up to 2 km) fiber SM/FC 1550 nm, 9/125 µm connector, (up to 120 km), with max. 32 dB link attenuation SM/FC 1550 nm, 9/125 µm connector, (up to 50 km), with max. 27 dB link attenuation
Serial Interface	Plastic optical fiber (ASIF-POF) Glass with ST connector (ASIF-GS) 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
Distance protection (21)	
Number of zones Rated current In Rated voltage Un Current effective range Voltage effective range Impedance effective range: In=1A In=5A Zone static accuracy: 48 Hz – 52 Hz 49.5 Hz – 50.5 Hz Operate time Minimum operate time Reset time	5 1/5A, parameter setting <2% 100/200V, parameter setting 20 – 2000% of In, accuracy: ±1% of In 2-110 % of Un, accuracy: ±1% of Un 0.1 – 200 Ohm, accuracy: ±5% 0.1 – 40 Ohm, accuracy: ±5% ±5% ±2% Typically 25 ms, accuracy: ±3 ms <20 ms 16 – 25 ms

Reset ratio	1.1
Synchrocheck (25)	
Rated Voltage Un Voltage effective range Frequency Phase angle accuracy Operate time Reset time Reset ratio	100/200V, parameter setting 10-110 % of Un, accuracy: ±1% of Un 47.5 – 52.5 Hz, accuracy: ±10 mHz ±3 ° Setting value, accuracy: ±3 ms <50 ms 0.95 Un
Definite time undervoltage protection (27)	
Pick-up starting accuracy Reset time U> → Un U> → 0 Operate time accuracy Minimum operate time	< ± 0,5 % 50 ms 40 ms < ± 20 ms 50 ms
Directional over-power protection (32)	
P,Q measurement	Effective range: I>5% In, accuracy: <3%
Directional under-power protection (37)	
P,Q measurement	Effective range: I>5% In, accuracy: <3%
Negative sequence overcurrent protection (46)	
Operating accuracy Operate time accuracy Reset ratio Reset time Dependent time char. Definite time char. Reset accuracy time Transient overreach Pickup time * Overshot time Dependent time char. Definite time char. Influence of time varying value of the input current (IEC 60255-151) accuracy	<2% (when 20 ≤ G_S ≤ 1000) ±5% or ±15 ms, whichever is greater 0.95 Dependent time char. Approx 60 ms < 2% or ±35 ms, whichever is greater < 2 % < 40 ms 25 ms 45 ms < 4 %
Brocken conductor protection (46BC)	
Pick-up starting accuracy Reset ratio Min. operate time	<2 % 0.95 70ms
Negative sequence overvoltage protection (47)	
Pick-up starting accuracy Blocking voltage accuracy Reset time U> → Un U> → 0 Operate time accuracy	< ± 0,5 % < ± 1,5 % 60 ms 50 ms < ± 20 ms

Drop-off ratio accuracy Minimum operate time	± 0,5 % 50 ms
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 Reset ratio Operate time at 2*I_S Reset time Transient overreach	Instantaneous, accuracy < 6 % 0.85 <15 ms <40 ms 90%
Using Fourier basic harmonic calculation	
Operating characteristic Reset ratio Operate time at 2*I_S Reset time Transient overreach	Instantaneous, accuracy < 2 % 0.85 <25 ms <60 ms 15%
Breaker failure protection (50BF)	
Pick-up starting accuracy Operating time accuracy Retrip time Reset ratio Current reset time	<2 % ±5% or ±15 ms, whichever is greater approx. 15 ms 0.9 16-25ms
Residual instantaneous overcurrent protection (50N/50Ns)	
Using peak value calculation	
Operating characteristic (I>0.1 In) Reset ratio Operate time at 2*I_S Reset time * Transient overreach	Instantaneous, accuracy <6% 0.85 < 15 ms < 35 ms 85 %
Using Fourier basic harmonic calculation	
Operating characteristic (I>0.1 In) Reset ratio Operate time at 2*I_S Reset time * Transient overreach	Instantaneous, accuracy <6% 0.85 < 25 ms < 60 ms 15 %
Three-phase time overcurrent protection (51)	
Operating accuracy Operate time accuracy Reset ratio Reset time Dependent time char. Definite time char. Reset time accuracy Transient overreach	<2% (when $20 \le G_S \le 1000$) ±5% or ±15 ms, whichever is greater 0.95 Dependent time char. Approx 60 ms < 2% or ±35 ms, whichever is greater < 2 %

