Relion® 615 series

Line Differential Protection and Control
RED615
Product Guide
1. Description

RED615 is a phase-segregated two-end line differential protection and control IED (intelligent electronic device) designed for utility and industrial power systems, including radial, looped and meshed distribution networks with or without distributed power generation. The RED615s communicate between substations over a fibre-optic link or a galvanic pilot wire connection. RED615 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 guided by the IEC 61850 standard for communication and interoperability of substation automation equipment.

The IED provides unit type main protection for overhead lines and cable feeders in distribution networks. The IED also features current-based protection functions for remote back-up for down-stream protection IEDs and local back-up for the line differential main protection. Further, standard configurations B and C also include earth-fault protection.

The IED is adapted for the protection of overhead line and cable feeders in isolated neutral, resistance earthed, compensated (impedance earthed) and solidly earthed networks. Once the 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

RED615 is available in three 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 utilizing 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Std. conf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line differential protection</td>
<td>A</td>
</tr>
<tr>
<td>Line differential protection with directional earth-fault protection</td>
<td>B</td>
</tr>
<tr>
<td>Line differential protection with non-directional earth-fault protection</td>
<td>C</td>
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Table 2. Supported functions

<table>
<thead>
<tr>
<th>Functionality</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
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<tbody>
<tr>
<td><strong>Protection</strong>[^1][^2]</td>
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<tr>
<td>Three-phase non-directional overcurrent protection, low stage, instance 1</td>
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<tr>
<td>Three-phase non-directional overcurrent protection, high stage, instance 2</td>
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<tr>
<td>Three-phase non-directional overcurrent protection, instantaneous stage, instance 1</td>
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<td>●</td>
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<tr>
<td>Non-directional earth-fault protection, low stage, instance 1</td>
<td>-</td>
<td>-</td>
<td>●[^4]</td>
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<tr>
<td>Non-directional earth-fault protection, low stage, instance 2</td>
<td>-</td>
<td>-</td>
<td>●[^4]</td>
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<tr>
<td>Non-directional earth-fault protection, high stage, instance 1</td>
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<td>●[^4]</td>
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<tr>
<td>Non-directional earth-fault protection, instantaneous stage</td>
<td>-</td>
<td>-</td>
<td>●[^4]</td>
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<tr>
<td>Directional earth-fault protection, low stage, instance 1</td>
<td>-</td>
<td>●[^3][^4][^5]</td>
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<tr>
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<td>Directional earth-fault protection, high stage</td>
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<tr>
<td>Admittance based earth-fault protection, instance 1</td>
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<td>●[^3][^4][^5]</td>
<td>-</td>
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<tr>
<td>Admittance based earth-fault protection, instance 2</td>
<td>-</td>
<td>●[^3][^4][^5]</td>
<td>-</td>
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<tr>
<td>Admittance based earth-fault protection, instance 3</td>
<td>-</td>
<td>●[^3][^4][^5]</td>
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<tr>
<td>Transient / intermittent earth-fault protection</td>
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<tr>
<td>Non-directional (cross-country) earth fault protection, using calculated Io</td>
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<td>●[^3][^7]</td>
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<tr>
<td>Negative-sequence overcurrent protection, instance 1</td>
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<tr>
<td>Negative-sequence overcurrent protection, instance 2</td>
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<tr>
<td>Phase discontinuity protection</td>
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<tr>
<td>Residual overvoltage protection, instance 1</td>
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<td>●[^3][^5]</td>
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<tr>
<td>Residual overvoltage protection, instance 2</td>
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<td>●[^3][^5]</td>
<td>-</td>
</tr>
<tr>
<td>Residual overvoltage protection, instance 3</td>
<td>-</td>
<td>●[^3][^5]</td>
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<tr>
<td>Three-phase thermal protection for feeders, cables and distribution transformers</td>
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<tr>
<td>Binary signal transfer</td>
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<tr>
<td>Functionality</td>
<td>A</td>
<td>B</td>
<td>C</td>
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<td>---------------</td>
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<td>---</td>
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<tr>
<td>Line differential protection and related measurements, stabilized and instantaneous stages</td>
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<td>●</td>
<td>●</td>
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<tr>
<td>Circuit breaker failure protection</td>
<td>●&lt;sup&gt;(i)&lt;/sup&gt;</td>
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<tr>
<td>Three-phase inrush detector</td>
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<td>Master trip, instance 1</td>
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<tr>
<td>Control</td>
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<tr>
<td>Circuit-breaker control</td>
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<tr>
<td>Disconnector position indication, instance 1</td>
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<td>Disconnector position indication, instance 2</td>
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<tr>
<td>Disconnector position indication, instance 3</td>
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<tr>
<td>Earthing switch indication</td>
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<td>Auto-reclosing</td>
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<td>Condition Monitoring</td>
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<tr>
<td>Circuit-breaker condition monitoring</td>
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<tr>
<td>Trip circuit supervision, instance 1</td>
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<tr>
<td>Trip circuit supervision, instance 2</td>
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<tr>
<td>Current circuit supervision</td>
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<tr>
<td>Protection communication supervision</td>
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<td>Measurement</td>
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<td>Disturbance recorder</td>
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<td>Residual current measurement, instance 1</td>
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</tr>
<tr>
<td>Residual voltage measurement</td>
<td>-</td>
<td>●</td>
<td>-</td>
</tr>
</tbody>
</table>

● = included, o = optional at the time of 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) Io selectable by parameter, Io measured as default.
5) Uo measured is always used.
6) Io measured is always used.
7) Io selectable by parameter, Io calculated as default.
3. Protection functions

The IED offers two-stage phase-segregated line differential protection, phase overcurrent protection, negative phase-sequence overcurrent protection and circuit-breaker failure protection. Depending on the standard configuration chosen, the basic functionality can be extended by thermal overload protection, directional or non-directional earth-fault protection, sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection, residual overvoltage protection and three-pole multi-shot auto-reclose functions for overhead line feeders. For standard configuration B admittance-based earth-fault protection, using the neutral admittance (Y0) 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.

Further, the admittance based earth-fault protection principle offers high independence of the fault resistance, straightforward setting principles and improved sensitivity of the protection.

The line differential protection function includes a stabilized low stage and an instantaneous high stage. The stabilized low stage provides sensitive differential protection and remains stable during, for example, current transformer saturation conditions. The low-stage operation can be restrained using second harmonic detection if an out-of-zone power transformer is to be energized. The instantaneous high stage offers less sensitive differential protection but enables fast operation during high fault currents.

The operating time characteristic for the low stage can be set to definite time or inverse definite time mode. The direct inter-trip function ensures that both ends are always simultaneously tripped, independent of the fault current contribution.

Figure 1. Protection function overview of standard configuration A
Figure 2. Protection function overview of standard configuration B
4. Application

RED615 can be used in a variety of applications requiring an absolutely selective unit type protection system. The zone-of-protection of a line differential protection system is the feeder section defined by the location of the current transformers in the local and the remote substation.

Combining horizontal GOOSE communication over a station bus and binary signal transfer over the protection communication link offers new application possibilities beyond traditional line differential protection. One interesting application based on inter-substation signal transfer is loss-of-mains (LOM) protection in networks with distributed generation. The performance of the combination of binary signal transfer and horizontal GOOSE communication performance as to speed, selectivity and reliability are hard to match with conventional loss-of-mains protection.

RED615 is the ideal IED for the protection of feeders in network configurations containing closed loops. Under normal operating conditions the feeder loop is closed. The aim of the closed loop is to secure the availability of power for the end users. As a result of the closed loop configuration, any fault spot in the system will be fed with fault current from two directions. Using plain overcurrent protection, either directional or non-directional, it is difficult to obtain fast and selective short circuit protection. With RED615 line differential protection IEDs the faulty part of the network can be selectively isolated, thus securing power distribution to the healthy part of the network.
Figure 4. Closed loop network configuration with RED615 line differential protection and control IEDs

Under certain operational circumstances, such as maintenance of primary equipment or substation extension projects there will be a need for interconnecting network parts, which normally are separated. To avoid major re-parameterization of the protection devices of the network when the network topology is changed, line differential protection IEDs can be used to obtain absolutely selective feeder protection in looped networks.

Figure 5. RED615 protecting an interconnecting feeder between two primary distribution substations
Figure 6. Line differential protection of an overhead line feeder using RED615 with the standard configuration B. Selectivity of earth-fault protection is ensured using binary signal transfer (BST) between the directional E/F protection stages of the local and remote end. The lowest directional E/F stages are not used for tripping purposes, but set to detect earth-faults in the reverse direction. Upon detection of an out-of-zone earth-fault, a blocking signal is sent to the remote end directional E/F protection stage preventing tripping of the circuit breaker. If the earth-fault is within the protected zone, no blocking signal will be issued, and the internal fault is cleared by the tripping stages of the directional E/F protection. To ensure simultaneous tripping of the local and remote end circuit breakers, BST is also used for sending an intertrip signal to the remote end during earth-fault situations within the protected zone.
Figure 7. Line differential protection of an overhead line feeder using RED615 with the standard configuration C and auto-reclosing option. By means of binary signal transfer (BST) uncoordinated auto-reclosing attempts are prevented. During the auto-reclosing sequence a "wait" command is sent to the auto-reclosing function of the lower circuit breaker and thereby blocking the function. The upper circuit breaker is thereafter closed by its auto-reclosing function. This blocking signal is reset after successful auto-reclosing of the upper circuit breaker, enabling the lower breaker to be closed by its auto-reclosing function.

