PRODUCT DESCRIPTION

EuroProt+ DTIVA

IED-EP+/DTIVA

FEEDER PROTECTION RELAY

PROTECTA HUNGARY

EUROPROT+ DTIVA

FEEDER PROTECTION RELAY

OVERVIEW

The **DTIVA** product type is a member of the **EuroProt+** numerial 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 **DTIVA** products are configured to protect, control and supervise elements of the utility and industrial distribution systems, including radial, looped and meshed distribution networks.

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 on-line. Every single record stored in 3 files with the same name and the following extensions: .dat, .cfg, .inf
- Several mounting methods: Rack; Flush mounting; Semi-flush mounting; Wall mounting; Wall-mounting with terminals; Flush mounting with IP54 rated cover.
- Wide range of communication protocols:
  - Ethernet-based communication protocol: IEC61850, DNP3.0 TCP, IEC60870-5-104, Modbus TCP
  - Serial communication protocol: DNP3.0, IEC60870-5-101, IEC60870-5-103, MODBUS, SPA
- Legacy network based protocols via 100Base-FX and 10/100Base-TX (RJ45)
- Optional communication ports: Fiber Ethernet (MM/ST, SM/FC), RJ45, Serial POF, Serial glass fiber, RS-485/422
- Handling 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 **DTIVA** products are configured to protect, control and supervise elements of the utility and industrial distribution systems, including radial, looped and meshed distribution networks.

The majority of the protections are based on current measurements only, but the application of distributed generation or loops in the network topology require additional voltage measurement and directional protection functions. The relays of this type support double breaker terminals such as breaker and a half or ring bus topology.

The main protection functions of the **DTIVA** type include directional and non-directional overcurrent protections, voltage-based protections and frequency-based protections.

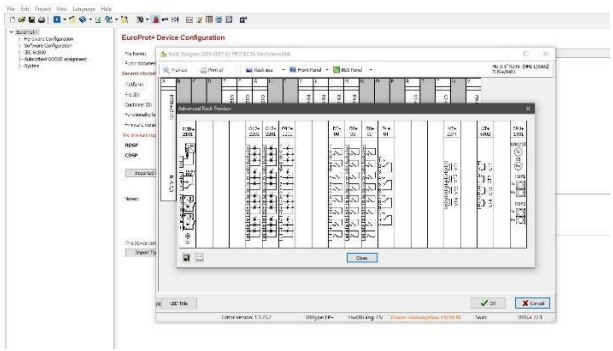
The automatic reclosing function (wherever present) provides multi-shot autoreclosing with a synchro-check feature. The dead times and shot numbers can be set individually for earth faults and phase faults. Additionally, the **DTIVA** product type includes a variety of versatile protection functions, such as

high-speed distance protection with five independent protection zones and line differential protection. More specialized applications, such as MV motor protection and capacitor bank protection, are also covered in this type by dedicated configuration variants. Because of the implemented control, measuring and monitoring function, the IEDs can also be used as a bay control unit.

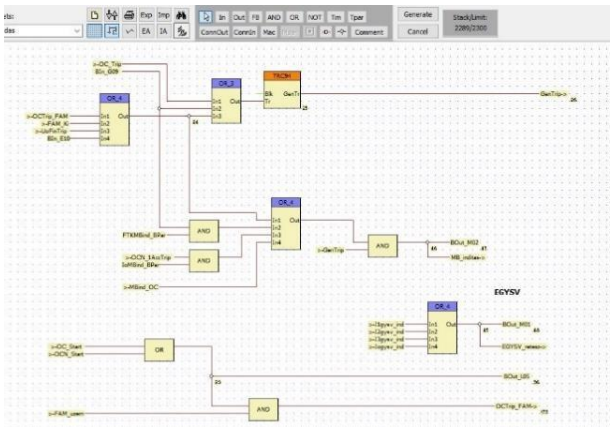
EUROCAP CONFIGURATION TOOL

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.

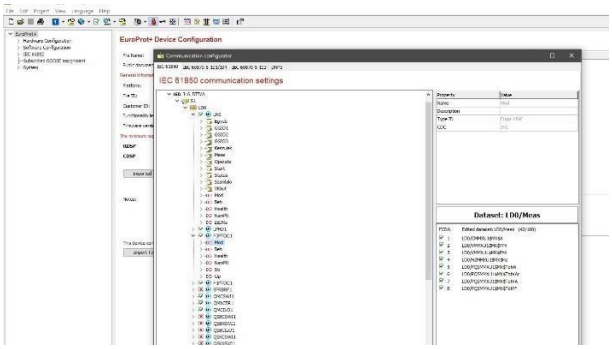
- **HW configuration**
  - View the exciting hardware configuration of the IED including card information and slot position
  - Modify (add or change) certain HW modules
  - Digital and analogue I/O signal definition



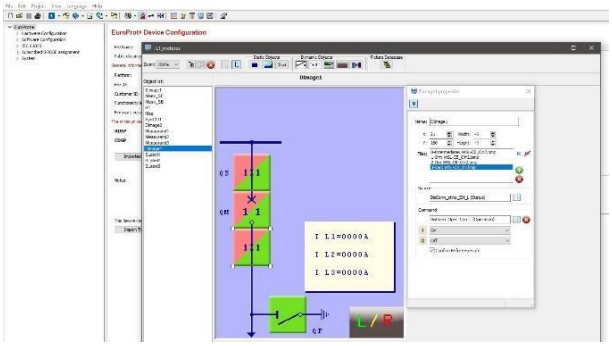
- **Logic editor**
  - Create/manage logical sheets
  - Factory pre-configured logical schemes to speed up the commissioning process



- **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**

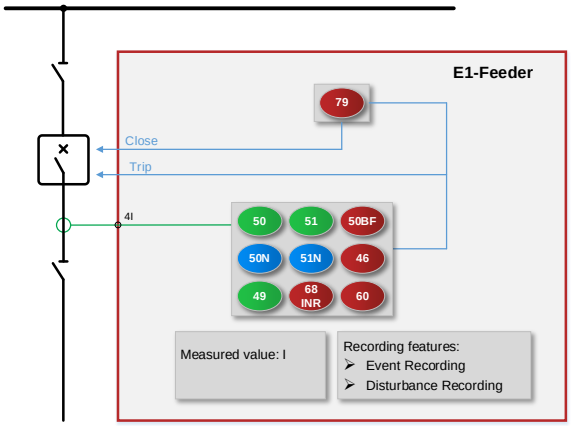
The number and the functionality of the members of each product type is put together according to the application philosophy, keeping in mind the possible main usages. The available configurations of the **DTIVA** type are listed in the table below.

VARIANT	MAIN APPLICATION
E1-Feeder	Non-directional 3ph+Io overcurrent protection, control & automation
E2-Feeder	Non-directional three-phase, directional residual overcurrent protection, control & automation
E3-Feeder	Directional 3ph+Io overcurrent, over- undervoltage, frequency protection & autorecloser
E4-Feeder	Distance protection, control & automation
E5-Feeder	Line differential protection, control & automation
E6-Feeder	Combined Distance and line differential protection, control & automation
E7-Feeder	Motor protection
E8-Feeder	Frequency and over- undervoltage protection
E9-Feeder	Vectorjump, over- and underpower and frequency protection
E10-Feeder	Capacitor bank protection

- **E1- Feeder Non-directional 3ph+Io overcurrent protection, control & automation**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Negative sequence overcurrent protection	I2 >	46	2
Broken conductor protection	I2/I1>	46BC	1
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
Current unbalance		60	1
Inrush current detection function	I2h >	68	1
Trip circuit supervision		74	1
Auto-reclose	0 → 1	79	1
Lockout trip logic function		86/94	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 - Feeder Non-directional three-phase, directional residual overcurrent protection, control & automation**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Definite time undervoltage protection	U <, U <<	27	2
Directional overpower	P >	32	2
Directional underpower	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
Directional residual time overcurrent protection	Io Dir >, Io Dir >>	67N	4
Inrush current detection function	I2h >	68	1
Trip circuit supervision		74	1
Auto-reclose	0 → 1	79	1
Lockout trip logic function		86/94	1

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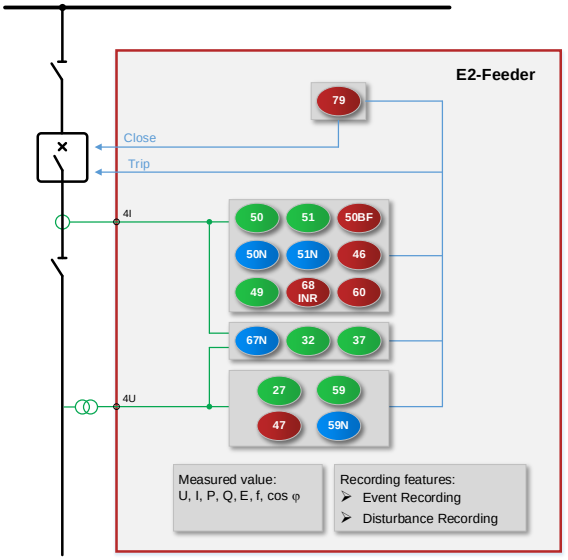