Pickup time * Overshot time Dependent time char. Definite time char. Influence of time varying value of the input current (IEC 60255-151)	< 40 ms 30 ms 50 ms < 4 %
Residual time overcurrent protection (51N/51Ns)	
Operating accuracy Operate time accuracy Reset ratio Reset time Dependent time char. Definite time char. Reset accuracy time Transient overreach Pickup time * Overshot time Dependent time char. Definite time char. Influence of time varying value of the input current (IEC 60255-151) accuracy	<3% (when 20 ≤ G_S ≤ 1000) ±5% or ±15 ms, whichever is greater 0.95 Dependent time char. Approx 60 ms < 2% or ±35 ms, whichever is greater < 2 % ≤ 40 ms 30 ms 50 ms < 4 %
Definite time overvoltage protection (59)	
Pick-up starting accuracy Reset time U> → Un U> → 0 Operate time accuracy Minimum operate time	< ± 0,5 % 60 ms 50 ms < ± 20 ms 50 ms
Residual overvoltage protection (59N)	
Pick-up starting accuracy 2 – 8 % 8 – 60 % Reset time U> → Un U> → 0 Operate time Operate time accurracy	 < ± 2 % < ± 1.5 % 60 ms 50 ms 50 ms < ± 20 ms
Current unbalance protection (60)	
Pick-up starting accuracy at In Reset ratio Operate time	Pick-up starting accuracy at In 0.95 70 ms
Voltage transformer supervision (60)	
Pick-up voltage accuracy Operate time Reset ratio	<1% <20 ms 0.95
Three-phase directional overcurrent protection (67)	

Operating accuracy	< 2 %
Operating accuracy	If Time multiplier is >0.1: ±5% or ±15 ms, whichever is greater
Accuracy in minimum time range	±35 ms
Reset ratio	0.95
Reset time	Approx 100 ms
Transient overreach	2 %
Pickup time	<100 ms
Memory storage time span	
50Hz	70 ms
60Hz	60 ms
Angular accuracy	<3º
Residual directional overcurrent protection (67N/67Ns)	
Operating accuracy	< ±2 %
Operating accuracy	±5% or ±15 ms, whichever is greater 0.95
Accuracy in minimum time range	±35 ms
Reset ratio	0.95
Reset time	Approx 50 ms
Reset time accuracy	±35 ms
Transient overreach	< 2 %
Pickup time	±35 ms
Angular accuracy	<3º
Io ≤ 0.1 In	<±10º
Io ≤ 0.1 In	<±5º
Io ≤ 0.1 In	<±2º
Angular reset ratio	
Forward and backward	10º
All other selection	5º
Inrush detection (68)	
Range	20 – 2000% of In
Current accuracy	±1% of In
Rate of change of frequency protection (81R)	
Min. operate voltage	0.1 Un
Operate range	± 10 Hz/s, accuracy: ± 50 mHz/s
Effective range	± 5 Hz/s, accuracy: ± 15 mHz/s
Minimum operate time	191 ms (50 Hz system), accuracy: ± 40 ms 159 ms (60 Hz system), accuracy: ± 39 ms 200 – 60000 ms (50 Hz), accuracy: ± 2 ms
Time delay (at 0.2 Hz/s)	± 1 mHz
Reset ratio (drop/pick in absolute values)	0.92 (>0.5 Hz/s), accuracy: -0.03 0.999 (<0.5 Hz/s), accuracy: -0.072
Reset time	187 ms (50Hz), accuracy: ±44ms 157 ms (60Hz), accuracy: ±38 ms
Overfrequency protection (81O) Undefrequency protection (81U)	
Min. operate voltage	0.1 Un
Operate range	40 - 60 Hz (50 Hz system) 50 - 70 Hz (60 Hz system)
Effective range	45 - 55 Hz (50 Hz system)