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 substations 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

<table>
<thead>
<tr>
<th>Product</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Automation COM600</td>
<td>3.4 or later</td>
</tr>
<tr>
<td>MicroSCADA Pro</td>
<td>9.2 SP2 or later</td>
</tr>
<tr>
<td>System 800xA</td>
<td>5.0 Service Pack 2</td>
</tr>
</tbody>
</table>

![Diagram of utility power distribution network example using 615 series IEDs, Station Automation COM600 and MicroSCADA Pro]

Figure 8. Utility power distribution network example using 615 series IEDs, Station Automation COM600 and MicroSCADA Pro
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.

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. 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 monitors the phase differential, bias and remote end phase currents.

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 the phase, differential and bias current 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, SF6 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.

12. Trip-circuit supervision

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.
13. Self-supervision

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.

14. Current circuit supervision

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 the line differential protection and negative sequence overcurrent 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.

15. Protection communication and supervision

The communication between the IEDs is enabled by means of a dedicated fibre-optic communication channel. 1300 nm multi-mode or single-mode fibres with LC connectors are used for line differential communication. The channel is used for transferring the phase segregated current value data between the IEDs. The current phasors from the two IEDs, geographically located apart from each other, must be time coordinated so that the current differential algorithm can be executed correctly. The so called echo method is used for time synchronization. No external devices such as GPS clocks are thereby needed for the line differential protection communication.

As an option to the fibre-optic communication link a galvanic connection over a pilot wire link composed of a twisted pair cable and RPW600 link-end communication modems can be established. The optional pilot wire communication link is also an ideal and cost efficient retrofit solution for electromechanical line differential protection installations. Compared to conventional combined sequence line differential protection solutions with analog pilot wire communication, RED615 IEDs in combination with RPW600 communication modems offer a modern phase-segregated line differential protection solution over existing pilot wire cables.

The pilot wire link supports the same protection and communication functionality as the fibre-optic link. The quality of service (QoS) is indicated by the modems and the communication link is continuously supervised by the IED. The RPW600 modem offers a 5 kV (RMS) level of isolation between the pilot wire terminals and ground. The RPW600 modems (master and follower) are galvanically connected to either end of the pilot wire and optically connected to the IEDs using short optical single-mode cables. Using 0.8 mm² twisted pair cables pilot wire link distances up to 8 km are typically supported. However, twisted pair pilot wire cables in good conditions may support even longer distances to be covered. The length of the supported pilot wire link also depends on the noise environment in the installation. Should the need arise to replace the pilot wire cables with fibre-optic cables, the single mode fibre-optic LC connectors of the IEDs can be utilized for direct connection of the fibre-optic communication link.
Apart from the continued protection communication, the communication channel can also be used for binary signal transfer (BST) that is, transferring of user configurable binary information between the IEDs. There are a total of eight BST signals available for user definable purposes. The BST signals can originate from the IED’s binary inputs or internal logics, and be assigned to the remote IED’s binary outputs or internal logics.

The protection communication supervision continuously monitors the protection communication link. The IED immediately blocks the line differential protection function in case that severe interference in the communication link, risking the correct operation of the function, is detected. An alarm signal will eventually be issued if the interference, indicating permanent failure in the protection communication, persists. The two high-set stages of the overcurrent protection are further by default released.

Figure 10. Fibre-optic protection communication link

Figure 11. Pilot wire protection communication link

16. Access control

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.
17. Inputs and outputs

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 and current circuit supervision, or three phase-current inputs, one residual-current input and one residual voltage input for directional earth-fault protection and current circuit supervision.

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 residual-voltage input covers the rated voltages 60-210 V.

Table 4. Input/output overview

<table>
<thead>
<tr>
<th>Standard configuration</th>
<th>Analog inputs</th>
<th>Binary inputs/outputs</th>
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</thead>
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<td>CT</td>
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<tr>
<td>A</td>
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<td>B</td>
<td>4</td>
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<tr>
<td>C</td>
<td>4</td>
<td>-</td>
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</tbody>
</table>

<sup>1)</sup> With optional binary I/O module ()

18. Station communication

The IED supports a range of communication protocols including IEC 61850, IEC 60870-5-103, Modbus® 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 for station bus communication redundancy. The communication module including two galvanic RJ-45 ports enables the creation of a cost efficient communication loop using CAT5 STP cables and a managed switch with (RSTP) support. The managed switch controls the consistency of the loop, routes the data and corrects the data flow in case of a communication disturbance. The redundant network solution avoids single point of failure concerns and improves the reliability of the communication. The redundancy 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 RS-485 network is required, a 9-pin screw-terminal connector, an optional 9-pin D-sub connector or an optional ST-type glass-fibre 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)

**Remote-end station time reference:**
- Line differential

In addition, the IED supports time synchronization via the following serial communication protocols:
- Modbus
- DNP3
- IEC 60870-5-103

**Remote-end station time reference:**
- Line differential
Figure 12. Redundant Ethernet solution

Table 5. Supported station communication interfaces and protocols

<table>
<thead>
<tr>
<th>Interfaces/Protocols</th>
<th>Ethernet</th>
<th>Serial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100BASE-TX RJ-45</td>
<td>100BASE-TX LC</td>
</tr>
<tr>
<td>IEC 61850</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>MODBUS RTU/ASCII</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MODBUS TCP/IP</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DNP3 (serial)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DNP3 TCP/IP</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>IEC 60870-5-103</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

● = Supported
## 19. Technical data

### Table 6. Dimensions

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Width</strong></td>
<td></td>
</tr>
<tr>
<td>frame</td>
<td>177 mm</td>
</tr>
<tr>
<td>case</td>
<td>164 mm</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td></td>
</tr>
<tr>
<td>frame</td>
<td>177 mm (4U)</td>
</tr>
<tr>
<td>case</td>
<td>160 mm</td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>201 mm (153 + 48 mm)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td></td>
</tr>
<tr>
<td>complete IED</td>
<td>4.1 kg</td>
</tr>
<tr>
<td>plug-in unit only</td>
<td>2.1 kg</td>
</tr>
</tbody>
</table>

### Table 7. Power supply

<table>
<thead>
<tr>
<th>Description</th>
<th>Type 1</th>
<th>Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U_auxnominal</strong></td>
<td>100, 110, 120, 220, 240 V AC, 50 and 60 Hz</td>
<td>24, 30, 48, 60 V DC</td>
</tr>
<tr>
<td>48, 60, 110, 125, 220, 250 V DC</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>U_auxvariation</strong></td>
<td>38...110% of U_n (38...264 V AC)</td>
<td>50...120% of U_n (12...72 V DC)</td>
</tr>
<tr>
<td>80...120% of U_n (38.4...300 V DC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Start-up threshold</strong></td>
<td>19.2 V DC (24 V DC * 80%)</td>
<td></td>
</tr>
<tr>
<td><strong>Burden of auxiliary voltage supply under quiescent (P_q)/operating condition</strong></td>
<td>DC &lt; 12.0 W (nominal)/&lt; 18.0 W (max)</td>
<td>DC &lt; 12.0 W (nominal)/&lt; 18.0 W (max)</td>
</tr>
<tr>
<td>AC&lt; 16.0 W (nominal)/&lt; 21.0W (max)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ripple in the DC auxiliary voltage</strong></td>
<td>Max 15% of the DC value (at frequency of 100 Hz)</td>
<td></td>
</tr>
<tr>
<td><strong>Maximum interruption time in the auxiliary DC voltage without resetting the IED</strong></td>
<td>30 ms at V_n, rated</td>
<td></td>
</tr>
<tr>
<td><strong>Fuse type</strong></td>
<td>T4A/250 V</td>
<td></td>
</tr>
</tbody>
</table>
### Table 8. Energizing inputs

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rated frequency</strong></td>
<td>50/60 Hz</td>
</tr>
<tr>
<td><strong>Current inputs</strong></td>
<td></td>
</tr>
<tr>
<td>Rated current, $I_n$</td>
<td>1/5 A(^1)</td>
</tr>
<tr>
<td>Thermal withstand capability:</td>
<td></td>
</tr>
<tr>
<td>• Continuously</td>
<td>4 A</td>
</tr>
<tr>
<td>• For 1 s</td>
<td>100 A</td>
</tr>
<tr>
<td>Dynamic current withstand:</td>
<td></td>
</tr>
<tr>
<td>• Half-wave value</td>
<td>250 A</td>
</tr>
<tr>
<td>Input impedance</td>
<td>&lt;100 mΩ</td>
</tr>
<tr>
<td><strong>Voltage inputs</strong></td>
<td></td>
</tr>
<tr>
<td>Rated voltage</td>
<td>60...210 V AC</td>
</tr>
<tr>
<td>Voltage withstand:</td>
<td></td>
</tr>
<tr>
<td>• Continuous</td>
<td>2 x $U_n$ (240 V AC)</td>
</tr>
<tr>
<td>• For 10 s</td>
<td>3 x $U_n$ (360 V AC)</td>
</tr>
<tr>
<td>Burden at rated voltage</td>
<td>&lt;0.05 VA</td>
</tr>
</tbody>
</table>

