RELION® PRODUCT FAMILY

# Grid Automation
# Recloser Protection and Control
# RER615
Product Guide

# Contents

## 1. Description

RER615 is a recloser controller designed for remote control and monitoring, protection, fault indication, power quality analysis and automation in medium-voltage secondary distribution systems, including radial, looped and meshed distribution networks, with or without distributed power generation.

RER615 is a member of the Relion® product family. The relay has inherited features from the 615 series relays that are characterized by their compactness as well as environmentally friendly (RoHS compliance) and withdrawable-unit design. Re-engineered from the ground up, the relays have been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices.

With RER615, grid reliability can be enhanced, ranging from basic, non-directional overload protection to extended protection functionality with power quality analyses. RER615 meets today’s requirements for smart grids and supports the protection of overhead lines in isolated neutral, resistance-earthed, compensated and solidly earthed networks. RER615 is freely programmable with horizontal GOOSE communication, thus enabling sophisticated interlocking functions. RER615 includes sophisticated protection functionality to detect, isolate and restore power in all types of networks but especially in compensated networks (including recloser tripping curves). As part of an ABB smart grid solution, the relay provides superior fault location, isolation and restoration (FLIR) to lower the frequency and shorten the duration of faults.

The adaptable standard configurations allow the relay to be taken into use right after the application-specific parameters have been set, thus enabling rapid commissioning. RER615 supports the same configuration tools as the other relays in the Relion product family. The freely programmable relay contains six easily manageable setting groups.

Via the relay's front panel HMI or a remote control system, one recloser can be controlled. The relay's large, easy-to-read LCD screen with single-line diagram offers local control and parametrization possibilities with dedicated push buttons for safe operation. Easy Web-based parametrization tool is also available with download possibility.

To protect the relay from unauthorized access and to maintain the integrity of information, the relay is provided with a four-level, role-based user authentication system, with individual passwords for the viewer, operator, engineer and administrator levels. The access control system applies to the front panel HMI, embedded Web browser-based HMI and Protection and Control IED Manager PCM600. In addition, the relay also includes cyber security features such as audit trail.

RER615 supports a variety of communication protocols for remote communication, such as IEC 60870-5-101/104, DNP3 level 2 and Modbus, simultaneously also supporting IEC 61850 with GOOSE messaging for high-speed protection, fault isolation and restoration.

## 2. Standard configurations

RER615 is available in three standard configurations. An example configuration suitable for recloser applications is delivered with each standard configuration. This minimizes the required amount of engineering, allowing fast commissioning by just parametrizing the protection functions. For applications where the example configuration is not suitable, the standard signal configuration can be easily altered using the application configuration or signal matrix functionality of the Protection and Control IED Manager PCM600. The application configuration functionality of PCM600 also supports the creation of multilayer logic functions using various logical elements. By combining protection functions with logic function blocks, the relay configuration can be adapted to user-specific application requirements.

Standard configuration A supports traditional current and voltage transformers. The residual current for the earth-fault protection is derived from the phase currents in a Holmgren connection. Alternatively, the core balance current transformers can be used for measuring the residual current, especially when sensitive earth-fault protection is required.

Standard configuration D supports a combination of traditional current and voltage transformers or alternatively voltage sensors. The residual current for the earth-fault protection is derived from the phase currents in a Holmgren connection. Alternatively, the core balance current transformers can be used for measuring the residual current, especially when sensitive earth-fault protection is required. The sensor inputs are highly flexible and are type-tested to support both ABB's capacitive and resistive voltage sensors.