- **E3 - Feeder Directional 3ph+Io overcurrent, over- undervoltage, frequency protection & autorecloser**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
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		60	1
Directional three-phase overcurrent protection	I Dir >, I Dir >>	67	4
Directional residual time overcurrent protection	Io Dir >, Io Dir >>	67N	4
Inrush current detection function	I2h >	68	1
Trip circuit supervision		74	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
Lockout trip logic function		86/94	1
Switch onto fault logic			1

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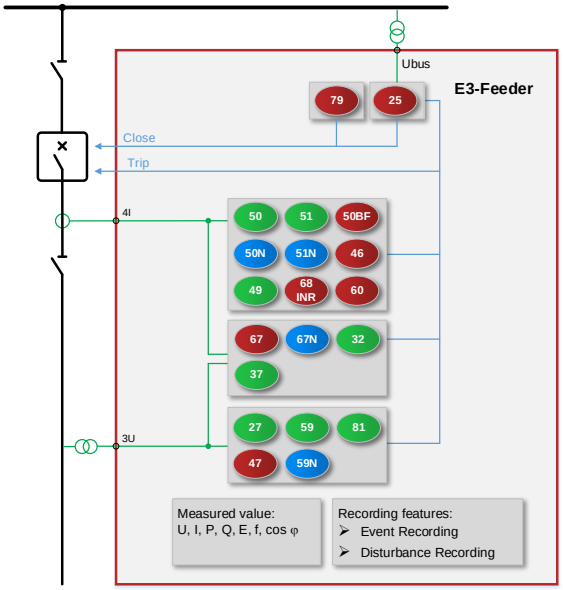

- **E4 - Feeder Distance protection, control & automation**

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		60	1
Voltage transformer 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
Inrush current detection function	I2h >	68	1
Trip circuit supervision		74	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
Lockout trip logic function		86/94	1
Switch onto fault logic			1

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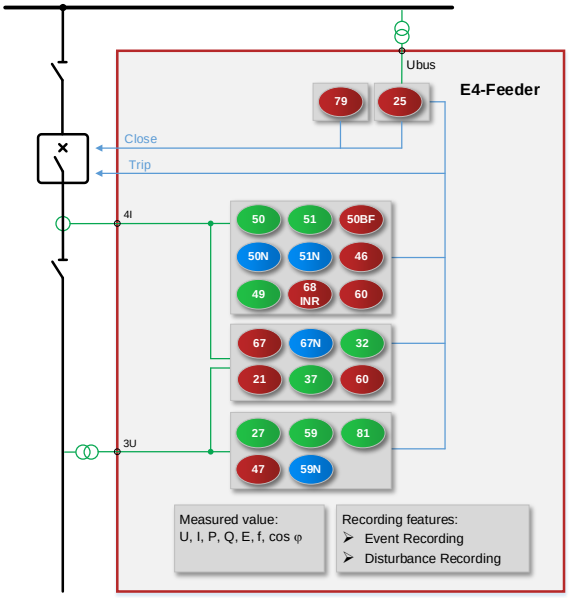
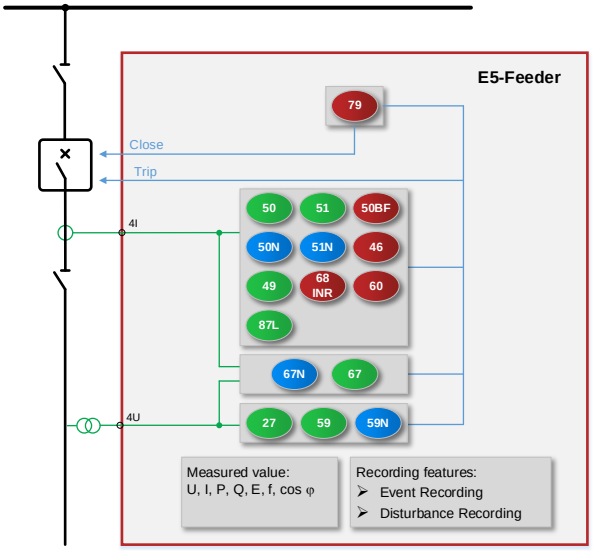


- **E5 - Feeder Line differential protection, control & automation**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Definite time undervoltage protection	U <, U <<	27	2
Negative sequence overcurrent protection	I2 >	46	2
Broken conductor protection	I2/I1>	46BC	1
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
Directional three-phase overcurrent protection	I Dir >, I Dir >>	67	4
Directional residual time overcurrent protection	Io Dir >, Io Dir >>	67N	4
Inrush current detection function	I2h >	68	1
Trip circuit supervision		74	1
Auto-reclose	0 → 1	79	1
Overfrequency protection	f >, f >>	81O	4
Overfrequency protection	f <, f <<	81U	4
Lockout trip logic function		86/94	1
Line differential protection	3IdL >	87L	1
Line differential protection with transformer in the protected zone	3IdL >	87LT	op.

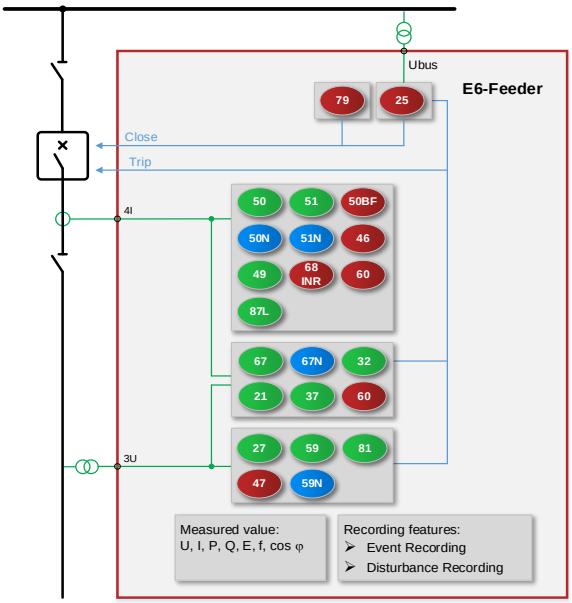
**The Inst. column contains the numbers of the pre-configured function blocks in the factory configuration. These numbers may be different in order to meet the user's requirements.*



- **E6 - Feeder Combined Distance and line differential protection, control & 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		60	1
Voltage transformer 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
Inrush current detection function	I2h >	68	1
Trip circuit supervision		74	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
Lockout trip logic function		86/94	1
Line differential protection	3IdL >	87L	1
Switch onto fault		SOFT	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.*



- **E7 - Feeder Motor protection**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Overexcitation protection	V/Hz	24	1
Definite time undervoltage protection	U <, U <<	27	2
Loss-of-load (undercurrent) protection	I<	37	1
Negative sequence overcurrent protection	I2 >	46	2
Motor startup supervision	Istart/I(t)	48/66	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 and dead line detection		60	1
Directional residual time overcurrent protection	Io Dir >, Io Dir >>	67N	4
Inrush current detection function	I2h >	68	1
Trip circuit supervision		74	1
Lockout trip logic function		86/94	1
Generator differential protection	3IdG >	87G/87M	Op.

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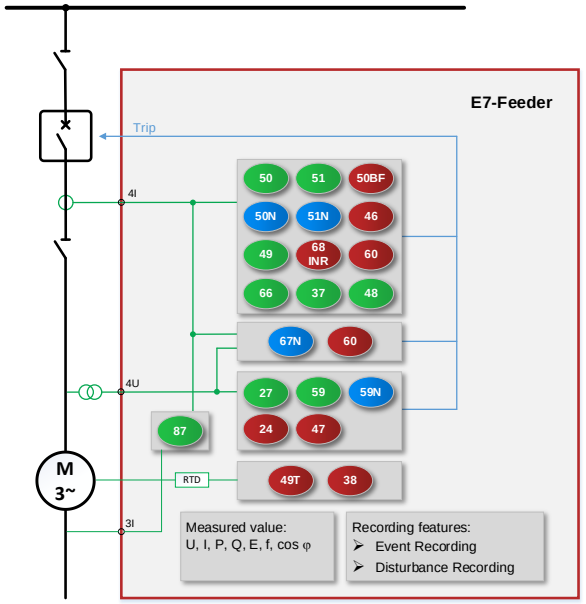

- **E8 - Feeder Frequency and over- undervoltage protection**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Synchrocheck	SYNC	25	1
Definite time undervoltage protection	U <, U <<	27	2
Definite time overvoltage protection	U >, U >>	59	2
Residual definite time overvoltage protection	Uo >, Uo >>	59N	2
Overfrequency protection	f >, f >>	81O	4
Overfrequency protection	f <, f <<	81U	4
Rate of change of frequency protection	df/dt	81R	2