\(^1\) Residual current and/or phase current

### Table 9. Binary inputs

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating range</td>
<td>±20% of the rated voltage</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>24...250 V DC</td>
</tr>
<tr>
<td>Current drain</td>
<td>1.6...1.9 mA</td>
</tr>
<tr>
<td>Power consumption</td>
<td>31.0...570.0 mW</td>
</tr>
<tr>
<td>Threshold voltage</td>
<td>18...176 V DC</td>
</tr>
<tr>
<td>Reaction time</td>
<td>3 ms</td>
</tr>
</tbody>
</table>
### Table 10. Signal outputs and IRF output

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>250 V AC/DC</td>
</tr>
<tr>
<td>Continuous contact carry</td>
<td>5 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Make and carry 0.5 s</td>
<td>15 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant (L/R&lt;40\ \text{ms}), at 48/110/220 V DC</td>
<td>1 A/0.25 A/0.15 A</td>
</tr>
<tr>
<td>Minimum contact load</td>
<td>100 mA at 24 V AC/DC</td>
</tr>
</tbody>
</table>

### Table 11. Double-pole power output relays with TCS function

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>250 V AC/DC</td>
</tr>
<tr>
<td>Continuous contact carry</td>
<td>8 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>15 A</td>
</tr>
<tr>
<td>Make and carry 0.5 s</td>
<td>30 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant (L/R&lt;40\ \text{ms}), at 48/110/220 V DC (two contacts connected in series)</td>
<td>5 A/3 A/1 A</td>
</tr>
<tr>
<td>Minimum contact load</td>
<td>100 mA at 24 V AC/DC</td>
</tr>
<tr>
<td>Trip-circuit supervision (TCS):</td>
<td></td>
</tr>
<tr>
<td>• Control voltage range</td>
<td>20...250 V AC/DC</td>
</tr>
<tr>
<td>• Current drain through the supervision circuit</td>
<td>~1.5 mA</td>
</tr>
<tr>
<td>• Minimum voltage over the TCS contact</td>
<td>20 V AC/DC (15...20 V)</td>
</tr>
</tbody>
</table>
### Table 12. Single-pole power output relays

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

### Table 13. Front port Ethernet interfaces

<table>
<thead>
<tr>
<th>Ethernet interface</th>
<th>Protocol</th>
<th>Cable</th>
<th>Data transfer rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>TCP/IP protocol</td>
<td>Standard Ethernet CAT 5 cable with RJ-45 connector</td>
<td>10 MBits/s</td>
</tr>
</tbody>
</table>

### Table 14. Station communication link, fibre-optic

<table>
<thead>
<tr>
<th>Connector</th>
<th>Fibre type¹)</th>
<th>Wave length</th>
<th>Max. distance</th>
<th>Permitted path attenuation²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC</td>
<td>MM 62.5/125 μm glass fibre core</td>
<td>1300 nm</td>
<td>2 km</td>
<td>&lt;8 dB</td>
</tr>
<tr>
<td>LC</td>
<td>SM 9/125 μm</td>
<td>1300 nm</td>
<td>2-20 km</td>
<td>&lt;8 dB</td>
</tr>
<tr>
<td>ST</td>
<td>MM 62.5/125 μm glass fibre core</td>
<td>820-900 nm</td>
<td>1 km</td>
<td>&lt;11 dB</td>
</tr>
</tbody>
</table>

1) (MM) multi-mode fibre, (SM) single-mode fibre
2) Maximum allowed attenuation caused by connectors and cable together

### Table 15. Protection communication link

<table>
<thead>
<tr>
<th>Wave length</th>
<th>Fibre type</th>
<th>Connector</th>
<th>Permitted path attenuation¹)</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1300 nm</td>
<td>MM 62.5/125 μm</td>
<td>LC</td>
<td>&lt; 8 dB</td>
<td>≤ 2 km</td>
</tr>
<tr>
<td>1300 nm</td>
<td>SM 9/125 μm²</td>
<td>LC</td>
<td>&lt; 8 dB</td>
<td>≤ 20 km</td>
</tr>
</tbody>
</table>

¹) Maximum allowed attenuation caused by connectors and cable altogether
²) Use single-mode fibre with recommended minimum length of 3 m to connect RED615 to the pilot wire modem RPW600.
Table 16. IRIG-B

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRIG time code format</td>
<td>B004, B005(^1)</td>
</tr>
<tr>
<td>Isolation</td>
<td>500V 1 min.</td>
</tr>
<tr>
<td>Modulation</td>
<td>Unmodulated</td>
</tr>
<tr>
<td>Logic level</td>
<td>TTL Level</td>
</tr>
<tr>
<td>Current consumption</td>
<td>2...4 mA</td>
</tr>
<tr>
<td>Power consumption</td>
<td>10...20 mW</td>
</tr>
</tbody>
</table>

\(^1\) According to 200-04 IRIG-standard

Table 17. Degree of protection of flush-mounted IED

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front side</td>
<td>IP 54</td>
</tr>
<tr>
<td>Rear side, connection terminals</td>
<td>IP 20</td>
</tr>
</tbody>
</table>

Table 18. Environmental conditions

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature range</td>
<td>-25...+55°C (continuous)</td>
</tr>
<tr>
<td>Short-time service temperature range</td>
<td>-40...+70°C (&lt;16h)(^1,2))</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>&lt;93%, non-condensing</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>86...106 kPa</td>
</tr>
<tr>
<td>Altitude</td>
<td>Up to 2000 m</td>
</tr>
<tr>
<td>Transport and storage temperature range</td>
<td>-40...+85°C</td>
</tr>
</tbody>
</table>

\(^1\) 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 19. Environmental tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
</table>
| Dry heat test (humidity <50%)        | • 96 h at +55°C  
  • 16 h at +70ºC<sup>1)</sup>                     | IEC 60068-2-2 |
| Dry cold test                        | • 96 h at -25°C  
  • 16 h at -40ºC                                      | IEC 60068-2-1 |
| Damp heat test, cyclic               | • 6 cycles (12 h + 12 h) at +25ºC…+55ºC, humidity >93% | IEC 60068-2-30|
| Storage test                         | • 96 h at -40ºC  
  • 96 h at +85ºC                                      | IEC 60068-2-48|

<sup>1)</sup> For IEDs with an LC communication interface the maximum operating temperature is +70ºC
### Table 20. Electromagnetic compatibility tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 MHz/100 kHz burst disturbance test:</strong></td>
<td></td>
<td>IEC 61000-4-18</td>
</tr>
<tr>
<td>• Common mode</td>
<td>2.5 kV</td>
<td>IEC 60255-22-1, class III</td>
</tr>
<tr>
<td>• Differential mode</td>
<td>2.5 kV</td>
<td>IEEE C37.90.1-2002</td>
</tr>
<tr>
<td><strong>Electrostatic discharge test:</strong></td>
<td></td>
<td>IEC 61000-4-2</td>
</tr>
<tr>
<td>• Contact discharge</td>
<td>8 kV</td>
<td>IEC 60255-22-2</td>
</tr>
<tr>
<td>• Air discharge</td>
<td>15 kV</td>
<td>IEEE C37.90.3-2001</td>
</tr>
<tr>
<td><strong>Radio frequency interference tests:</strong></td>
<td></td>
<td>IEC 60255-22-6, class III</td>
</tr>
<tr>
<td></td>
<td>10 V (rms)</td>
<td>IEC 61000-4-6</td>
</tr>
<tr>
<td></td>
<td>f=150 kHz-80 MHz</td>
<td>IEC 60255-22-3, class III</td>
</tr>
<tr>
<td></td>
<td>10 V/m (rms)</td>
<td>ENV 50204</td>
</tr>
<tr>
<td></td>
<td>f=80-2700 MHz</td>
<td>IEC 61000-4-3</td>
</tr>
<tr>
<td></td>
<td>10 V/m</td>
<td>IEEE C37.90.2-2004</td>
</tr>
<tr>
<td></td>
<td>f=900 MHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 V/m (rms)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f=80-1000 MHz</td>
<td></td>
</tr>
<tr>
<td><strong>Fast transient disturbance tests:</strong></td>
<td></td>
<td>IEC 61000-4-4</td>
</tr>
<tr>
<td>• All ports</td>
<td>4 kV</td>
<td>IEC 60255-22-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEEE C37.90.1-2002</td>
</tr>
<tr>
<td><strong>Surge immunity test:</strong></td>
<td></td>
<td>IEC 61000-4-5</td>
</tr>
<tr>
<td>• Communication</td>
<td>1 kV, line-to-earth</td>
<td></td>
</tr>
<tr>
<td>• Other ports</td>
<td>4 kV, line-to-earth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 kV, line-to-line</td>
<td></td>
</tr>
<tr>
<td><strong>Power frequency (50 Hz) magnetic field:</strong></td>
<td></td>
<td>IEC 61000-4-8</td>
</tr>
<tr>
<td>• Continuous</td>
<td>300 A/m</td>
<td></td>
</tr>
<tr>
<td>• 1-3 s</td>
<td>1000 A/m</td>
<td></td>
</tr>
</tbody>
</table>
### Table 20. Electromagnetic compatibility tests, continued

