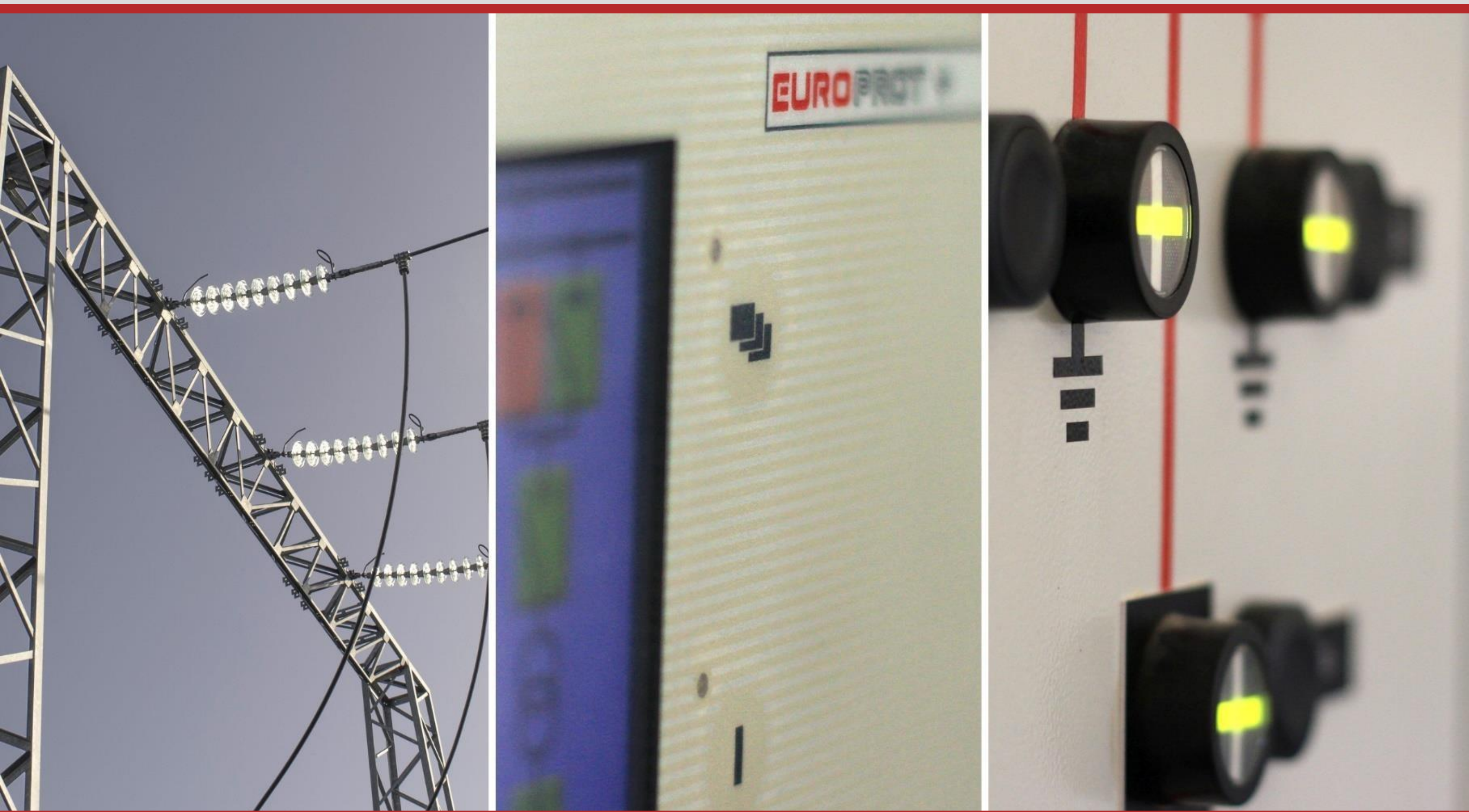


PRODUCT DESCRIPTION

EuroProt+ Smart Line S16 Series

IED-EP+S/S16

CURRENT/VOLTAGE PROTECTION RELAY

PROTECTA HUNGARY

EUROPROT+ SMART LINE S16 SERIES

CURRENT/VOLTAGE PROTECTION RELAY

OVERVIEW

The **IED-EP+ S16** series is part of the **EuroProt+ Smart Line numerical protection relay**. Members of the Smart Line also offer a wide range of functions but they do so in a small, compact enclosure so that they can be installed in locations with limited space available for the protection equipment.

The **IED-EP+ S16** series contains a special selection of the EuroProt+ modules, bearing in mind the cost effective realization. The low-cost **IED-EP+ S16** series was able to be realized with predefined hardware arrangement and fixed standard configurations

GENERAL FEATURES

- Compact (16HP) housing
- Software-configurable secondary rated current for the phase and the residual currents (1-3CT channel rated current: 1 or 5A; 4th channel: 0.2,1,5A)
- Universal power supply (19.2 - 300 VDC; 80 - 255 VAC)
- Event recorder for up to 1000 events
- Free, user-friendly software tool (S16 tool software).
- High-speed, supervised TRIP contacts Built-in supervision
- Several mounting methods: Flush mounting; Semi- flush mounting; Din rail mounting
- Software-configurable rated voltage of the binary inputs
- Ready-to-use and straightforward handling
- Supported communication protocols:
  - IEC 60870-5-101
  - IEC 60870-5-103
- 128x64 Black/White LCD with white blacklight 4x pushbuttons
- 8x three-color matrix programmable alarm LED indicators
- Three-color status LED
- Time synchronization protocol: PPS, IRIG-B

APPLICATION

The primary target of the **IED-EP+ S16** feeder protection relay is the protection of incoming and outgoing feeders in distribution substations. **IED-EP+ S16** is also used as back-up protection for feeders, motors, transformers and generators in utility and industry applications, where an independent and redundant protection system is required. Depending on the selected standard configuration, the IED is adapted to the protection of medium voltage feeders in isolated neutral, resistance earthed, compensated or solidly earthed networks. Once the standard configuration IED has been given the application-specific settings, it can be directly put into service.

