



Relion® 615 series

# Feeder Protection and Control REF615 Product Guide

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## 1. Description

REF615 is a dedicated feeder IED (intelligent electronic device) designed for the protection, control, measurement and supervision of utility substations and industrial power systems including radial, looped and meshed distribution networks with or without distributed power generation. REF615 is a member of ABB's Relion® product family and part of its 615 protection and control product series. The 615 series IEDs are characterized by their compactness and withdrawable-unit design.

Re-engineered from the ground up, the 615 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices.

The IED provides main protection for overhead lines and cable feeders in distribution networks. The IED is also used as back-up protection in applications, where an independent and redundant protection system is required.

Depending on the chosen standard configuration, the IED is adapted for the protection of overhead line and cable feeders in isolated neutral, resistance earthed,

compensated and solidly earthed networks. Once the standard configuration IED has been given the application-specific settings, it can directly be put into service.

The 615 series IEDs support a range of communication protocols including IEC 61850 with GOOSE messaging, IEC 60870-5-103, Modbus® and DNP3.

## 2. Standard configurations

REF615 is available in eight alternative standard configurations. The standard signal configuration can be altered by means of the graphical signal matrix or the optional graphical application functionality of the Protection and Control IED Manager PCM600. Further, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions using various logical elements, including timers and flip-flops. By combining protection functions with logic function blocks, the IED configuration can be adapted to user-specific application requirements.

**Table 1. Standard configurations**

<b>Description</b>	<b>Std. conf.</b>
Non-directional overcurrent and directional earth-fault protection	A and B
Non-directional overcurrent and non-directional earth-fault protection	C and D
Non-directional overcurrent and directional earth-fault protection with phase-voltage based measurements	E
Directional overcurrent and directional earth-fault protection with phase-voltage based measurements, undervoltage and overvoltage protection	F
Directional overcurrent and directional earth-fault protection, phase-voltage based protection and measurement functions, sensor inputs	G
Non-directional overcurrent and non-directional earth-fault protection, phase-voltage and frequency based protection and measurement functions, synchro-check	H

**Table 2. Supported functions**

Functionality	A	B	C	D	E	F	G	H
<b>Protection<sup>1)2)</sup></b>								
Three-phase non-directional overcurrent protection, low stage, instance 1	●	●	●	●	●	-	-	●
Three-phase non-directional overcurrent protection, high stage, instance 1	●	●	●	●	●	-	-	●
Three-phase non-directional overcurrent protection, high stage, instance 2	●	●	●	●	●	-	-	●
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	●	●	●	●	●	●	●	●
Three-phase directional overcurrent protection, low stage, instance 1	-	-	-	-	-	●	●	-
Three-phase directional overcurrent protection, low stage, instance 2	-	-	-	-	-	●	●	-
Three-phase directional overcurrent protection, high stage	-	-	-	-	-	●	●	-
Non-directional earth-fault protection, low stage, instance 1	-	-	● <sup>4)</sup>	● <sup>4)</sup>	-	-	-	● <sup>4)</sup>
Non-directional earth-fault protection, low stage, instance 2	-	-	● <sup>4)</sup>	● <sup>4)</sup>	-	-	-	● <sup>4)</sup>
Non-directional earth-fault protection, high stage, instance 1	-	-	● <sup>4)</sup>	● <sup>4)</sup>	-	-	-	● <sup>4)</sup>
Non-directional earth-fault protection, instantaneous stage	-	-	● <sup>4)</sup>	● <sup>4)</sup>	-	-	-	● <sup>4)</sup>
Directional earth-fault protection, low stage, instance 1	● <sup>3)4)6)</sup>	● <sup>3)4)6)</sup>	-	-	● <sup>3)4)5)</sup>	● <sup>3)4)5)</sup>	● <sup>3)4)7)</sup>	-

**Table 2. Supported functions, continued**

Functionality	A	B	C	D	E	F	G	H
Directional earth-fault protection, low stage, instance 2	● <sup>3)4)6)</sup>	● <sup>3)4)6)</sup>	-	-	● <sup>3)4)5)</sup>	● <sup>3)4)5)</sup>	● <sup>3)4)7)</sup>	-
Directional earth-fault protection, high stage	● <sup>3)4)6)</sup>	● <sup>3)4)6)</sup>	-	-	● <sup>3)4)5)</sup>	● <sup>3)4)5)</sup>	● <sup>3)4)7)</sup>	-
Admittance based earth-fault protection, instance 1	● <sup>3)4)6)</sup>	● <sup>3)4)6)</sup>	-	-	● <sup>3)4)5)</sup>	● <sup>3)4)5)</sup>	● <sup>3)4)7)</sup>	-
Admittance based earth-fault protection, instance 2	● <sup>3)4)6)</sup>	● <sup>3)4)6)</sup>	-	-	● <sup>3)4)5)</sup>	● <sup>3)4)5)</sup>	● <sup>3)4)7)</sup>	-
Admittance based earth-fault protection, instance 3	● <sup>3)4)6)</sup>	● <sup>3)4)6)</sup>	-	-	● <sup>3)4)5)</sup>	● <sup>3)4)5)</sup>	● <sup>3)4)7)</sup>	-
Transient / intermittent earth-fault protection	● <sup>6)8)</sup>	● <sup>6)8)</sup>	-	-	● <sup>6)8)</sup>	● <sup>6)8)</sup>		-
Non-directional (cross-country) earth fault protection, using calculated I <sub>0</sub>	● <sup>9)</sup>	● <sup>9)</sup>	-	-	● <sup>9)</sup>	● <sup>9)</sup>	● <sup>9)</sup>	-
Negative-sequence overcurrent protection, instance 1	●	●	●	●	●	●	●	●
Negative-sequence overcurrent protection, instance 2	●	●	●	●	●	●	●	●
Phase discontinuity protection	●	●	●	●	●	●	●	●
Residual overvoltage protection, instance 1	● <sup>6)</sup>	● <sup>6)</sup>	-	-	● <sup>5)</sup>	● <sup>5)</sup>	● <sup>7)</sup>	● <sup>5)</sup>
Residual overvoltage protection, instance 2	● <sup>6)</sup>	● <sup>6)</sup>	-	-	● <sup>5)</sup>	● <sup>5)</sup>	● <sup>7)</sup>	● <sup>5)</sup>
Residual overvoltage protection, instance 3	● <sup>6)</sup>	● <sup>6)</sup>	-	-	● <sup>5)</sup>	● <sup>5)</sup>	● <sup>7)</sup>	● <sup>5)</sup>
Three-phase undervoltage protection, instance 1	-	-	-	-	-	●	●	●
Three-phase undervoltage protection, instance 2	-	-	-	-	-	●	●	●
Three-phase undervoltage protection, instance 3	-	-	-	-	-	●	●	●

**Table 2. Supported functions, continued**

Functionality	A	B	C	D	E	F	G	H
Three-phase overvoltage protection, instance 1	-	-	-	-	-	●	●	●
Three-phase overvoltage protection, instance 2	-	-	-	-	-	●	●	●
Three-phase overvoltage protection, instance 3	-	-	-	-	-	●	●	●
Positive-sequence undervoltage protection, instance 1	-	-	-	-	-	●	●	-
Negative-sequence overvoltage protection, instance 1	-	-	-	-	-	●	●	-
Frequency protection, instance 1	-	-	-	-	-	-	-	●
Frequency protection, instance 2	-	-	-	-	-	-	-	●
Frequency protection, instance 3	-	-	-	-	-	-	-	●
Three-phase thermal protection for feeders, cables and distribution transformers	●	●	●	●	●	●	●	-
Circuit breaker failure protection	●	●	●	●	●	●	●	●
Three-phase inrush detector	●	●	●	●	●	●	●	●
Master trip, instance 1	●	●	●	●	●	●	●	●
Master trip, instance 2	●	●	●	●	●	●	●	●
Arc protection, instance 1	○	○	○	○	○	○	○	○
Arc protection, instance 2	○	○	○	○	○	○	○	○
Arc protection, instance 3	○	○	○	○	○	○	○	○
<b>Control</b>								
Circuit-breaker control	●	●	●	●	●	●	●	●
Disconnecter position indication, instance 1	-	●	-	●	●	●	●	●

**Table 2. Supported functions, continued**

Functionality	A	B	C	D	E	F	G	H
Disconnecter position indication, instance 2	-	●	-	●	●	●	●	●
Disconnecter position indication, instance 3	-	●	-	●	●	●	●	●
Earthing switch indication	-	●	-	●	●	●	●	●
Auto-reclosing	○	○	○	○	○	○	○	○
Synchronism and energizing check	-	-	-	-	-	-	-	●
<b>Condition monitoring</b>								
Circuit-breaker condition monitoring	-	●	-	●	●	●	●	●
Trip circuit supervision, instance 1	●	●	●	●	●	●	●	●
Trip circuit supervision, instance 2	●	●	●	●	●	●	●	●
Current circuit supervision	-	-	-	-	●	●	●	●
Fuse failure supervision	-	-	-	-	●	●	●	●
<b>Measurement</b>								
Disturbance recorder	●	●	●	●	●	●	●	●
Three-phase current measurement, instance 1	●	●	●	●	●	●	●	●
Sequence current measurement	●	●	●	●	●	●	●	●
Residual current measurement, instance 1	●	●	●	●	●	●	●	●
Three-phase voltage measurement	-	-	-	-	●	●	●	●
Residual voltage measurement	●	●	-	-	●	●	-	●
Sequence voltage measurement	-	-	-	-	●	●	●	●



**Table 2. Supported functions, continued**

Functionality	A	B	C	D	E	F	G	H
Three-phase power and energy measurement, including power factor	-	-	-	-	●	●	●	●
Frequency measurement	-	-	-	-	-	-	-	●

● = Included, ○ = Optional at the time of the order

- 1) Note that all directional protection functions can also be used in non-directional mode.
- 2) The instances of a protection function represent the number of identical function blocks available in a standard configuration. By setting the application specific parameters of an instance, a protection function stage can be established.
- 3) Admittance based E/F can be selected as an alternative to directional E/F when ordering.
- 4) I<sub>o</sub> selectable by parameter, I<sub>o</sub> measured as default.
- 5) U<sub>o</sub> selectable by parameter, U<sub>o</sub> measured as default.
- 6) U<sub>o</sub> measured is always used.
- 7) U<sub>o</sub> calculated is always used.
- 8) I<sub>o</sub> measured is always used.
- 9) I<sub>o</sub> selectable by parameter, I<sub>o</sub> calculated as default.

### 3. Protection functions

The IED offers directional and non-directional overcurrent and thermal overload protection as well as directional and non-directional earth-fault protection. Depending on the standard configuration, admittance-based earth-fault protection is offered as an alternative to the directional earth-fault protection. Further, the IED features sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection, overvoltage and undervoltage protection, residual overvoltage protection, positive-sequence undervoltage and negative-sequence overvoltage protection. Frequency protection, including overfrequency,

underfrequency and frequency rate-of-change protection, is offered in IEDs with standard configuration H. In addition, the IED offers three-pole multi-shot auto-reclose functions for overhead line feeders.

Enhanced with optional hardware and software, the IED also features three light detection channels for arc fault protection of the circuit breaker, busbar and cable compartment of metal-enclosed indoor switchgear.

The arc-fault protection sensor interface is available on the optional communication module. Fast tripping increases personnel safety and limits switchgear damage, should an arc fault occur.