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage dips and short interruptions</td>
<td>30%/10 ms</td>
<td>IEC 61000-4-11</td>
</tr>
<tr>
<td></td>
<td>60%/100 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60%/1000 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;95%/5000 ms</td>
<td></td>
</tr>
<tr>
<td>Power frequency immunity test:</td>
<td>Binary inputs only</td>
<td>IEC 61000-4-16</td>
</tr>
<tr>
<td>• Common mode</td>
<td>300 V rms</td>
<td>IEC 60255-22-7, class A</td>
</tr>
<tr>
<td>• Differential mode</td>
<td>150 V rms</td>
<td></td>
</tr>
<tr>
<td>Emission tests:</td>
<td></td>
<td>EN 55011, class A</td>
</tr>
<tr>
<td>• Conducted</td>
<td>&lt; 79 dB(µV) quasi peak</td>
<td>IEC 60255-25</td>
</tr>
<tr>
<td>0.15-0.50 MHz</td>
<td>&lt; 66 dB(µV) average</td>
<td></td>
</tr>
<tr>
<td>0.5-30 MHz</td>
<td>&lt; 73 dB(µV) quasi peak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 60 dB(µV) average</td>
<td></td>
</tr>
<tr>
<td>• Radiated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-230 MHz</td>
<td>&lt; 40 dB(µV/m) quasi peak, measured at 10 m distance</td>
<td></td>
</tr>
<tr>
<td>230-1000 MHz</td>
<td>&lt; 47 dB(µV/m) quasi peak, measured at 10 m distance</td>
<td></td>
</tr>
</tbody>
</table>
### Table 21. Insulation tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric tests</td>
<td></td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td>• Test voltage</td>
<td>2 kV, 50 Hz, 1 min</td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td></td>
<td>500 V, 50 Hz, 1 min, communication</td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td>Impulse voltage test</td>
<td></td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td>• Test voltage</td>
<td>5 kV, 1.2/50 μs, 0.5 J</td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td></td>
<td>1 kV, 1.2/50 μs, 0.5 J, communication</td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td>Insulation resistance</td>
<td></td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td>• Isolation resistance</td>
<td>&gt;100 MΩ, 500 V DC</td>
<td>IEC 60255-5 and IEC 60255-27</td>
</tr>
<tr>
<td>Protective bonding resistance</td>
<td></td>
<td>IEC 60255-27</td>
</tr>
<tr>
<td>• Resistance</td>
<td>&lt;0.1 Ω, 4 A, 60 s</td>
<td>IEC 60255-27</td>
</tr>
</tbody>
</table>

### Table 22. Mechanical tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration tests (sinusoidal)</td>
<td>IEC 60068-2-6 (test Fc) IEC 60255-21-1</td>
<td>Class 2</td>
</tr>
<tr>
<td>Shock and bump test</td>
<td>IEC 60068-2-27 (test Ea shock) IEC 60068-2-29 (test Eb bump) IEC 60255-21-2</td>
<td>Class 2</td>
</tr>
<tr>
<td>Seismic test</td>
<td>IEC 60255-21-3</td>
<td>Class 2</td>
</tr>
</tbody>
</table>

### Table 23. Product safety

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV directive</td>
<td>2006/95/EC</td>
</tr>
</tbody>
</table>
### Table 24. EMC compliance

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC directive</td>
<td>2004/108/EC</td>
</tr>
<tr>
<td>Standard</td>
<td>EN 50263 (2000)</td>
</tr>
<tr>
<td></td>
<td>EN 60255-26 (2007)</td>
</tr>
</tbody>
</table>

### Table 25. RoHS compliance

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complies with RoHS directive 2002/95/EC</td>
</tr>
</tbody>
</table>

### Protection functions

### Table 26. Line differential protection (LNPLDF)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy 1)</td>
<td>Depending on the frequency of the current measured: $f_n \pm 2$ Hz</td>
</tr>
<tr>
<td></td>
<td>Low stage: $\pm 2.5%$ of the set value</td>
</tr>
<tr>
<td></td>
<td>High stage: $\pm 2.5%$ of the set value</td>
</tr>
<tr>
<td>High stage, operate time 2)3)</td>
<td>22 ms, 25 ms, 29 ms</td>
</tr>
<tr>
<td>Reset time</td>
<td>&lt; 40 ms</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>Typical $0.96$</td>
</tr>
<tr>
<td>Retardation time (Low stage)</td>
<td>&lt; 40 ms</td>
</tr>
<tr>
<td>Operate time accuracy in definite time mode</td>
<td>$\pm 1.0%$ of the set value or $\pm 20$ ms</td>
</tr>
<tr>
<td>Operate time accuracy in inverse time mode</td>
<td>$\pm 5.0%$ of the set value or $\pm 20$ ms 4)</td>
</tr>
</tbody>
</table>

---

1) With the symmetrical communication channel (as when using dedicated fiber optic).
2) Without additional delay in the communication channel (as when using dedicated fiber optic).
3) Including the delay of the output contact. When differential current = 2 x *High operate value* and $f_n = 50$ Hz with galvanic pilot wire link + 5 ms.
4) *Low operate value* multiples in range of 1.5 to 20.
### Table 27. Line differential protection (LNPLDF) main settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values (Range)</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High operate value</td>
<td>200...4000</td>
<td>% ( I_n )</td>
<td>Instantaneous stage operate value</td>
</tr>
<tr>
<td>Low operate value</td>
<td>10...200</td>
<td>% ( I_n )</td>
<td>Basic setting for the stabilized stage start</td>
</tr>
<tr>
<td>Operate delay time</td>
<td>45...200000</td>
<td>ms</td>
<td>Operate delay time for stabilized stage</td>
</tr>
<tr>
<td>Operate curve type</td>
<td>1=ANSI Ext. inv. 3=ANSI Norm. inv. 5=ANSI Def. Time 9=IEC Norm. inv. 10=IEC Very inv. 12=IEC Ext. inv. 15=IEC Def. Time</td>
<td></td>
<td>Selection of time delay curve for stabilized stage</td>
</tr>
<tr>
<td>Time multiplier</td>
<td>0.05...15.00</td>
<td></td>
<td>Time multiplier in IDMT curves</td>
</tr>
<tr>
<td>Start value 2.H</td>
<td>10...50</td>
<td>%</td>
<td>The ratio of the 2. harmonic component to fundamental component required for blocking</td>
</tr>
<tr>
<td>CT ratio correction</td>
<td>0.200...5.000</td>
<td></td>
<td>Remote phase current transformer ratio correction</td>
</tr>
</tbody>
</table>

### Table 28. Binary signal transfer (BSTGIO)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber optic link</td>
<td>&lt; 5 ms</td>
</tr>
<tr>
<td>Galvanic pilot wire link</td>
<td>&lt; 10 ms</td>
</tr>
</tbody>
</table>
Table 29. Three-phase non-directional overcurrent protection (PHxPTOC)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td></td>
</tr>
<tr>
<td>PHLPTOC</td>
<td>Depending on the frequency of the current measured: f_n ±2 Hz</td>
</tr>
<tr>
<td></td>
<td>±1.5% of the set value or ±0.002 x I_n</td>
</tr>
<tr>
<td>PHHPTOC and PHIPTOC</td>
<td>±1.5% of set value or ±0.002 x I_n</td>
</tr>
<tr>
<td></td>
<td>(at currents in the range of 0.1…10 x I_n)</td>
</tr>
<tr>
<td></td>
<td>±5.0% of the set value</td>
</tr>
<tr>
<td></td>
<td>(at currents in the range of 10…40 x I_n)</td>
</tr>
<tr>
<td>Start time 1)2)</td>
<td></td>
</tr>
<tr>
<td>PHIPTOC:</td>
<td>Minimum</td>
</tr>
<tr>
<td></td>
<td>Typical</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
</tr>
<tr>
<td>I_fault = 2 x set Start value</td>
<td>16 ms</td>
</tr>
<tr>
<td></td>
<td>11 ms</td>
</tr>
<tr>
<td>I_fault = 10 x set Start value</td>
<td>19 ms</td>
</tr>
<tr>
<td></td>
<td>12 ms</td>
</tr>
<tr>
<td></td>
<td>23 ms</td>
</tr>
<tr>
<td></td>
<td>14 ms</td>
</tr>
<tr>
<td>PHHPTOC and PHLPTOC:</td>
<td></td>
</tr>
<tr>
<td>I_fault = 2 x set Start value</td>
<td>22 ms</td>
</tr>
<tr>
<td></td>
<td>24 ms</td>
</tr>
<tr>
<td></td>
<td>25 ms</td>
</tr>
<tr>
<td>Reset time</td>
<td>&lt; 40 ms</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>Typical 0.96</td>
</tr>
<tr>
<td>Retardation time</td>
<td>&lt; 30 ms</td>
</tr>
<tr>
<td>Operate time accuracy in definite time mode</td>
<td>±1.0% of the set value or ±20 ms</td>
</tr>
<tr>
<td>Operate time accuracy in inverse time mode</td>
<td>±5.0% of the theoretical value or ±20 ms 3)</td>
</tr>
<tr>
<td>Suppression of harmonics</td>
<td></td>
</tr>
<tr>
<td>RMS: No suppression</td>
<td></td>
</tr>
<tr>
<td>DFT: -50 dB at f = n x f_n, where n = 2, 3, 4, 5, ...</td>
<td></td>
</tr>
<tr>
<td>Peak-to-Peak: No suppression</td>
<td></td>
</tr>
<tr>
<td>P-to-P+backup: No suppression</td>
<td></td>
</tr>
</tbody>
</table>