Application area also covers protection functions for a large variety of applications, e.g. frequency and voltage based protections, motor protection and thermal overload protection function.

The **IED-EP+ S16** is available in five predefined standard configurations to suit the most common feeder protection applications.

- **Variant 1** is mainly used as main or backup overcurrent protection.
- **Variant 2** provides additional motor protection functions compared to Variant 1.
- **Variant 3** is suitable for those application where only voltage and frequency based protection functions are required.
- **Variant 4** is extended with one voltage input. It can be used for residual voltage measuring. Consequently, the **Variant 4** application includes the residual directional overcurrent protection function.
- **Variant 5** provides motor protection functions above Variant 4.

PROTECTION & CONTROL FUNCTIONS

- **Pre-defined configuration variants**

The different configurations can measure three phase currents, the residual current component and additionally three phase voltages and the residual voltage. These measurements allow in addition to the current- or voltage-based functions directionality extension to the configured phase and residual overcurrent functions. Based on the voltage measurement also the frequency is evaluated to realize frequency-based protection functions.

The configured protection functions of each predefined standard configuration are listed in the table below.

PROTECTION & CONTROL FUNCTIONS	IEC	ANSI	*Inst.	Var. 1	Var. 2	Var. 3	Var. 4	Var. 5
Definite time undervoltage protection	U <, U <<	27	2			✓		
Undercurrent protection	I <	37	1		✓			✓
Negative sequence overcurrent protection	I2 >	46	1	✓	✓		✓	✓
Negative sequence overvoltage protection	U2 >	47	1			✓		
Startup supervision with restart inhibit	I^2start	48/66	1		✓			✓
Thermal protection (Line/Motor)	T >	49L/49M	1	✓	✓		✓	✓
Three-phase instantaneous overcurrent protection	I >>>	50	1	✓	✓		✓	✓
Breaker failure protection	CBFP	50BF	1	✓	✓	✓	✓	✓
Residual instantaneous overcurrent protection	Io >>>	50N	1	✓	✓		✓	✓
Three-phase time overcurrent protection	I >, I >>	51	2	✓	✓		✓	✓
Residual time overcurrent protection	Io >, Io >>	51N	2	✓	✓		✓	✓
Definite time overvoltage protection	U >, U >>	59	2			✓		
Residual overvoltage protection	Uo >, Uo >>	59N	2			✓	✓	✓
Residual directional overcurrent protection	Io Dir >, Io Dir >>	67N	2				✓	✓
Inrush detection	I2h >	68	1	✓	✓		✓	
Trip circuit supervision		74	1	✓	✓	✓	✓	✓
Vector jump protection	ΔφU>	78V	1			✓		
Overfrequency protection	f >, f >>	81O	2			✓		
Underfrequency protection	f <, f <<	81U	2			✓		
Rate of change of frequency protection	df/dt	81R	1			✓		

- **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.

- **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.

- **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.

- **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.

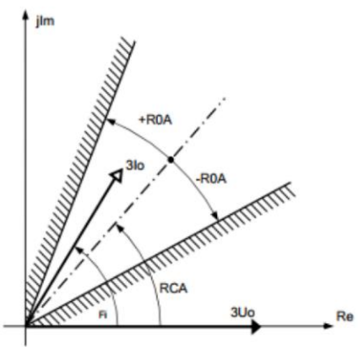
The function generates start signal if the residual voltage is above the level defined by parameter setting value. The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

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.

- **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.

- **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.

MEASUREMENT FUNCTIONS

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

- Current (I1, I2, I3, Io)
- Voltage (U1, U2, U3, U12, U23, U31, Uo, Useq) and frequency
- Supervised trip contacts (TCS)

HMI AND COMMUNICATION TASKS

- **Human-Machine Interface**
  - The HMI of the IED contains the following elements:
  - Display (128 x 64pixel monochrome, with white backlight)
  - Mechanical buttons: up, down, enter, cancel (cancel also has LED acknowledge function)
  - 3-color matrix programmable alarm LED indicators (8 pieces). The LEDs can be configured with configuration software.
  - 3-color status LED
  - Communication port (USB 2.0 connection)
- **Communication:**

  The serial communication protocols supported by the IED can be selected using the local LCD
  - IEC 60870-5-101
  - IEC 60870-5-103

  Link level parameters: 1200-57600 bps, 8 data bit (fixed), 1 stop bit (fixed), even parity (fixed)