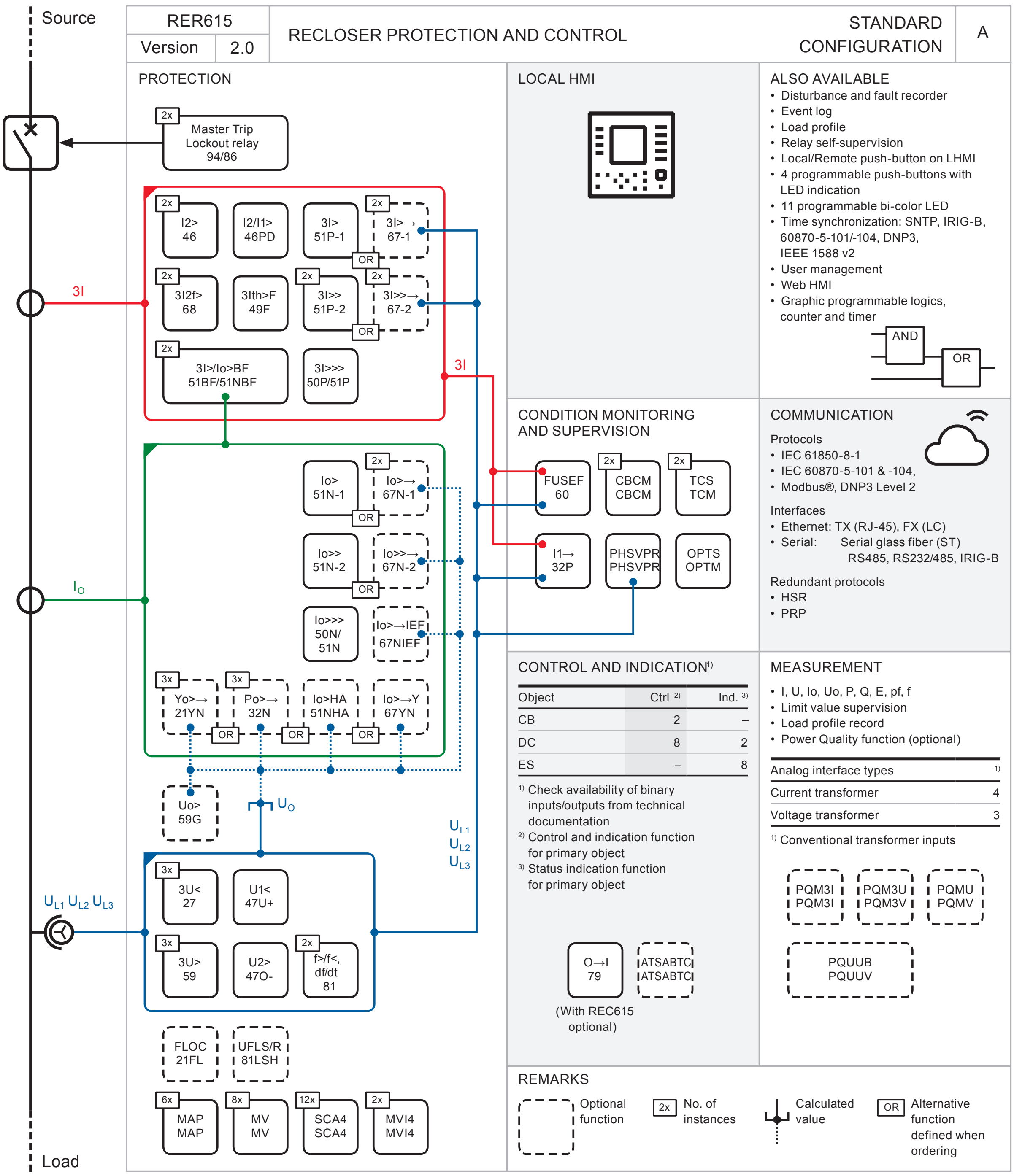


**Figure 1. Functionality overview of standard configuration A**

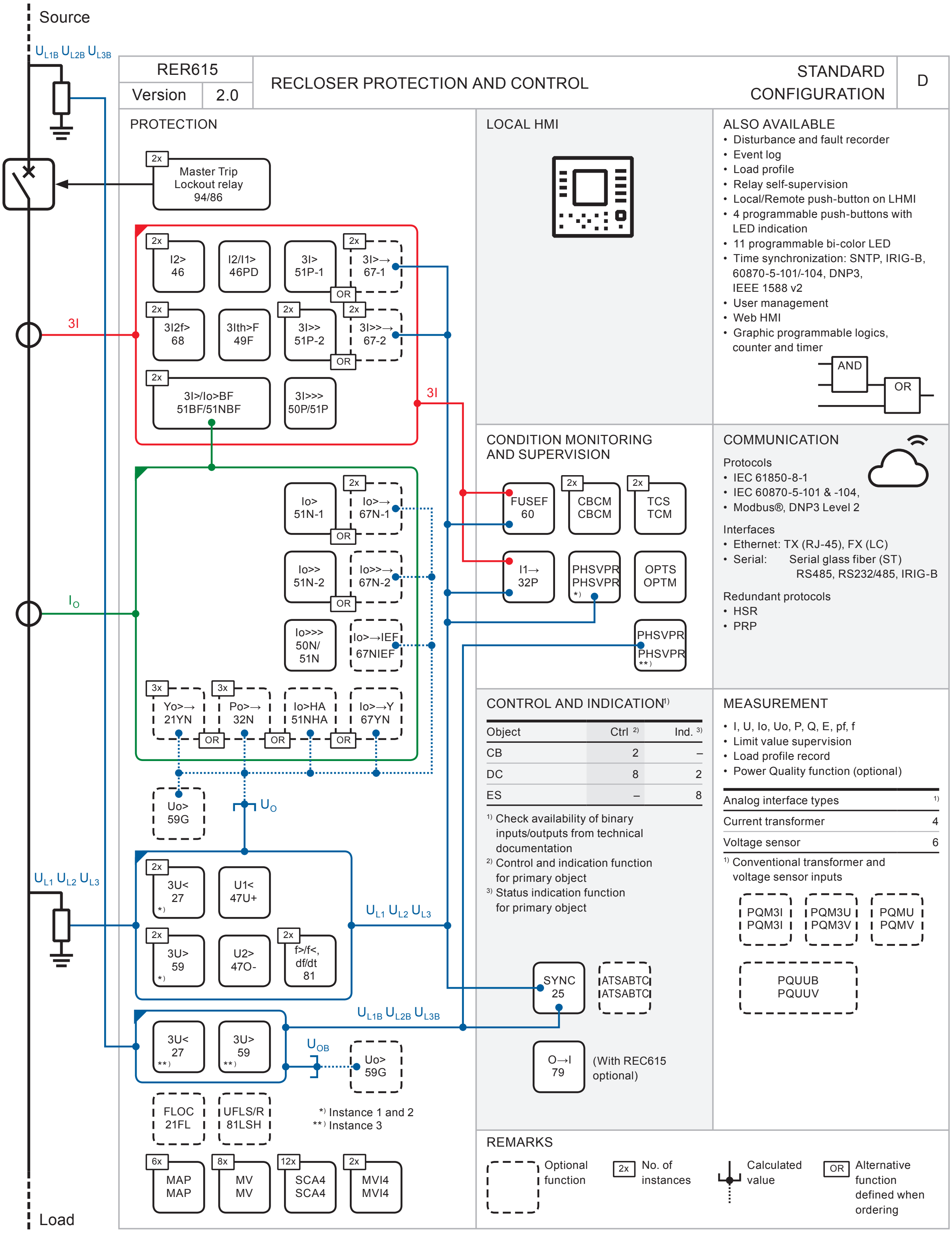


Figure 2. Functionality overview of standard configuration D

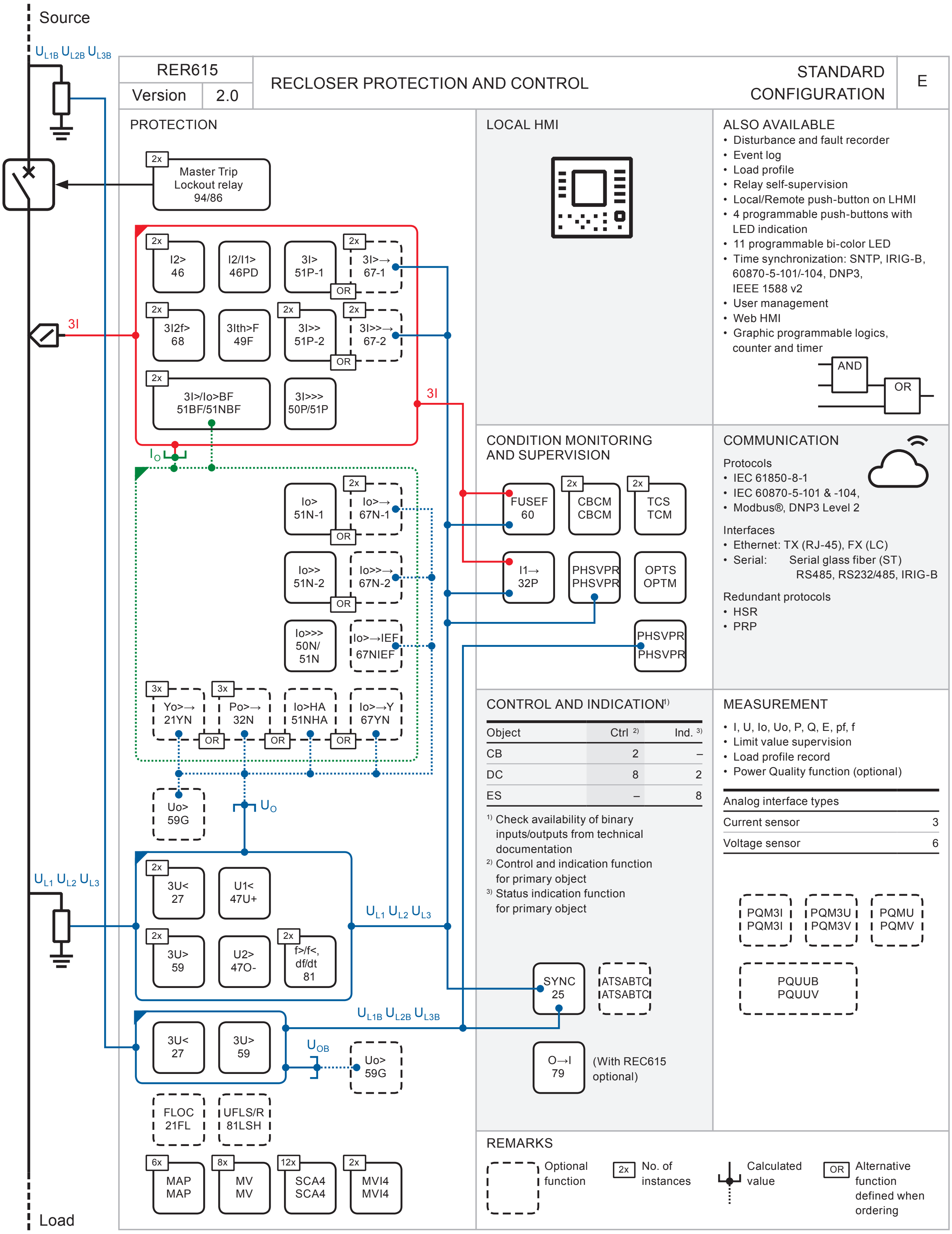


Figure 3. Functionality overview of standard configuration E

Table 1. Standard configurations

| Description | Std. conf. |
| --- | --- |
| Sectionalizer/Midpoint recloser application to be used with conventional transformers supporting reclosing function, directional overcurrent and directional earth-fault protection with phase voltage-based protection and measurement functions, voltage protection, frequency and load-shedding protection, condition monitoring:<br>• Phase voltage inputs based on conventional VTs<br>• Phase current inputs based on conventional CTs<br>• Residual current input based on conventional CT | A |
| Tie point recloser application to be used with mixed transformers supporting reclosing function, directional overcurrent and directional earth-fault protection with phase voltage-based protection and measurement functions, voltage protection, frequency and load-shedding protection, synchrocheck, condition monitoring:<br>• Phase voltage inputs based on conventional VTs/voltage sensors<br>• Phase current inputs based on conventional CTs<br>• Residual current input based on conventional CT | D |
| Remote monitoring and control to be used with combi-sensor and additional voltage sensor supporting reclosing function, directional overcurrent and directional earth-fault protection with phase voltage-based protection and measurement functions, voltage protection, frequency and load-shedding protection, synchrocheck, condition monitoring:<br>• Phase voltage inputs based on voltage sensors<br>• Phase current inputs based on current sensors (Rogowsky coil) | E |