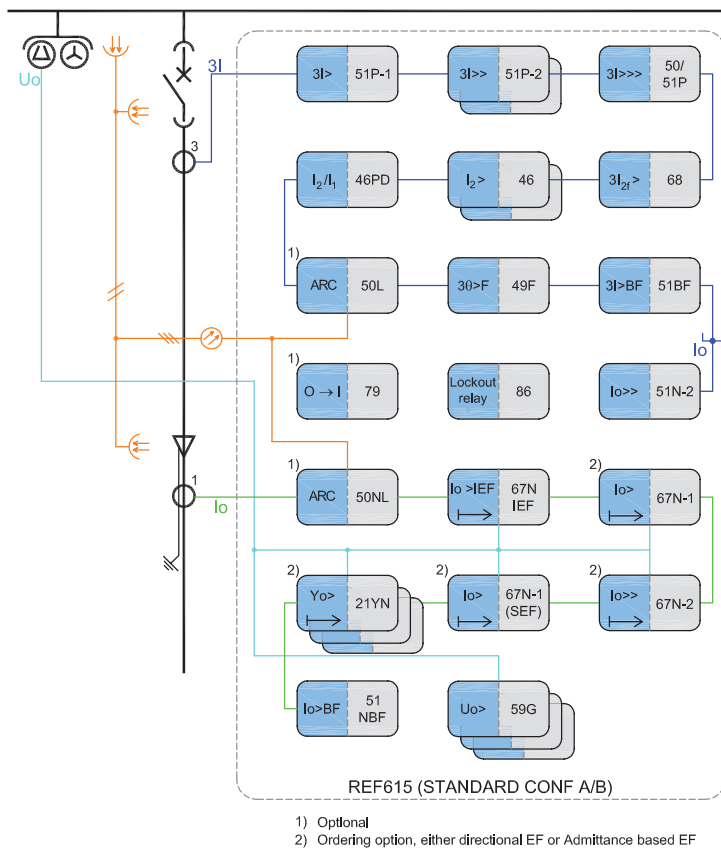


Figure 1. Protection function overview of standard configuration A and B

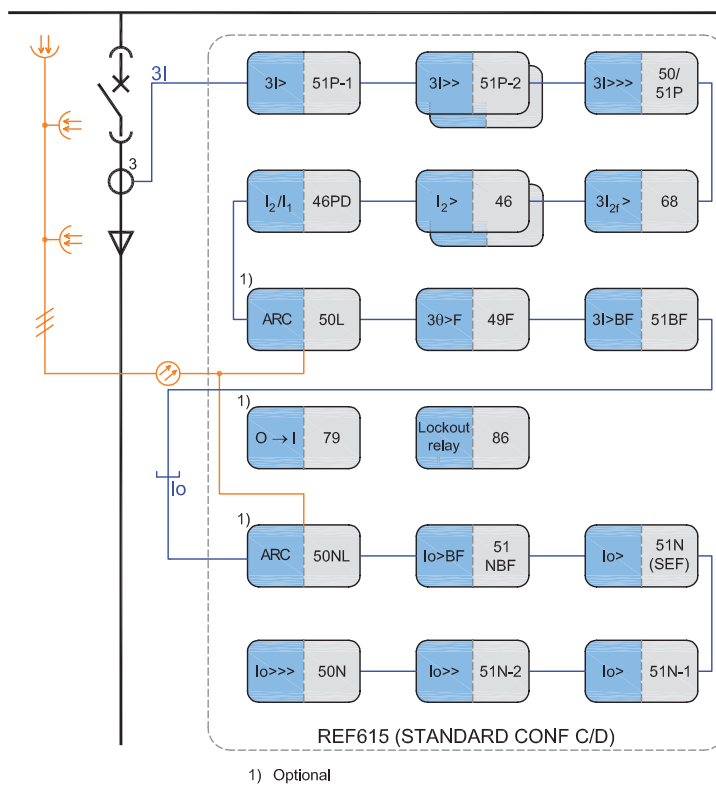


Figure 2. Protection function overview of standard configuration C and D

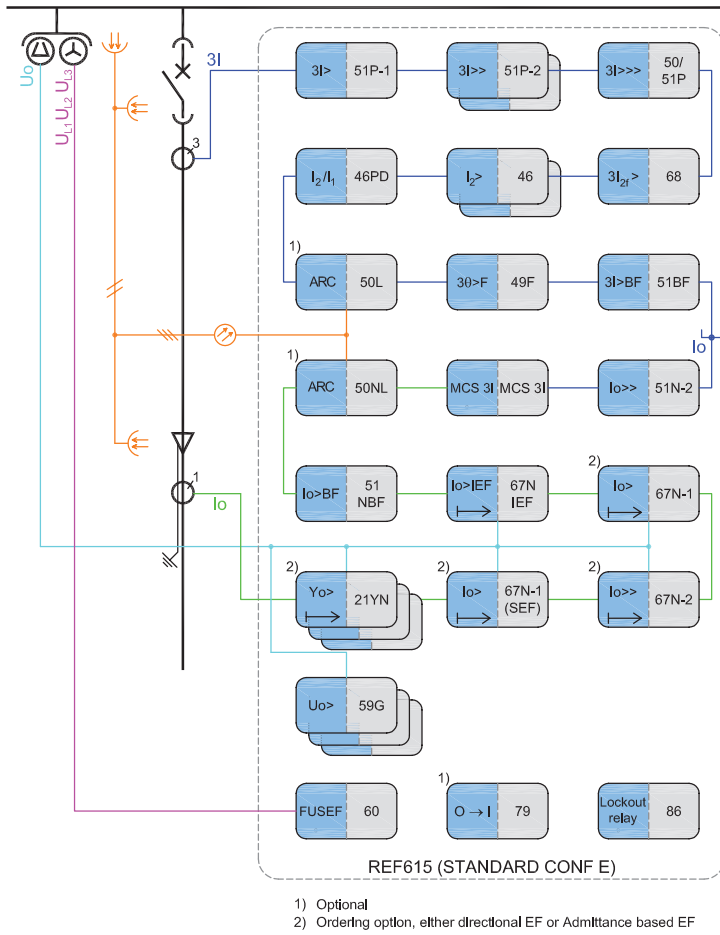


Figure 3. Protection function overview of standard configuration E

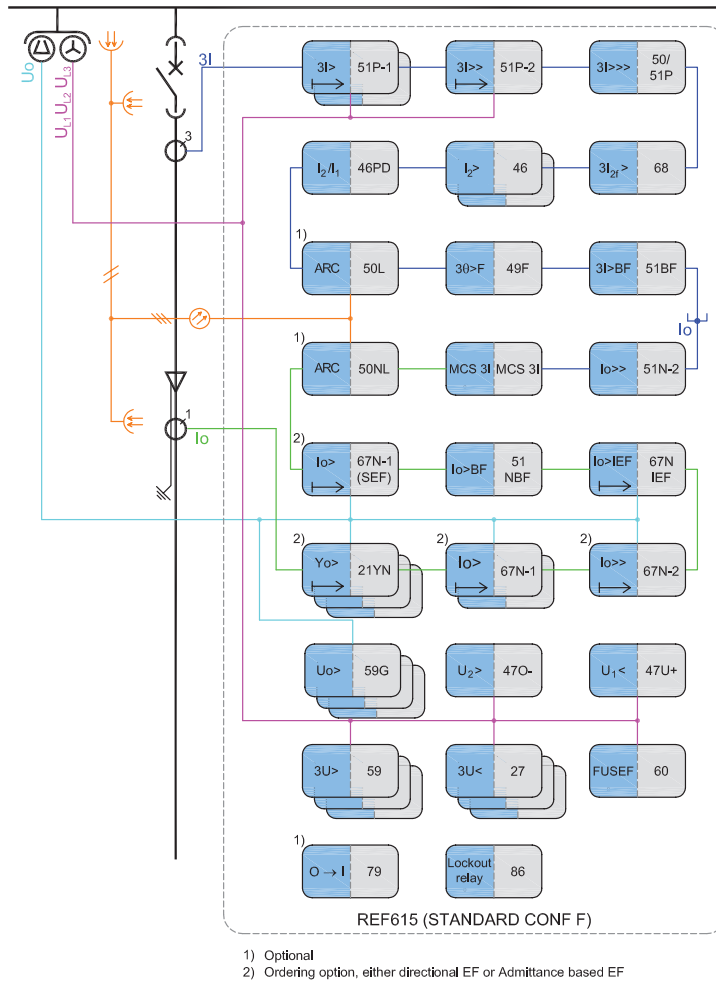


Figure 4. Protection function overview of standard configuration F

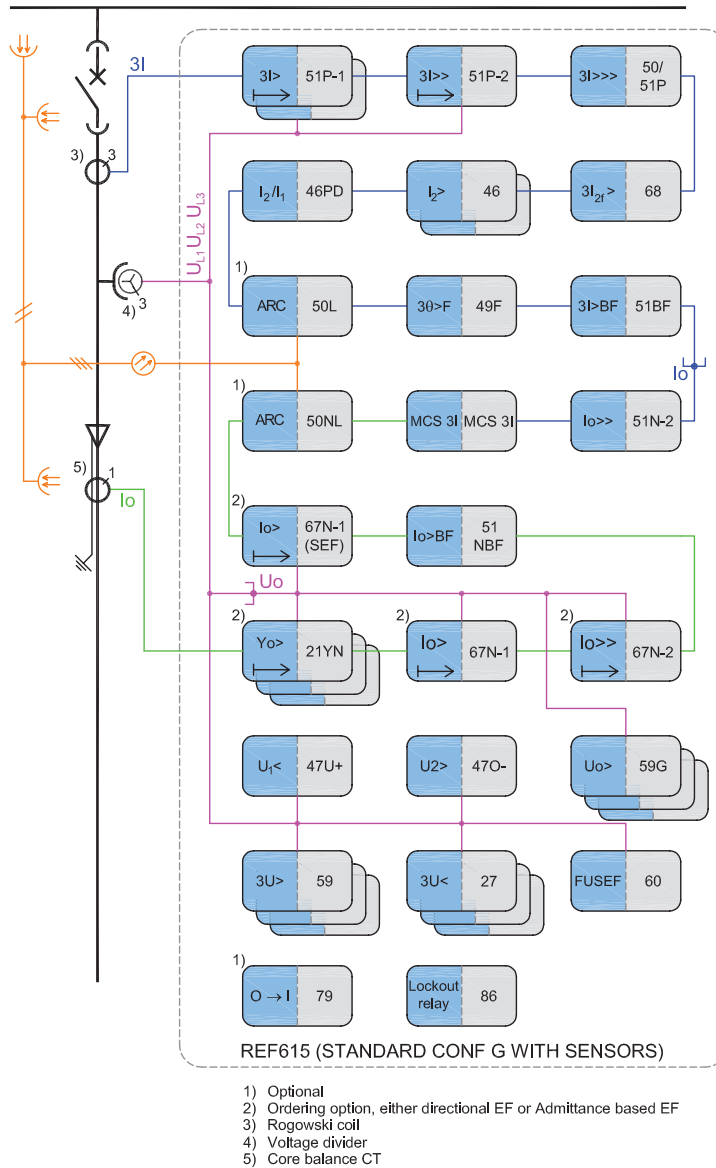


Figure 5. Protection function overview of standard configuration G

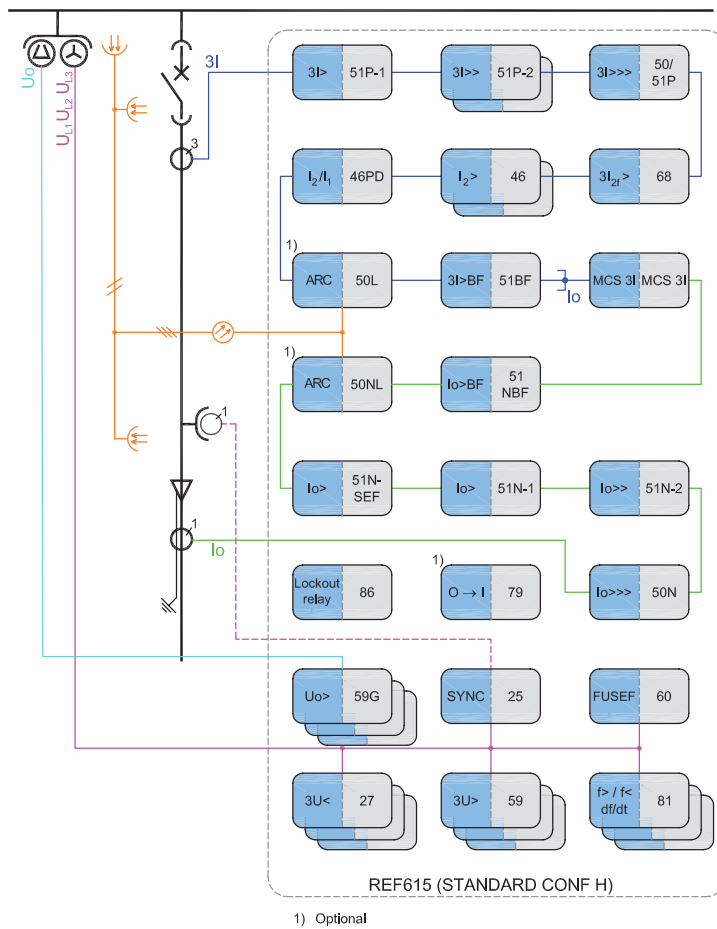


Figure 6. Protection function overview of standard configuration H

## 4. Application

The feeder protection IED REF615 can be supplied either with directional or non-directional earth-fault protection. Directional earth-fault protection is mainly used in isolated neutral or compensated networks, whereas non-directional earth-fault protection is intended for directly or low impedance earthed neutral networks. The IED can also be used for protection of ring-type and meshed distribution networks as well of radial networks containing distributed power generation.

The standard configurations A and B offer directional earth-fault protection, if the outgoing feeder is equipped with phase current transformers, a core-balance current transformer and residual voltage measurement. The residual current calculated from the phase currents can be used for double (cross country) earth-fault protection. The IED further features transient/intermittent earth-fault protection. The standard configurations C and D offer non-directional earth-fault protection for outgoing feeders equipped with phase current transformers. The residual current for the earth-fault protection is derived from the phase currents. When applicable, the core-balance current transformers can be used for

measuring the residual current, especially when sensitive earth-fault protection is required. The standard configurations E and F offer directional earth-fault protection with phase voltage and residual voltage measurement. Furthermore, the two standard configurations E and F include current circuit supervision and fuse failure supervision for incoming feeders provided with busbar voltage measurement. In addition to the functionality of standard configuration E, the standard configuration F offers directional overcurrent protection, overvoltage and undervoltage protection, positive-sequence undervoltage and negative-sequence overvoltage protection and residual voltage protection.

The standard configuration G includes one conventional residual current ( $I_o$ ) input and three sensor inputs for the connection of three combi-sensors with RJ-45 connectors. The sensor inputs enable the use of the IED in compact medium voltage switchgear with limited space for conventional measuring transformers, thus requiring the use of sensor technology. Compact medium voltage switchgear, such as ABB's SafeRing and SafePlus, are designed for applications like compact secondary substations, wind turbine power plants, small industry installations and large buildings. As an alternative to combi-

sensors, separate current and voltage sensors can be utilized using adapters. Further, the adapters also enable the use of sensors with Twin-BNC connectors.

The standard configuration H includes non-directional overcurrent and non-directional earth-fault protection, phase-voltage and frequency based protection and measurement functions. The provided functionality supports the use of the standard configuration in industrial power systems, where the power is generated in the plant itself and/or derived from the distribution network. Completed with the synchro-check function, IEDs with standard configuration H ensure a safe interconnection of two networks.

For standard configurations A, B, E, F and G admittance-based earth-fault protection, using the neutral admittance ( $Y_o$ ) criterion, is offered as an option to the directional earth-fault protection. The admittance-based earth-fault protection ensures the correct operation of the earth-fault protection even if the connection status information of the Petersen coil is missing. Furthermore, the admittance based earth-fault protection principle offers high independence of the fault resistance, straightforward setting principles and improved sensitivity of the protection.



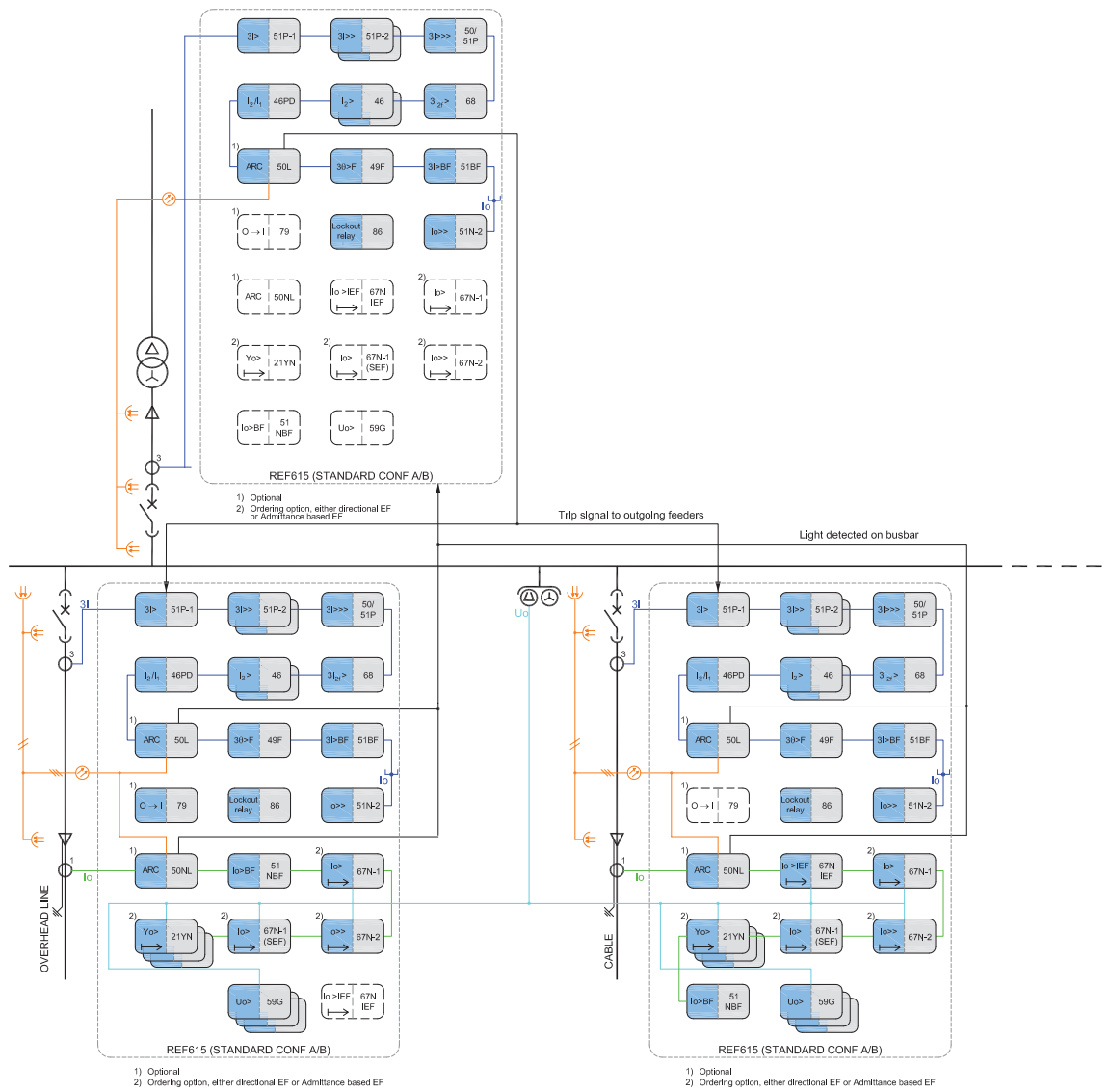
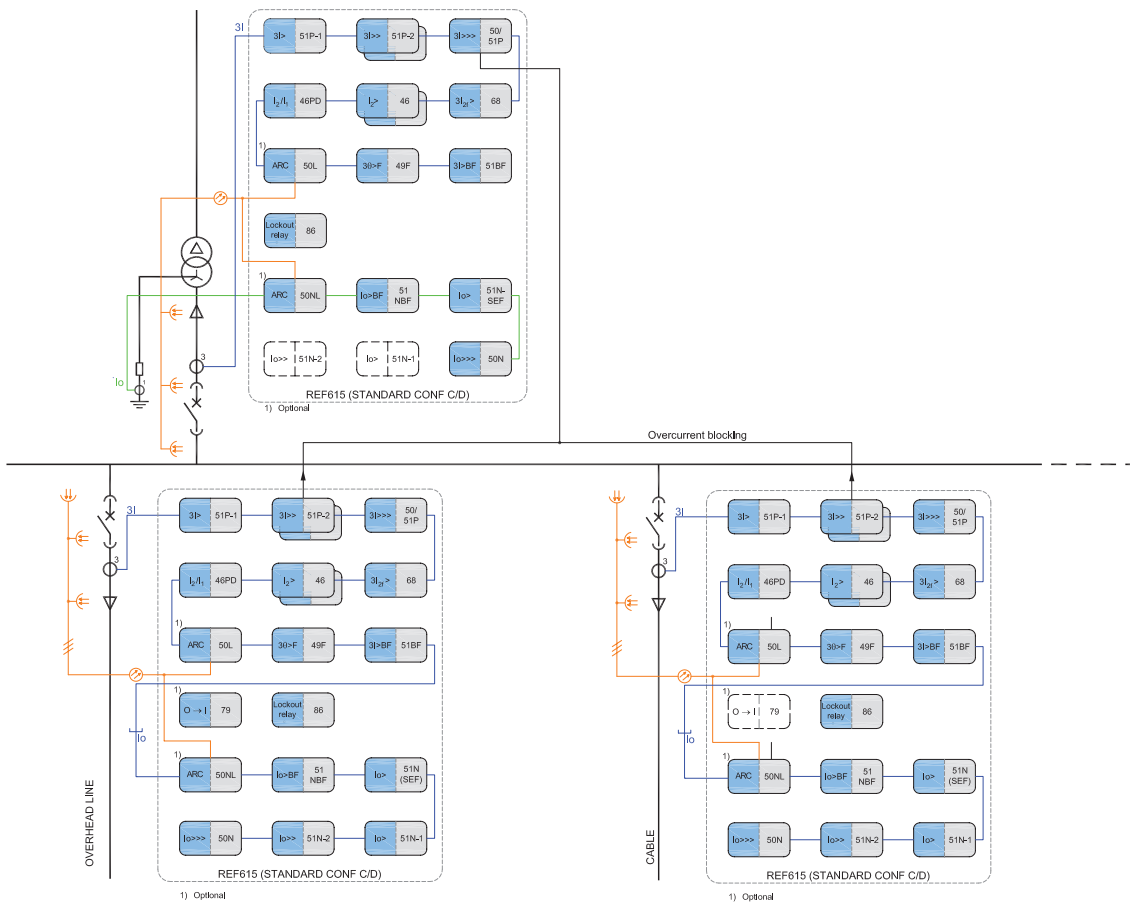


Figure 7. Substation O/C and E/F protection using the standard configuration A or B with relevant options. In the incoming feeder bay, the protection functions not used are uncoloured and indicated with a dashed block outline. The IEDs are equipped with optional arc protection functions, enabling fast and selective arc protection throughout the switchgear.