FUNCTIONAL PARAMETERS

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
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
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 Start current	Off, Peak value, Fundamental value 5-3000% in 1% steps
Breaker failure protection (50BF)	
Operation Start Ph Current Start Res Current Backup Time Delay Pulse Duration	Off, Current, Contact, Current/Contact ±5 ms 20-200% in 1% steps 10-200% in 1% steps 60-1000ms in 1ms steps 0-60000ms in 1ms steps
Residual instantaneous overcurrent protection (50N/50Ns)	
Operation Start Current	Off, Peak value, Fundamental value 5-3000% in 1% steps
Three-phase time overcurrent protection (51)	
Operation	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 Time Multiplier Minimum time delay for the inverse char. Definite time delay for definite type char. Reset time delay for the IEC type inverse char.	5-3000% in 1% steps 0.05-999 in 0.01 steps 40-60000ms in 1ms steps 40-60000ms in 1ms steps 60-60000ms in 1ms steps
Residual time overcurrent protection (51N/51Ns)	
Operation	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 In = 200mA or 1A Time Multiplier Minimum time delay for the inverse char. Definite time delay for definite type char. Reset time delay for the inverse char.	 5-3000% in 1% steps 5-3000% in 1% steps 0.05-999 in 0.01 steps 40-60000ms in 1ms steps 40-60000ms in 1ms steps 60-60000ms in 1ms steps
Definite time overvoltage protection (59)	
Operation Start Voltage Reset Ratio Time Delay	Off, On 30-130% in 1% steps 1-10% in 1% steps 0-60000ms in 1ms steps
Residual overvoltage protection (59N)	
Operation Start Voltage Time Delay	Off, On 2-60% in 1% steps 0-60000ms in 1ms steps
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
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

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	0-250VAC/VDC continuous, 275VAC/350VDC for 1s
Burden	
Phase current inputs	0.05VA at In = 1A, 0.25VA at In = 5A
Voltage inputs	0.3VA at 100V
Power Supply	
Rated auxiliary voltage	19.2-300VDC/80-250VAC
Power consumption	<10W
Binary Inputs	
Selectable rated voltage	24VDC, 48VDC, 110VDC, 220VDC
Maximum withstand voltage	265VDC
Binary Outputs	
Maximum withstand voltage	250 VAC/DC
Continuous carry	6A
Mechanical Design	
Installation	Flush mounting, semi flush mounting, vertical on DIN-rail
Case	16 HP (height:3U)
Protection class	IP4x from front side, IP30 from rear side
Key & LED	
Device keys	4x Pushbutton
Number of configurable LED	8
Device status LED	1 piece three-color, 3 mm circular LED
Local Interface	
Service port on front panel	USB 2.0
System Interface	
Serial Interface	RS485, 1200-57600bps, 8 data bit (fixed), 1 stop bit (fixed), even parity (fixed)
PROTECTION & CONTROL FUNCTIONS	
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
Loss-of-load (undercurrent) protection (37)	
Current Accuracy Reset Ratio Operating Time Accuracy Min. Operating Time Reset Time	±1% of In (Range: 20-2000% of In) 0.95 ±5% or ±15 ms, whichever is greater <60ms <60ms
Negative sequence overcurrent protection (46)	
Operating accuracy Operate time accuracy Reset ratio Reset time Dependent time char. Definite time char. Reset accuracy time Transient overreach Pickup time * Overshot time Dependent time char. Definite time char. Influence of time varying value of the input current (IEC 60255-151) accuracy	<2% (when 20 ≤ G_S ≤ 1000) ±5% or ±15 ms, whichever is greater 0.95 Dependent time char. Approx 60 ms < 2% or ±35 ms, whichever is greater < 2 % < 40 ms 25 ms 45 ms < 4 %
Negative sequence overvoltage protection (47)	
Pick-up starting accuracy Blocking voltage accuracy Reset time U> → Un U> → 0 Operate time accuracy Drop-off ratio accuracy Minimum operate time	< ± 0,5 % < ± 1,5 % 60 ms 50 ms < ± 20 ms ± 0,5 % 50 ms
Motor startup supervision (48/66)	
Current Accuracy Reset Ratio Operating Time Accuracy Reset Time	<6% of In (Range: 20-2000% of In) 0.95 at Startup Current ±5% or ±15 ms, whichever is greater <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 Reset ratio Operate time at $2*I_S$ Reset time Transient overreach	Instantaneous, accuracy < 6 % 0.85 <15 ms <40 ms 90%

Using Fourier basic harmonic calculation	
Operating characteristic	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)	
Current accuracy	<2 %
BF Time accuracy	±5 ms
Current reset time	20 ms
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 %
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
Residual directional overcurrent protection (67N/67Ns)	
Operating accuracy	< ±2 %
Operating accuracy	±5% or ±15 ms, whichever is greater 0.95
Accuracy in minimum time range	±35 ms
Reset ratio	0.95
Reset time	Approx 50 ms
Reset time accuracy	±35 ms
Transient overreach	< 2 %
Pickup time	±35 ms
Angular accuracy	<3º
Io ≤ 0.1 In	<±10º
Io ≤ 0.1 In	<±5º
Io ≤ 0.1 In	<±2º
Angular reset ratio	
Forward and backward	10º
All other selection	5º
Overfrequency protection (81O) Underfrequency 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)