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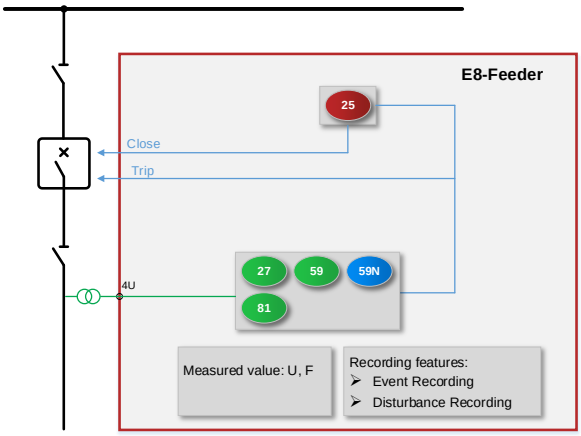

- **E9 - Feeder Vectorjump, over- and underpower and frequency protection**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Definite time undervoltage protection	U <, U <<	27	2
Directional overpower protection	P >	32	2
Directional underpower protection	P <	37	2
Broken conductor protection	I2/I1>	46BC	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
Trip circuit supervision		74	1
Vector jump protection	ΔφU>	78	1
Overfrequency protection	f >, f >>	81O	4
Overfrequency protection	f <, f <<	81U	4
Rate of change of frequency protection	df/dt	81R	2
Lockout trip logic function		86/94	1

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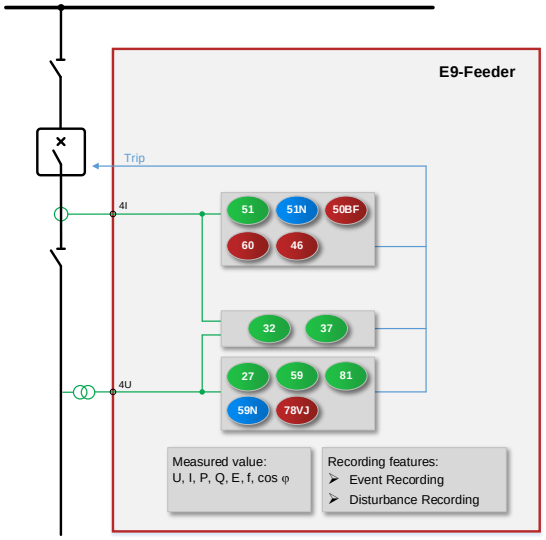

- **E10 - Feeder Capacitor bank protection**

THE IMPLEMENTED PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.
Circuit breaker control (included interlocking function)			
Disconnector control (included interlocking function)			
Definite time undervoltage protection	U <, U <<	27	2
Loss-of-load (undercurrent) protection	I<	37	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 and dead line detection		60	1
Capacitor unbalance protection for blocks in bridge connection		51NC	1
Capacitor unbalance protection for blocks in double star connection		51NC	1
Capacitor overvoltage protection		59C	1
Trip circuit supervision		74	1
Lockout trip logic		86/94	1

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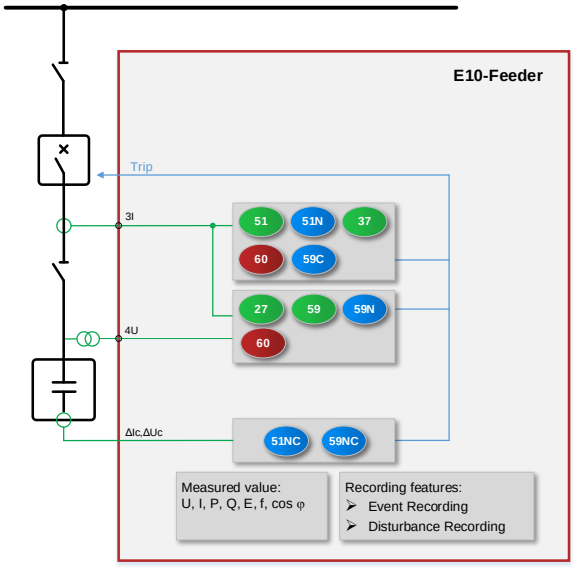


- **Circuit breaker control function block (CB1Pol)**

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.

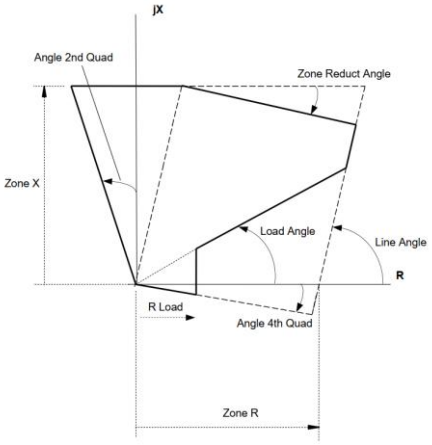
- **Distance protection (21)**

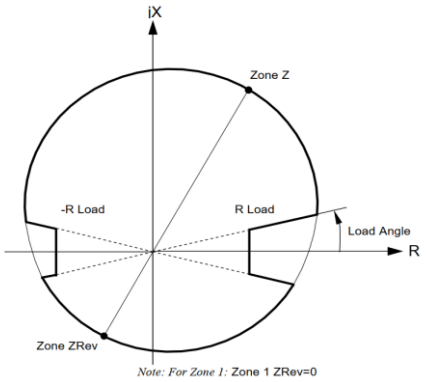
The distance protection function provides main protection for overhead lines and cables of solidly grounded networks. Its main features are as follows:

- 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





Note: For Zone 1: Zone 1 ZRev=0

- 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.

▪ **Overexcitation protection (24)**

The overexcitation protection function is applied to protect generators and unit transformers against high flux values causing saturation of the iron cores and consequently high magnetizing currents.

The peak value of the flux increases if the magnitude of the voltage increases, and/or the flux can be high if the duration of a period increases; this means that the frequency of the voltage decreases. That is, the flux is proportional to the peak value of the voltage (or to the RMS value) and inversely proportional to the frequency.

The effect of high flux values is the symmetrical saturation of the iron core of the generator or that of the unit transformer. During saturation, the magnetizing current is high and distorted; high current peaks can be detected. The odd harmonic components of the current are of high magnitude and the RMS value of the current also increases. The high peak current values generate high dynamic forces, the high RMS value causes overheating. During saturation, the flux leaves the iron core and high eddy currents are generated in the metallic part of the generator or transformer in which normally no current flows, and which is not designed to withstand overheating. The overexcitation protection is designed to prevent this long-term overexcited state

The magnitude can be calculated if at least one positive and one negative peak value have been found, and the function starts if the calculated flux magnitude is above the setting value. Accordingly, the starting delay of the function depends on the frequency: if the frequency is low, more time is needed to reach the opposite peak value. In case of energizing, the time to find the first peak depends on the starting phase angle of the sinusoidal flux. If the voltage is increased continuously by increasing the excitation of the generator, this time delay cannot be measured.

As the heating effect of the distorted current is not directly proportional to the flux value, the applied characteristic is of inverse type (so called IEEE type): If the overexcitation increases, the operating time decreases. To meet the requirements of application, a definite-time characteristic is also offered in this protection function as an alternative.

Overexcitation is a typically symmetrical phenomenon. There are other dedicated protection functions against asymmetry. Accordingly, the processing of a single voltage is sufficient. In a network with isolated start point, the phase voltage is not exactly defined due to the uncertain zero

sequence voltage component. Therefore, line-to-line voltages are calculated based on the measured phase voltages, and one of them is assigned to overfluxing protection.

The effective frequency range includes all frequencies where the defined accuracy can be achieved. If the frequency is too small, then the time needed to find the peak values and to calculate the flux increases. In contrast, at high frequencies the accuracy of the detected peak value decreases. The frequency range monitored extends from 10 Hz to 70 Hz. The details are given among the technical data.

Similar to the frequency range, the voltage range is also limited. If the voltage is too small, the voltage measurement becomes inaccurate due to the sampling. In case of high voltage at low frequencies the voltage transformers may also saturate. Accordingly, the frequency range and the voltage range are closely related. The voltage range monitored extends from 10 V to 170 V. The details are given among the technical data.

The flux range is the combination of the voltage range and the frequency range. For overfluxing protection, the effective flux range extends from 0.5 to 1.5 UN/fN

- **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”.

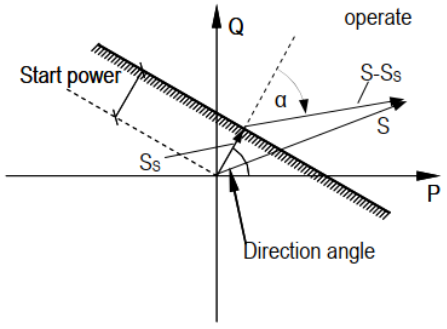
The overvoltage protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

- **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.

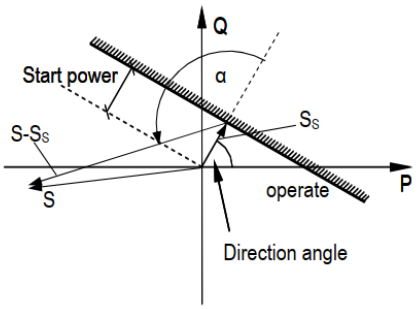


- **Directional under-power protection (37)**

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.