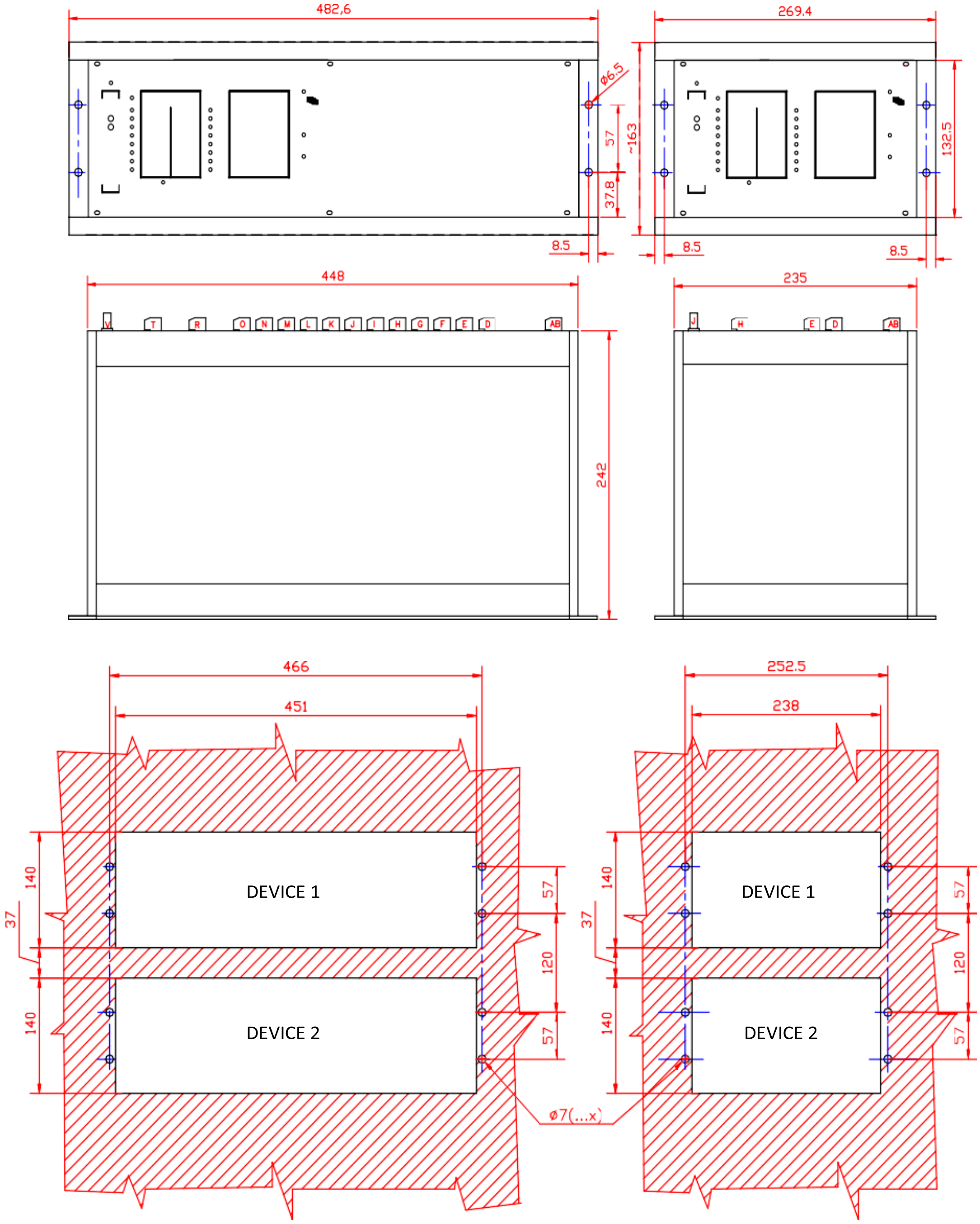
	55 - 65 Hz (60 Hz system)
Accuracy	± 3 mHz
Minimum operate time	93ms (50 Hz system)
	73ms Hz (60 Hz system)
Minimum operate time accuracy	± 32 ms (50 Hz system)
	± 27 ms (60 Hz system)
Accuracy when time delay:	
140 – 60000 ms	± 4 ms
<140 ms (50 Hz system)	± 32 ms
<140 ms (60 Hz system)	± 27 ms
Reset frequency	[Start freq.] – 101 mHz, accuracy: ± 1 mHz
Reset time	98 ms (50 Hz)
	85 ms (60 Hz)
Reset time accuracy	± 6 ms
Rate of change of frequency protection (81R)	
Min. operate voltage	0.1 Un
Operate range	± 10 Hz/s, accuracy: ± 50 mHz/s
Effective range	± 5 Hz/s, accuracy: ± 15 mHz/s
Minimum operate time	191 ms (50 Hz system), accuracy: ± 40 ms
	159 ms (60 Hz system), accuracy: ± 39 ms
	200 – 60000 ms (50 Hz), accuracy: ± 2 ms
Time delay (at 0.2 Hz/s)	± 1 mHz
Reset ratio (drop/pick in absolute values)	0.92 (>0.5 Hz/s), accuracy: -0.03
	0.999 (<0.5 Hz/s), accuracy: -0.072
Reset time	187 ms (50Hz), accuracy: ±44ms
	157 ms (60Hz), accuracy: ±38 ms
Lockout trip logic (86/94)	
Pulse time	<3 ms
Line differential protection (87L)	
Operating characteristic	2 breakpoints and unrestrained decision
Reset ratio	0.95
Characteristic accuracy (Ibias>2xIn)	<2%
Operate time (Ibias>0.3xIn)	Typically 35 ms
Reset time	Typically 60 ms
Switch-onto-fault (SOTF)	
Timer accuracy	±5% or ±15 ms, whichever is greater
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
	Range: 50 – 70 Hz (60Hz system); accuracy: ±2mHz