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

1) For further reference please refer to the Operating characteristics table
Table 31. Non-directional earth-fault protection (EFxPTOC)

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

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Value (Range)</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value</td>
<td>EFLPTOC</td>
<td>0.010...5.000 x I_n</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>EFHPTOC</td>
<td>0.10...40.00 x I_n</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>EFIPTOC</td>
<td>1.00...40.00 x I_n</td>
<td>0.01</td>
</tr>
<tr>
<td>Time multiplier</td>
<td>EFLPTOC</td>
<td>0.05...15.00</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>EFHPTOC</td>
<td>0.05...15.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Operate delay time</td>
<td>EFLPTOC</td>
<td>40...200000 ms</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>EFHPTOC</td>
<td>40...200000 ms</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>EFIPTOC</td>
<td>20...200000 ms</td>
<td>10</td>
</tr>
</tbody>
</table>
| Operating curve type\(^1\) | 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)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td>DEFLPDEF: Depending on the frequency of the current measured: ( f_n \pm 2 \text{ Hz} )</td>
</tr>
</tbody>
</table>
|                                     | 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 1)2)                      | DEFLPDEF: \( I_{\text{Fault}} = 2 \times \text{set Start value} \)  
|                                     | Minimum: 61 ms, Typical: 64 ms, Maximum: 66 ms                      |
|                                     | DEFHPDEF: \( I_{\text{Fault}} = 2 \times \text{set Start value} \)  
|                                     | Minimum: 42 ms, Typical: 44 ms, Maximum: 46 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 \( \pm 20 \text{ ms} \)  |
| Operate time accuracy in inverse time mode | \( \pm 5.0\% \) of the theoretical value or \( \pm 20 \text{ ms} \) 3) |
| Suppression of harmonics            | RMS: No suppression  
|                                     | DFT: -50 dB at \( f = n \times f_n \), where \( n = 2, 3, 4, 5, \ldots \)  
|                                     | Peak-to-Peak: No suppression                                          |

1) Set \( \text{Operate delay time} = 0.06 \text{ s}, \text{Operate curve type} = \text{IEC definite time}, \text{Measurement mode} = \text{default (depends on stage)}, \text{current before fault} = 0.0 \times I_n, \ f_n = 50 \text{ Hz}, \text{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 \( \text{Start value} = 2.5 \times I_n \), \( \text{Start value multiples in range of 1.5 to 20} \)
### Table 34. Directional earth-fault protection (DEFxPDEF) main settings

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

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

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

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy (Uo criteria with transient protection)</td>
<td>Depending on the frequency of the current measured: ( f_n \pm 2 \text{ Hz} )  [ \pm 1.5% \text{ of the set value or } \pm 0.002 \times U_o ]</td>
</tr>
<tr>
<td>Operate time accuracy</td>
<td>[ \pm 1.0% \text{ of the set value or } \pm 20 \text{ ms} ]</td>
</tr>
<tr>
<td>Suppression of harmonics</td>
<td>DFT: -50 dB at ( f = n \times f_n ), where ( n = 2, 3, 4, 5 )</td>
</tr>
</tbody>
</table>
### Table 36. Transient/intermittent earth-fault protection (INTRPTEF) main settings

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

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

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

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values (Range)</th>
<th>Unit</th>
<th>Step</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage start value</td>
<td>0.05...5.00</td>
<td>xUn</td>
<td>0.01</td>
<td>0.05</td>
<td>Voltage start value</td>
</tr>
<tr>
<td>Directional mode</td>
<td>1=Non-directional 2=Forward 3=Reverse</td>
<td></td>
<td></td>
<td>2=Forward</td>
<td>Directional mode</td>
</tr>
<tr>
<td>Operation mode</td>
<td>1=Yo 2=Go 3=Bo 4=Yo, Go 5=Yo, Bo 6=Go, Bo 7=Yo, Go, Bo</td>
<td></td>
<td></td>
<td>1=Yo</td>
<td>Operation criteria</td>
</tr>
<tr>
<td>Operate delay time</td>
<td>60...200000</td>
<td>ms</td>
<td>10</td>
<td>60</td>
<td>Operate delay time</td>
</tr>
<tr>
<td>Circle radius</td>
<td>0.05...500.00</td>
<td>mS</td>
<td>0.01</td>
<td>1.00</td>
<td>Admittance circle radius</td>
</tr>
<tr>
<td>Circle conductance</td>
<td>-500.00...500.00</td>
<td>mS</td>
<td>0.01</td>
<td>0.00</td>
<td>Admittance circle midpoint, conductance</td>
</tr>
<tr>
<td>Circle susceptance</td>
<td>-500.00...500.00</td>
<td>mS</td>
<td>0.01</td>
<td>0.00</td>
<td>Admittance circle midpoint, susceptance</td>
</tr>
<tr>
<td>Conductance forward</td>
<td>-500.00...500.00</td>
<td>mS</td>
<td>0.01</td>
<td>1.00</td>
<td>Conductance threshold in forward direction</td>
</tr>
<tr>
<td>Conductance reverse</td>
<td>-500.00...500.00</td>
<td>mS</td>
<td>0.01</td>
<td>-1.00</td>
<td>Conductance threshold in reverse direction</td>
</tr>
<tr>
<td>Conductance tilt Ang</td>
<td>-30...30</td>
<td>deg</td>
<td>1</td>
<td>0</td>
<td>Tilt angle of conductance boundary line</td>
</tr>
</tbody>
</table>
Table 38. Admittance-based earth-fault protection (EFPADM) main settings, continued

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values (Range)</th>
<th>Unit</th>
<th>Step</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susceptance forward</td>
<td>-500.00...500.00</td>
<td>mS</td>
<td>0.01</td>
<td>1.00</td>
<td>Susceptance threshold in forward direction</td>
</tr>
<tr>
<td>Susceptance reverse</td>
<td>-500.00...500.00</td>
<td>mS</td>
<td>0.01</td>
<td>-1.00</td>
<td>Susceptance threshold in reverse direction</td>
</tr>
<tr>
<td>Susceptance tilt Ang</td>
<td>-30...30</td>
<td>deg</td>
<td>1</td>
<td>0</td>
<td>Tilt angle of susceptibility boundary line</td>
</tr>
</tbody>
</table>

Table 39. Residual overvoltage protection (ROVPTOV)

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

\(^1\) Residual voltage before fault = 0.0 \times U_n, \( f_n = 50 \text{ Hz} \), 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 40. Residual overvoltage protection (ROVPTOV) main settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Value (Range)</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value</td>
<td>ROVPTOV</td>
<td>0.010...1.000 \times U_n</td>
<td>0.001</td>
</tr>
<tr>
<td>Operate delay time</td>
<td>ROVPTOV</td>
<td>40...300000 ms</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 41. Negative phase-sequence overcurrent protection (NSPTOC)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
</table>
| Operation accuracy                  | Depending on the frequency of the current measured: \( f_n \pm 2 \text{ Hz} \) \[
|                                     | \pm 1.5\% of the set value or \( \pm 0.002 \times I_n \)            |
| Start time 1,2)                     | \[ 
| \( I_{\text{Fault}} = 2 \times \text{set Start value} \)         | Minimum: 22 ms, 14 ms                                               |
|                                     | Typical: 24 ms, 16 ms                                              |
|                                     | Maximum: 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 \( \pm 20 \text{ ms} \)            |
| Operate time accuracy in inverse time mode | \pm 5.0\% of the theoretical value or \( \pm 20 \text{ ms} \) 3) |
| Suppression of harmonics            | DFT: -50 dB at \( f = n \times f_n \), where \( n = 2, 3, 4, 5, \ldots \) |

1) Negative sequence current before fault = 0.0, \( f_n = 50 \text{ Hz} \), results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum \( \text{Start value} = 2.5 \times I_n \), \( \text{Start value} \) multiples in range of 1.5 to 20

Table 42. Negative phase-sequence overcurrent protection (NSPTOC) main settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Value (Range)</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value</td>
<td>NSPTOC</td>
<td>0.01...5.00 x ( I_n )</td>
<td>0.01</td>
</tr>
<tr>
<td>Time multiplier</td>
<td>NSPTOC</td>
<td>0.05...15.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Operate delay time</td>
<td>NSPTOC</td>
<td>40...200000 ms</td>
<td>10</td>
</tr>
<tr>
<td>Operating curve type1)</td>
<td>NSPTOC</td>
<td>Definite or inverse time</td>
<td>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19</td>
</tr>
</tbody>
</table>