Table 2. Supported functions

| Function | IEC 61850 | IEC 60617 | IEC-ANSI | A | D | E |
|---|---|---|---|---|---|---|
| **Protection** | | | | | | |
| Three-phase non-directional overcurrent protection, low stage | PHLPTOC | 3I> | 51P-1 | (1) | (1) | (1) |
| | FPHLPTOC | F3I> | F51P-1 | (1) | (1) | (1) |
| Three-phase non-directional overcurrent protection, high stage | PHHPTOC | 3I>> | 51P-2 | (1) | (1) | (1) |
| Three-phase non-directional overcurrent protection, instantaneous stage | PHIPTOC | 3I>>> | 50P/51P | 1 | 1 | 1 |
| Three-phase directional overcurrent protection, low stage | DPHLPDOC | 3I> -> | 67-1 | (2) | (2) | (2) |
| | FDPHLPDOC | F3I> -> | F67-1 | (2) | (2) | (2) |
| Three-phase directional overcurrent protection, high stage | DPHHPDOC | 3I>> -> | 67-2 | (1) | (1) | (1) |
| Non-directional earth-fault protection, low stage | EFLPTOC | Io> | 51N-1 | (1) | (1) | (1)[1] |
| | FEFLPTOC | FIo> | F51N-1 | (1) | (1) | (1)[1] |
| Non-directional earth-fault protection, high stage | EFHPTOC | Io>> | 51N-2 | (1) | (1) | (1)[1] |
| Non-directional earth-fault protection, instantaneous stage | EFIPTOC | Io>>> | 50N/51N | 1 | 1 | 1[1] |
| Directional earth-fault protection, low stage | DEFLPDEF | Io> -> | 67N-1 | (2)[2] | (2)[2] | (2)[1,2] |
| | FDEFLPDEF | FIo> -> | F67N-1 | (2)[2] | (2)[2] | (2)[1,2] |
| Directional earth-fault protection, high stage | DEFHPDEF | Io>> -> | 67N-2 | (1)[2] | (1)[2] | (1)[1,2] |
| Transient / intermittent earth-fault protection | INTRPTEF | Io> -> IEF | 67NIEF | (1)[2] | (1)[2] | (1)[1,2] |
| Admittance-based earth-fault protection | EFPADM | Yo> -> | 21YN | (3)[2] | (3)[2] | (3)[1,2] |
| Wattmetric-based earth-fault protection | WPWDE | Po> -> | 32N | (3)[2] | (3)[2] | (3)[1,2] |
| Harmonics-based earth-fault protection | HAEFPTOC | Io>HA | 51NHA | (1) | (1) | (1)[1] |
| Multifrequency admittance-based earth-fault protection | MFADPSDE | Io> -> Y | 67YN | (1)[2] | (1)[2] | (1)[1,2] |
| Negative-sequence overcurrent protection | NSPTOC | I2> | 46 | 2 | 2 | 2 |
| Phase discontinuity protection | PDNSPTOC | I2/I1> | 46PD | 1 | 1 | 1 |
| Residual overvoltage protection | ROVPTOV | Uo> | 59G | (1)[2] | (2)[3,4] | (2)[3,4] |
| Three-phase undervoltage protection | PHPTUV | 3U< | 27 | (3) | (3)[5] | (3)[5] |
| Three-phase overvoltage protection | PHPTOV | 3U> | 59 | (3) | (3)[5] | (3)[5] |
| Positive-sequence undervoltage protection | PSPTUV | U1< | 47U+ | (1) | (1) | (1) |
| Negative-sequence overvoltage protection | NSPTOV | U2> | 47O- | (1) | (1) | (1) |
| Frequency protection | FRPFRQ | f>/f<,df/dt | 81 | (2) | (2) | (2) |
| Three-phase thermal protection for feeders, cables and distribution transformers | T1PTTR | 3Ith>F | 49F | 1 | 1 | 1 |
| Circuit breaker failure protection | CCBRBRF | 3I>/Io>BF | 51BF/51NBF | 2 | 2 | 2[1] |
| Three-phase inrush detector | INRPHAR | 3I2f> | 68 | 1 | 1 | 1 |
| Master trip | TRPPTRC | Master Trip | 94/86 | 2 | 2 | 2 |
| Multipurpose protection | MAPGAPC | MAP | MAP | 6 | 6 | 6 |