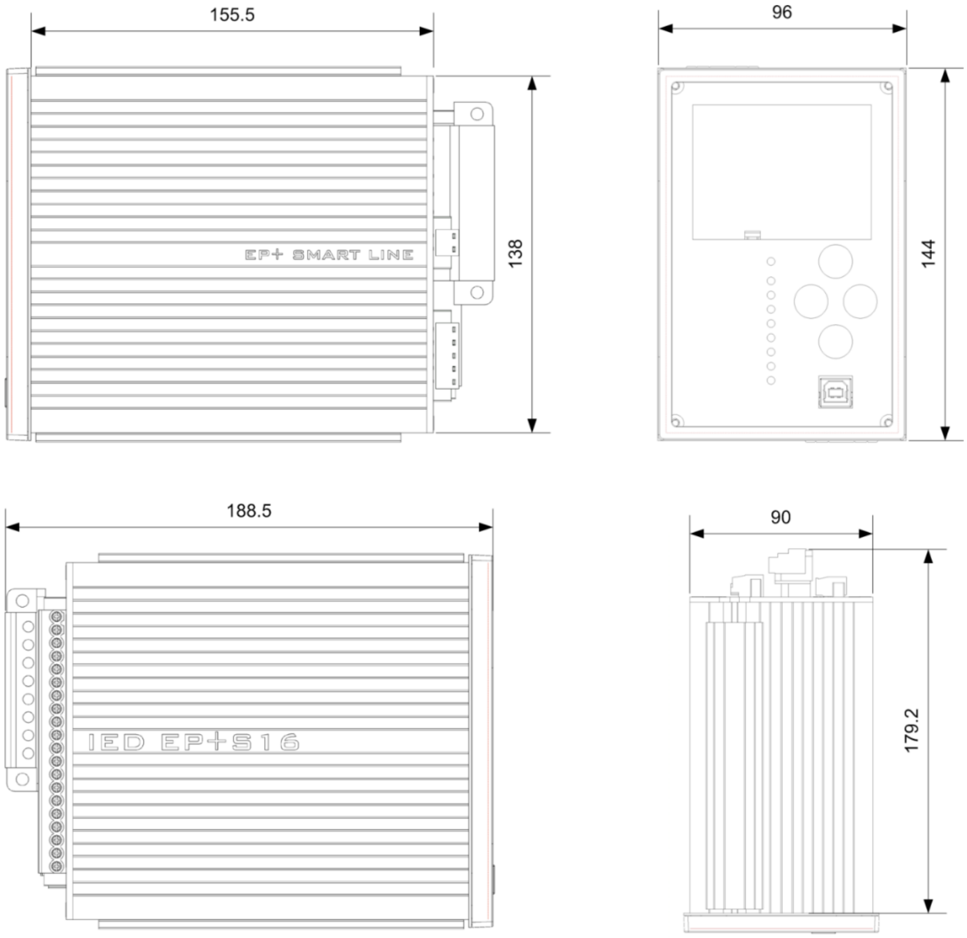
	± 27 ms (60 Hz system)
Accuracy when time delay:	
140 – 60000 ms	± 4 ms
<140 ms (50 Hz system)	± 32 ms
<140 ms (60 Hz system)	± 27 ms
Reset frequency	[Start freq.] – 101 mHz, accuracy: ± 1 mHz
Reset time	98 ms (50 Hz) 85 ms (60 Hz)
Reset time accuracy	± 6 ms
Rate of change of frequency protection (81R)	
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
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

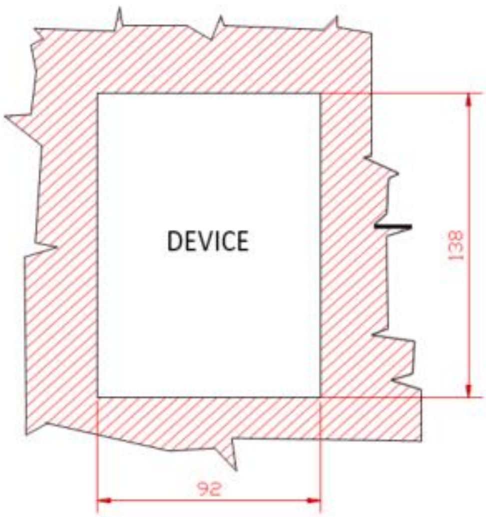
Atmospheric Environment		
Temperature	IEC 60068-2-1 IEC 60068-2-2 IEC 60068-2-14	Storage temperature: - 30 ºC … + 70 ºC Operation temperature: - 20 ºC … + 55 ºC
Humidity	IEC 60255-1 IEC 60068-2-78	Humidity: 10 % ... 93 %
Enclosure protection	IEC 60529	IP4x from front side, IP30 from rear side
Mechanical 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 voltage: 8 kV AD, 6 kV CD
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	Test voltage: 10 V
Power frequency magnetic field immunity	IEC 61000-4-8 IEC 60255-26	Test field field strength: 30 A/m continuous, 300 A/m for 3 s
Damped oscillatory wave immunity	IEC 61000-4-18 IEC 60255-26	Test voltage: 2.5 kV