**Figure 8. Substation O/C and E/F protection using the standard configuration C or D with relevant options. In the incoming feeder bay the unemployed protection functions are uncoloured and indicated with a dashed block outline. The busbar protection is based on the interlocking principle, where the start of the O/C protection of the outgoing feeder sends a blocking signal to the instantaneous O/C stage of the incoming feeder. In the absence of the blocking signal, the O/C protection of the incoming feeder will clear the internal switchgear (busbar) fault.**

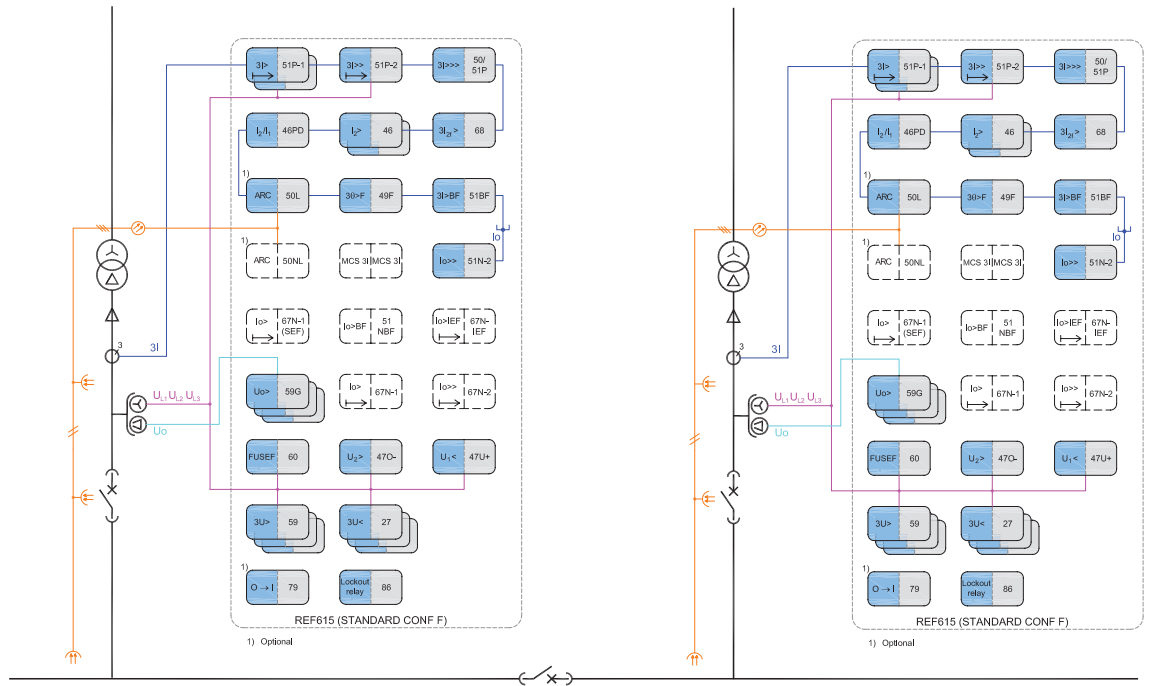


Figure 9. Protection and control of two incoming feeders using IEDs with standard configuration F. The two incoming feeders can be connected in parallel by closing the busbar-sectionaling breaker. To achieve selective overcurrent protection, directional overcurrent stages are needed. Busbar main and back-up protection for outgoing feeders is implemented using residual overvoltage protection stages. Phase undervoltage and overvoltage protection can be used for tripping or just alarming purposes.

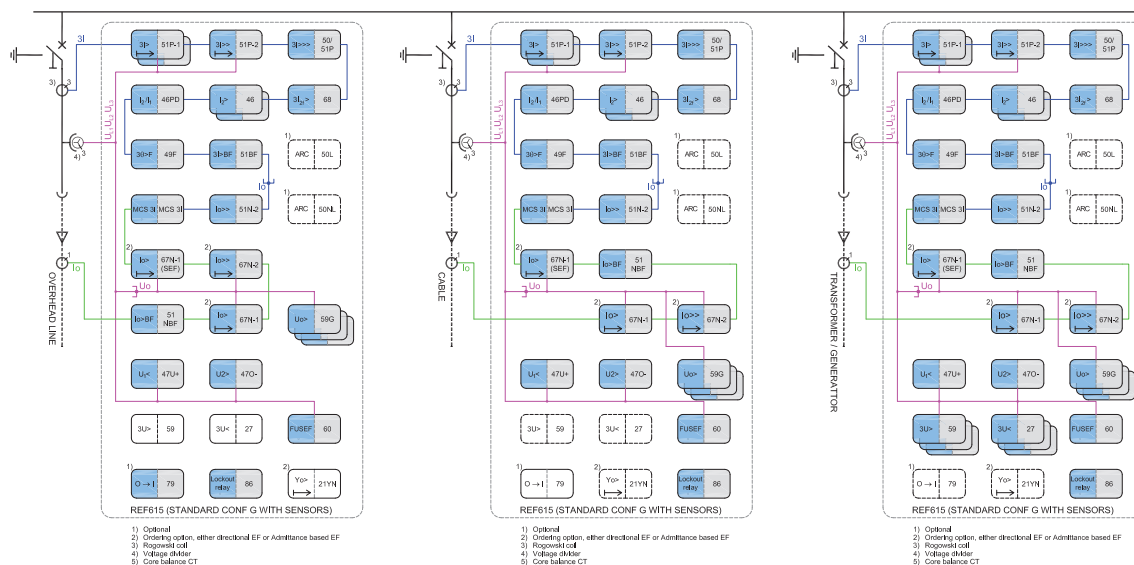


Figure 10. Protection and control of a typical compact medium voltage switchgear using REF615 IEDs with the standard configuration G. The phase currents and phase voltages are measured using combi-sensors supporting the Rogowski current sensor and voltage divider principles. The earth-fault current is measured using a conventional cable current transformer.

## 5. Supported ABB solutions

ABB's 615 series protection and control IEDs together with the COM600 Station Automation device constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate and streamline the system engineering ABB's IEDs are supplied with Connectivity Packages containing a compilation of software and IED-specific information including single-line diagram templates, a full IED data model including event and parameter lists. By utilizing the Connectivity Packages the IEDs can be readily configured via the PCM600 Protection and Control IED Manager and integrated with the COM600 Station Automation device or the MicroSCADA Pro network control and management system.

The 615 series IEDs offer native support for the IEC 61850 standard also including binary and analog horizontal GOOSE messaging. Compared with traditional hard-wired inter-device signaling, peer-to-peer communication over a switched Ethernet LAN offers an advanced and versatile platform for power system protection. Fast software-based communication, continuous supervision of the integrity of the protection and communication system, and inherent flexibility for reconfiguration and upgrades are among the distinctive features of the protection system approach enabled by the full implementation of the IEC 61850 substation automation standard.

At the substation level COM600 uses the data content of the bay level IEDs to offer enhanced substation level functionality. COM600 features a web-browser based HMI providing a customizable graphical display for visualizing single line mimic diagrams for switchgear bay solutions. The SLD feature is

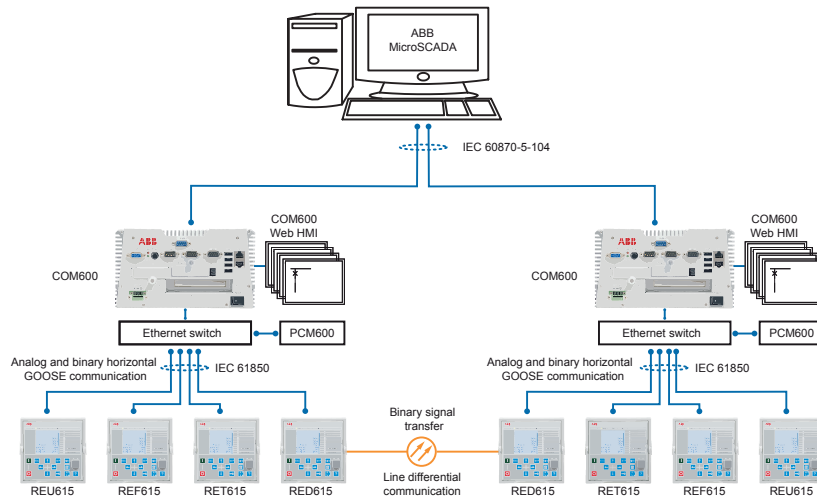
especially useful when 615 series IEDs without the optional single line diagram feature are used. Further, the web HMI of COM600 offers an overview of the whole substation, including IED-specific single line diagrams, thus enabling convenient information accessibility. To enhance personnel safety, the web HMI also enables remote access to substation devices and processes. Furthermore, COM600 can be used as a local data warehouse for technical documentation of the substation and for network data collected by the IEDs. The collected network data facilitates extensive reporting and analyzing of network fault situations using the data historian and event

handling features of COM600. The data historian can be used for accurate process performance monitoring by following process and equipment performance calculations with real-time and history values. Better understanding of the process behaviour by joining time-based process measurements with production and maintenance events helps the user in understanding the process dynamics.

COM600 also features gateway functionality providing seamless connectivity between the substation IEDs and network-level control and management systems such as MicroSCADA Pro and System 800xA

**Table 3. Supported ABB solutions**

Product	Version
Station Automation COM600	3.4 or later
MicroSCADA Pro	9.2 SP2 or later
System 800xA	5.0 Service Pack 2



*Figure 11. Utility power distribution network example using 615 series IEDs, Station Automation COM600 and MicroSCADA Pro*

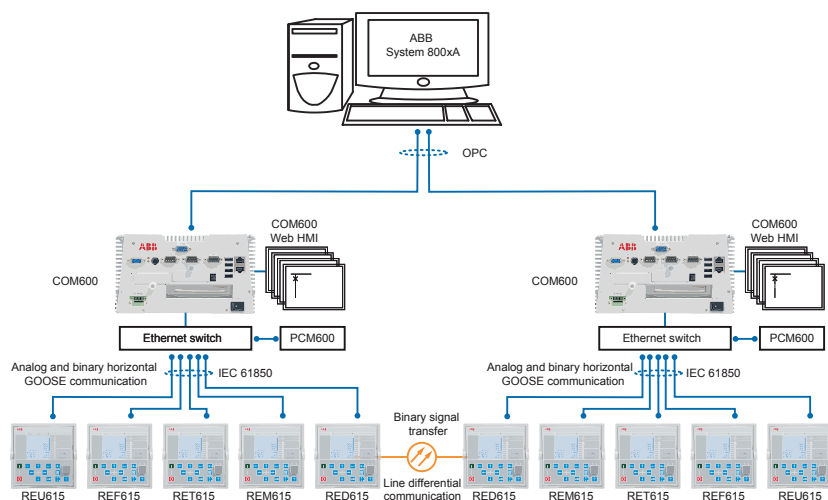


Figure 12. Industrial power system example using 615 series IEDs, Station Automation COM600 and System 800xA

## 6. Control

The IED offers control of one circuit breaker with dedicated push-buttons for circuit breaker opening and closing. Further, the optional large graphical LCD of the IED's HMI includes a single-line diagram (SLD) with position indication for the relevant circuit breaker. Interlocking schemes required by the application are configured using the signal matrix or the application configuration feature of PCM600.

Depending on the standard configuration, the IED also incorporates a synchro-check function to ensure that the voltage, phase angle and frequency on either side of an open circuit breaker satisfy the conditions for safe interconnection of two networks.

## 7. Measurement

The IED continuously measures the phase currents, the symmetrical components of the currents and the residual current. If the IED includes voltage measurements it also measures the residual voltage, the phase voltages and the voltage sequence components. Depending on the standard configuration the IED additionally offers frequency measurement. In addition, the IED calculates the demand value of current over a user-selectable pre-set time frames, the thermal overload of the protected object, and the phase unbalance value based on the ratio between the negative sequence and positive sequence current.

Further, the IED offers three-phase power and energy measurement including power factor.

The values measured can be accessed locally via the user interface on the IED front panel or remotely via the communication interface of the IED. The values can also be accessed

locally or remotely using the web-browser based user interface.

## 8. Disturbance recorder

The IED is provided with a disturbance recorder featuring up to 12 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltage measured.

The analog channels can be set to trigger the recording function when the measured value falls below or exceeds the set values. The binary signal channels can be set to start a recording on the rising or the falling edge of the binary signal or both.

By default, the binary channels are set to record external or internal IED signals, for example the start or trip signals of the IED stages, or external blocking or control signals. Binary IED signals such as a protection start or trip signal, or an external IED control signal over a binary input can be set to trigger the recording. The recorded information is stored in a non-volatile memory and can be uploaded for subsequent fault analysis.

## 9. Event log

To collect sequence-of-events (SoE) information, the IED incorporates a non-volatile memory with a capacity of storing 512 events with associated time stamps. The non-volatile memory retains its data also in case the IED temporarily loses its auxiliary supply. The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances. The increased capacity to process and store data and events in the IED offers prerequisites to support the growing

information demand of future network configurations.

The SoE information can be accessed locally via the user interface on the IED front panel or remotely via the communication interface of the IED. The information can further be accessed, either locally or remotely, using the web-browser based user interface.

## 10. Recorded data

The IED has the capacity to store the records of 32 latest fault events. The records enable the user to analyze the power system events. Each record includes current, voltage and angle values, time stamp, etc. The fault recording can be triggered by the start signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. In addition, the maximum demand current with time stamp is separately recorded. By default, the records are stored in a non-volatile memory.

## 11. Condition monitoring

The condition monitoring functions of the IED constantly monitors the performance and the condition of the circuit breaker. The monitoring comprises the spring charging time, SF<sub>6</sub> gas pressure, the travel-time and the inactivity time of the circuit breaker.

The monitoring functions provide operational CB history data, which can be used for scheduling preventive CB maintenance.

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## 12. Trip-circuit supervision

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The trip-circuit supervision continuously monitors the availability and operability of the trip circuit. It provides open-circuit monitoring both when the circuit breaker is in its closed and in its open position. It also detects loss of circuit-breaker control voltage.

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## 13. Self-supervision

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The IED's built-in self-supervision system continuously monitors the state of the IED hardware and the operation of the IED software. Any fault or malfunction detected will be used for alerting the operator.

A permanent IED fault will block the protection functions to prevent incorrect operation.

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## 14. Fuse failure supervision

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Depending on the chosen standard configuration, the IED includes fuse failure supervision functionality. The fuse failure supervision detects failures between the voltage measurement circuit and the IED. The failures are detected by the negative-sequence based algorithm or by the delta voltage and delta current algorithm. Upon the detection of a failure the fuse failure supervision function activates an alarm and blocks voltage-dependent protection functions from unintended operation.

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## 15. Current circuit supervision

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Depending on the chosen standard configuration, the IED includes current circuit supervision. Current circuit supervision is used for detecting faults in the current transformer secondary circuits. On detecting of a fault the current circuit supervision function activates an alarm LED and blocks certain protection functions to avoid unintended operation. The current circuit supervision function calculates the sum of the phase currents from the protection cores and compares the sum with the measured single reference current from a core balance current transformer or from separate cores in the phase current transformers.

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## 16. Access control

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To protect the IED from unauthorized access and to maintain information integrity, the IED is provided with a four-level, role-based authentication system with administrator-programmable individual passwords for the viewer, operator, engineer and administrator level. The access control applies to the front-panel user interface, the web-browser based user interface and the PCM600 tool.

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## 17. Inputs and outputs

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Depending on the standard configuration selected, the IED is equipped with three phase-current inputs and one residual-current input for non-directional earth-fault protection, or three phase-current inputs, one residual-current input and one residual voltage input for directional earth-fault protection or three phase-current inputs, one residual-current input, three phase-voltage inputs and one



residual voltage input for directional earth-fault protection and directional overcurrent protection. The standard configuration G includes one conventional residual current (Io 0.2/1 A) input and three sensor inputs for the direct connection of three combi-sensors with RJ-45 connectors. As an alternative to combi-sensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors.

The phase-current inputs are rated 1/5 A. Two optional residual-current inputs are available, i.e. 1/5 A or 0.2/1 A. The 0.2/1 A input is normally used in applications requiring sensitive earth-fault protection and featuring core-balance current transformers. The three phase-voltage inputs and the residual-voltage input covers the rated voltages 60-210 V. Both phase-to-phase

voltages and phase-to-earth voltages can be connected.

The phase-current input 1 A or 5 A, the residual-current input 1 A or 5 A, alternatively 0.2 A or 1 A, and the rated voltage of the residual voltage input are selected in the IED software. In addition, the binary input thresholds 18...176 V DC are selected by adjusting the IED's parameter settings.

All binary inputs and outputs contacts are freely configurable with the signal matrix or application configuration functionality of PCM600.

Please refer to the Input/output overview table and the terminal diagrams for more detailed information about the inputs and outputs.