Table 2. Supported functions, continued

| Function | IEC 61850 | IEC 60617 | IEC-ANSI | A | D | E |
|---|---|---|---|---|---|---|
| Load-shedding and restoration | LSHDPFRQ | UFLS/R | 81LSH | (1) | (1) | (1) |
| Fault locator | SCEFRFLO | FLOC | 21FL | (1) | (1) | (1) |
| Three-phase power directional element | DPSRDIR | I1-> | 32P | 1 | 1 | 1 |
| **Power quality** | | | | | | |
| Current total demand distortion | CMHAI | PQM3I | PQM3I | (1) | (1) | (1) |
| Voltage total harmonic distortion | VMHAI | PQM3U | PQM3V | (1) | (1) | (1) |
| Voltage variation | PHQVVR | PQMU | PQMV | (1) | (1) | (1) |
| Voltage unbalance | VSQVUB | PQUUB | PQVUB | (1) | (1) | (1) |
| **Control** | | | | | | |
| Circuit-breaker control | CBXCBR | I <-> O CB | I <-> O CB | 2 | 2 | 2 |
| Disconnector control | DCXSWI | I <-> O DCC | I <-> O DCC | 8 | 8 | 8 |
| Disconnector position indication | DCSXSWI | I <-> O DC | I <-> O DC | 2 | 2 | 2 |
| Earthing switch indication | ESSXSWI | I <-> O ES | I <-> O ES | 8 | 8 | 8 |
| Autoreclosing | DARREC | O -> I | 79 | 1 | 1 | 1 |
| Synchronism and energizing check | SECRSYN | SYNC | 25 | | 1 | 1 |
| Automatic transfer switch | ATSABTC | ATSABTC1 | ATSABTC1 | (1) | (1) | (1) |
| **Condition monitoring** | | | | | | |
| Circuit-breaker condition monitoring | SSCBR | CBCM | CBCM | 2 | 2 | 2 |
| Trip circuit supervision | TCSSCBR | TCS | TCM | 2 | 2 | 2 |
| Fuse failure supervision | SEQSPVC | FUSEF | 60 | 1 | 1 | 1 |
| Runtime counter for machines and devices | MDSOPT | OPTS | OPTM | 1 | 1 | 1 |
| Voltage presence | PHSVPR | PHSVPR | PHSVPR | 1 | 2[6)] | 2[6)] |
| **Measurement** | | | | | | |
| Three-phase current measurement | CMMXU | 3I | 3I | 1 | 1 | 1 |
| Sequence current measurement | CSMSQI | I1, I2, I0 | I1, I2, I0 | 1 | 1 | 1 |
| Residual current measurement | RESCMMXU | Io | In | 1 | 1 | |
| Three-phase voltage measurement | VMMXU | 3U | 3V | 1 | 2[6)] | 2[6)] |
| Sequence voltage measurement | VSMSQI | U1, U2, U0 | V1, V2, V0 | 1 | 2[6)] | 2[6)] |
| Three-phase power and energy measurement | PEMMXU | P, E | P, E | 1 | 1 | 1 |
| Single-phase power and energy measurement | SPEMMXU | SP, SE | SP, SE | 1 | 1 | 1 |
| Frequency measurement | FMMXU | f | f | 1 | 2[6)] | 2[6)] |
| Load profile record | LDPRLRC | LOADPROF | LOADPROF | 1 | 1 | 1 |
| **Other** | | | | | | |
| Minimum pulse timer (2 pcs) | TPGAPC | TP | TP | 2 | 2 | 2 |
| Minimum pulse timer (2 pcs, second resolution) | TPSGAPC | TPS | TPS | 1 | 1 | 1 |
| Minimum pulse timer (2 pcs, minute resolution) | TPMGAPC | TPM | TPM | 1 | 1 | 1 |
| Pulse timer (8 pcs) | PTGAPC | PT | PT | 2 | 2 | 2 |