ENVIRONMENTAL PERFORMANCE

Atmospheric Environment		
Temperature	IEC 60068-2-1 IEC 60068-2-2 IEC 60068-2-14	Storage temperature: - 40 ºC … + 70 ºC Operation temperature: - 20 ºC … + 55 ºC
Humidity	IEC 60255-1 IEC 60068-2-78 IEC 60068-2-30	Humidity: 10 % ... 93 %
Enclosure protection	IEC 60529	IP41 from front side, IP2x from rear side 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 IEC 60255-26	Test voltages: 15 kV air discharge, 8 kV contact discharge
Radiated radio frequency electromagnetic field immunity	IEC 61000-4-3 IEC 60255-26	Test field strength: 10 V/m
Electrical fast transient	IEC 61000-4-4 IEC 60255-26	Test voltage: 4 kV, 5kHz
Surge immunity	IEC 61000-4-5 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 IEC 60255-26	Frequency sweep: 150kHz…80 MHz Spot frequencies: 27 MHz, 68 MHz Test voltage: 10 V
Power frequency magnetic field immunity	IEC 61000-4-8 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 IEC 60255-26	Test frequency: 100 kHz, 1 MHz Test voltage: 2.5 kV in common mode, 1 kV in differential mode

DIMENSION AND PANEL CUT-OUT

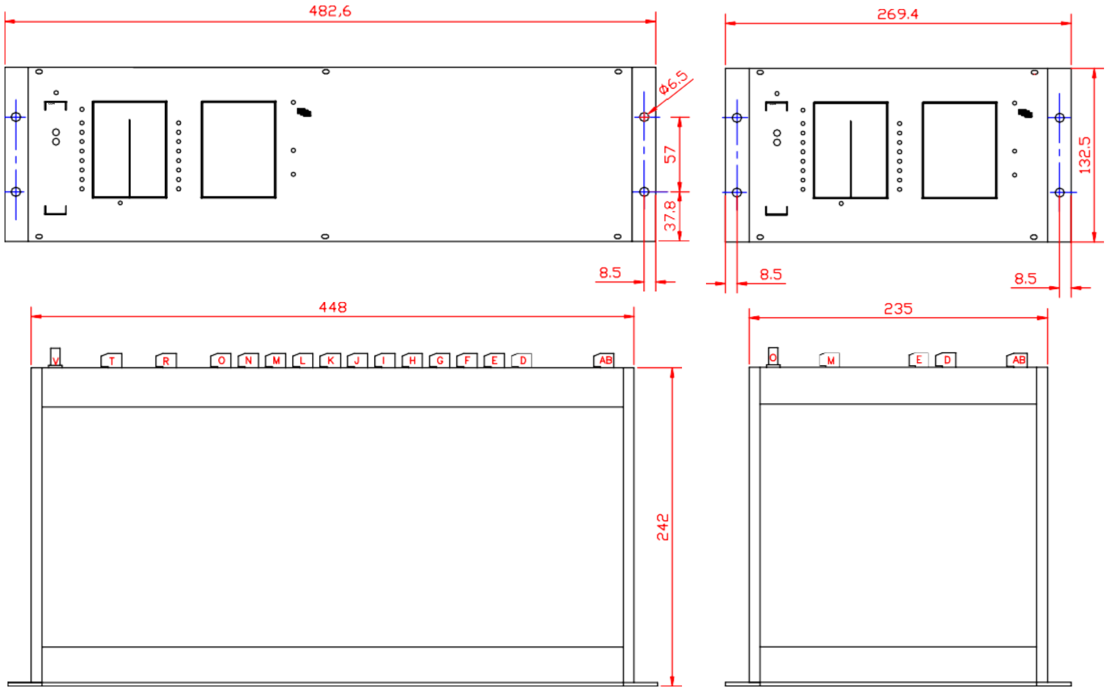
- **Flush mounting**



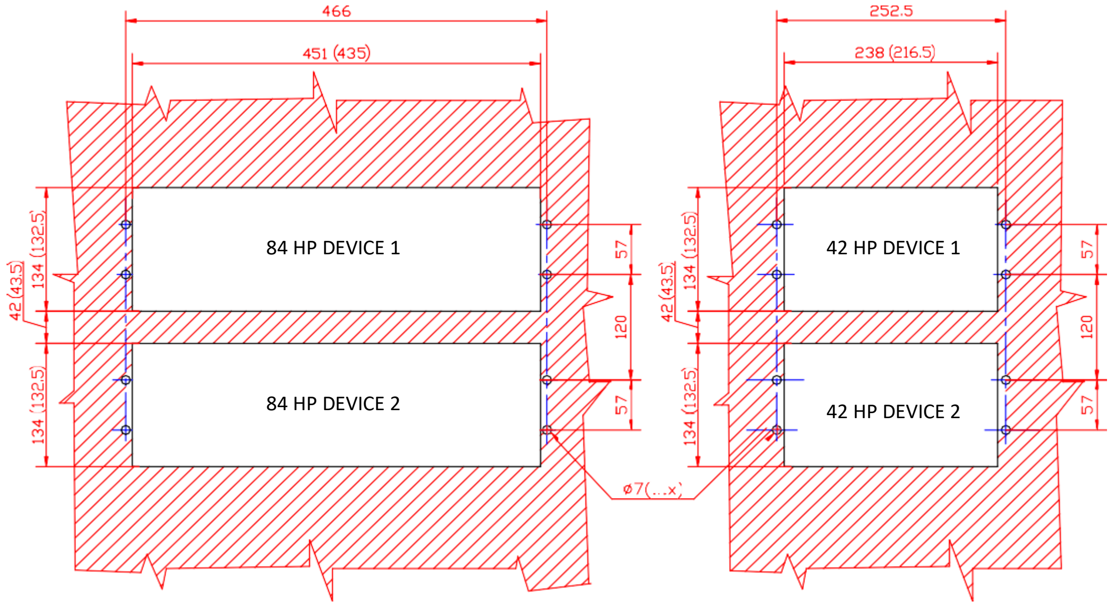
Dimension and panel cut-out for DTVA devices (Flush mounting type)

- **Rack mounting**

When rack mounting is used the devices do not have a cover profile fit on. So it is possible to mount them in a 19" rack.



Dimension and panel cut-out for DTVA devices (Rack mounting type)



Note that rack mounting type devices can also be mounted in a cut-out (e.g. on a switchgear door). It is possible to mount them from the front or from the back of the cut-out. The dimensions for rack mounting cut-outs are in the figure below. Dimensions in brackets are applicable in case of mounting from the back.