**Table 4. Input/output overview**

Standard configuration	Analog inputs		Binary inputs/outputs	
	CT	VT	BI	BO
A	4	1	3	6
B	4	1	11 (17) <sup>1)</sup>	10 (13) <sup>1)</sup>
C	4	-	4	6
D	4	-	12 (18) <sup>1)</sup>	10 (13) <sup>1)</sup>
E	4	5 <sup>2)</sup>	16	10
F	4	5 <sup>2)</sup>	16	10
G	3+1 <sup>3)</sup>	3 <sup>3)</sup>	8	10
H	4	5	16	10

1) With optional binary I/O module ( )

2) One of the five inputs is reserved for future applications

3) Support for three Combi Sensors and one conventional Io input or three current sensors, three voltage sensors and one conventional Io input

## 18. Communication

The IED supports a range of communication protocols including IEC 61850, IEC 60870-5-103, Modbus<sup>®</sup> and DNP3.

Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the IEDs, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the standard COMTRADE file format. The IED supports simultaneous event reporting to five different clients on the station bus.

The IED can send binary signals to other IEDs (so called horizontal communication) using the IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) profile. Binary GOOSE messaging can, for example, be employed for protection and interlocking-based protection schemes. The IED meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. Further, the IED supports the sending and receiving of analog values using GOOSE messaging. Analog GOOSE messaging enables fast transfer of analog measurement values over the station bus, thus facilitating for example sharing of RTD input values, such as surrounding temperature values, to other IED applications.

The IED offers an optional second Ethernet bus to enable the creation of a self-healing Ethernet ring topology. The IED communication module options include both galvanic and fibre-optic Ethernet combinations. The communication module including one fibre-optic LC port and two galvanic RJ-45 ports is used when the ring

between the IEDs is built using CAT5 STP cables. The LC port can in this case be used for connecting the IED to communication ports outside the switchgear. The communication module including three RJ-45 ports is used when the whole substation bus is based on CAT5 STP cabling.

The self-healing Ethernet ring solution enables a cost efficient communication ring controlled by a managed switch with rapid spanning tree protocol (RSTP) support to be created. The managed switch controls the consistency of the loop, routes the data and corrects the data flow in case of a communication disturbance. The IEDs in the ring topology act as unmanaged switches forwarding unrelated data traffic. The Ethernet ring solution supports the connection of up to thirty 615 series IEDs. If more than 30 IEDs are to be connected, it is recommended that the network is split into several rings with no more than 30 IEDs per ring. The self-healing Ethernet ring solution avoids single point of failure concerns and improves the reliability of the communication. The solution can be applied for the Ethernet-based IEC 61850, Modbus and DNP3 protocols.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The IED can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fibre-optic LC connector (100Base-FX). If connection to a serial bus is required, the 10-pin RS-485 screw-terminal or the fibre-optic ST connector can be used.

Modbus implementation supports RTU, ASCII and TCP modes. Besides standard Modbus functionality, the IED supports retrieval of time-stamped events, changing the active setting group and uploading of the latest fault records. If a Modbus TCP connection is used, five clients can be connected to the IED simultaneously. Further, Modbus serial and Modbus TCP can be used in parallel, and if

required both IEC 61850 and Modbus protocols can be run simultaneously.

The IEC 60870-5-103 implementation supports two parallel serial bus connections to two different masters. Besides basic standard functionality, the IED supports changing of the active setting group and uploading of disturbance recordings in IEC 60870-5-103 format.

DNP3 supports both serial and TCP modes for connection to one master. Further, changing of the active setting group is supported.

When the IED uses the RS-485 bus for the serial communication, both two- and four wire connections are supported. Termination and pull-up/down resistors can be configured with jumpers on the communication card so external resistors are not needed.

The IED supports the following time synchronization methods with a time-stamping resolution of 1 ms:

Ethernet-based:

- SNTP (Simple Network Time Protocol)

With special time synchronization wiring:

- IRIG-B (Inter-Range Instrumentation Group - Time Code Format B)

In addition, the IED supports time synchronization via the following serial communication protocols:

- Modbus
- DNP3
- IEC 60870-5-103

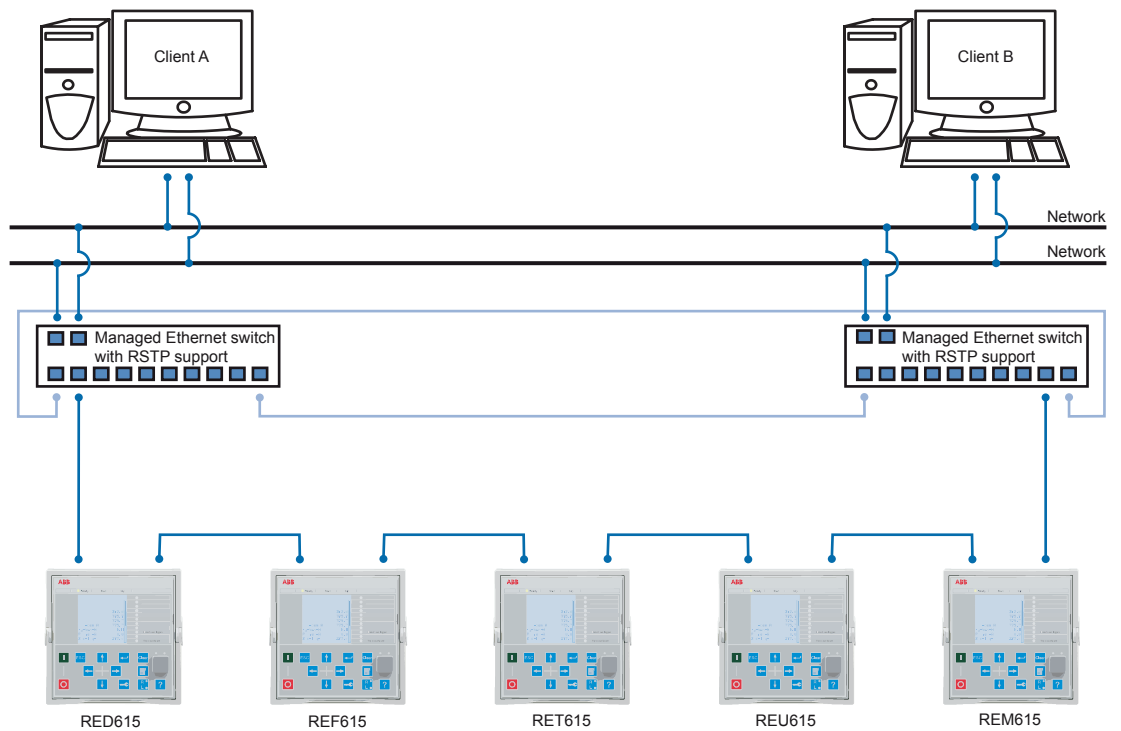


Figure 13. Self-healing Ethernet ring solution

**Table 5. Supported station communication interfaces and protocols**

Interfaces/ Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/RS-485	Fibre-optic ST
IEC 61850	●	●	-	-
MODBUS RTU/ ASCII	-	-	●	●
MODBUS TCP/ IP	●	●	-	-
DNP3 (serial)	-	-	●	●
DNP3 TCP/IP	●	●	-	-
IEC 60870-5-103	-	-	●	●

● = Supported

## 19. Technical data

**Table 6. Dimensions**

Description	Value	
Width	frame	177 mm
	case	164 mm
Height	frame	177 mm (4U)
	case	160 mm
Depth	201 mm (153 + 48 mm)	
Weight	complete IED	4.1 kg
	plug-in unit only	2.1 kg

**Table 7. Power supply**

Description	Type 1	Type 2
U <sub>aux</sub> nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
U <sub>aux</sub> variation	38...110% of U <sub>n</sub> (38...264 V AC)	50...120% of U <sub>n</sub> (12...72 V DC)
	80...120% of U <sub>n</sub> (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC * 80%)
Burden of auxiliary voltage supply under quiescent (P <sub>q</sub> )/operating condition	DC < 12.0 W (nominal)/< 18.0 W (max) AC < 16.0 W (nominal)/< 21.0W (max)	DC < 12.0 W (nominal)/< 18.0 W (max)
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the IED	30 ms at V <sub>n</sub> rated	
Fuse type	T4A/250 V	

**Table 8. Energizing inputs**

Description		Value	
Rated frequency		50/60 Hz	
Current inputs	Rated current, $I_n$	0.2/1 A <sup>1)</sup>	1/5 A <sup>2)</sup>
	Thermal withstand capability:		
	• Continuously	4 A	20 A
	• For 1 s	100 A	500 A
	Dynamic current withstand:		
• Half-wave value	250 A	1250 A	
Input impedance		<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	60...210 V AC	
	Voltage withstand:		
	• Continuous	2 x $U_n$ (240 V AC)	
	• For 10 s	3 x $U_n$ (360 V AC)	
Burden at rated voltage		<0.05 VA	

1) Ordering option for residual current input

2) Residual current and/or phase current

**Table 9. Energizing inputs**

Description		Value
Current sensor input	Rated current voltage (in secondary side)	75 mV...2812.5 mV <sup>1)</sup>
	Continuous voltage withstand	125 V
	Input impedance at 50/60 Hz	2-3 MOhm <sup>2)</sup>
Voltage sensor input	Rated voltage	6 kV...30 kV <sup>3)</sup>
	Continuous voltage withstand	50 V
	Input impedance at 50/60 Hz	3 MOhm

1) Equals the current range of 40A - 1250A with a 80A, 3mV/Hz Rogowski

2) Depending on the used nominal current (hardware gain)

3) This range is covered (up to 2\*rated) with sensor division ratio of 10 000 : 1

**Table 10. Binary inputs**

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...570.0 mW
Threshold voltage	18...176 V DC
Reaction time	3 ms

**Table 11. Signal outputs and IRF output**

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	15 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

**Table 12. Double-pole power output relays with TCS function**

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit supervision (TCS):	
• Control voltage range	20...250 V AC/DC
• Current drain through the supervision circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V AC/DC (15...20 V)

**Table 13. Single-pole power output relays**

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

**Table 14. Front port Ethernet interfaces**

Ethernet interface	Protocol	Cable	Data transfer rate
Front	TCP/IP protocol	Standard Ethernet CAT 5 cable with RJ-45 connector	10 MBits/s



**Table 15. Station communication link, fibre-optic**

Connector	Fibre type <sup>1)</sup>	Wave length	Max. distance	Permitted path attenuation <sup>2)</sup>
LC	MM 62.5/125 µm glass fibre core	1300 nm	2 km	<8 dB
LC	SM 9/125 µm	1300 nm	2-20 km	<8 dB
ST	MM 62.5/125 µm glass fibre core	820-900 nm	1 km	<11 dB

1) (MM) multi-mode fibre, (SM) single-mode fibre

2) Maximum allowed attenuation caused by connectors and cable together

**Table 16. IRIG-B**

Description	Value
IRIG time code format	B004, B005 <sup>1)</sup>
Isolation	500V 1 min.
Modulation	Unmodulated
Logic level	TTL Level
Current consumption	2...4 mA
Power consumption	10...20 mW

1) According to 200-04 IRIG -standard

**Table 17. Lens sensor and optical fibre for arc protection**

Description	Value
Fibre-optic cable including lens	1.5 m, 3.0 m or 5.0 m
Normal service temperature range of the lens	-40...+100°C
Maximum service temperature range of the lens, max 1 h	+140°C
Minimum permissible bending radius of the connection fibre	100 mm

**Table 18. Degree of protection of flush-mounted IED**

Description	Value
Front side	IP 54
Rear side, connection terminals	IP 20

**Table 19. Environmental conditions**

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+85°C (<16h) <sup>1)2)</sup>
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+85°C

1) Degradation in MTBF and HMI performance outside the temperature range of -25...+55 °C

2) For IEDs with an LC communication interface the maximum operating temperature is +70 °C

**Table 20. Environmental tests**

Description	Type test value	Reference
Dry heat test (humidity <50%)	<ul style="list-style-type: none"> <li>• 96 h at +55°C</li> <li>• 16 h at +85°C<sup>1)</sup></li> </ul>	IEC 60068-2-2
Dry cold test	<ul style="list-style-type: none"> <li>• 96 h at -25°C</li> <li>• 16 h at -40°C</li> </ul>	IEC 60068-2-1
Damp heat test, cyclic	<ul style="list-style-type: none"> <li>• 6 cycles (12 h + 12 h) at +25°C...+55°C, humidity &gt;93%</li> </ul>	IEC 60068-2-30
Storage test	<ul style="list-style-type: none"> <li>• 96 h at -40°C</li> <li>• 96 h at +85°C</li> </ul>	IEC 60068-2-48

1) For IEDs with an LC communication interface the maximum operating temperature is +70°C

**Table 21. Electromagnetic compatibility tests**

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test:  <ul style="list-style-type: none"> <li>• Common mode</li> <li>• Differential mode</li> </ul>	  2.5 kV  2.5 kV	IEC 61000-4-18 IEC 60255-22-1, class III IEEE C37.90.1-2002
Electrostatic discharge test:  <ul style="list-style-type: none"> <li>• Contact discharge</li> <li>• Air discharge</li> </ul>	  8 kV  15 kV	IEC 61000-4-2 IEC 60255-22-2 IEEE C37.90.3-2001
Radio frequency interference tests:	10 V (rms) f=150 kHz-80 MHz  10 V/m (rms) f=80-2700 MHz  10 V/m f=900 MHz  20 V/m (rms) f=80-1000 MHz	IEC 61000-4-6 IEC 60255-22-6, class III  IEC 61000-4-3 IEC 60255-22-3, class III  ENV 50204 IEC 60255-22-3, class III  IEEE C37.90.2-2004
Fast transient disturbance tests:  <ul style="list-style-type: none"> <li>• All ports</li> </ul>	  4 kV	IEC 61000-4-4 IEC 60255-22-4 IEEE C37.90.1-2002
Surge immunity test:  <ul style="list-style-type: none"> <li>• Communication</li> <li>• Other ports</li> </ul>	  1 kV, line-to-earth  4 kV, line-to-earth 2 kV, line-to-line	IEC 61000-4-5 IEC 60255-22-5
Power frequency (50 Hz) magnetic field:  <ul style="list-style-type: none"> <li>• Continuous</li> <li>• 1-3 s</li> </ul>	  300 A/m 1000 A/m	IEC 61000-4-8

**Table 21. Electromagnetic compatibility tests, continued**

Description	Type test value	Reference
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11
Power frequency immunity test:  • Common mode  • Differential mode	Binary inputs only  300 V rms  150 V rms	IEC 61000-4-16 IEC 60255-22-7, class A
Emission tests:  • Conducted  0.15-0.50 MHz  0.5-30 MHz  • Radiated  30-230 MHz  230-1000 MHz	   < 79 dB(μV) quasi peak < 66 dB(μV) average  < 73 dB(μV) quasi peak < 60 dB(μV) average   < 40 dB(μV/m) quasi peak, measured at 10 m distance  < 47 dB(μV/m) quasi peak, measured at 10 m distance	EN 55011, class A IEC 60255-25

**Table 22. Insulation tests**

Description	Type test value	Reference
Dielectric tests • Test voltage	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min, communication	IEC 60255-5 and IEC 60255-27
Impulse voltage test • Test voltage	5 kV, 1.2/50 $\mu$ s, 0.5 J 1 kV, 1.2/50 $\mu$ s, 0.5 J, communication	IEC 60255-5 and IEC 60255-27
Insulation resistance measurements • Isolation resistance	>100 M $\Omega$ , 500 V DC	IEC 60255-5 and IEC 60255-27
Protective bonding resistance • Resistance	<0.1 $\Omega$ , 4 A, 60 s	IEC 60255-27

**Table 23. Mechanical tests**

Description	Reference	Requirement
Vibration tests (sinusoidal)	IEC 60068-2-6 (test Fc) IEC 60255-21-1	Class 2
Shock and bump test	IEC 60068-2-27 (test Ea shock) IEC 60068-2-29 (test Eb bump) IEC 60255-21-2	Class 2
Seismic test	IEC 60255-21-3	Class 2

**Table 24. Product safety**

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005) EN 60255-1 (2009)

**Table 25. EMC compliance**

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

**Table 26. RoHS compliance**

Description
Complies with RoHS directive 2002/95/EC

## Protection functions

**Table 27. Three-phase non-directional overcurrent protection (PHxPTOC)**

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: $f_n \pm 2$ Hz		
	PHLPTOC	$\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$		
	PHHPTOC and PHIPTOC	$\pm 1.5\%$ of set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$ ) $\pm 5.0\%$ of the set value (at currents in the range of $10 \dots 40 \times I_n$ )		
Start time <sup>1)2)</sup>		Minimum	Typical	Maximum
	PHIPTOC: $I_{\text{Fault}} = 2 \times \text{set Start value}$ $I_{\text{Fault}} = 10 \times \text{set Start value}$	16 ms	19 ms	23 ms
		11 ms	12 ms	14 ms
	PHHPTOC and PHLPTOC: $I_{\text{Fault}} = 2 \times \text{set Start value}$	22 ms	24 ms	25 ms
Reset time	< 40 ms			
Reset ratio	Typical 0.96			
Retardation time	< 30 ms			
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or $\pm 20$ ms			
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or $\pm 20$ ms <sup>3)</sup>			
Suppression of harmonics	RMS: No suppression DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression P-to-P+backup: No suppression			