DIMENSION AND PANEL CUT-OUT

- **Drawings of panel instrument case (16 HP) and recommended panel cut-out**



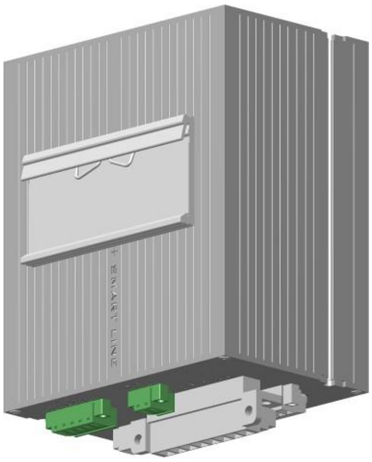
S16 dimensions with STVS CT connector

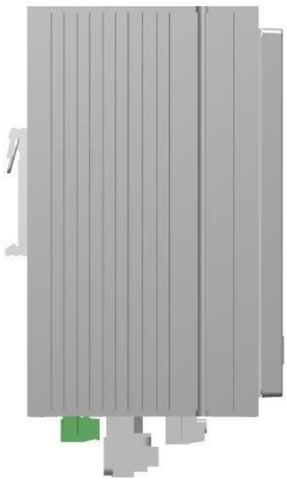


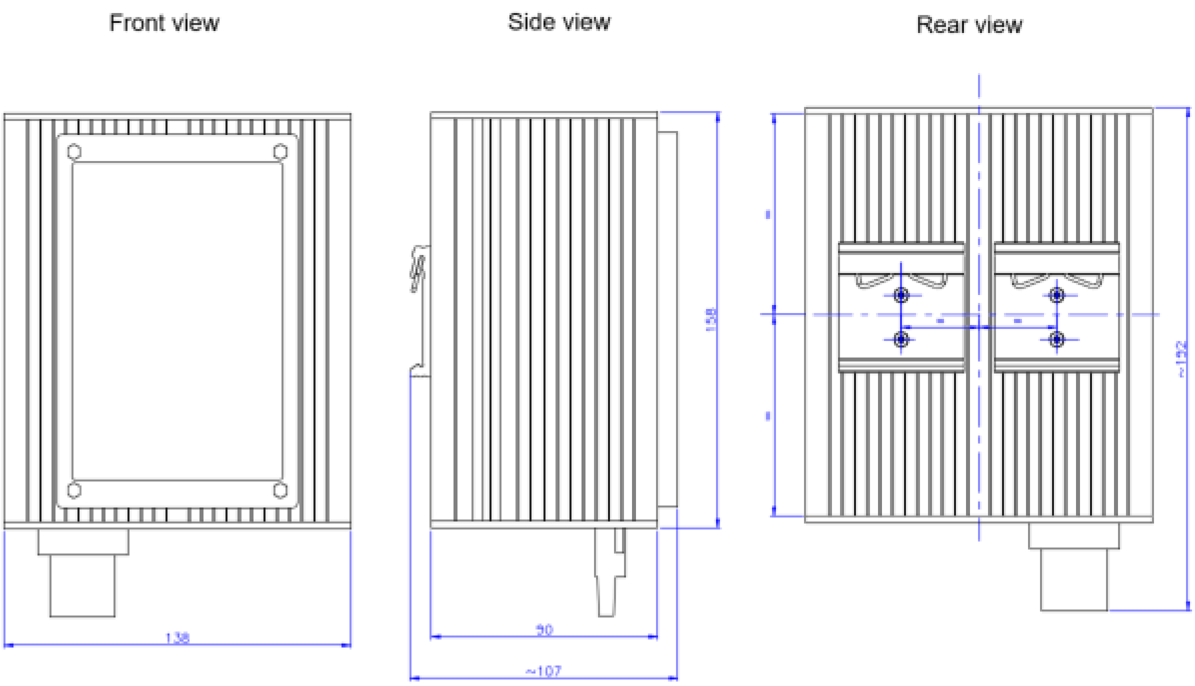
S16 panel cut-out for flush and semi-flush mounting

S16 semi-flush mounting method (max. depth = 75mm)