HARDWARE CONFIGURATION

- **I/O configuration**

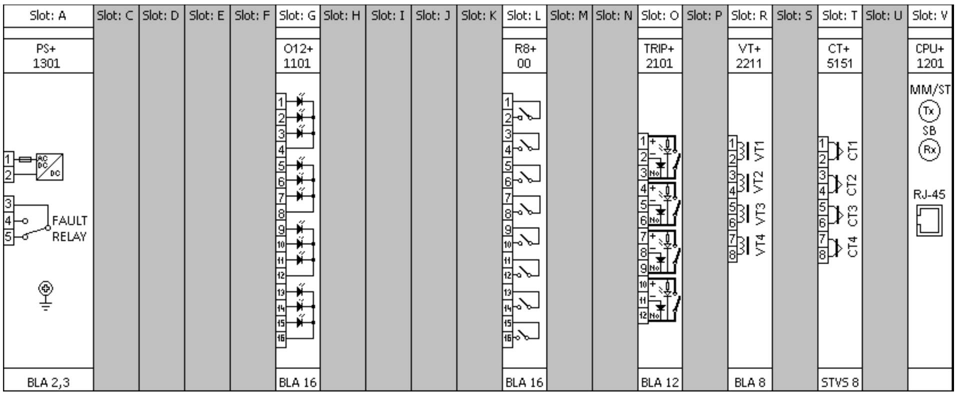
The standard number of inputs and outputs of each variant are listed in the table below.

Hardware configuration	E1-Line	E2-Line
Current inputs (4th channel can be sensitive)	4	4
Voltage inputs	4	4
Binary inputs	12	12
Binary outputs	8	8
Fast trip outputs	4	4

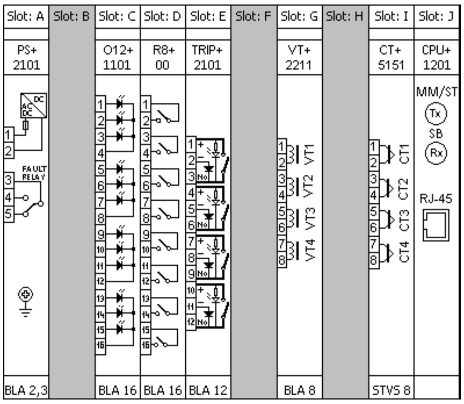
The maximum number of inputs and outputs of each variant are listed in the table below.

Hardware configuration	E1-Line	E2-Line
Binary inputs (Max)	128	128
Binary outputs (Max)	60	60
Fast trip outputs (Max)	12	12

- **Module arrangement**
  - **E1-Line Variant**

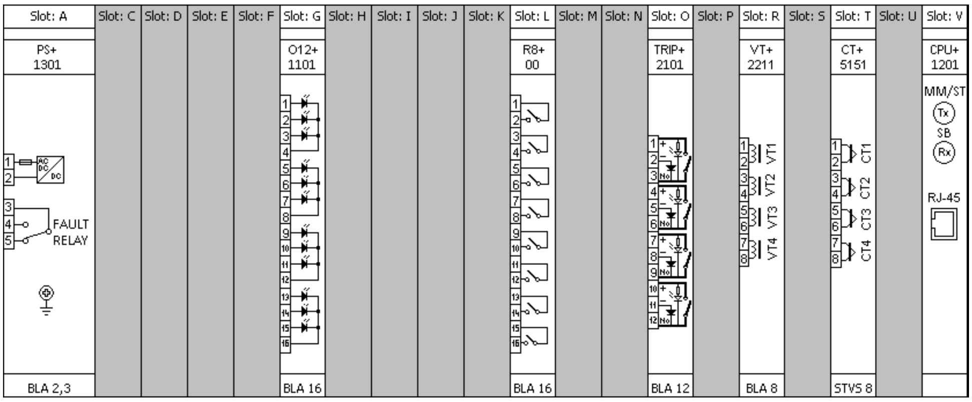


Basic module arrangement of the E1-Line configuration (84TE, rear view)

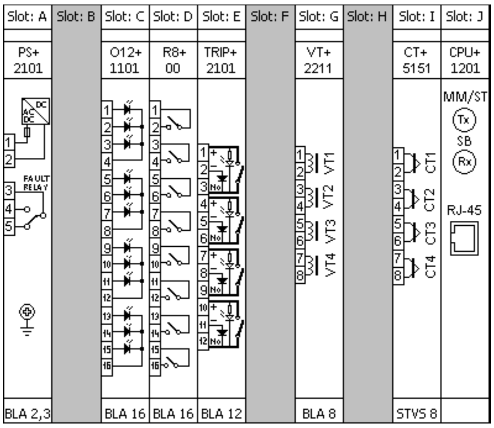


Basic module arrangement of the E1-Line configuration (42TE, rear view)