1) Set *Operate delay time* = 0,02 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault =  $0.0 \times I_n$ ,  $f_n = 50$  Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

3) Includes the delay of the heavy-duty output contact

**Table 28. Three-phase non-directional overcurrent protection (PHxPTOC) main settings**

Parameter	Function	Value (Range)	Step
Start Value	PHLPTOC	0.05...5.00 x I <sub>n</sub>	0.01
	PHHPTOC	0.10...40.00 x I <sub>n</sub>	0.01
	PHIPTOC	1.00...40.00 x I <sub>n</sub>	0.01
Time multiplier	PHLPTOC	0.05...15.00	0.05
	PHHPTOC	0.05...15.00	0.05
Operate delay time	PHLPTOC	40...200000 ms	10
	PHHPTOC	40...200000 ms	10
	PHIPTOC	20...200000 ms	10
Operating curve type <sup>1)</sup>	PHLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

1) For further reference please refer to the Operating characteristics table



**Table 29. Three-phase directional overcurrent protection (DPHxPDOC)**

Characteristic		Value			
Operation accuracy	DPHLPDOC	Depending on the frequency of the current/ voltage measured: $f_n \pm 2$ Hz			
		Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$			
	DPHHPDOC	Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$ ) $\pm 5.0\%$ of the set value (at currents in the range of $10 \dots 40 \times I_n$ ) Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$			
		Start time <sup>1)2)</sup>	$I_{\text{Fault}} = 2.0 \times \text{set } \textit{Start value}$	Minimum	Typical
			37 ms	40 ms	42 ms
Reset time		< 40 ms			
Reset ratio		Typical 0.96			
Retardation time		< 35 ms			
Operate time accuracy in definite time mode		$\pm 1.0\%$ of the set value or $\pm 20$ ms			
Operate time accuracy in inverse time mode		$\pm 5.0\%$ of the theoretical value or $\pm 20$ ms <sup>3)</sup>			
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$			

- 1) *Measurement mode* and *Pol quantity* = default, current before fault =  $0.0 \times I_n$ , voltage before fault =  $1.0 \times U_n$ ,  $f_n = 50$  Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- 2) Includes the delay of the signal output contact
- 3) Maximum *Start value* =  $2.5 \times I_n$ , *Start value* multiples in range of 1.5 to 20

**Table 30. Three-phase directional overcurrent protection (DPHxPDOC) main settings**

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 x In	0.01
	DPHHPDOC	0.10...40.00 x In	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.05
Operate delay time	DPHxPDOC	40...200000 ms	10
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHxPDOC	-179...180 deg	1
Operating curve type <sup>1)</sup>	DPHLPDOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	

1) For further reference, refer to the Operating characteristics table

**Table 31. Non-directional earth-fault protection (EFxPTOC)**

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: $f_n \pm 2$ Hz		
	EFLPTOC	$\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$		
	EFHPTOC and EFIPTOC	$\pm 1.5\%$ of set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$ ) $\pm 5.0\%$ of the set value (at currents in the range of $10 \dots 40 \times I_n$ )		
Start time <sup>1)2)</sup>		Minimum	Typical	Maximum
	EFIPTOC: $I_{\text{Fault}} = 2 \times \text{set Start value}$ $I_{\text{Fault}} = 10 \times \text{set Start value}$	16 ms 11 ms	19 ms 12 ms	23 ms 14 ms
		EFHPTOC and EFLPTOC: $I_{\text{Fault}} = 2 \times \text{set Start value}$	22 ms	24 ms
	Reset time	< 40 ms		
Reset ratio	Typical 0.96			
Retardation time	< 30 ms			
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or $\pm 20$ ms			
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or $\pm 20$ ms <sup>3)</sup>			
Suppression of harmonics	RMS: No suppression DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression			

- 1) *Measurement mode* = default (depends on stage), current before fault =  $0.0 \times I_n$ ,  $f_n = 50$  Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- 2) Includes the delay of the signal output contact
- 3) Maximum *Start value* =  $2.5 \times I_n$ , *Start value* multiples in range of 1.5 to 20

**Table 32. Non-directional earth-fault protection (EFxPTOC) main settings**

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 x I <sub>n</sub>	0.005
	EFHPTOC	0.10...40.00 x I <sub>n</sub>	0.01
	EFIPTOC	1.00...40.00 x I <sub>n</sub>	0.01
Time multiplier	EFLPTOC	0.05...15.00	0.05
	EFHPTOC	0.05...15.00	0.05
Operate delay time	EFLPTOC	40...200000 ms	10
	EFHPTOC	40...200000 ms	10
	EFIPTOC	20...200000 ms	10
Operating curve type <sup>1)</sup>	EFLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further reference please refer to the Operating characteristics table

**Table 33. Directional earth-fault protection (DEFxPDEF)**

Characteristic		Value		
Operation accuracy	DEFLPDEF	Depending on the frequency of the current measured: $f_n \pm 2$ Hz		
	DEFHPDEF	Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Voltage $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$		
Start time <sup>1)2)</sup>	DEFHPDEF $I_{\text{Fault}} = 2 \times \text{set Start value}$	Minimum	Typical	Maximum
	DEFLPDEF $I_{\text{Fault}} = 2 \times \text{set Start value}$	42 ms	44 ms	46 ms
Reset time		61ms	64 ms	66 ms
Reset ratio		< 40 ms		
Retardation time		Typical 0.96		
Operate time accuracy in definite time mode		< 30 ms		
Operate time accuracy in inverse time mode		$\pm 1.0\%$ of the set value or $\pm 20$ ms		
Suppression of harmonics		$\pm 5.0\%$ of the theoretical value or $\pm 20$ ms <sup>3)</sup>		
		RMS: No suppression DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression		

- 1) Set *Operate delay time* = 0.06 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault =  $0.0 \times I_n$ ,  $f_n = 50$  Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- 2) Includes the delay of the signal output contact
- 3) Maximum *Start value* =  $2.5 \times I_n$ , *Start value* multiples in range of 1.5 to 20

**Table 34. Directional earth-fault protection (DEFxPDEF) main settings**

Parameter	Function	Value (Range)	Step
Start Value	DEFLPDEF	0.010...5.000 x I <sub>n</sub>	0.005
	DEFHPDEF	0.10...40.00 x I <sub>n</sub>	0.01
Directional mode	DEFLPDEF and DEFHPDEF	1=Non-directional 2=Forward 3=Reverse	
Time multiplier	DEFLPDEF	0.05...15.00	0.05
	DEFHPDEF	0.05...15.00	0.05
Operate delay time	DEFLPDEF	60...200000 ms	10
	DEFHPDEF	40...200000 ms	10
Operating curve type <sup>1)</sup>	DEFLPDEF	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFLPDEF and DEFHPDEF	1=Phase angle 2=IoSin 3=IoCos 4=Phase angle 80 5=Phase angle 88	

1) For further reference, refer to the Operating characteristics table

**Table 35. Transient/intermittent earth-fault protection (INTRPTEF)**

Characteristic	Value
Operation accuracy (U <sub>o</sub> criteria with transient protection)	Depending on the frequency of the current measured: f <sub>n</sub> ±2 Hz
	±1.5% of the set value or ±0.002 x U <sub>o</sub>
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n x f <sub>n</sub> , where n = 2, 3, 4, 5

**Table 36. Transient/intermittent earth-fault protection (INTRPTEF) main settings**

Parameter	Function	Value (Range)	Step
Directional mode	INTRPTEF	1=Non-directional 2=Forward 3=Reverse	-
Operate delay time	INTRPTEF	40...1200000 ms	10
Voltage start value (voltage start value for transient EF)	INTRPTEF	0.01...0.50 x Un	0.01
Operation mode	INTRPTEF	1=Intermittent EF 2=Transient EF	-
Peak counter limit (Min requirement for peak counter before start in IEF mode)	INTRPTEF	2...20	-

**Table 37. Admittance-based earth-fault protection (EFPADM)**

Characteristic	Value		
Operation accuracy <sup>1)</sup>	At the frequency $f = f_n$		
	$\pm 1.0\%$ or $\pm 0.01$ mS (In range of 0.5 - 100 mS)		
Start time <sup>2)</sup>	Minimum	Typical	Maximum
	56 ms	60 ms	64 ms
Reset time	40 ms		
Operate time accuracy	$\pm 1.0\%$ of the set value of $\pm 20$ ms		
Suppression of harmonics	-50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$		

1)  $U_o = 1.0 \times U_n$

2) Includes the delay of the signal output contact. Results based on statistical distribution of 1000 measurements.

**Table 38. Admittance-based earth-fault protection (EFPADM) main settings**

Parameter	Values (Range)	Unit	Step	Default	Description
Voltage start value	0.05...5.00	xUn	0.01	0.05	Voltage start value
Directional mode	1=Non-directional 2=Forward 3=Reverse			2=Forward	Directional mode
Operation mode	1=Yo 2=Go 3=Bo 4=Yo, Go 5=Yo, Bo 6=Go, Bo 7=Yo, Go, Bo			1=Yo	Operation criteria
Operate delay time	60...200000	ms	10	60	Operate delay time
Circle radius	0.05...500.00	mS	0.01	1.00	Admittance circle radius
Circle conductance	-500.00...500.00	mS	0.01	0.00	Admittance circle midpoint, conductance
Circle susceptance	-500.00...500.00	mS	0.01	0.00	Admittance circle midpoint, susceptance
Conductance forward	-500.00...500.00	mS	0.01	1.00	Conductance threshold in forward direction
Conductance reverse	-500.00...500.00	mS	0.01	-1.00	Conductance threshold in reverse direction
Conductance tilt Ang	-30...30	deg	1	0	Tilt angle of conductance boundary line



**Table 38. Admittance-based earth-fault protection (EFPADM) main settings, continued**

Parameter	Values (Range)	Unit	Step	Default	Description
Susceptance forward	-500.00...500.00	mS	0.01	1.00	Susceptance threshold in forward direction
Susceptance reverse	-500.00...500.00	mS	0.01	-1.00	Susceptance threshold in reverse direction
Susceptance tilt Ang	-30...30	deg	1	0	Tilt angle of susceptance boundary line

**Table 39. Three-phase overvoltage protection (PHPTOV)**

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz		
		$\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$		
Start time <sup>1)2)</sup>	$U_{Fault} = 1.1 \times \text{set Start value}$	Minimum	Typical	Maximum
		22 ms	24 ms	26 ms
Reset time		< 40 ms		
Reset ratio		Depends of the set <i>Relative hysteresis</i>		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		$\pm 1.0\%$ of the set value or $\pm 20$ ms		
Operate time accuracy in inverse time mode		$\pm 5.0\%$ of the theoretical value or $\pm 20$ ms <sup>3)</sup>		
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$		

- 1) *Start value* =  $1.0 \times U_n$ , Voltage before fault =  $0.9 \times U_n$ ,  $f_n = 50$  Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- 2) Includes the delay of the signal output contact
- 3) Maximum *Start value* =  $1.20 \times U_n$ , *Start value* multiples in range of 1.10 to 2.00

**Table 40. Three-phase overvoltage protection (PHPTOV) main settings**

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.05...1.60 x U <sub>n</sub>	0.01
Time multiplier	PHPTOV	0.05...15.00	0.05
Operate delay time	PHPTOV	40...300000 ms	10
Operating curve type <sup>1)</sup>	PHPTOV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

1) For further reference please refer to the Operating characteristics table

**Table 41. Three phase undervoltage protection (PHPTUV)**

Characteristic	Value			
Operation accuracy	Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz			
	$\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$			
Start time <sup>1)2)</sup>	U <sub>Fault</sub> = 0.9 x set <i>Start value</i>	Minimum	Typical	Maximum
		62 ms	64 ms	66 ms
Reset time	< 40 ms			
Reset ratio	Depends on the set <i>Relative hysteresis</i>			
Retardation time	< 35 ms			
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or $\pm 20$ ms			
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or $\pm 20$ ms <sup>3)</sup>			
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5,$ ...			

1) *Start value* = 1.0 x U<sub>n</sub>, Voltage before fault = 1.1 x U<sub>n</sub>, f<sub>n</sub> = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90 to 0.20

**Table 42. Three-phase undervoltage protection (PHPTUV) main settings**

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	0.05...1.20 x U <sub>n</sub>	0.01
Time multiplier	PHPTUV	0.05...15.00	0.05
Operate delay time	PHPTUV	60...300000 ms	10
Operating curve type <sup>1)</sup>	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference please refer to the Operating characteristics table

**Table 43. Positive sequence undervoltage protection (PSPTUV)**

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f <sub>n</sub> ±2 Hz		
		±1.5% of the set value or ±0.002 x U <sub>n</sub>		
Start time <sup>1)2)</sup>	U <sub>Fault</sub> = 0.99 x set <i>Start value</i> U <sub>Fault</sub> = 0.9 x set <i>Start value</i>	Minimum	Typical	Maximum
		51 ms 43 ms	53 ms 45 ms	54 ms 46 ms
Reset time		< 40 ms		
Reset ratio		Depends of the set <i>Relative hysteresis</i>		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n x f <sub>n</sub> , where n = 2, 3, 4, 5, ...		

1) *Start value* = 1.0 x U<sub>n</sub>, Positive sequence voltage before fault = 1.1 x U<sub>n</sub>, f<sub>n</sub> = 50 Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

**Table 44. Positive sequence undervoltage protection (PSPTUV) main settings**

Parameter	Function	Value (Range)	Step
Start value	PSPTUV	0.010...1.200 x U <sub>n</sub>	0.001
Operate delay time	PSPTUV	40...120000 ms	10
Voltage block value	PSPTUV	0.01...1.0 x U <sub>n</sub>	0.01

**Table 45. Frequency protection (FRPFRQ)**

Characteristic		Value
Operation accuracy	f>/f<	±10 mHz
	df/dt	±100 mHz/s (in range $ df/dt  < 5 \text{ Hz/s}$ ) ± 2.0% of the set value (in range $5 \text{ Hz/s} <  df/dt  < 15 \text{ Hz/s}$ )
Start time	f>/f<	< 80 ms
	df/dt	< 120 ms
Reset time		< 150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

**Table 46. Frequency protection (FRPFRQ) main settings**

Parameter	Values (Range)	Unit	Step	Default	Description
Operation mode	1=Freq< 2=Freq> 3=df/dt 4=Freq< + df/dt 5=Freq> + df/dt 6=Freq< OR df/dt 7=Freq> OR df/dt			1=Freq<	Frequency protection operation mode selection
Start value Freq>	0.900...1.200	xFn	0.001	1.050	Frequency start value overfrequency
Start value Freq<	0.800...1.100	xFn	0.001	0.950	Frequency start value underfrequency
Start value df/dt	-0.200...0.200	xFn /s	0.005	0.010	Frequency start value rate of change
Operate Tm Freq	80...200000	ms	10	200	Operate delay time for frequency
Operate Tm df/dt	120...200000	ms	10	400	Operate delay time for frequency rate of change

**Table 47. Negative sequence overvoltage protection (NSPTOV)**

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz		
		$\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$		
Start time <sup>1)2)</sup>	$U_{\text{Fault}} = 1.1 \times \text{set}$ <i>Start value</i> $U_{\text{Fault}} = 2.0 \times \text{set}$ <i>Start value</i>	Minimum	Typical	Maximum
		33 ms 24 ms	35 ms 26 ms	37 ms 28 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		$\pm 1.0\%$ of the set value or $\pm 20$ ms		
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5,$ ...		