- **Loss-of-load (undercurrent) protection (37)**

The loss-of-load (undercurrent) protection function operates when the current decreases below a predetermined value.

This protection function can be applied for fan or pump drives, where the flowing media provides cooling for the motor itself. If this cooling stops, the motor must not remain I operation. In these cases the protection against low load after a given time delay disconnects the motor from the power supply.

It can also stop a motor in case of a failure in a mechanical transmission (e.g. conveyor belt).

A time delay may be required after start of the function to prevent operation during transient of the power systems.

The advantage of this function is its simplicity: no voltage measurement is needed, no power calculations are performed. The operation is based on phase currents only.

- **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.

- **Motor startup supervision (48/66)**

  - Monitoring the startup

The available functions of the motor startup supervision provide optimal protection during the startup procedure.

The starting process, which is an extreme stress for the motor, is automatically detected based on the fact that the current is zero before starting (below the set Idle Current parameter), then it increases above that level. During the motor

starting process, the duration of which is limited by the Start-up Time parameter, a dedicated binary output signal indicates the startup process. This signal can be applied, for instance, to activate the startup overcurrent protection function, which takes over the protection tasks from the normal overcurrent protection functions.

During the starting time the normal overcurrent protection function is not effective, but the special overcurrent function can operate without any considerable time delay: if the current rises above the increased current setting, the function generates an immediate trip command for the circuit breaker. Based on the starting signal at the end of the successful starting process, the normal overcurrent function is activated again, the setting of which can be below the starting current, providing optimal protection for the motor.

- Locked rotor protection:

If the starting process of the motor lasts too long, the motor is subject to a harmful overstress. If the starting current in excess of the motor Start-up Current parameter value can be detected after the defined Start-up Time, the function generates a trip command.

- Operation of the motor startup supervision

As the basic setting, the rated current of the motor must be defined as a percentage of the rated current of the current transformer.

The starting state is recognized by the algorithm if the current changes from zero value to a higher current. This event triggers a timer, which is in “running” state for the starting time set, then it changes to the “time-out” state. The starting time is set by the parameter Start-up Time.

If the current is above the Idle Current limit, then the motor is considered to be in running state.

If the timer defined by the Start-up Time parameter runs out, then the current must be below a level defined by the parameter Start-up Current. Otherwise, it is an indication of prolonged startup time or a locked rotor. In this case, the function generates a signal, which can be applied to interrupt the starting procedure by tripping the circuit breaker.

When the startup timer runs out, another independent timer is started. During the running time of this second timer no restarting is allowed because the repeated increased starting current could cause overheating in the motor. This inhibition timer’s designated parameter is the Restart Time.

The restart inhibition time is also started if the starting process is interrupted and the current falls below the Idle Current.

The function counts the subsequent startups within the last hours. This count must not be above the permitted startup numbers, defined by a dedicated parameter. If this parameter is 0 then no limit is considered. The last remaining restart possibility is indicated by an output status signal of the function block.

- **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.

- **Capacitor overvoltage protection (59C)**

The capacitors on a network in most cases have no dedicated voltage measurement, the voltage transformers on the busbar measure voltage even in disconnected state of the capacitors. To avoid these kinds of problems, this protection function measures the currents in the phases of the capacitor, and calculates the voltages in the phases independently. The warning and trip decision is based on the calculated voltage values.

- **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.

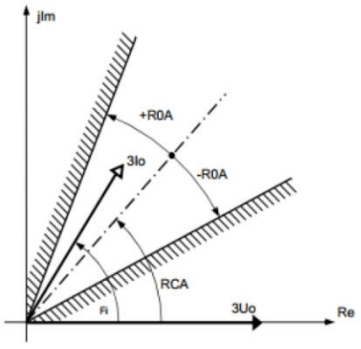
- **Voltage transformer supervision (60)**

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.)

- **Vector jump protection (78)**

The modern electric power systems include an increasing number of small generators (distributed generation system). There can be several events in the network resulting that the small generators get disconnected from the system, and the small generator supplies some consumer only, remaining in the electric "island" (unintended islanding).

If a small generator remains in an island with some consumers, it is highly possible that the balance of the generated and consumed active and reactive power is not fulfilled. This results changing of the frequency and/or voltage, accordingly the voltage vector position of the island is changing, related to that of the disconnected grid. An automatic reclosing of the circuit breaker at an unfavorable vector position can result high currents and serious damages. To prevent these damages a protection is needed to detect the islanding and to disconnect the generator from the island.

One of the protection methods to detect unintended islanding is this vector jump protection function.

- **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.

- **Generator/motor differential protection function (87G/87M)**

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

The inputs of the function are:

- the sampled values of three phase currents measured at the network side,
- the sampled values of three phase currents measured at the neutral connection,
- parameters,
- status signal.

The outputs of the function are:

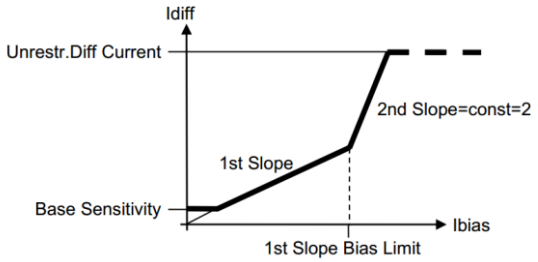
- the binary output status signals,
- the measured values for displaying.

The current base harmonic module of the differential protection function calculates the basic Fourier components of the phase currents both for the network side and for the neutral side. The result is needed to calculate the Ibias for the differential characteristic evaluation.

The differential base harmonic module calculates the differential currents in the phases as the difference between the currents measured on the network side and those on the neutral side and the basic Fourier components of the three differential currents. These results are needed also for the high-speed differential current decision

The differential characteristics module performs the necessary calculations for the evaluation of the “percentage differential characteristics”. The module evaluates the differential characteristics. It compares the magnitude of the differential currents and those of the restraint currents

The generator differential protection characteristics are shown in Figure below: The characteristics compares the magnitude of the differential currents and those of the restraint currents.



The high-speed differential current decision is applied if the calculated differential current is very high. Then the differential characteristic is not considered anymore, because separate status-signals for the phases are set to “true” value if the differential currents in the individual phases are above the limit (Unrestr.Diff Current), defined by parameter setting.

The decision logic module combines enabling parameter and blocking signal with the status signals of the differential decision to generate output trip signals and commands

- **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.

The EuroProt+ protection devices communicate via fiber optic cables. Generally, mono-mode cables are required, but for distances below 2 km a multi-mode cable may be sufficient. The line differential protection can be applied up to the distance of 120 km. (The limiting factor is the damping of the fiber optic channel: up to 30 dB is permitted to prevent the disturbance of operation.)

The hardware module applied is the CPU module of the EuroProt+ protection device. The two devices are interconnected via the “process bus”.

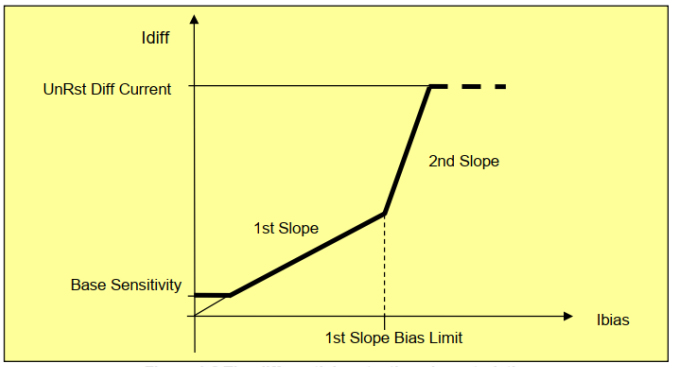


Figure 1-2 The differential protection characteristics

- **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.