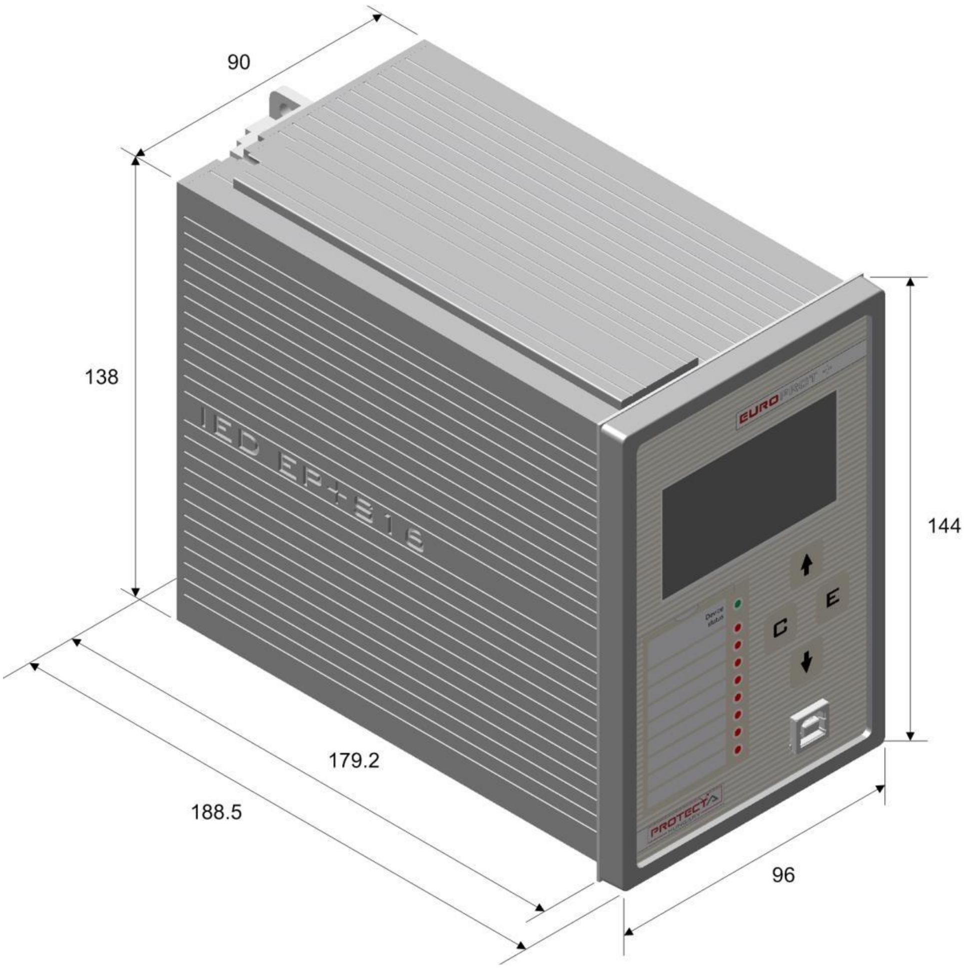
S16 flush mounting method







S16 DIN-rail mounting dimensions



S16 dimensions with STVS CT connector

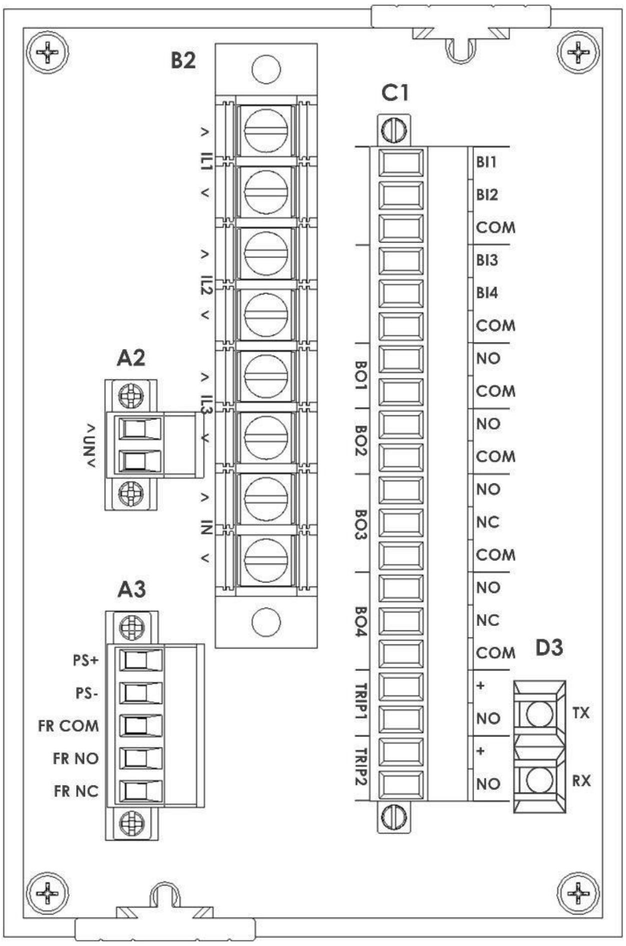
HARDWARE CONFIGURATION

- **Variant 1&2**

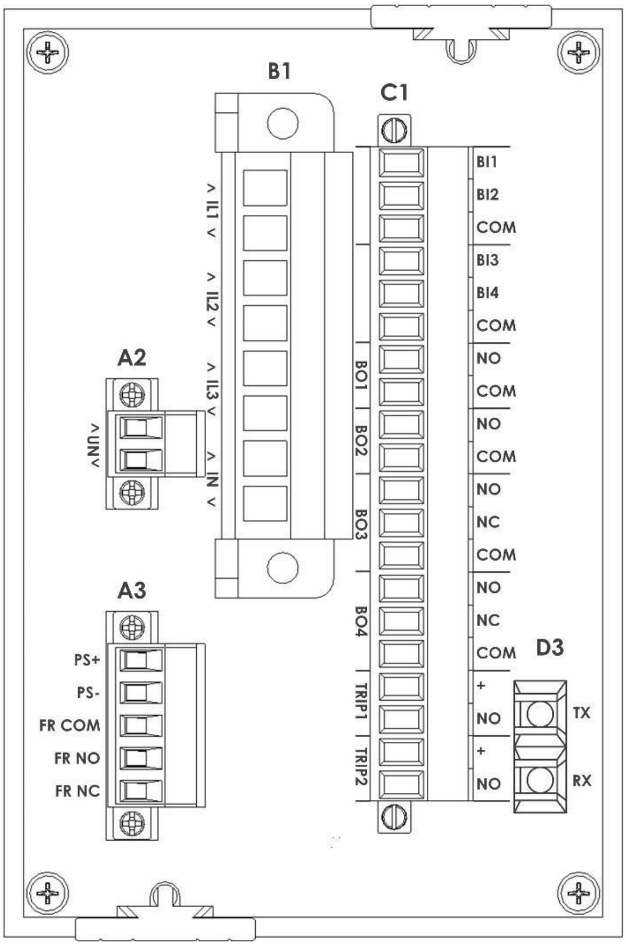
The number of inputs and outputs or the Variant 1&2 are listed in the table below. Note that the voltage input is unused in the Variant 1 & 2 configurations.