1) Negative-sequence voltage before fault =  $0.0 \times U_n$ ,  $f_n = 50$  Hz, negative-sequence overvoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

**Table 48. Negative sequence overvoltage protection (NSPTOV) main settings**

Parameter	Function	Value (Range)	Step
Start value	NSPTOV	$0.010 \dots 1.000 \times U_n$	0.001
Operate delay time	NSPTOV	40...120000 ms	1

**Table 49. Residual overvoltage protection (ROVPTOV)**

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz		
		$\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$		
Start time <sup>1)2)</sup>	$U_{\text{Fault}} = 1.1 \times \text{set Start value}$	Minimum	Typical	Maximum
		55 ms	56 ms	58 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		$\pm 1.0\%$ of the set value or $\pm 20$ ms		
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$		

- 1) Residual voltage before fault =  $0.0 \times U_n$ ,  $f_n = 50$  Hz, residual voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements  
 2) Includes the delay of the signal output contact

**Table 50. Residual overvoltage protection (ROVPTOV) main settings**

Parameter	Function	Value (Range)	Step
Start value	ROVPTOV	$0.010 \dots 1.000 \times U_n$	0.001
Operate delay time	ROVPTOV	40...300000 ms	1

**Table 51. Negative phase-sequence overcurrent protection (NSPTOC)**

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: $f_n \pm 2$ Hz		
		$\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$		
Start time <sup>1)2)</sup>	$I_{\text{Fault}} = 2 \times \text{set Start value}$ $I_{\text{Fault}} = 10 \times \text{set Start value}$	Minimum	Typical	Maximum
		22 ms 14 ms	24 ms 16 ms	25 ms 17 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		$\pm 1.0\%$ of the set value or $\pm 20$ ms		
Operate time accuracy in inverse time mode		$\pm 5.0\%$ of the theoretical value or $\pm 20$ ms <sup>3)</sup>		
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$		

1) Negative sequence current before fault = 0.0,  $f_n = 50$  Hz, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

3) Maximum *Start value* =  $2.5 \times I_n$ , *Start value* multiples in range of 1.5 to 20

**Table 52. Negative phase-sequence overcurrent protection (NSPTOC) main settings**

Parameter	Function	Value (Range)	Step
Start value	NSPTOC	0.01...5.00 x $I_n$	0.01
Time multiplier	NSPTOC	0.05...15.00	0.05
Operate delay time	NSPTOC	40...200000 ms	10
Operating curve type <sup>1)</sup>	NSPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	

1) For further reference please refer to the Operating characteristics table



**Table 53. Phase discontinuity protection (PDNSPTOC)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f_n \pm 2$ Hz
	$\pm 2\%$ of the set value
Start time	< 70 ms
Reset time	< 40 ms
Reset ratio	Typical 0.96
Retardation time	< 35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or $\pm 20$ ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$

**Table 54. Phase discontinuity protection (PDNSPTOC) main settings**

Parameter	Function	Value (Range)	Step
Start value (Current ratio setting $I_2/I_1$ )	PDNSPTOC	10...100 %	1
Operate delay time	PDNSPTOC	100...30000 ms	1
Min phase current	PDNSPTOC	$0.05 \dots 0.30 \times I_n$	0.01

**Table 55. Circuit breaker failure protection (CCBRBRF)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f_n \pm 2$ Hz
	$\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
Operate time accuracy	$\pm 1.0\%$ of the set value or $\pm 20$ ms

**Table 56. Circuit breaker failure protection (CCBRBRF) main settings**

Parameter	Function	Value (Range)	Step
Current value (Operating phase current)	CCBRBRF	0.05...1.00 x I <sub>n</sub>	0.05
Current value Res (Operating residual current)	CCBRBRF	0.05...1.00 x I <sub>n</sub>	0.05
CB failure mode (Operating mode of function)	CCBRBRF	1=Current 2=Breaker status 3=Both	-
CB fail trip mode	CCBRBRF	1=Off 2=Without check 3=Current check	-
Retrip time	CCBRBRF	0...60000 ms	10
CB failure delay	CCBRBRF	0...60000 ms	10
CB fault delay	CCBRBRF	0...60000 ms	10

**Table 57. Three-phase thermal overload protection for feeders (T1PTTR)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f <sub>n</sub> ±2 Hz  Current measurement: ±1.5% of the set value or ±0.002 x I <sub>n</sub> (at currents in the range of 0.01...4.00 x I <sub>n</sub> )
Operate time accuracy <sup>1)</sup>	±2.0% of the theoretical value or ±0.50 s

1) Overload current > 1.2 x Operate level temperature

**Table 58. Three-phase thermal overload (T1PTTR) main settings**

Parameter	Function	Value (Range)	Step
Env temperature Set (Ambient temperature used when the AmbSens is set to Off)	T1PTTR	-50...100°C	1
Current multiplier (Current multiplier when function is used for parallel lines)	T1PTTR	1...5	1
Current reference	T1PTTR	0.05...4.00 x I <sub>n</sub>	0.01
Temperature rise (End temperature rise above ambient)	T1PTTR	0.0...200.0°C	0.1
Time constant (Time constant of the line in seconds)	T1PTTR	60...60000 s	1
Maximum temperature (temperature level for operate)	T1PTTR	20.0...200.0°C	0.1
Alarm value (Temperature level for start (alarm))	T1PTTR	20.0...150.0°C	0.1
Reclose temperature (Temperature for reset of block reclose after operate)	T1PTTR	20.0...150.0°C	0.1
Initial temperature (Temperature raise above ambient temperature at startup)	T1PTTR	-50.0...100.0°C	0.1

**Table 59. Three-phase inrush current detection (INRPHAR)**

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	Current measurement: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Ratio I2f/I1f measurement: $\pm 5.0\%$ of the set value
Reset time	+35 ms / -0 ms
Reset ratio	Typical 0.96
Operate time accuracy	+35 ms / -0 ms

**Table 60. Three-phase inrush detection (INRPHAR) main settings**

Parameter	Function	Value (Range)	Step
Start value (Ratio of the 2nd to the 1st harmonic leading to restraint)	INRPHAR	5...100 %	1
Operate delay time	INRPHAR	20...60000 ms	1

**Table 61. Arc protection (ARCSARC)**

Characteristic	Value			
Operation accuracy	$\pm 3\%$ of the set value or $\pm 0.01 \times I_n$			
Operate time		Minimum	Typical	Maximum
	<i>Operation mode = "Light+current"<sup>1)2)</sup></i>	9 ms	12 ms	15 ms
	<i>Operation mode = "Light only"<sup>2)</sup></i>	9 ms	10 ms	12 ms
Reset time	< 40 ms			
Reset ratio	Typical 0.96			

1) *Phase start value* =  $1.0 \times I_n$ , current before fault =  $2.0 \times$  set *Phase start value*,  $f_n = 50$  Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements

2) Includes the delay of the heavy-duty output contact

**Table 62. Arc protection (ARCSARC) main settings**

Parameter	Function	Value (Range)	Step
Phase start value (Operating phase current)	ARCSARC	0.50...40.00 x I <sub>n</sub>	0.01
Ground start value (Operating residual current)	ARCSARC	0.05...8.00 x I <sub>n</sub>	0.01
Operation mode	ARCSARC	1=Light+current 2=Light only 3=BI controlled	

**Table 63. Operation characteristics**

Parameter	Values (Range)
Operating curve type	1=ANSI Ext. inv. 2=ANSI Very. inv. 3=ANSI Norm. inv. 4=ANSI Mod inv. 5=ANSI Def. Time 6=L.T.E. inv. 7=L.T.V. inv. 8=L.T. inv. 9=IEC Norm. inv. 10=IEC Very inv. 11=IEC inv. 12=IEC Ext. inv. 13=IEC S.T. inv. 14=IEC L.T. inv 15=IEC Def. Time 17=Programmable 18=RI type 19=RD type
Operating curve type (voltage protection)	5=ANSI Def. Time 15=IEC Def. Time 17=Inv. Curve A 18=Inv. Curve B 19=Inv. Curve C 20=Programmable 21=Inv. Curve A 22=Inv. Curve B 23=Programmable

## Control functions

**Table 64. Autoreclosure (DARREC)**

Characteristic	Value
Operate time accuracy	$\pm 1.0\%$ of the set value or $\pm 20$ ms

**Table 65. Synchrocheck (SECRSYN)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: $f_n \pm 1$ Hz Voltage: $\pm 3.0\%$ of the set value or $\pm 0.01 \times U_n$ Frequency: $\pm 10$ mHz Phase angle: $\pm 3^\circ$
Reset time	< 50 ms
Reset ratio	Typical 0.96
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or $\pm 20$ ms

**Table 66. Synchronism and energizing check (SECRSYN) main settings**

Parameter	Values (Range)	Unit	Step	Default	Description
Live dead mode	-1=Off 1=Both Dead 2=Live L, Dead B 3=Dead L, Live B 4=Dead Bus, L Any 5=Dead L, Bus Any 6=One Live, Dead 7=Not Both Live			1=Both Dead	Energizing check mode
Difference voltage	0.01...0.50	xUn	0.01	0.05	Maximum voltage difference limit
Difference frequency	0.001...0.100	xFn	0.001	0.001	Maximum frequency difference limit
Difference angle	5...90	deg	1	5	Maximum angle difference limit
Synchrocheck mode	1=Off 2=Synchronous 3=Asynchronous			2=Synchronous	Synchrocheck operation mode
Control mode	1=Continuous 2=Command			1=Continuous	Selection of the synchrocheck command or continuous control mode
Dead line value	0.1...0.8	xUn	0.1	0.2	Voltage low-limit line for energizing check
Live line value	0.2...1.0	xUn	0.1	0.5	Voltage high-limit line for energizing check

**Table 66. Synchronism and energizing check (SECRSYN) main settings, continued**

Parameter	Values (Range)	Unit	Step	Default	Description
Close pulse	200...60000	ms	10	200	Breaker-closing pulse duration
Max energizing V	0.50...1.15	xUn	0.01	1.05	Maximum voltage for energizing
Phase shift	-180...180	deg	1	180	Correction of phase difference between measured U_BUS and U_LINE
Minimum Syn time	0...60000	ms	10	0	Minimum time to accept synchronizing
Maximum Syn time	100...6000000	ms	10	2000	Maximum time to accept synchronizing
Energizing time	100...60000	ms	10	100	Time delay for energizing check
Closing time of CB	40...250	ms	10	60	Closing time of the breaker

## Measurement functions

**Table 67. Three-phase current measurement (CMMXU)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f_n \pm 2$ Hz  $\pm 0.5\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.01...4.00 \times I_n$ )
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$ RMS: No suppression



**Table 68. Current sequence components (CSMSQI)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f/f_n = \pm 2$ Hz
	$\pm 1.0\%$ or $\pm 0.002 \times I_n$ at currents in the range of $0.01 \dots 4.00 \times I_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$

**Table 69. Three-phase voltage measurement (VMMXU)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz At voltages in range $0.01 \dots 1.15 \times U_n$
	$\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

**Table 70. Voltage sequence components (VSMSQI)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz At voltages in range $0.01 \dots 1.15 \times U_n$
	$\pm 1.0\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$

**Table 71. Residual current measurement (RESCMMXU)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f/f_n = \pm 2$ Hz
	$\pm 0.5\%$ or $\pm 0.002 \times I_n$ at currents in the range of $0.01 \dots 4.00 \times I_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

**Table 72. Residual voltage measurement (RESVMMXU)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f/f_n = \pm 2$ Hz $\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

**Table 73. Three-phase power and energy (PEMMXU)**

Characteristic	Value
Operation accuracy	At all three currents in range $0.10 \dots 1.20 \times I_n$ At all three voltages in range $0.50 \dots 1.15 \times U_n$ At the frequency $f_n \pm 1$ Hz Active power and energy in range $ PF  > 0.71$ Reactive power and energy in range $ PF  < 0.71$ $\pm 1.5\%$ for power (S, P and Q) $\pm 0.015$ for power factor $\pm 1.5\%$ for energy
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$

**Table 74. Frequency measurement (FMMXU)**

Characteristic	Value
Operation accuracy	$\pm 10$ mHz (in measurement range 35 - 75 Hz)

## Supervision functions

**Table 75. Current circuit supervision (CCRDIF)**

Characteristic	Value
Operate time <sup>1)</sup>	< 30 ms

1) Including the delay of the output contact.

**Table 76. Current circuit supervision (CCRDIF) main settings**

Parameter	Values (Range)	Unit	Description
Start value	0.05...0.20	$\times I_n$	Minimum operate current differential level
Maximum operate current	1.00...5.00	$\times I_n$	Block of the function at high phase current

**Table 77. Fuse failure supervision (SEQRFUF)**

Characteristic	Value		
Operate time <sup>1)</sup>	• NPS function	$U_{Fault} = 1.1 \times \text{set } Neg$ <i>Seq voltage Lev</i>	< 33 ms
		$U_{Fault} = 5.0 \times \text{set } Neg$ <i>Seq voltage Lev</i>	< 18 ms
	• Delta function	$\Delta U = 1.1 \times \text{set}$ <i>Voltage change rate</i>	< 30 ms
		$\Delta U = 2.0 \times \text{set}$ <i>Voltage change rate</i>	< 24 ms

1) Includes the delay of the signal output contact,  $f_n = 50$  Hz, fault voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

## 20. Local HMI

The IED is available with two optional displays, a large one and a small one. The large display is suited for IED installations where the front panel user interface is frequently used and a single line diagram is required. The small display is suited for remotely controlled substations where the IED is only occasionally accessed locally via the front panel user interface.

Both LCD displays offer front-panel user interface functionality with menu navigation and menu views. However, the large display offers increased front-panel usability with less menu scrolling and improved information overview. In addition, the large display includes a user-configurable single line diagram (SLD) with position indication for the associated primary equipment. Depending on the chosen standard

configuration, the IED displays the related measuring values, apart from the default single line diagram. The SLD view can also be accessed using the web-browser based user interface. The default SLD can be modified according to user requirements by using the graphical display editor in PCM600.

The local HMI includes a push button (L/R) for local/remote operation of the IED. When the IED is in the local mode, the IED can be operated only by using the local front panel user interface. When the IED is in the remote mode, the IED can execute commands sent from a remote location. The IED supports the remote selection of local/remote mode via a binary input. This feature facilitates, for example, the use of an external switch at the substation to ensure that all IEDs are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control centre.

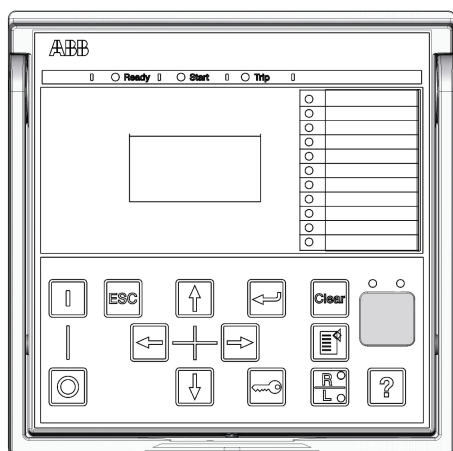


Figure 14. Small display

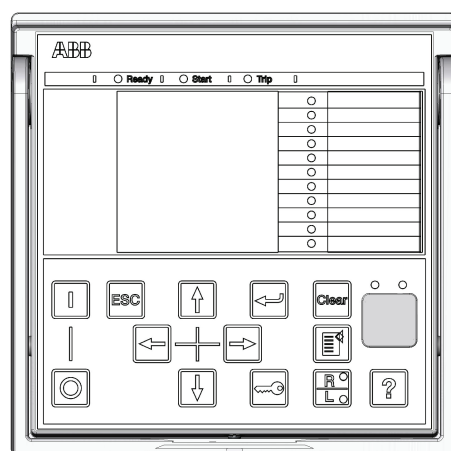


Figure 15. Large display

Table 78. Small display

Character size <sup>1)</sup>	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	5	20
Large, variable width (13x14 pixels)	4	8 or more

1) Depending on the selected language

**Table 79. Large display**

Character size <sup>1)</sup>	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	10	20
Large, variable width (13x14 pixels)	8	8 or more

1) Depending on the selected language

## 21. Mounting methods

By means of appropriate mounting accessories the standard IED case for the 615 series IED can be flush mounted, semi-flush mounted or wall mounted. The flush mounted and wall mounted IED cases can also be mounted in a tilted position (25°) using special accessories.

Further, the IEDs can be mounted in any standard 19" instrument cabinet by means of 19" mounting panels available with cut-outs for one or two IEDs. Alternatively, the IED can be mounted in 19" instrument cabinets by means of 4U Combiflex equipment frames.

For the routine testing purposes, the IED cases can be equipped with test switches,

type RTXP 18, which can be mounted side by side with the IED cases.

Mounting methods:

- Flush mounting
- Semi-flush mounting
- Semi-flush mounting in a 25° tilt
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame
- Mounting with a RTXP 18 test switch to a 19" rack

Panel cut-out for flush mounting:

- Height: 161.5±1 mm
- Width: 165.5±1 mm

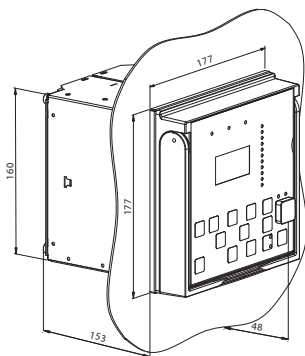


Figure 16. Flush mounting

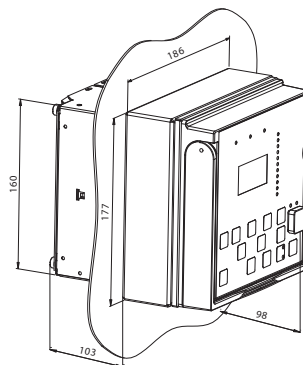


Figure 17. Semi-flush mounting

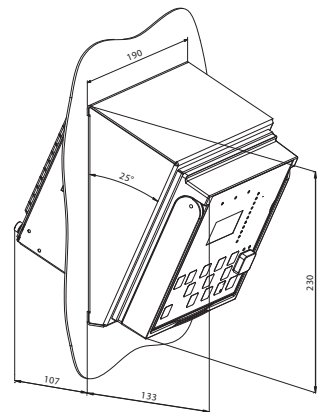


Figure 18. Semi-flush with a 25° tilt

## 22. IED case and IED plug-in unit

For safety reasons, the IED cases for current measuring IEDs are provided with automatically operating contacts for short-circuiting the CT secondary circuits when a IED unit is withdrawn from its case. The IED case is further provided with a mechanical coding system preventing current measuring IED units from being inserted into a IED case for a voltage measuring IED unit and vice versa, i.e. the IED cases are assigned to a certain type of IED plug-in unit.

placed above the HMI on the upper part of the plug-in-unit. An order number label is placed on the side of the plug-in unit as well as inside the case. The order number consists of a string of codes generated from the IED's hardware and software modules.

Use the ordering key information to generate the order number when ordering complete IEDs.