MEASUREMENT FUNCTIONS

- **Measurement functions**

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

Measurement functions	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Current (I1, I2, I3, I4, Iseq (I0, I1, I2))	X	X	X	X	X	X	X		X	X
Voltage (U1, U2, U3, U4, U12, U23, U31, Useq (U0, U1, U2)) and frequency		X	X	X	X	X	X	X	X	X
Power (P, Q, S, pf) and Energy (E+, E-, Eq+, Eq-)		X	X	X	X	X	X		X	X
Circuit breaker wear	X	X	X	X	X	X	X	X	X	X
Supervised trip contacts (TCS)	X	X	X	X	X	X	X	X	X	X

The measurement functions of the DTIVA configuration

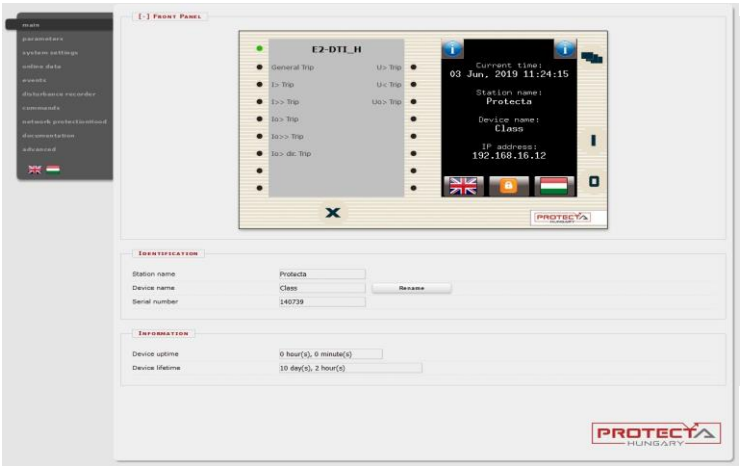
- **Monitoring functions**

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

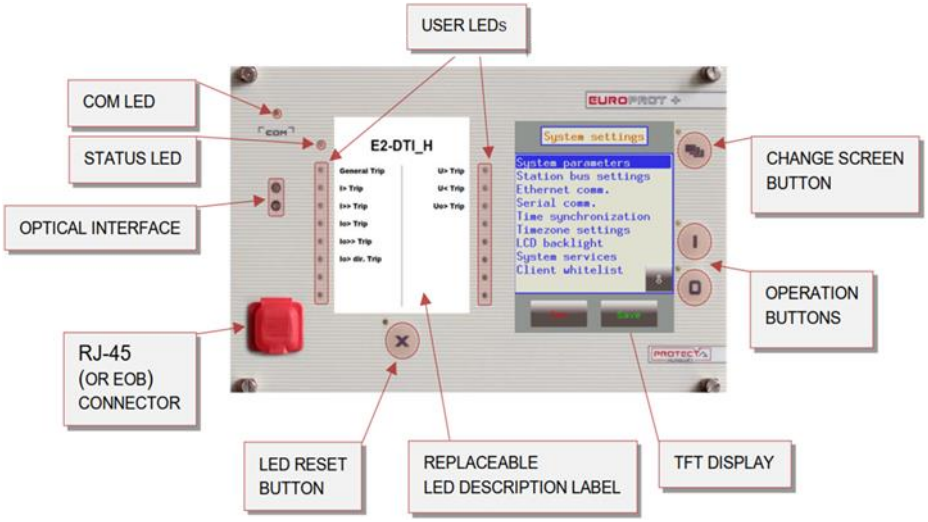
- Harmonics contents of each voltage and current channel (order 1st to order 19th)
- Current total demand distortion (TDD)
- Voltage total harmonic distortion (THD)
- Sags (Dips), Swells and Interrupts

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 Ethern user interface on front panel
    - Optional 10/100Base-T port via RJ-45 connector
  - PRP/HSR seamless redundancy for Ethernet networking (100Base-FX Ethernet; 10/10 Base-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
Overexcitation protection function (24)	
Operation	Off, Definite Time, IEEE
Start U/f LowSet	80-140% in 1% steps
Start U/f HighSet	80-140% in 1% steps
Time Multiplier	1-100 in 1 steps
Min Time Delay	0.50-60.00s in 0.01s steps
Max Time Delay	300.00-8000.00s in 0.01s step
Cooling Time	60.00-8000.00s in 0.01s step
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	0.02-0.5Hz in 0.02Hz steps
FrDiff SynSW Auto	0.10-1.00Hz in 0.2Hz steps
FrDiff SynCheck Man	0.02-0.5Hz in 0.02Hz steps
FrDiff SynSW Man	0.10-1.00Hz in 0.2Hz steps
Breaker Time	0-500ms in 1ms steps
Close Pulse	10-60000ms in 1ms steps
Max Switch Time	100-60000ms in 1ms steps
Definite time undervoltage protection (27)	
Operation	Off, 1 out of 3, 2 out of 3, All
Start Voltage	30-130% in 1% steps
Block Voltage	0-20% in 1% steps
Reset Ratio	1-10% in 1% steps
Time Delay	50-60000ms in 1ms steps
Directional overpower protection (32)	
Operation	Off, On
Direction Angle	-179-180deg in 1deg steps
Start Power	1-200% in 0.1% steps
Time Delay	0-60000ms in 1ms steps
Directional underpower protection (37)	
Operation	Off, On
Direction Angle	-179-180deg in 1deg steps
Start Power	1-200% in 0.1% steps
Time Delay	0-60000ms in 1ms steps
Loss-of-load (undercurrent) (37)	
Operation	Off, On
Start signal only	False, True
Start Current	20-100% in 1% steps
Idle Current	1-20% in 1% steps
Time delay	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	5-3000% in 1% steps
Time Multiplier	0.05-999 in 0.01 steps
Minimal time delay for the inverse char.	0-60000ms in 1ms steps
Definite time delay	0-60000ms in 1ms steps
Reset time delay for the inverse char	0-60000ms in 1ms steps

Broken conductor protection (46BC)	
Operation	Off, On
Start signal only	False, True
Start current	10-90% in 1% steps
Time Delay	100-60000ms in 1ms steps
Negative sequence overvoltage protection (47)	
Operation	Off, On
Start Voltage	2-40% in 1% steps
Time Delay	50-60000ms in 1ms steps
Motor startup supervision (48/66)	
Operation	Off, On
InMotor/InCT	20-150% in 1% steps
Start-up Current	50-1000% in 1% steps
Idle Current	5-50% in 1% steps
Start-up Time	1-100s in 1s steps
Restart Time	10-5000s in 1s steps
No. of Startup	0-5 in 1 steps
Thermal protection (49)	
Operation	Off, Pulsed, Locked
Alarm Temperature	60-200deg in 1deg steps
Trip Temperature	60-200deg in 1deg steps
Rated Temperature	60-200deg in 1deg steps
Base Temperature	0-40deg in 1deg steps
Unlock Temperature	20-200deg in 1deg steps
Ambient Temperature	0-40deg in 1deg steps
Startup Term	0-60% in 1% steps
Rated Load Current	20-150% in 1% steps
Time Constan	1-999min in 1min step
Three-phase instantaneous overcurrent protection (50)	
Operation	Off, Peak value, Fundamental value
Start current	5-3000% in 1% steps
Breaker failure protection (50BF)	
Operation	Off, Current, Contact, Current/Contact
Retrip	Off, On
Start Ph Current	20-200% in 1% steps
Start Res Current	10-200% in 1% steps
Retrip Time Delay	0-1000ms in 1ms steps
Backup Time Delay	100-60000ms in 1ms steps
Pulse Duration	0-60000ms in 1ms steps
Residual instantaneous overcurrent protection (50N/50Ns)	
Operation	Off, Peak value, Fundamental value
Start Current	5-3000% in 1% steps
Three-phase time overcurrent protection (51)	

Operation	Off, Definite Time, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI0.95 Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv
Start current	5-3000% in 1% steps
Time Multiplier	0.05-999 in 0.01 steps
Minimum time delay for the inverse char.	40-60000ms in 1ms steps
Definite time delay for definite type char.	40-60000ms in 1ms steps
Reset time delay for the IEC type inverse char.	60-60000ms in 1ms steps
Residual time overcurrent protection (51N/51Ns)	
Operation	Off, DefiniteTime, IEC Inv,IEC VeryInv, IEC ExtInv,IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv
Start current	
In = 1A or 5A	5-3000% in 1% steps
In = 200mA or 1A	5-3000% in 1% steps
Time Multiplier	0.05-999 in 0.01 steps
Minimum time delay for the inverse char.	40-60000ms in 1ms steps
Definite time delay for definite type char.	40-60000ms in 1ms steps
Reset time delay for the inverse char.	60-60000ms in 1ms steps
Definite time overvoltage protection (59)	
Operation	Off, On
Start Voltage	30-130% in 1% steps
Reset Ratio	1-10% in 1% steps
Time Delay	0-60000ms in 1ms steps
Capacitor overvoltage protection function (59C)	
Operation	Off, On
Rated Current	15-120% in 1% steps
Warning Start	80-120% in 1% steps
Reset time	1-60000ms in 1ms steps
Warning Delay	1-3600ms in 1ms steps
Time Multiplier	0.2-2 in 0.01 steps
Residual overvoltage protection (59N)	
Operation	Off, On
Start Voltage	2-60% in 1% steps
Time Delay	0-60000ms in 1ms steps
Current transformer supervision (60)	
Operation	Off, On
Start Signal Only	False, True
Start Current Diff	10-90% in 1% steps
Time Delay	100-60000ms in 1ms steps
Voltage transformer supervision (60)	
Operation	Off, Zero sequence, Negative sequence, Special
Min Operate Voltage	10-100% in 1% steps
Min Operate Current	2-100% in 1% steps
Start URes	5-50% in 1% steps