1) For further reference please refer to the Operating characteristics table
Table 43. Phase discontinuity protection (PDNSPTOC)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
</table>
| Operation accuracy                    | Depending on the frequency of the current measured: \( f_n \pm 2 \text{ Hz} \)  
|                                       | \( \pm 2\% \) of the set value                                    |
| Start time                            | \(< 70 \text{ ms} \)                                              |
| Reset time                            | \(< 40 \text{ ms} \)                                              |
| Reset ratio                           | Typical 0.96                                                       |
| Retardation time                      | \(< 35 \text{ ms} \)                                              |
| Operate time accuracy in definite time mode | \( \pm 1.0\% \) of the set value or \( \pm 20 \text{ ms} \) |
| Suppression of harmonics              | DFT: -50 dB at \( f = n \times f_n \), where \( n = 2, 3, 4, 5, \ldots \) |

Table 44. Phase discontinuity protection (PDNSPTOC) main settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Value (Range)</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value (Current ratio setting ( I_2/I_1 ))</td>
<td>PDNSPTOC</td>
<td>10...100 %</td>
<td>1</td>
</tr>
<tr>
<td>Operate delay time</td>
<td>PDNSPTOC</td>
<td>100...30000 ms</td>
<td>1</td>
</tr>
<tr>
<td>Min phase current</td>
<td>PDNSPTOC</td>
<td>0.05...0.30 \times I_n</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 45. Circuit breaker failure protection (CCBRBRF)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
</table>
| Operation accuracy                    | Depending on the frequency of the current measured: \( f_n \pm 2 \text{ Hz} \)  
|                                       | \( \pm 1.5\% \) of the set value or \( \pm 0.002 \times I_n \) |
| Operate time accuracy                 | \( \pm 1.0\% \) of the set value or \( \pm 20 \text{ ms} \) |
Table 46. Circuit breaker failure protection (CCBRBRF) main settings

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

Table 47. Three-phase thermal overload protection for feeders (T1PTTR)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td>Depending on the frequency of the current measured: $f_n \pm 2$ Hz</td>
</tr>
<tr>
<td></td>
<td>Current measurement: ±1.5% of the set value or ±0.002 x I_n (at currents in the range of 0.01...4.00 x I_n)</td>
</tr>
<tr>
<td>Operate time accuracy$^1$</td>
<td>±2.0% of the theoretical value or ±0.50 s</td>
</tr>
</tbody>
</table>

$^1$ Overload current > 1.2 x Operate level temperature
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Value (Range)</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Env temperature Set (Ambient temperature used when the AmbSens is set to Off)</td>
<td>T1PTTR</td>
<td>-50...100°C</td>
<td>1</td>
</tr>
<tr>
<td>Current multiplier (Current multiplier when function is used for parallel lines)</td>
<td>T1PTTR</td>
<td>1...5</td>
<td>1</td>
</tr>
<tr>
<td>Current reference</td>
<td>T1PTTR</td>
<td>0.05...4.00 x Iₙ</td>
<td>0.01</td>
</tr>
<tr>
<td>Temperature rise (End temperature rise above ambient)</td>
<td>T1PTTR</td>
<td>0.0...200.0°C</td>
<td>0.1</td>
</tr>
<tr>
<td>Time constant (Time constant of the line in seconds)</td>
<td>T1PTTR</td>
<td>60...60000 s</td>
<td>1</td>
</tr>
<tr>
<td>Maximum temperature (temperature level for operate)</td>
<td>T1PTTR</td>
<td>20.0...200.0°C</td>
<td>0.1</td>
</tr>
<tr>
<td>Alarm value (Temperature level for start (alarm))</td>
<td>T1PTTR</td>
<td>20.0...150.0°C</td>
<td>0.1</td>
</tr>
<tr>
<td>Reclose temperature (Temperature for reset of block reclose after operate)</td>
<td>T1PTTR</td>
<td>20.0...150.0°C</td>
<td>0.1</td>
</tr>
<tr>
<td>Initial temperature (Temperature raise above ambient temperature at startup)</td>
<td>T1PTTR</td>
<td>-50.0...100.0°C</td>
<td>0.1</td>
</tr>
</tbody>
</table>
### Table 49. Three-phase inrush current detection (INRPHAR)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td>At the frequency $f = f_n$</td>
</tr>
<tr>
<td>Current measurement:</td>
<td>$\pm 1.5%$ of the set value or $\pm 0.002 \times I_n$</td>
</tr>
<tr>
<td>Ratio $I_2f/I_1f$ measurement:</td>
<td>$\pm 5.0%$ of the set value</td>
</tr>
<tr>
<td>Reset time</td>
<td>$+35$ ms / $-0$ ms</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>Typical 0.96</td>
</tr>
<tr>
<td>Operate time accuracy</td>
<td>$+35$ ms / $-0$ ms</td>
</tr>
</tbody>
</table>

### Table 50. Three-phase inrush detection (INRPHAR) main settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Value (Range)</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value (Ratio of the 2nd to the 1st harmonic leading to restraint)</td>
<td>INRPHAR</td>
<td>5...100 %</td>
<td>1</td>
</tr>
<tr>
<td>Operate delay time</td>
<td>INRPHAR</td>
<td>20...60000 ms</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 51. Operation characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values (Range)</th>
</tr>
</thead>
</table>

| 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 |

Supervision functions

Table 52. Current circuit supervision (CCRDIF)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate time(^1)</td>
<td>&lt; 30 ms</td>
</tr>
</tbody>
</table>

\(^1\) Including the delay of the output contact.
Table 53. Current circuit supervision (CCRDIF) main settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values (Range)</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value</td>
<td>0.05...0.20</td>
<td>x (I_n)</td>
<td>Minimum operate current differential level</td>
</tr>
<tr>
<td>Maximum operate current</td>
<td>1.00...5.00</td>
<td>x (I_n)</td>
<td>Block of the function at high phase current</td>
</tr>
</tbody>
</table>

Control functions

Table 54. Autoreclosure (DARREC)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate time accuracy</td>
<td>±1.0% of the set value or ±20 ms</td>
</tr>
</tbody>
</table>

Measurement functions

Table 55. Three-phase current measurement (CMMXU)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td>Depending on the frequency of the current measured: (f_n \pm 2) Hz (\pm 0.5% \text{ or } \pm 0.002 \times I_n) (at currents in the range of 0.01...4.00 (x I_n))</td>
</tr>
<tr>
<td>Suppression of harmonics</td>
<td>DFT: (-50) dB at (f = n \times f_n), where (n = 2, 3, 4, 5, \ldots) (\text{RMS: No suppression})</td>
</tr>
</tbody>
</table>

Table 56. Current sequence components (CSMSQI)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td>Depending on the frequency of the current measured: (f/f_n = \pm 2) Hz (\pm 1.0% \text{ or } \pm 0.002 \times I_n) at currents in the range of 0.01...4.00 (x I_n))</td>
</tr>
<tr>
<td>Suppression of harmonics</td>
<td>DFT: (-50) dB at (f = n \times f_n), where (n = 2, 3, 4, 5, \ldots)</td>
</tr>
</tbody>
</table>
Table 57. Residual current measurement (RESCMMXU)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td>Depending on the frequency of the current measured: ( f/f_n = \pm 2 ) Hz</td>
</tr>
<tr>
<td></td>
<td>( \pm 0.5% ) or ( \pm 0.002 \times I_n )</td>
</tr>
<tr>
<td></td>
<td>at currents in the range of ( 0.01...4.00 \times I_n )</td>
</tr>
<tr>
<td>Suppression of harmonics</td>
<td>DFT: (-50 \text{ dB at } f = n \times f_n), where ( n = 2, 3, 4, 5, \ldots )</td>
</tr>
<tr>
<td></td>
<td>RMS: No suppression</td>
</tr>
</tbody>
</table>

Table 58. Residual voltage measurement (RESVMMXU)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation accuracy</td>
<td>Depending on the frequency of the current measured: ( f/f_n = \pm 2 ) Hz</td>
</tr>
<tr>
<td></td>
<td>( \pm 0.5% ) or ( \pm 0.002 \times U_n )</td>
</tr>
<tr>
<td>Suppression of harmonics</td>
<td>DFT: (-50 \text{ dB at } f = n \times f_n), where ( n = 2, 3, 4, 5, \ldots )</td>
</tr>
<tr>
<td></td>
<td>RMS: No suppression</td>
</tr>
</tbody>
</table>
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 13. Small display**

**Figure 14. Large display**

**Table 59. Small display**

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

1) Depending on the selected language
Table 60. Large display

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

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
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.