## 23. Selection and ordering data

The IED type and serial number label identifies the protection IED. The label is

**HBF**FAEAGBCC1BBN1XD

#	DESCRIPTION	
1	<b>IED</b>	
	615 series IED (including case)	<b>H</b>
	615 series IED (including case) with test switch, wired and installed in a 19" equipment panel. Not available for standard configuration "G".	<b>K</b>
2	<b>Standard</b>	
	IEC	<b>B</b>
3	<b>Main application</b>	
	Feeder protection and control	<b>F</b>

The standard configuration determines the I/O hardware and available options.  
 The example below shows standard configuration “B” with chosen options.

HBFFAEAGBCC1BBA1XD

#	DESCRIPTION
4-8	<b>Standard configurations, analog and binary I/O options</b>  <b>Standard configuration descriptions in short:</b> <b>A</b> = Non-directional O/C and directional E/F protection. <b>B</b> = Non-directional O/C and directional E/F protection, CB condition monitoring <b>C</b> = Non-directional O/C and non-directional E/F protection <b>D</b> = Non-directional O/C and non-directional E/F protection, CB condition monitoring <b>E</b> = Non-directional O/C and directional E/F protection with phase-voltage based measurements, CB condition monitoring <b>F</b> = Directional O/C and directional E/F protection with phase-voltage based measurements, undervoltage and overvoltage protection, CB condition monitoring <b>G</b> = Directional O/C and directional E/F protection, phase-voltage based protection and measurement functions, CB condition monitoring, (sensor inputs) <b>H</b> = Non-directional O/C and non-directional E/F protection, voltage and frequency based protection and measurement functions, synchro-check and CB condition monitoring
	Std. conf A: 4I + Uo (Io 1/5 A) + 3 BI + 6 BO
	AAAAA
	Std. conf A: 4I + Uo (Io 0.2/1 A) + 3 BI + 6 BO
	AABAA
	Std. conf B: 4I +Uo (Io 1/5 A) + 11 BI + 10 BO
	BAAAC
	Std. conf B: 4I +Uo (Io 1/5 A) + 17 BI + 13 BO
	BAAAE
	Std. conf B: 4I +Uo (Io 0.2/1 A) + 11 BI + 10 BO
	BABAC
	Std. conf B: 4I +Uo (Io 0.2/1 A) + 17 BI + 13 BO
	BABAE
	Std. conf C: 4I (Io 1/5 A) + 4 BI + 6 BO
	CACAB
	Std. conf C: 4I (Io 0.2/1 A) + 4 BI + 6 BO
	CADAB
	Std. conf D: 4I (Io 1/5 A) + 12 BI + 10 BO
	DACAD
	Std. conf D: 4I (Io 1/5 A) + 18 BI + 13 BO
	DACAF
	Std. conf D: 4I (Io 0.2/1 A) + 12 BI + 10 BO
	DADAD
	Std. conf D: 4I (Io 0.2/1 A) + 18 BI + 13 BO
	DADAF
	Std. conf E: 4I (Io 1/5 A) + 5U + 16 BI + 10 BO
	EAEAG
	Std. conf E: 4I (Io 0.2/1 A) + 5U + 16 BI + 10 BO
	EAFAG
	Std. conf F: 4I (Io 1/5 A) + 5U + 16 BI + 10 BO
	<b>FAEAG</b>
	Std. conf F: 4I (Io 0.2/1 A) + 5U + 16 BI + 10 BO
	FAFAG
	Std. conf G: 3Is + 3Us +Io (Io 0.2/1 A) + 8 BI + 10 BO
	GDAAH
	Std. conf H: 4I (Io 1/5 A) + 5U + 16 BI + 10 BO
	HAEAG
	Std. conf H: 4I (Io 0.2/1 A) + 5U + 16 BI + 10 BO
	HAFAG

The communication module hardware determines the available communication protocols.  
 Choose the hardware from one of the rows below to define the digits # 9-10.

HBFFAEAG **BC** C1BBA1XD

#	DESCRIPTION	
<b>9</b>	<b>Communication modules (Serial/Ethernet)</b>	
<b>10</b>	Serial RS-485, incl. an input for IRIG-B + Ethernet 100Base-FX (1 x LC)	<b>AA</b>
	Serial RS-485, incl. an input for IRIG-B + Ethernet 100Base-TX (1 x RJ-45)	<b>AB</b>
	Serial RS-485, incl. an input for IRIG-B	<b>AN</b>
	Serial glass fibre (ST), incl. an RS-485 connector and an input for IRIG-B (cannot be combined with arc protection)	<b>BN</b>
	Serial glass fibre (ST) + Ethernet 100Base-TX (1 x RJ-45) + Serial RS-485 connector, RS-232/485 D-Sub 9 connector + input for IRIG-B (cannot be combined with arc protection)	<b>BB</b>
	Serial glass fibre (ST) + Ethernet 100Base-TX (3 x RJ-45)	<b>BD</b>
	Serial glass fibre (ST) + Ethernet 100Base-TX and -FX (2 x RJ-45 + 1 x LC)	<b>BC</b>
	Ethernet 100Base-FX (1 x LC)	<b>NA</b>
	Ethernet 100Base-TX (1 x RJ-45)	<b>NB</b>
	Ethernet 100Base-TX (2 x RJ-45 + 1 x LC)	<b>NC</b>
	Ethernet 100Base-TX (3 x RJ-45)	<b>ND</b>
	No communication module	<b>NN</b>

If serial communication is chosen, please choose a serial communication module including Ethernet (for example “BC”) if a service bus for PCM600 or the WebHMI is required.



HBFFAEAGBCC1BBA1XD

#	DESCRIPTION	
11	<b>Communication protocols</b>	
	<b>IEC 61850</b> (for Ethernet communication modules and IEDs without a communication module )	<b>A</b>
	<b>Modbus</b> (for Ethernet/serial <b>or</b> Ethernet + serial communication modules)	<b>B</b>
	<b>IEC 61850 + Modbus</b> (for Ethernet <b>or</b> serial + Ethernet communication modules)	<b>C</b>
	<b>IEC 60870-5-103</b> (for serial <b>or</b> Ethernet + serial communication modules)	<b>D</b>
	<b>DNP3</b> (for Ethernet/serial <b>or</b> Ethernet + serial communication modules)	<b>E</b>

HBFFAEAGBCC1BBA1XD

#	DESCRIPTION	
12	<b>Language</b>	
	English	1
	English and German	3
	English and Swedish	4
	English and Spanish	5
	English and Russian	6
13	<b>Front panel</b>	
	Small LCD	A
	Large LCD with single line diagram (SLD)	B
14	<b>Option 1</b>	
	Auto-reclosing	A
	Arc protection (requires a communication module, cannot be combined with communication modules BN or BB)	B
	Arc protection and auto-reclosing (requires a communication module, cannot be combined with communication modules BN, BB)	C
15	<b>Option 2</b>	
	Directional earth-fault protection (only for std configuration: A, B, E, F, G)	A
	Admittance based earth-fault protection (only for std configuration: A, B, E, F, G)	B
16	<b>Power supply</b>	
	48...250 V DC, 100...240 V AC	1
	24...60 V DC	2
17	<b>Vacant digit</b>	
	Vacant	X
18	<b>Version</b>	
	Version 3.0	D

Example code: HBFFAEAGBCC1BBA1XD

Your ordering code:

Digit (#)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Code	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Figure 19. Ordering key for complete IEDs

## 24. Accessories and ordering data

**Table 80. Cables**

Item	Order number
Cable for optical sensors for arc protection 1.5 m	1MRS120534-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS120534-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS120534-5.0

**Table 81. Mounting accessories**

Item	Order number
Semi-flush mounting kit	1MRS050696
Wall mounting kit	1MRS050697
Inclined semi-flush mounting kit	1MRS050831
19" rack mounting kit with cut-out for one IED	1MRS050694
19" rack mounting kit with cut-out for two IEDs	1MRS050695
Mounting bracket for one IED with test switch RTXP in 4U Combiflex (RHGT 19" variant C)	2RCA022642P0001
Mounting bracket for one IED in 4U Combiflex (RHGT 19" variant C)	2RCA022643P0001
19" rack mounting kit for one IED and one RTXP18 test switch (the test switch is not included in the delivery)	2RCA021952A0003
19" rack mounting kit for one IED and one RTXP24 test switch (the test switch is not included in the delivery)	2RCA022561A0003

## 25. Tools

The IED is delivered as a pre-configured unit. The default parameter setting values can be changed from the front-panel user interface, the web-browser based user interface (WebHMI) or the PCM600 tool in combination with the IED-specific connectivity package.

The Protection and Control IED Manager PCM600 is available in three different variants, that is PCM600, PCM600 Engineering and PCM600 Engineering Pro. Depending on the chosen variant, PCM600

offers extensive IED configuration functions such as IED signal configuration, application configuration, graphical display configuration including single line diagram configuration, and IEC 61850 communication configuration including horizontal GOOSE communication.

When the web-browser based user interface is used, the IED can be accessed either locally or remotely using a web browser (IE 7.0 or later). For security reasons, the web-browser based user interface is disabled by default. The interface can be enabled with the PCM600 tool or from the front panel user interface. The functionality of the interface

can be limited to read-only access by means of PCM600.

The IED connectivity package is a collection of software and specific IED information, which enable system products and tools to connect and interact with the IED. The connectivity packages reduce the risk of errors in system integration, minimizing device configuration and set-up times.

Further, the Connectivity Packages for the 615 series IEDs include a flexible update tool for adding one additional local HMI language to the IED. The update tool is activated using PCM600 and enables multiple updates of the additional HMI language, thus offering flexible means for possible future language updates.

**Table 82. Tools**

<b>Configuration and setting tools</b>	<b>Version</b>
PCM600	2.3 or later
Web-browser based user interface	IE 7.0 or later
REF615 Connectivity Package	3.0.2 or later

**Table 83. Supported functions**

Function	WebHMI	PCM600	PCM600 Engineering	PCM600 Engineering Pro
IED parameter setting	•	•	•	•
Saving of IED parameter settings in the IED	•	•	•	•
Signal monitoring	•	•	•	•
Disturbance recorder handling	•	•	•	•
Alarm LED viewing	•	•	•	•
Access control management	•	•	•	•
IED signal configuration (signal matrix)	-	•	•	•
Modbus® communication configuration (communication management)	-	•	•	•
DNP3 communication configuration (communication management)	-	•	•	•
IEC 60870-5-103 communication configuration (communication management)	-	•	•	•
Saving of IED parameter settings in the tool	-	•	•	•
Disturbance record analysis	-	•	•	•
XRIO parameter export/import	-	•	•	•
Graphical display configuration	-	•	•	•

**Table 83. Supported functions, continued**

Function	WebHMI	PCM600	PCM600 Engineering	PCM600 Engineering Pro
Application configuration	-	-	•	•
IEC 61850 communication configuration, GOOSE (communication configuration)	-	-	-	•
Phasor diagram viewing	•	-	-	-
Event viewing	•	-	-	-
Saving of event data on the user's PC	•	-	-	-