Start IRes	10-50% in 1% steps
Start UNeg	5-50% in 1% steps
Start INeg	10-50% in 1% steps
Three-phase directional overcurrent protection (67)	
Direction	NonDir, Forward, Backward
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
Operating Angle	30-80º in 1º steps
Characteristic Angle	40-90º in 1º steps
Start Current	5-3000% in 1% steps
Time Multiplier	0.05-999 in 0.01 steps
Minimum time delay for the inverse char.	30-60000ms in 1ms steps
Definite time delay	30-60000ms in 1ms steps
Reset time	60-60000ms in 1ms steps
Residual directional overcurrent protection (67N/67Ns)	
Direction	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)
Operation	Off, DefiniteTime, IEC Inv,IEC VeryInv, IEC ExtInv,IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv
Start Current	5-3000% in 1% steps
URes Min	1-20% in 1% steps
IRes Min	1-50% in 1% steps
Operating Angle	30-85º in 1º steps
Characteristic Angle	-180-180º in 1º steps
Time Multiplier	0.05-999 in 0.01 step
Minimal time delay for the inverse char.	30-60000ms in 1ms steps
Definite time delay	30-60000ms in 1ms steps
Reset time delay for the inverse char.	30-60000ms in 1ms steps
Inrush detection (68)	
Operation	Off, On
2nd Harm Ratio	5-50% in 1% steps
Basic sensitivity of the function	20-100% in 1% steps
Vector jump protection (78)	
Operation	Off, On
PhaseDiff Limit	5-25deg in 1deg steps
Max NegSeq Voltage	10-100% in 1% steps
Time Delay	5-50% in 1% steps
Max ZeroSeq Voltage	1-30% in 1% steps
Pulse Duration	150-500ms in 1ms steps
Auto-reclose (79)	
Operation	Off, On
EarthFault RecCycle	Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4. Enabled
PhaseFault RecCycle	Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4.

	Enabled
Reclosing Started by	Trip reset, CB open
1. Dead Time Ph	0-100000ms in 10ms steps
2. Dead Time Ph	10-100000ms in 10ms steps
3. Dead Time Ph	10-100000ms in 10ms steps
4. Dead Time Ph	10-100000ms in 10ms steps
1. Dead Time EF	0-100000ms in 10ms steps
2. Dead Time EF	10-100000ms in 10ms steps
3. Dead Time EF	10-100000ms in 10ms steps
4. Dead Time EF	10-100000ms in 10ms steps
Reclaim Time	100-300000ms in 10ms steps
Close Command Time	10-10000ms in 10ms steps
Dynamic Blocking Time	10-100000ms in 10ms steps
Block after Man Close	0-100000ms in 10ms steps
Action Time	0-20000ms in 10ms steps
Start Signal Max Time	0-10000ms in 10ms steps
DeadTime Max Delay	0-100000ms in 10ms steps
CB Supervision Time	10-100000ms in 10ms steps
SynCheck Max Time	500-100000ms in 10ms steps
SynCheck Max Time	500-100000ms in 10ms steps
CB State Monitoring	False, True
Accelerate 1.Trip	False, True
Accelerate 2.Trip	False, True
Accelerate 3.Trip	False, True
Accelerate 4.Trip	False, True
Overfrequency protection (81O) **Undefrequency protection (81U)**	
Operation	Off, On
Start signal only	False, True
Start frequency	40-70Hz in 0.01Hz steps
Time Delay	0-60000ms in 1ms steps
Voltage limit	0.3-1.0 Un
Rate of change of frequency protection (81R)	
Operation	Off, On
Start signal only	False, True
Start df/dt	-5.00-5.00Hz/s in 0.01Hz/s steps
Time Delay	0-60000ms in 1ms steps
Lockout trip logic (86/94)	
Operation	Off, On, Lockout
Min pulse duration	50-60000ms in 1ms steps
Generator/Motor differential protection (87G/87M)	
Operation	Off, On
Base Sensitivity	10-50% in 1% step
1st Slope	10-50% in 1% step
1st Slope Bias Limit	200-2000% in 1% step
UnRst Diff Current	800-2500% in 1% step
Line differential protection (87L)	
Operation	Off, On

Base Sensitivity	10-50% in 1% steps
1st Slope	10-50% in 1% steps
2nd Slope	50-100% in 1% steps
1st Slope Bias Limit	100-400% in 1% steps
UnRst Diff Current	500-1000% in 1% steps
Local Ratio	0.10-2.00 in 0.01 steps
Remote Ratio	0.10-2.00 in 0.01 steps
Switch-onto-fault (SOTF)	
Operation	Off, On
SOTF Drop Delay	10-10000ms in 1ms steps
Disturbance recorder	
Operation	Off, On
Resolution	1/1.2 kHz; 2/2.4kHz
Prefault	100-1000ms in 1ms steps
PostFault	100-10000ms in 1ms steps
Max Recording Time	500-10000ms in 1ms steps

TECHNICAL DATA

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

Installation Case Protection class	Flush 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 Serial Interface	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 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
Overexcitation protection (24)	
U/f pick up accuracy	<1%
U/f drop off ratio	0.95
DT and custom char. time delay accuracy	< 1%
IEEE char. time delay accuracy	< 5%
Synchrocheck (25)	
Rated Voltage Un	100/200V, parameter setting
Voltage effective range	10-110 % of Un, accuracy: ±1% of Un
Frequency	47.5 – 52.5 Hz, accuracy: ±10 mHz
Phase angle accuracy	±3 °
Operate time	Setting value, accuracy: ±3 ms
Reset time	<50 ms
Reset ratio	0.95 Un
Definite time undervoltage protection (27)	
Pick-up starting accuracy	< ± 0,5 %
Reset time	
U> → Un	50 ms
U> → 0	40 ms
Operate time accuracy	< ± 20 ms
Minimum operate time	50 ms
Directional over-power protection (32)	
P,Q measurement	Effective range: I>5% In, accuracy: <3%
Loss-of-load (undercurrent) protection (37)	
Current Accuracy	±1% of In (Range: 20-2000% of In)
Reset Ratio	0.95
Operating Time Accuracy	±5% or ±15 ms, whichever is greater
Min. Operating Time	<60ms
Reset Time	<60ms
Directional under-power protection (37)	
P,Q measurement	Effective range: I>5% In, accuracy: <3%
Negative sequence overcurrent protection (46)	
Operating accuracy	<2% (when 20 ≤ G_S ≤ 1000)
Operate time accuracy	±5% or ±15 ms, whichever is greater
Reset ratio	0.95
Reset time	
Dependent time char.	Dependent time char.
Definite time char.	Approx 60 ms
Reset accuracy time	< 2% or ±35 ms, whichever is greater
Transient overreach	< 2 %
Pickup time *	< 40 ms
Overshot time	
Dependent time char.	25 ms

Definite time char.	45 ms
Influence of time varying value of the input current (IEC 60255-151) accuracy	< 4 %
Brocken conductor protection (46BC)	
Pick-up starting accuracy	<2 %
Reset ratio	0.95
Min. operate time	70ms
Negative sequence overvoltage protection (47)	
Pick-up starting accuracy	< ± 0,5 %
Blocking voltage accuracy	< ± 1,5 %
Reset time	
U> → Un	60 ms
U> → 0	50 ms
Operate time accuracy	< ± 20 ms
Drop-off ratio accuracy	± 0,5 %
Minimum operate time	50 ms
Motor startup supervision (48/66)	
Current Accuracy	<6% of In (Range: 20-2000% of In)
Reset Ratio	0.95 at Startup Current
Operating Time Accuracy	±5% or ±15 ms, whichever is greater
Reset Time	<60ms
Thermal protection (49)	
Operate time at I>1.2*Itrip accuracy	<3 % or <+ 20 ms
Three-phase instantaneous overcurrent protection (50)	
Using peak value calculation	
Operating characteristic	Instantaneous, accuracy < 6 %
Reset ratio	0.85
Operate time at 2*I_S	<15 ms
Reset time	<40 ms
Transient overreach	90%
Using Fourier basic harmonic calculation	
Operating characteristic	Instantaneous, accuracy < 2 %
Reset ratio	0.85
Operate time at 2*I_S	<25 ms
Reset time	<60 ms
Transient overreach	15%
Breaker failure protection (50BF)	
Pick-up starting accuracy	<2 %
Operating time accuracy	±5% or ±15 ms, whichever is greater
Retrip time	approx. 15 ms
Reset ratio	0.9
Current reset time	16-25ms
Residual instantaneous overcurrent protection (50N/50Ns)	
Using peak value calculation	