- **E2-Line Variant**



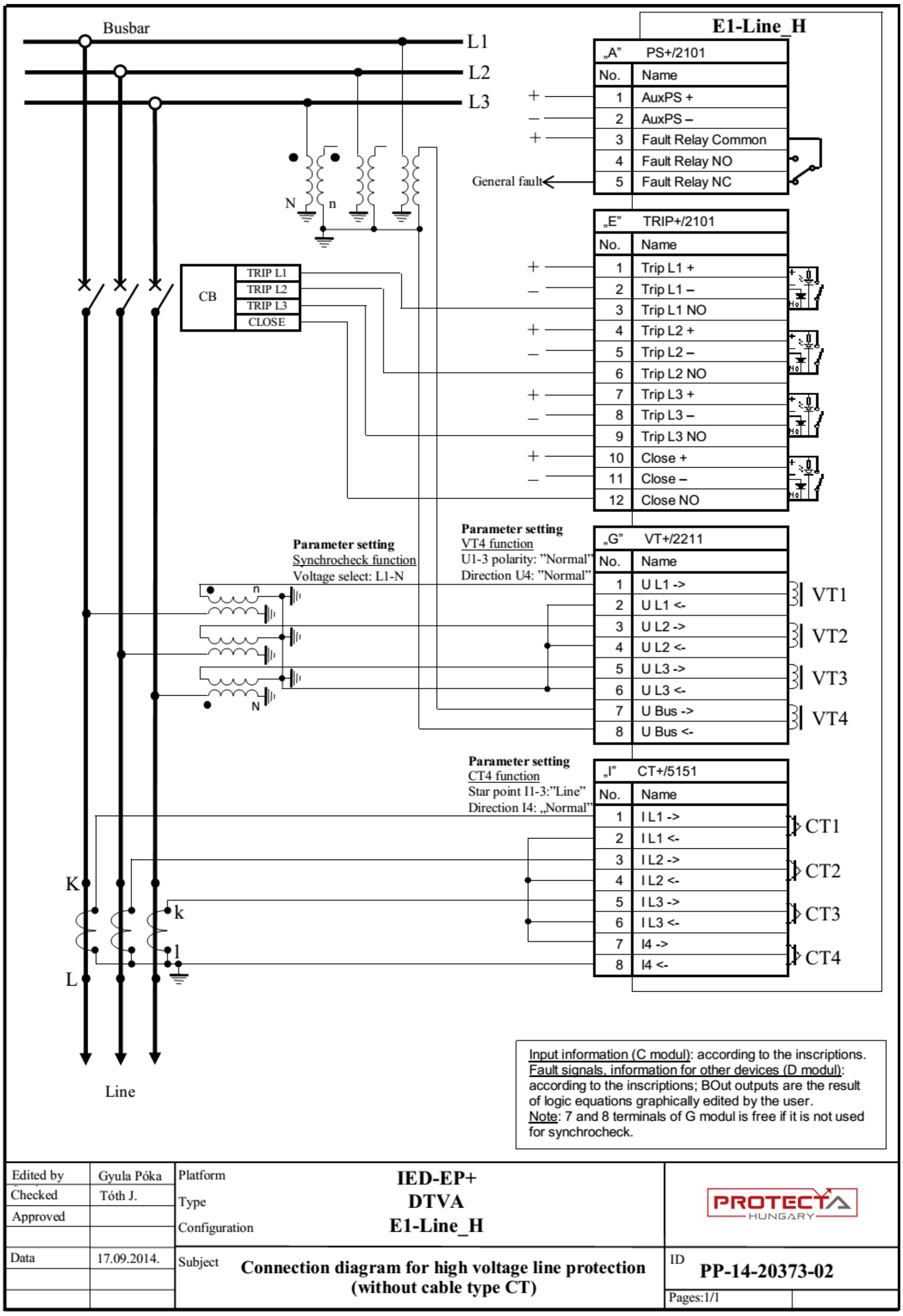
Basic module arrangement of the E2-Line configuration (84TE, rear view)



Basic module arrangement of the E2-Line configuration (42TE, rear view)