23. Selection and ordering data

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

<table>
<thead>
<tr>
<th>#</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IED</td>
</tr>
<tr>
<td></td>
<td>615 series IED (including case)</td>
</tr>
<tr>
<td></td>
<td>615 series IED (including case) with test switch, wired and installed in a 19” equipment panel</td>
</tr>
<tr>
<td></td>
<td>615 series IED (including case) with test switch, wired and installed in a mounting bracket for CombiFlex rack mounting (RGHT 19” 4U variant C)</td>
</tr>
<tr>
<td>2</td>
<td>Standard</td>
</tr>
<tr>
<td></td>
<td>IEC</td>
</tr>
<tr>
<td>3</td>
<td>Main application</td>
</tr>
<tr>
<td></td>
<td>Line differential protection and control</td>
</tr>
</tbody>
</table>
The standard configuration determines the I/O hardware and available options. The example below shows standard configuration “B” with chosen options.

<table>
<thead>
<tr>
<th>#</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-8</td>
<td>Standard configurations, analog and binary I/O options</td>
</tr>
<tr>
<td></td>
<td>Standard configuration descriptions in short:</td>
</tr>
<tr>
<td></td>
<td>A = Line differential protection</td>
</tr>
<tr>
<td></td>
<td>B = Line differential protection and directional E/F protection, CB condition monitoring</td>
</tr>
<tr>
<td></td>
<td>C = Line differential protection and non-directional E/F protection, CB condition monitoring</td>
</tr>
<tr>
<td>Std. conf A: 4I (Io 1/5 A) + 12 BI + 10 BO</td>
<td>AACAD</td>
</tr>
<tr>
<td>Std. conf A: 4I (Io 1/5 A) + 18 BI + 13 BO</td>
<td>AACAF</td>
</tr>
<tr>
<td>Std. conf B: 4I (Io 1/5 A) + Uo + 11 BI + 10 BO</td>
<td>BAAAC</td>
</tr>
<tr>
<td>Std. conf B: 4I (Io 1/5 A) + Uo + 17 BI + 13 BO</td>
<td>BAAAE</td>
</tr>
<tr>
<td>Std. conf B: 4I (Io 0.2/1 A) + Uo + 11 BI + 10 BO</td>
<td>BABAC</td>
</tr>
<tr>
<td>Std. conf B: 4I (Io 0.2/1 A) + Uo + 17 BI + 13 BO</td>
<td>BABAE</td>
</tr>
<tr>
<td>Std. conf C: 4I (Io 1/5 A) + 12 BI + 10 BO</td>
<td>CACAD</td>
</tr>
<tr>
<td>Std. conf C: 4I (Io 1/5 A) + 18 BI + 13 BO</td>
<td>CACAF</td>
</tr>
</tbody>
</table>
The communication module hardware determines the available communication protocols. Choose the hardware from one of the rows below to define the digits # 9-10.

<table>
<thead>
<tr>
<th>#</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Communication modules (Serial/Ethernet)</td>
</tr>
<tr>
<td>10</td>
<td>Serial RS-485 incl. IRIG-B + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial RS-485 + Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial RS-485 incl. IRIG-B + Ethernet 100Base-TX (RJ-45) + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial RS-485 incl. IRIG-B + Ethernet 100Base-TX (RJ-45) + Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial RS-485 incl. IRIG-B + Ethernet 100Base-TX (2 x RJ-45) + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial RS-485 incl. IRIG-B + Ethernet 100Base-TX (2 x RJ-45) + Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial glass fibre (ST) incl. an input for IRIG-B + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial glass fibre (ST) incl. an input for IRIG-B + Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial glass fibre (ST) incl. an input for IRIG-B + Ethernet 100Base-TX (RJ-45) + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial glass fibre (ST) incl. an input for IRIG-B + Ethernet 100Base-TX (RJ-45) + Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Serial glass fibre (ST) incl. an input for IRIG-B + Ethernet 100Base-TX (2 x RJ-45) + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Glass fibre (ST) incl. an input for IRIG-B + Ethernet 100Base-TX (2 x RJ-45) + Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Ethernet 100Base-TX (RJ-45) + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Ethernet 100Base-TX (RJ-45) + Line differential, single mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Ethernet 100Base-TX (2 x RJ-45) + Line differential, multi mode fibre (LC)</td>
</tr>
<tr>
<td></td>
<td>Ethernet 100Base-TX (2 x RJ-45) + Line differential, single mode fibre (LC)</td>
</tr>
</tbody>
</table>

If serial communication is chosen, please choose a serial communication module including Ethernet (for example “BK”) if a service bus for PCM600 or the WebHMI is required.
<table>
<thead>
<tr>
<th>#</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Communication protocols</td>
</tr>
<tr>
<td>A</td>
<td>IEC 61850 (for Ethernet communication modules and IEDs without a communication module)</td>
</tr>
<tr>
<td>B</td>
<td>Modbus (for Ethernet/serial or Ethernet + serial communication modules)</td>
</tr>
<tr>
<td>C</td>
<td>IEC 61850 + Modbus (for Ethernet or serial + Ethernet communication modules)</td>
</tr>
<tr>
<td>D</td>
<td>IEC 60870-5-103 (for serial or Ethernet + serial communication modules)</td>
</tr>
<tr>
<td>E</td>
<td>DNP3 (for Ethernet/serial or Ethernet + serial communication modules)</td>
</tr>
<tr>
<td>#</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>----</td>
<td>-------------</td>
</tr>
<tr>
<td>12</td>
<td>Language</td>
</tr>
<tr>
<td></td>
<td>English</td>
</tr>
<tr>
<td></td>
<td>English and German</td>
</tr>
<tr>
<td></td>
<td>English and Swedish</td>
</tr>
<tr>
<td></td>
<td>English and Spanish</td>
</tr>
<tr>
<td></td>
<td>English and Russian</td>
</tr>
<tr>
<td></td>
<td>English and Portuguese (Brazilian)</td>
</tr>
<tr>
<td>13</td>
<td>Front panel</td>
</tr>
<tr>
<td></td>
<td>Small LCD</td>
</tr>
<tr>
<td></td>
<td>Large LCD with single line diagram (SLD)</td>
</tr>
<tr>
<td>14</td>
<td>Option 1</td>
</tr>
<tr>
<td></td>
<td>Auto-reclosing (only for std conf B and C)</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>15</td>
<td>Option 2</td>
</tr>
<tr>
<td></td>
<td>Directional earth-fault protection (only for std configuration B)</td>
</tr>
<tr>
<td></td>
<td>Admittance based earth-fault protection (only for std configuration B)</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>16</td>
<td>Power supply</td>
</tr>
<tr>
<td></td>
<td>48...250 V DC, 100...240 V AC</td>
</tr>
<tr>
<td></td>
<td>24...60 V DC</td>
</tr>
<tr>
<td>17</td>
<td>Vacant digit</td>
</tr>
<tr>
<td></td>
<td>Vacant</td>
</tr>
<tr>
<td>18</td>
<td>Version</td>
</tr>
<tr>
<td></td>
<td>Version 3.0</td>
</tr>
</tbody>
</table>

**Example code:** `H B D C A D B K C 1 B A N 1 X D`

**Your ordering code:**

Digit (#) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Code

*Figure 18. Ordering key for complete IEDs*
24. Accessories and ordering data

Table 61. Pilot wire communication

<table>
<thead>
<tr>
<th>Item</th>
<th>Order number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Wire communication package including two Pilot Wire modems: RPW600AM (master) and RPW600AF (follower)</td>
<td>RPW600AMF</td>
</tr>
<tr>
<td>Diagnostics kit including the RPW-diagnostic tool, a diagnostic cable and a CD with necessary drivers and information</td>
<td>RPW600ADP</td>
</tr>
<tr>
<td>3.0 meter LC-LC single-mode fibre-optic patch cable for connecting one Pilot Wire modem to the RED615 IED</td>
<td>1MRS120547-3</td>
</tr>
</tbody>
</table>

1) Please note that two patch cables are required for connecting the Pilot Wire communication package (RPW600AMF).