Operating characteristic (I>0.1 In)	Instantaneous, accuracy <6%
Reset ratio	0.85
Operate time at 2*I_S	< 15 ms
Reset time *	< 35 ms
Transient overreach	85 %
Using Fourier basic harmonic calculation	
Operating characteristic (I>0.1 In)	Instantaneous, accuracy <6%
Reset ratio	0.85
Operate time at 2*I_S	< 25 ms
Reset time *	< 60 ms
Transient overreach	15 %
Three-phase time overcurrent protection (51)	
Operating accuracy	<2% (when 20 ≤ G_S ≤ 1000)
Operate time accuracy	±5% or ±15 ms, whichever is greater
Reset ratio	0.95
Reset time	
Dependent time char.	Dependent time char.
Definite time char.	Approx 60 ms
Reset time accuracy	< 2% or ±35 ms, whichever is greater
Transient overreach	< 2 %
Pickup time *	< 40 ms
Overshot time	
Dependent time char.	30 ms
Definite time char.	50 ms
Influence of time varying value of the input current (IEC 60255-151)	< 4 %
Residual time overcurrent protection (51N/51Ns)	
Operating accuracy	<3% (when 20 ≤ G_S ≤ 1000)
Operate time accuracy	±5% or ±15 ms, whichever is greater
Reset ratio	0.95
Reset time	
Dependent time char.	Dependent time char.
Definite time char.	Approx 60 ms
Reset accuracy time	< 2% or ±35 ms, whichever is greater
Transient overreach	< 2 %
Pickup time *	≤ 40 ms
Overshot time	
Dependent time char.	30 ms
Definite time char.	50 ms
Influence of time varying value of the input current (IEC 60255-151) accuracy	< 4 %
Capacitor overvoltage protection (59C)	
Pick-up starting accuracy	<1%
Operate time accuracy	<5%
Definite time overvoltage protection (59)	
Pick-up starting accuracy	< ± 0,5 %
Reset time	

U> → Un	60 ms
U> → 0	50 ms
Operate time accuracy	< ± 20 ms
Minimum operate time	50 ms
Residual overvoltage protection (59N)	
Pick-up starting accuracy	
2 – 8 %	< ± 2 %
8 – 60 %	< ± 1.5 %
Reset time	
U> → Un	60 ms
U> → 0	50 ms
Operate time	50 ms
Operate time accurracy	< ± 20 ms
Current unbalance protection (60)	
Pick-up starting accuracy at In	Pick-up starting accuracy at In
Reset ratio	0.95
Operate time	70 ms
Voltage transformer supervision (60)	
Pick-up voltage accuracy	<1%
Operate time	<20 ms
Reset ratio	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	<3°
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	<3°
Io ≤ 0.1 In	<±10°
Io ≤ 0.1 In	<±5°
Io ≤ 0.1 In	<±2°
Angular reset ratio	

Forward and backward	10°
All other selection	5°
Inrush detection (68)	
Range	20 – 2000% of In
Current accuracy	±1% of In
Vector jump protection (78)	
Pick-up starting accuracy	±5%
Blocking voltage	U>0.2Un, accuracy: <5%
Operate time	
Jump>2*setting	<50 ms
Minimum operate time	40 ms
Pulse duration	150 … 500 ms, accuracy: <10 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
Generator/Motor differential protection (87G/87M)	

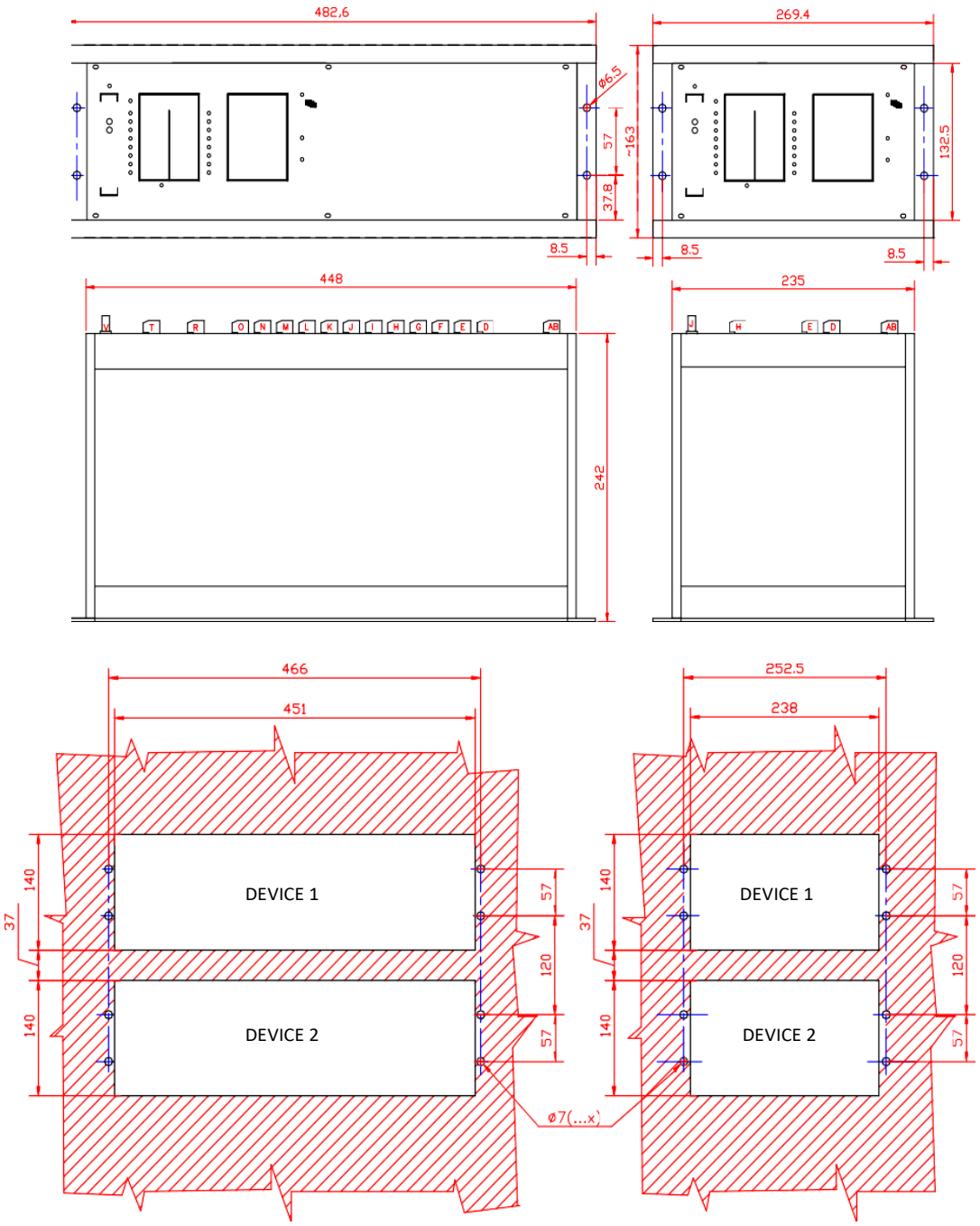
Operating characteristic	2 breakpoints
Reset ratio	0.95
Characteristic accuracy	<2%
Operate time, unrestrained	Typically 20 ms
Reset time, unrestrained	Typically 25 ms
Operate time, restrained	Typically 30 ms
Reset time, restrained	Typically 25 ms
Lockout trip logic (86/94)	
Pulse time	<3 ms
Line differential 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