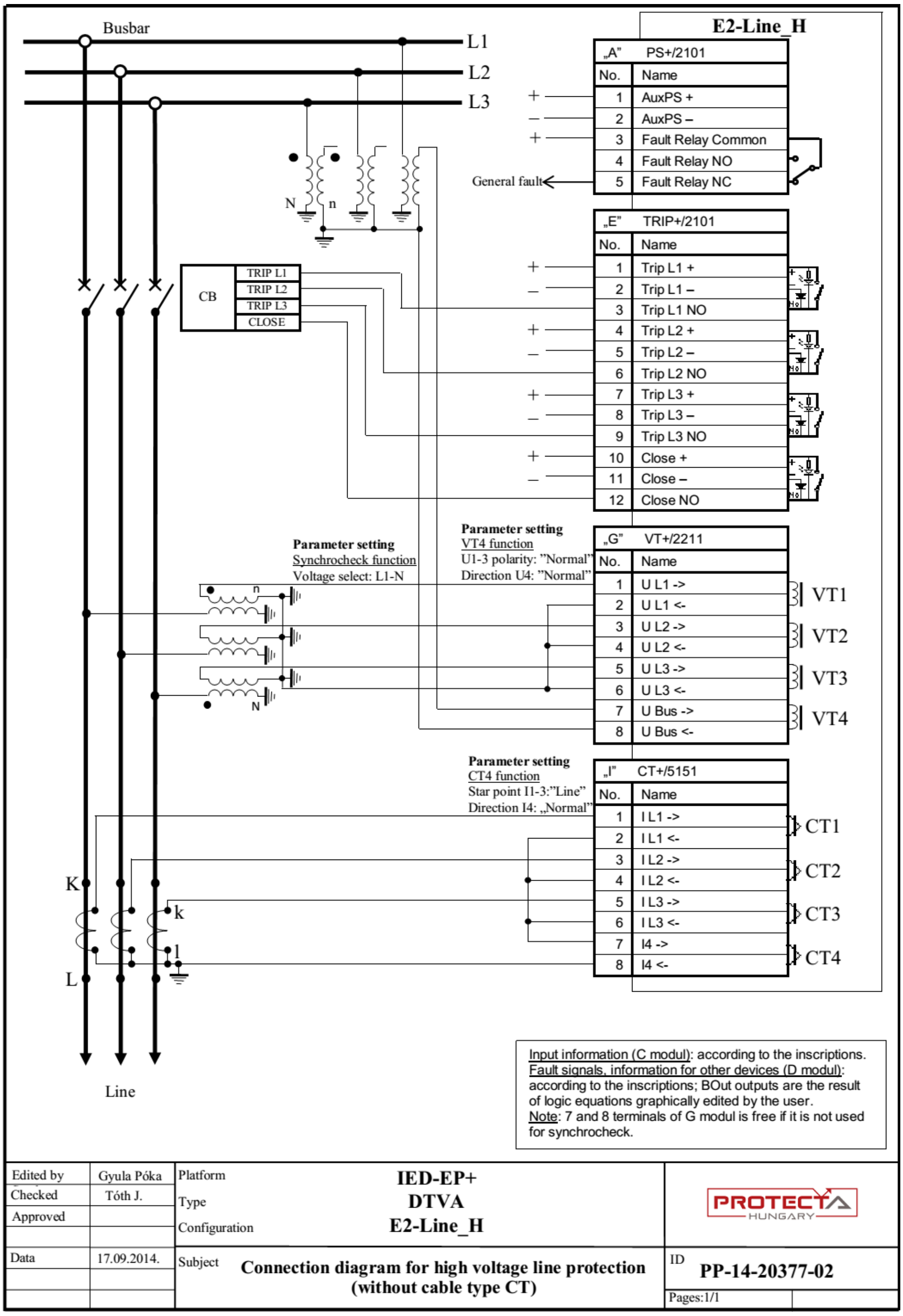
EXTERNAL CONNECTION DIAGRAM

- **E1-Line Variant**



Typical connection diagram for E1-Line transmission line distance protection

- **E2-Line Variant**



Typical connection diagram for E2-Line transmission line differential protection

CONTACT

For more information, please refer to the **DTVA** configuration description document or contact us:

Protecta Electronics Ltd.
Address: Késmárk u. 7/A, 1158 Budapest, Hungary
Mailing Address: 1601 Budapest, Pf. 74., Hungary
Phone Number: +36 1 415 3800
E-Mail: protecta@protecta.hu