• = Supported

## 26. Terminal diagrams

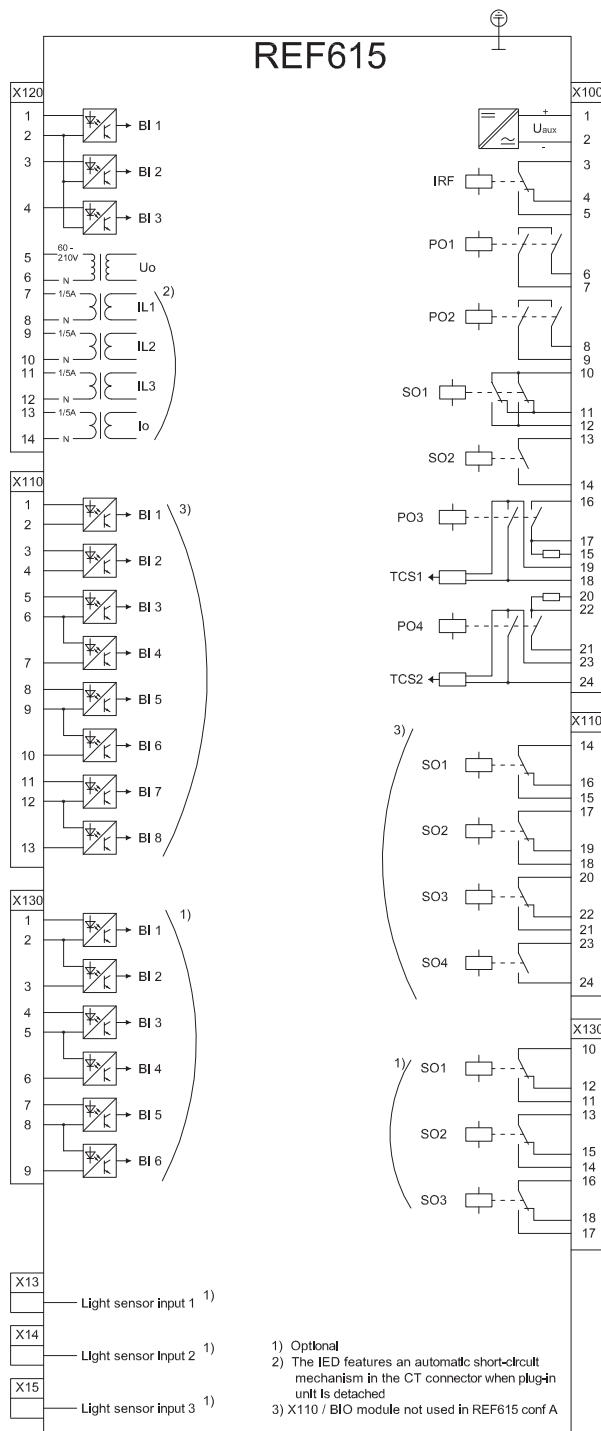


Figure 20. Terminal diagram of standard configurations A and B

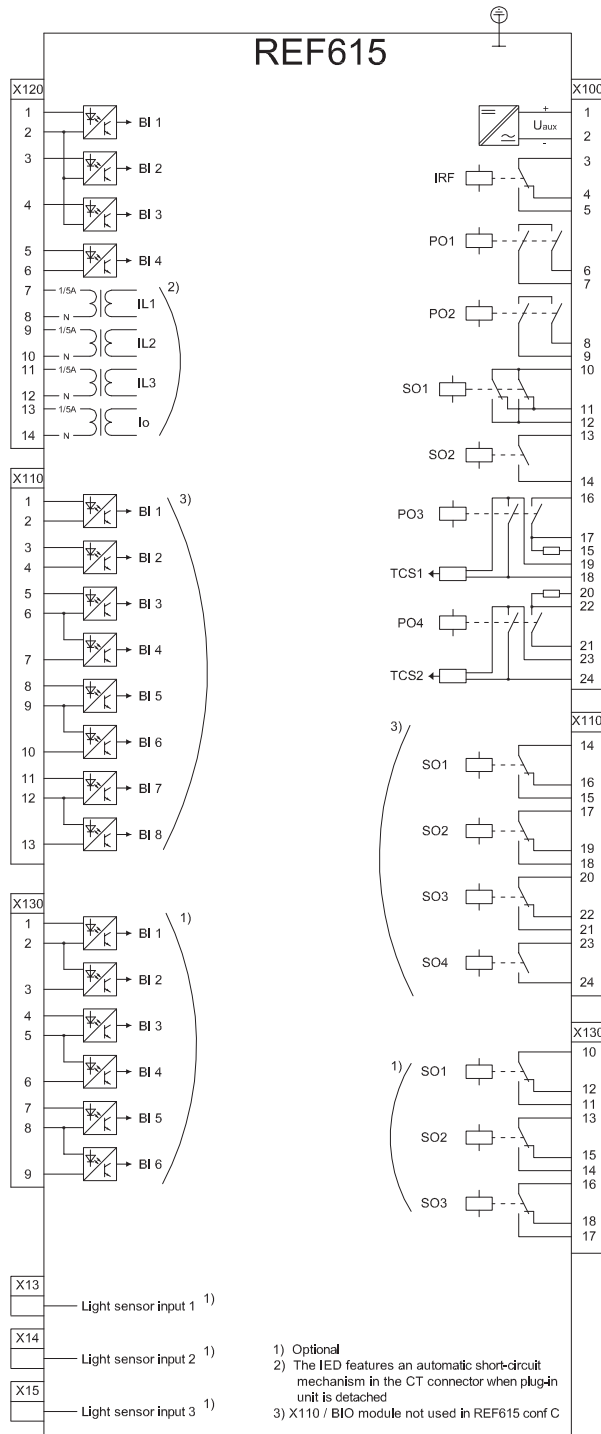


Figure 21. Terminal diagram of standard configurations C and D



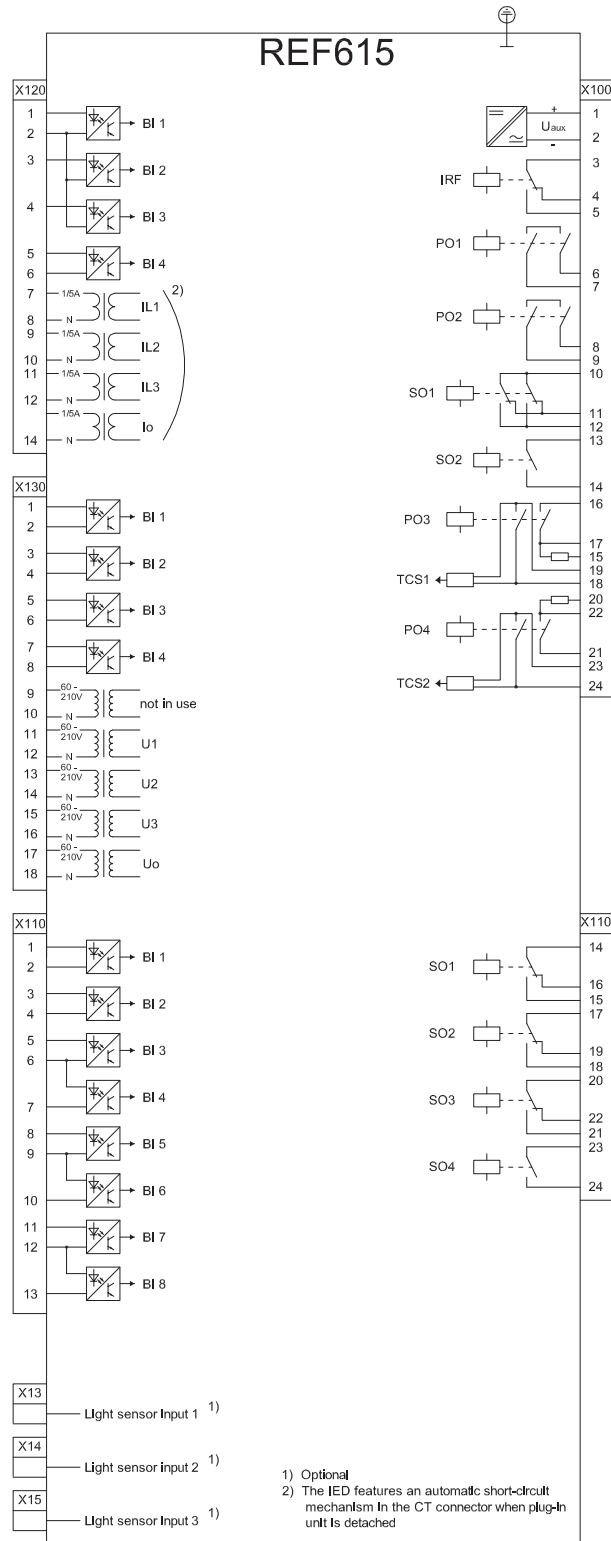


Figure 22. Terminal diagram of standard configuration E and F

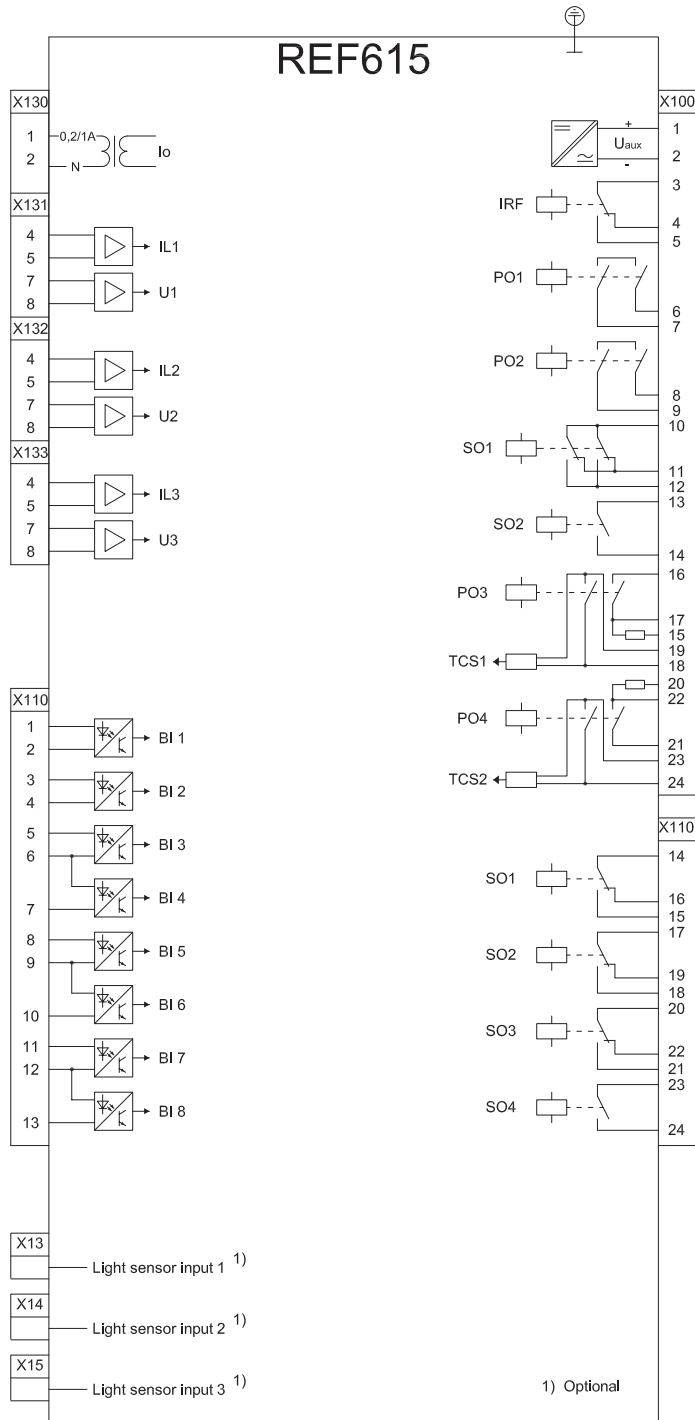


Figure 23. Terminal diagram of standard configuration G

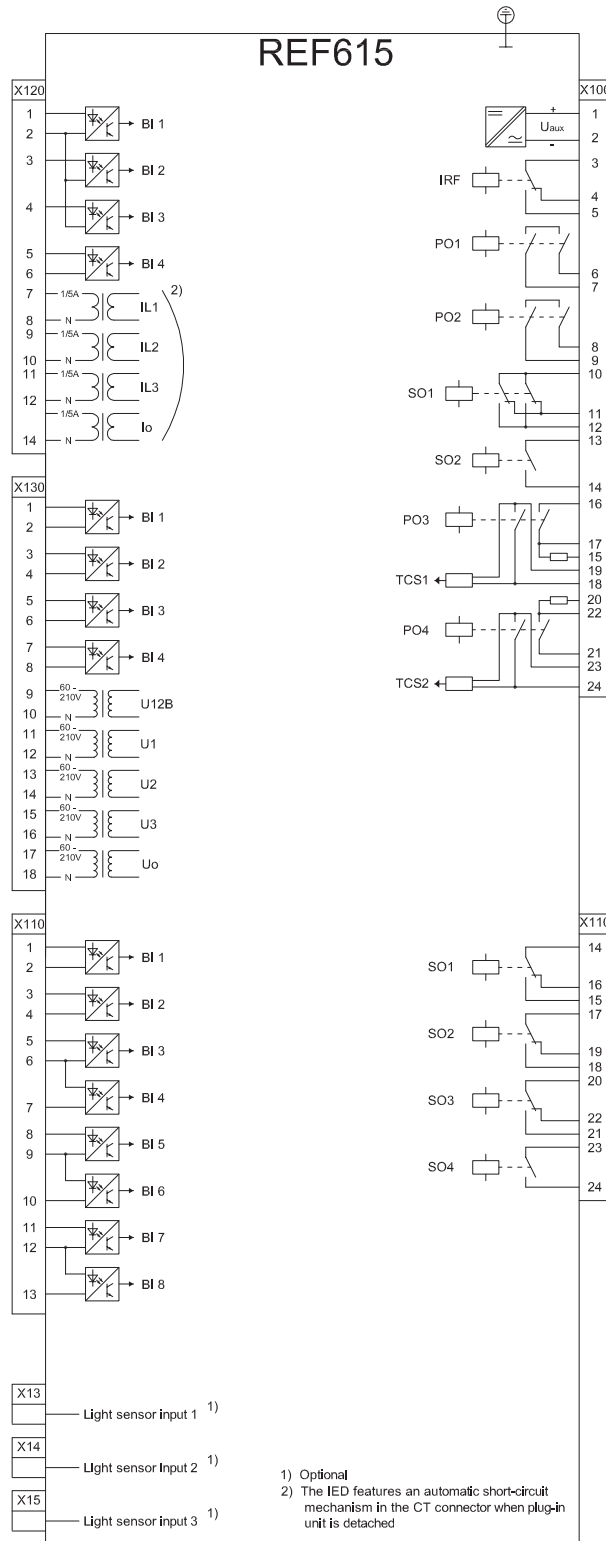


Figure 24. Terminal diagram of standard configuration H

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## 27. Certificates

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KEMA has issued an IEC 61850 Certificate Level A<sup>1</sup> for REF615. Certificate number: 30710144-Consulting 08-0115.

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## 28. Inspection reports

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KEMA has issued an Inspection report for REF615, "Comparison between hardwired and GOOSE performance of UniGear switchgear panels with REF615 and REF630 Feeder Protection and Control IEDs based on IEC 62271-3". Report number: 70972064-TDT 09-1398.

The Inspection report concludes in its summary, apart from the performance comparisons, that "both the REF630 and REF615 comply to the performance class P1 message type 1A "Trip" for distribution bays (transfer time <10 msec) as defined in IEC 61850-5".

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## 29. References

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The [www.abb.com/substationautomation](http://www.abb.com/substationautomation) portal offers you information about the distribution automation product and service range.

You will find the latest relevant information on the REF615 protection IED on the [product page](#).

The download area on the right hand side of the web page contains the latest product documentation, such as technical reference manual, installation manual, operators manual, etc. The selection tool on the web page helps you find the documents by the document category and language.

The Features and Application tabs contain product related information in a compact format.

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## Feeder Protection and Control REF615

**Overview** Service & Support Application Features Contacts

REF615 is a dedicated feeder protection IED perfectly aligned for the protection, control, measurement and supervision of utility substations and industrial power systems. REF615 is a member of ABB's Relion® family and a part of its 615 product series. The IEDs are characterized by their compactness and withdrawable design. Re-engineered from the ground up, the series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability of substation automation devices.

REF615 provides main protection for overhead lines, cable feeders and busbar systems of distribution substations. It fits both isolated neutral networks and networks with resistance or impedance earthed neutrals. The REF615 suite consists of six standard configurations to suit your current and forthcoming feeder protection requirements.

The IEC 61850 implementation in REF615 also includes fast horizontal communication over the station bus. By GOOSE communication the REF615 IEDs of the incoming and outgoing feeders of a substation can co-operate to form a stable, reliable and high-speed blocking based busbar protection. REF615 also supports Modbus protocol, DNP3 and IEC 60870-5-103.

**Related links**

- [Feeder Protection Relay REF615 ANSI](#)
- [Try REF615 HMI simulator](#)
- [PCM600 management tool](#)
- [Switchgear & Motor Control](#)
- [Substation Automation and Protection](#)
- [Distribution Protection and Control](#)
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English - 1.38 MB - zip

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[High-Speed Busbar Protection with GOOSE](#)  
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**Brochure**

[Life Cycle Services, Modification and upgrade](#)  
English - 1.09 MB - pdf

[Life Cycle Services, Repair](#)  
English - 0.97 MB - pdf

[REF615 2.0 IEC, Feeder Protection and Control, Brochure](#)  
English - 0.59 MB - pdf

[REF615 2.0 IEC, Standard configurations, Selection table brochure](#)  
English - 0.23 MB - pdf

**Connection diagram**

[REF615 Terminal Diagram, REF615 + RTX18, std. conf. C and D](#)  
English - 0.04 MB - pdf

[REF615 Terminal Diagram, REF615 + RTX18, std. conf. C and D](#)  
English - 0.78 MB - dxt

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Figure 25. Product page

## 30. Functions, codes and symbols

**Table 84. REF615 Functions, codes and symbols**

Function	IEC 61850	IEC 60617	IEC-ANSI
<b>Protection</b>			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> ->	67-2
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, low stage, instance 2	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage, instance 1	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	Io>>>	50N/51N
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> ->	67N-2

**Table 84. REF615 Functions, codes and symbols, continued**

Function	IEC 61850	IEC 60617	IEC-ANSI
Admittance based earth-fault protection, instance 1	EFPADM1	Yo> -> (1)	21YN (1)
Admittance based earth-fault protection, instance 2	EFPADM2	Yo> -> (2)	21YN (2)
Admittance based earth-fault protection, instance 3	EFPADM3	Yo> -> (3)	21YN (3)
Transient / intermittent earth-fault protection	INTRPTEF1	Io> -> IEF	67NIEF
Non-directional (cross-country) earth fault protection, using calculated Io	EFHPTOC1	Io>> (1)	51N-2 (1)
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1>	46PD
Residual overvoltage protection, instance 1	ROVPTOV1	Uo> (1)	59G (1)
Residual overvoltage protection, instance 2	ROVPTOV2	Uo> (2)	59G (2)
Residual overvoltage protection, instance 3	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection, instance 1	PHPTOV1	3U> (1)	59 (1)
Three-phase overvoltage protection, instance 2	PHPTOV2	3U> (2)	59 (2)
Three-phase overvoltage protection, instance 3	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection, instance 1	PSPTUV1	U1< (1)	47U+ (1)

**Table 84. REF615 Functions, codes and symbols, continued**

Function	IEC 61850	IEC 60617	IEC-ANSI
Negative-sequence overvoltage protection, instance 1	NSPTOV1	U <sub>2&gt;</sub> (1)	47O- (1)
Frequency protection, instance 1	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
Frequency protection, instance 2	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Frequency protection, instance 3	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3I <sub>th</sub> >F	49F
Circuit breaker failure protection	CCBRBRF1	3I>/I <sub>o</sub> >BF	51BF/51NBF
Three-phase inrush detector	INRPHAR1	3I <sub>2f</sub> >	68
Master trip, instance 1	TRPPTRC1	Master Trip (1)	94/86 (1)
Master trip, instance 2	TRPPTRC2	Master Trip (2)	94/86 (2)
Arc protection, instance 1	ARCSARC1	ARC (1)	50L/50NL (1)
Arc protection, instance 2	ARCSARC2	ARC (2)	50L/50NL (2)
Arc protection, instance 3	ARCSARC3	ARC (3)	50L/50NL (3)
<b>Control</b>			
Circuit-breaker control	CBXCBR1	I <-> O CB	I <-> O CB
Disconnecter position indication, instance 1	DCSXS1W1	I <-> O DC (1)	I <-> O DC (1)
Disconnecter position indication, instance 2	DCSXS1W2	I <-> O DC (2)	I <-> O DC (2)
Disconnecter position indication, instance 3	DCSXS1W3	I <-> O DC (3)	I <-> O DC (3)
Earthing switch indication	ESSXS1W1	I <-> O ES	I <-> O ES
Auto-reclosing	DARREC1	O -> I	79
Synchronism and energizing check	SECRSYN1	SYNC	25
<b>Condition monitoring</b>			
Circuit-breaker condition monitoring	SSCBR1	CBCM	CBCM
Trip circuit supervision, instance 1	TCSSCBR1	TCS (1)	TCM (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCRDIF1	MCS 3I	MCS 3I



**Table 84. REF615 Functions, codes and symbols, continued**

Function	IEC 61850	IEC 60617	IEC-ANSI
Fuse failure supervision	SEQRFUF1	FUSEF	60
<b>Measurement</b>			
Disturbance recorder	RDRE1	-	-
Three-phase current measurement, instance 1	CMMXU1	3I	3I
Sequence current measurement	CSMSQI1	I1, I2, I0	I1, I2, I0
Residual current measurement, instance 1	RESCMMXU1	Io	In
Three-phase voltage measurement	VMMXU1	3U	3U
Residual voltage measurement	RESVMMXU1	Uo	Vn
Sequence voltage measurement	VSMSQI1	U1, U2, U0	U1, U2, U0
Three-phase power and energy measurement, including power factor	PEMMXU1	P, E	P, E
Frequency measurement	FMMXU1	f	f

## 31. Document revision history

Document revision/ date	Product version	History
A/2007-12-20	1.0	First release
B/2008-02-22	1.0	Content updated
C/2008-06-20	1.1	Content updated to correspond to the product version
D/2009-03-03	2.0	Content updated to correspond to the product version. New layout on front and back page
E/2009-07-03	2.0	Content updated
F/2009-10-01	2.0	Content updated
G/2010-06-11	3.0	Content updated to correspond to the product version
H/2010-06-29	3.0	Terminology corrected
K/2010-09-07	3.0	Content corrected



# Contact us

## **ABB Oy**

### **Distribution Automation**

P.O. Box 699

FI-65101 VAASA, Finland

Phone +358 10 22 11

Fax +358 10 22 41094

## **ABB Limited**

### **Distribution Automation**

Maneja

Vadodara 390013, India

Phone +91 265 2604032

Fax +91 265 2638922

## **ABB**

### **Transmission and Distribution**

### **Automation Equipment (Xiamen) Co. Ltd.**

ABB Industrial Park, Torch Hi-tech

Development Zone 361006

Xiamen, Fujian, China

Phone +86 592 5702288

Fax +86 592 5718598

[www.abb.com/substationautomation](http://www.abb.com/substationautomation)