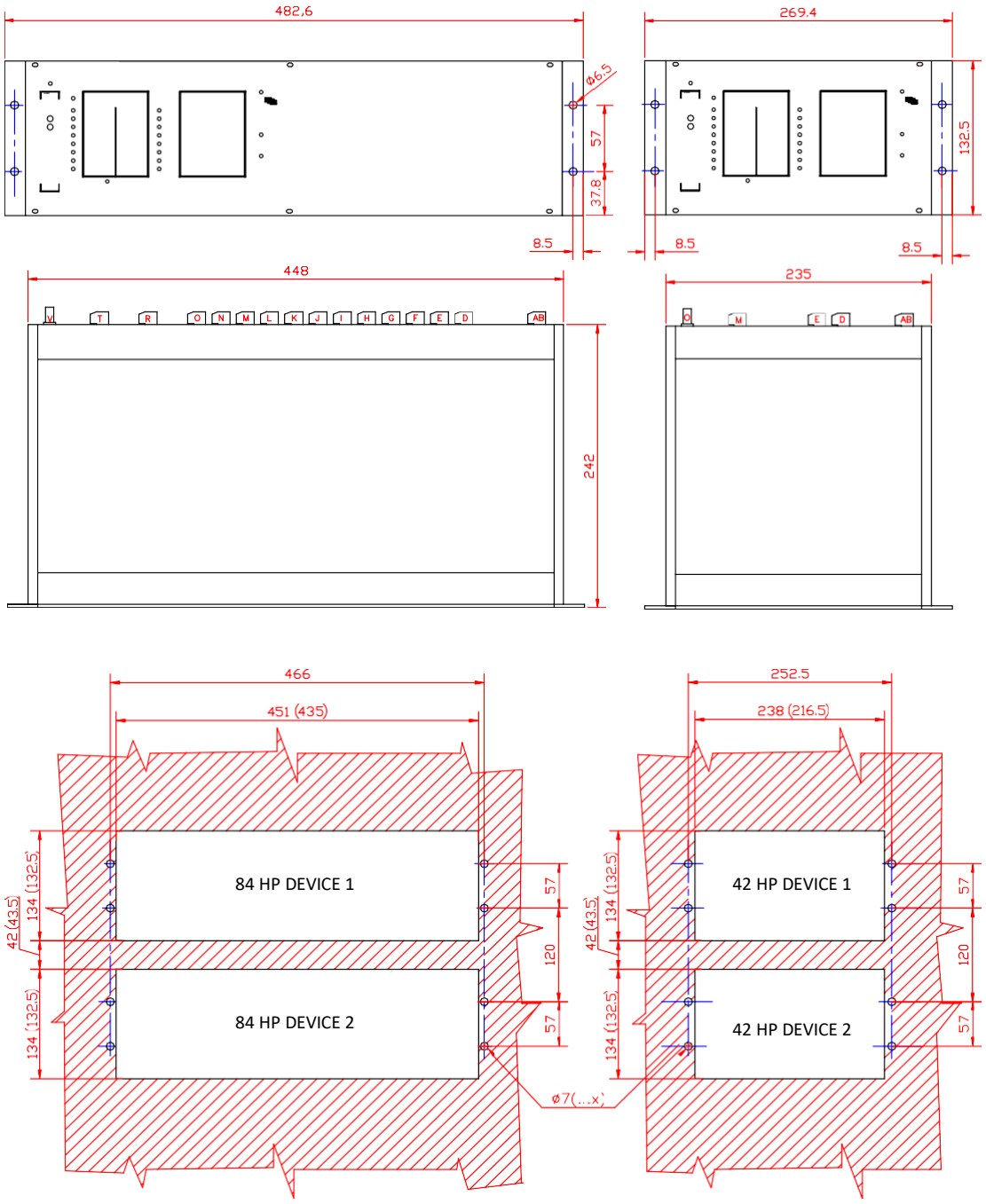
- **Flush mounting**



Dimension and panel cut-out for DTIVA 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 DTIVA 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**

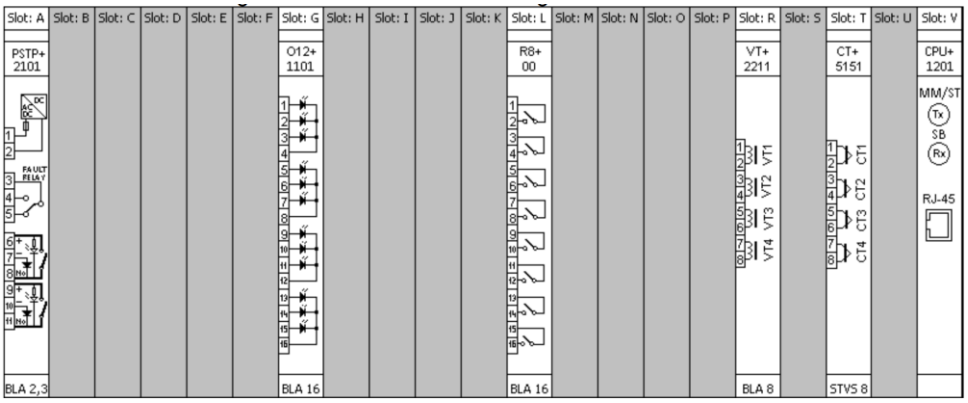
The standard number of inputs and outputs of each variant are listed in the table below.

Hardware configuration	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Current inputs (4th channel can be sensitive)	4	4	4	4	4	4	4		4	4
Voltage inputs		4	4	4	4	4	4	4	4	4
Binary inputs	12	12	12	12	12	12	12	12	12	12
Binary outputs	8	8	8	8	8	8	8	8	8	8
Fast trip outputs	4	4	4	4	4	4	4	4	4	4

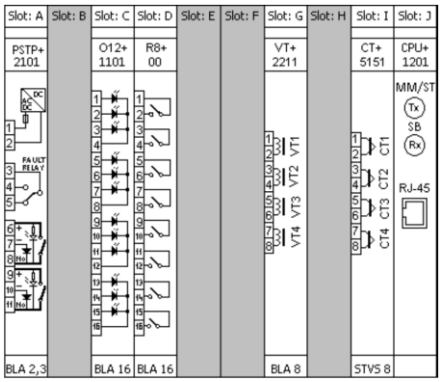
The maximum number of inputs and outputs of each variant are listed in the table below.

Hardware configuration	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Binary inputs (Max)	136	128	128	128	128	128	128	136	128	128
Binary outputs (Max)	60	60	60	60	60	60	60	60	60	60
Fast trip outputs (Max)	12	12	12	12	12	12	12	12	12	12

- **Module arrangement**

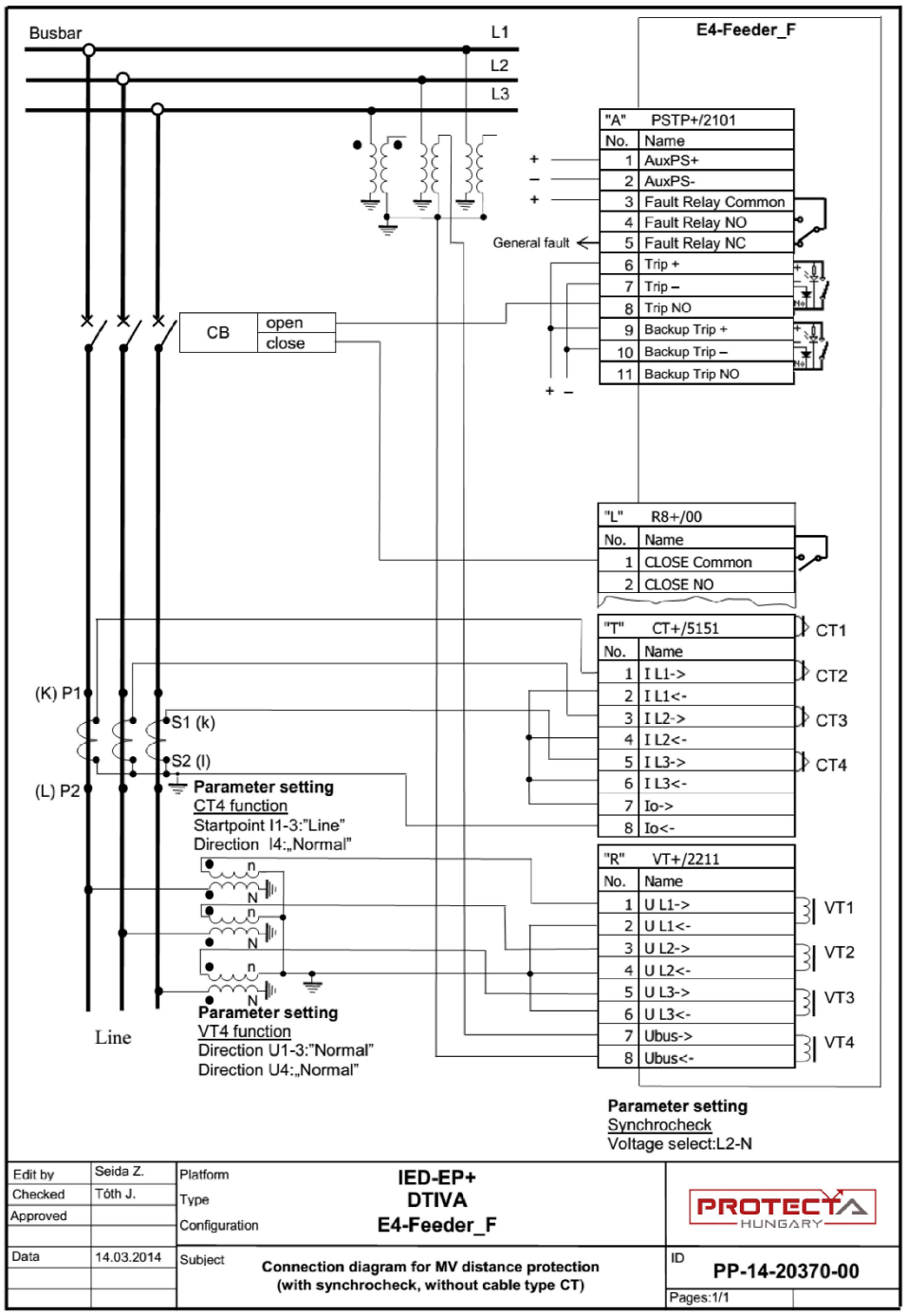


Basic module arrangement of the DTIVA configuration (84TE, rear view)

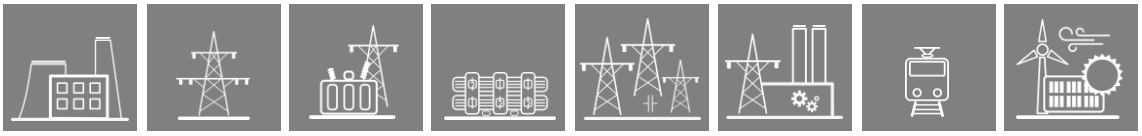


Basic module arrangement of the DTIVA configuration (42TE, rear view)

EXTERNAL CONNECTION DIAGRAM



Typical connection diagram for DTIVA configuration



CONTACT

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

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