Variant 1 & 2	
Housing	Panel instrument enclosure (16 HP size)
Current inputs (4th channel can be sensitive)	4 sets (3 × 1/5 A and 1 × 0.2/1/5 A)
Voltage inputs	0 (connector not used)
Digital inputs	4 sets (Selectable Rated Voltage)
Digital outputs	4 sets (2 x NO, 2 x CO)
Fast trip outputs	2 sets (1 A, L/R = 40 ms, NO)
IRF contact	1 set (CO)

Variant 1 & 2 hardware configuration



Variant 1 & 2 backplane with barrier strip connector for ring lug



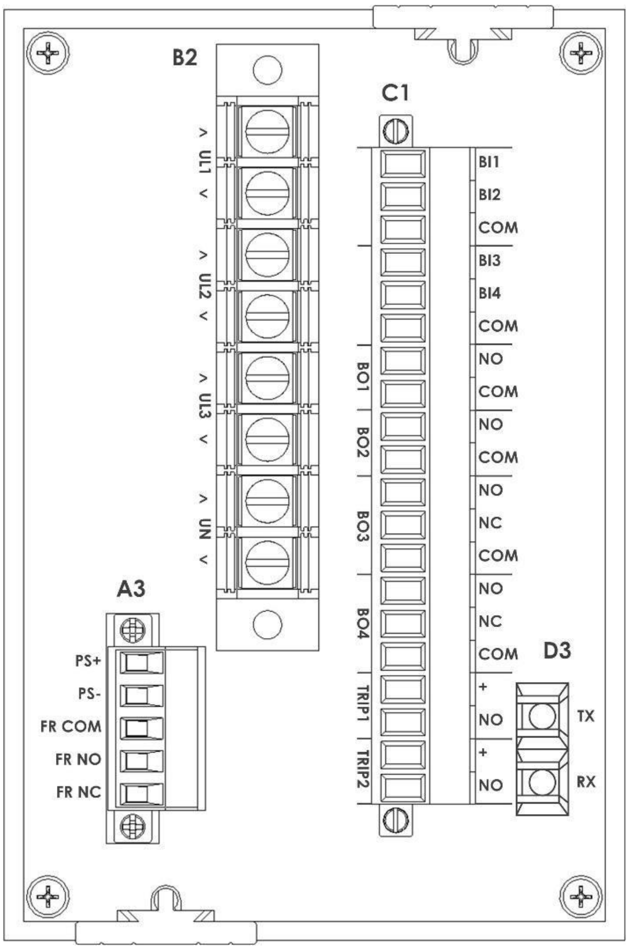
Variant 1 & 2 backplane with terminal block connector

- **Variant 3**

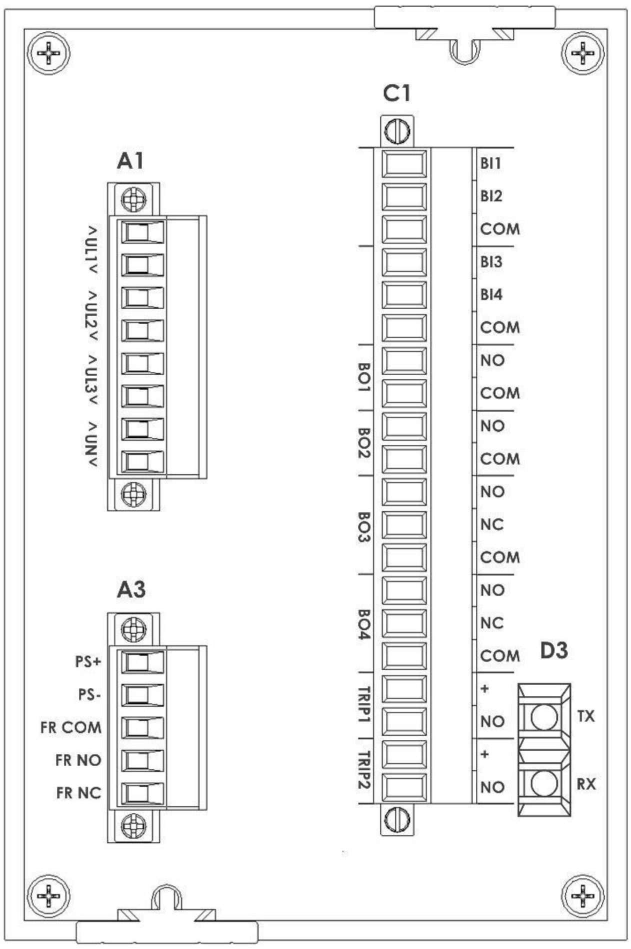
The number of inputs and outputs or the Variant 3 are listed in the table below.

Variant 3	
Housing	Panel instrument enclosure (16 HP size)
Voltage inputs	4 sets
Digital inputs	4 sets (Selectable Rated Voltage)
Digital outputs	4 sets (2 x NO, 2 x CO)
Fast trip outputs	2 sets (1 A, L/R = 40 ms, NO)
IRF contact	1 sets (CO)

Variant 3 hardware configuration



Variant 3 backplane with barrier strip connector for ring lug



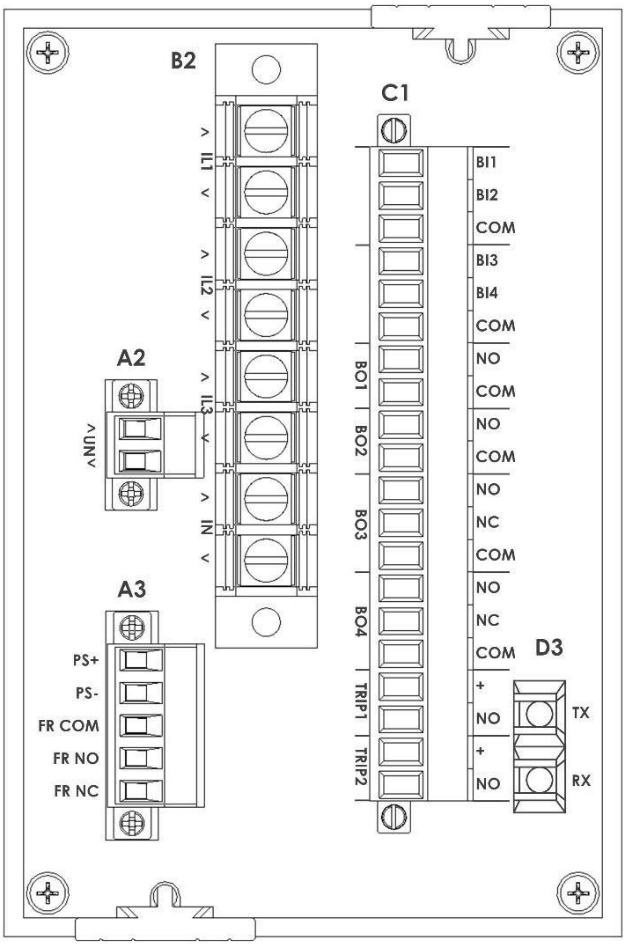
Variant 3 backplane with terminal block connector