Table 62. Mounting accessories

<table>
<thead>
<tr>
<th>Item</th>
<th>Order number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-flush mounting kit</td>
<td>1MRS050696</td>
</tr>
<tr>
<td>Wall mounting kit</td>
<td>1MRS050697</td>
</tr>
<tr>
<td>Inclined semi-flush mounting kit</td>
<td>1MRS050831</td>
</tr>
<tr>
<td>19&quot; rack mounting kit with cut-out for one IED</td>
<td>1MRS050694</td>
</tr>
<tr>
<td>19&quot; rack mounting kit with cut-out for two IEDs</td>
<td>1MRS050695</td>
</tr>
<tr>
<td>Mounting bracket for one IED with test switch RTXP in 4U Combiflex (RHGT 19” variant C)</td>
<td>2RCA022642P0001</td>
</tr>
<tr>
<td>Mounting bracket for one IED in 4U Combiflex (RHGT 19” variant C)</td>
<td>2RCA022643P0001</td>
</tr>
<tr>
<td>19” rack mounting kit for one IED and one RTXP18 test switch (the test switch is not included in the delivery)</td>
<td>2RCA021952A0003</td>
</tr>
<tr>
<td>19” rack mounting kit for one IED and one RTXP24 test switch (the test switch is not included in the delivery)</td>
<td>2RCA022561A0003</td>
</tr>
</tbody>
</table>

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 63. Tools

<table>
<thead>
<tr>
<th>Configuration and setting tools</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCM600</td>
<td>2.3</td>
</tr>
<tr>
<td>Web-browser based user interface</td>
<td>IE 7.0 or later</td>
</tr>
<tr>
<td>RED615 Connectivity Package</td>
<td>3.0 or later</td>
</tr>
</tbody>
</table>
## Table 64. Supported functions

<table>
<thead>
<tr>
<th>Function</th>
<th>WebHMI</th>
<th>PCM600</th>
<th>PCM600 Engineering</th>
<th>PCM600 Engineering Pro</th>
</tr>
</thead>
<tbody>
<tr>
<td>IED parameter setting</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Saving of IED parameter settings in the IED</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Signal monitoring</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Disturbance recorder handling</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Alarm LED viewing</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Access control management</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>IED signal configuration (signal matrix)</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Modbus® communication configuration (communication management)</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DNP3 communication configuration (communication management)</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>IEC 60870-5-103 communication configuration (communication management)</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Saving of IED parameter settings in the tool</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Disturbance record analysis</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>XRIO parameter export/import</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Graphical display configuration</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
Table 64. Supported functions, continued

<table>
<thead>
<tr>
<th>Function</th>
<th>WebHMI</th>
<th>PCM600</th>
<th>PCM600 Engineering</th>
<th>PCM600 Engineering Pro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application configuration</td>
<td>-</td>
<td>-</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>IEC 61850 communication configuration, GOOSE (communication configuration)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>Phasor diagram viewing</td>
<td>●</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Event viewing</td>
<td>●</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Saving of event data on the user's PC</td>
<td>●</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

● = Supported
26. Terminal diagrams

Figure 19. Terminal diagram for configuration A and C
Figure 20. Terminal diagram for configuration B
27. References

The 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 RED615 protection IED on the product page.

For information regarding the RPW600 modems please refer to the RPW600 User’s Guide, document id 6621-2260. The document is available for download on the RED615 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.

![Figure 21. Product page](image)
28. Functions, codes and symbols

Table 65. RED615 Functions, codes and symbols

<table>
<thead>
<tr>
<th>Function</th>
<th>IEC 61850</th>
<th>IEC 60617</th>
<th>IEC-ANSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three-phase non-directional overcurrent protection, low stage, instance 1</td>
<td>PHLPTOC1</td>
<td>3I&gt; (1)</td>
<td>51P-1 (1)</td>
</tr>
<tr>
<td>Three-phase non-directional overcurrent protection, high stage, instance 1</td>
<td>PHHPTOC1</td>
<td>3I&gt;&gt; (1)</td>
<td>51P-2 (1)</td>
</tr>
<tr>
<td>Three-phase non-directional overcurrent protection, high stage, instance 2</td>
<td>PHHPTOC2</td>
<td>3I&gt;&gt; (2)</td>
<td>51P-2 (2)</td>
</tr>
<tr>
<td>Three-phase non-directional overcurrent protection, instantaneous stage, instance 1</td>
<td>PHIPTOC1</td>
<td>3I&gt;&gt;&gt; (1)</td>
<td>50P/51P (1)</td>
</tr>
<tr>
<td>Non-directional earth-fault protection, low stage, instance 1</td>
<td>EFLPTOC1</td>
<td>Io&gt; (1)</td>
<td>51N-1 (1)</td>
</tr>
<tr>
<td>Non-directional earth-fault protection, low stage, instance 2</td>
<td>EFLPTOC2</td>
<td>Io&gt; (2)</td>
<td>51N-1 (2)</td>
</tr>
<tr>
<td>Non-directional earth-fault protection, high stage, instance 1</td>
<td>EFHPTOC1</td>
<td>Io&gt;&gt; (1)</td>
<td>51N-2 (1)</td>
</tr>
<tr>
<td>Non-directional earth-fault protection, instantaneous stage</td>
<td>EFIPTOC1</td>
<td>Io&gt;&gt;&gt;</td>
<td>50N/51N</td>
</tr>
<tr>
<td>Directional earth-fault protection, low stage, instance 1</td>
<td>DEFLPDEF1</td>
<td>Io&gt; -&gt; (1)</td>
<td>67N-1 (1)</td>
</tr>
<tr>
<td>Directional earth-fault protection, low stage, instance 2</td>
<td>DEFLPDEF2</td>
<td>Io&gt; -&gt; (2)</td>
<td>67N-1 (2)</td>
</tr>
<tr>
<td>Directional earth-fault protection, high stage</td>
<td>DEFHPDEF1</td>
<td>Io&gt;&gt; -&gt;</td>
<td>67N-2</td>
</tr>
<tr>
<td>Admittance based earth-fault protection, instance 1</td>
<td>EFPADM1</td>
<td>Yo&gt; -&gt; (1)</td>
<td>21YN (1)</td>
</tr>
<tr>
<td>Admittance based earth-fault protection, instance 2</td>
<td>EFPADM2</td>
<td>Yo&gt; -&gt; (2)</td>
<td>21YN (2)</td>
</tr>
<tr>
<td>Admittance based earth-fault protection, instance 3</td>
<td>EFPADM3</td>
<td>Yo&gt; -&gt; (3)</td>
<td>21YN (3)</td>
</tr>
<tr>
<td>Transient / intermittent earth-fault protection</td>
<td>INTRPTEF1</td>
<td>Io&gt; -&gt; IEF</td>
<td>67NIEF</td>
</tr>
<tr>
<td>Function</td>
<td>IEC 61850</td>
<td>IEC 60617</td>
<td>IEC-ANSI</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Non-directional (cross-country) earth fault protection, using calculated Io</td>
<td>EFHPTOC1</td>
<td>Iο&gt;&gt; (1)</td>
<td>51N-2 (1)</td>
</tr>
<tr>
<td>Negative-sequence overcurrent protection, instance 1</td>
<td>NSPTOC1</td>
<td>I2&gt; (1)</td>
<td>46 (1)</td>
</tr>
<tr>
<td>Negative-sequence overcurrent protection, instance 2</td>
<td>NSPTOC2</td>
<td>I2&gt; (2)</td>
<td>46 (2)</td>
</tr>
<tr>
<td>Phase discontinuity protection</td>
<td>PDNSPTOC1</td>
<td>I2/I1&gt;</td>
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<td>Residual overvoltage protection, instance 1</td>
<td>ROVPTOV1</td>
<td>Uo&gt; (1)</td>
<td>59G (1)</td>
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<td>Residual overvoltage protection, instance 2</td>
<td>ROVPTOV2</td>
<td>Uo&gt; (2)</td>
<td>59G (2)</td>
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<td>ROVPTOV3</td>
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<td>59G (3)</td>
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<td>Three-phase thermal protection for feeders, cables and distribution transformers</td>
<td>T1PTTR1</td>
<td>3Ith&gt;F</td>
<td>49F</td>
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<td>Binary signal transfer</td>
<td>BSTGGIO1</td>
<td>BST</td>
<td>BST</td>
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<td>Line differential protection and related measurements, stabilized and instantaneous stages</td>
<td>LNPLDF1</td>
<td>3dl&gt;L</td>
<td>87L</td>
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<tr>
<td>Circuit breaker failure protection</td>
<td>CCBRBFR1</td>
<td>3I&gt;/Iο&gt;BF</td>
<td>51BF/51NBF</td>
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<td>Three-phase inrush detector</td>
<td>INRPHAR1</td>
<td>3I2f&gt;</td>
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<td>Master trip, instance 1</td>
<td>TRPPTRC1</td>
<td>Master Trip (1)</td>
<td>94/86 (1)</td>
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<tr>
<td>Master trip, instance 2</td>
<td>TRPPTRC2</td>
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**Control**

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<td>DCSXSWI1</td>
<td>I &lt;&gt; O DC (1)</td>
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<td>Earthing switch indication</td>
<td>ESSXSWI1</td>
<td>I &lt;&gt; O ES</td>
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<td>Auto-reclosing</td>
<td>DARREC1</td>
<td>O -&gt; I</td>
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Table 65. RED615 Functions, codes and symbols, continued

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<th>IEC 60617</th>
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<td>Condition monitoring</td>
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<td>Circuit-breaker condition monitoring</td>
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<td>CBCM</td>
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<td>TCS (1)</td>
<td>TCM (1)</td>
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<td>TCSSCBR2</td>
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<td>Current circuit supervision</td>
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<td>Protection communication supervision</td>
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<td>Measurement</td>
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<td>Disturbance recorder</td>
<td>RDRE1</td>
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<td>Three-phase current measurement, instance 1</td>
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<td>3I</td>
<td>3I</td>
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<td>Sequence current measurement</td>
<td>CSMSQI1</td>
<td>I1, I2, I0</td>
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<td>Io</td>
<td>In</td>
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<td>RESVMMXU1</td>
<td>Uo</td>
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29. Document revision history

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<td>A/2008-10-03</td>
<td>1.1</td>
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<tr>
<td>B/2009-07-03</td>
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<tr>
<td>C/2010-06-11</td>
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