- **Variant 4&5**

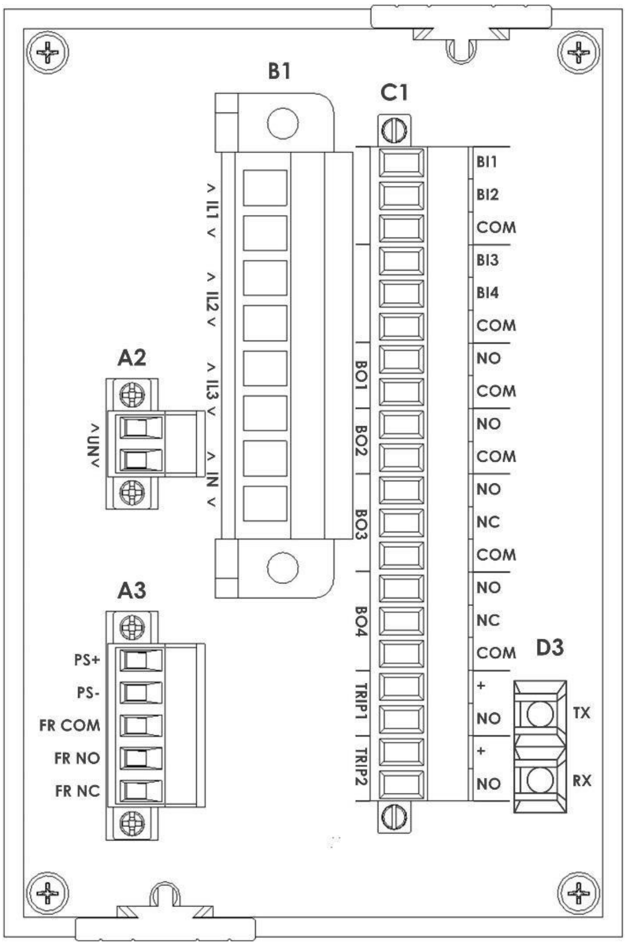
The number of inputs and outputs or the Variant 4&5 are listed in the table below.

Variant 4 & 5	
Housing	Panel instrument enclosure (16 HP size)
Current inputs (4th channel can be sensitive)	4 sets (3 × 1/5 A and 1 × 0.2/1/5 A)
Voltage inputs	1 set
Digital inputs	4 sets (Selectable Rated Voltage)
Digital outputs	4 sets (2 x NO, 2 x CO)
Fast trip outputs	2 sets (1 A, L/R = 40 ms, NO)
IRF contact	1 set (CO)

Variant 4 & 5 hardware configuration



Variant 4 & 5 backplane with barrier strip connector for ring lug



Variant 4 & 5 backplane with terminal block connectors

CONNECTION ASSIGNMENT

Connector ID	Pin number	Signal name
A1	1	UL1 →
	2	UL1 ←
	3	UL2 →
	4	UL2 ←
	5	UL3 →
	6	UL3 ←
	7	UN →
	8	UN ←
A2	1	UN →
	2	UN ←

Connector ID	Pin number	Signal name		
		Var 1 & 2	Var 3	Var 4 & 5
B2	1	IL1 →	UL1 →	IL1 →
	2	IL1 ←	UL1 ←	IL1 ←
	3	IL2 →	UL2 →	IL2 →
	4	IL2 ←	UL2 ←	IL2 ←
	5	IL3 →	UL3 →	IL3 →
	6	IL3 ←	UL3 ←	IL3 ←
	7	IN →	UN →	IN →
	8	IN ←	UN ←	IN ←

Connector ID	Pin number	Signal name
A3	1	PS+
	2	PS-
	3	FR COM
	4	FR NO
	5	FR NC

Connector ID	Pin number	Signal name
B1	1	IL1 →
	2	IL1 ←
	3	IL2 →
	4	IL2 ←
	5	IL3 →
	6	IL3 ←
	7	IN →
	8	IN ←

Connector ID	Pin number	Signal name
C1	1	BI1
	2	BI2
	3	BI12 COM
	4	BI3
	5	BI4
	6	BI34 COM
	7	BO1 NO
	8	BO1 COM
	9	BO2 NO
	10	BO2 COM
	11	BO3 NO
	12	BO3 NC
	13	BO3 COM
	14	BO4 NO
	15	BO4 NC
	16	BO4 COM
	17	TRIP1+
	18	TRIP1 NO
	19	TRIP2+
	20	TRIP2 NO

CONTACT

For more information, please refer to the **S16 Series** configuration description document or contact us:

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