Table 2. Supported functions, continued

| Function | IEC 61850 | IEC 60617 | IEC-ANSI | A | D | E |
|---|---|---|---|---|---|---|
| Time delay off (8 pcs) | TOFGAPC | TOF | TOF | 2 | 2 | 2 |
| Time delay on (8 pcs) | TONGAPC | TON | TON | 2 | 2 | 2 |
| Set-reset (8 pcs) | SRGAPC | SR | SR | 2 | 2 | 2 |
| Move (8 pcs) | MVGAPC | MV | MV | 8 | 8 | 8 |
| Generic control point (16 pcs) | SPCGAPC | SPC | SPC | 2 | 2 | 2 |
| Remote generic control points | SPCRGAPC | SPCR | SPCR | 1 | 1 | 1 |
| Local generic control points | SPCLGAPC | SPCL | SPCL | 1 | 1 | 1 |
| Generic up-down counters | UDFCNT | UDCNT | UDCNT | 3 | 3 | 3 |
| Analog value scaling | SCA4GAPC | SCA4 | SCA4 | 12 | 12 | 12 |
| Integer value move | MVI4GAPC | MVI4 | MVI4 | 2 | 2 | 2 |
| Daily timer function | DTMGAPC | DTMGAPC1 | DTMGAPC1 | 2 | 2 | 2 |
| Programmable buttons (4 buttons) | FKEY4GGIO | FKEY4GGIO1 | FKEY4GGIO1 | 1 | 1 | 1 |
| **Logging functions** | | | | | | |
| Disturbance recorder | RDRE | DR | DFR | 1 | 1 | 1 |
| Fault record | FLTRFRC | FAULTREC | FAULTREC | 1 | 1 | 1 |

1, 2, ... = number of included instances
() = optional

1) Io calculated is always used
2) Uo calculated is always used
3) Uo calculated is always used with the first instance
4) UoB calculated is always used with the second instance
5) Voltage group B is always used with the third instance
6) Voltage group B is always used with the second instance

## 3. Protection functions

To allow the customers to customize the relay according to their requirements, it can be ordered as a basic relay or enhanced with selected protection functions. The selection depends on the application, whether it is a compensated network, and whether the compensated network is with distributed generation or closed-loop feeders.

As a standard offering, the relay includes non-directional overcurrent and non-directional earth-fault functions, as well as other protection functions commonly accepted as a means to significantly improve the grid reliability in recloser applications, such as breaker failure and negative-sequence overcurrent protection to detect a broken conductor. Alternatively, a more sensitive phase-discontinuity protection is available. Thermal protection, which is used for protecting feeders, cables and distribution transformers, is also included.

The optional functionalities of the relay include more advanced methods to detect the earth faults in various distribution networks. On top of the permanent earth faults, the relay can be equipped with algorithms that can be used to detect intermittent and transient temporary faults. This can be used to localize possible future problem points in the distribution network, even before they develop to a fault that causes interruption in the power distribution seen by the end users.

A syncrocheck function is offered with standard configuration D. The synchrocheck function ensures that the voltage, phase angle and frequency on either side of an open circuit breaker meet the conditions for a safe interconnection of two networks.

Some advanced protection functions are optionally available in RER615.

## 4. Application

The recloser protection and control relay RER615 is suitable for a variety of applications, ranging from basic applications on the line recloser to sophisticated applications including distributed generation and demanding interlocking applications. Because of the large number of protection functions, the illustrated applications are only example applications which can be extended to meet tomorrow's requirements.

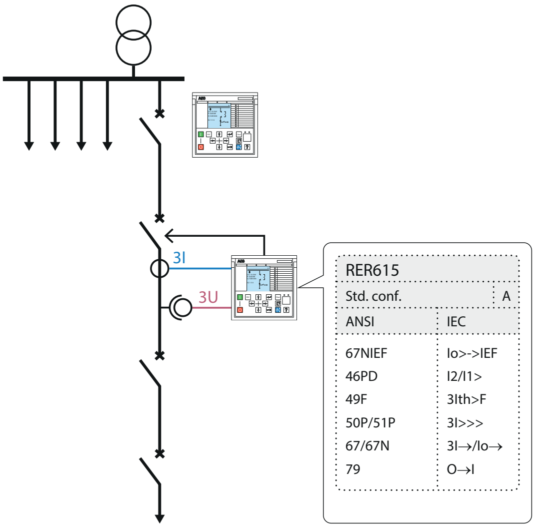


**Figure 4. Selective protection in radial feeder**

Figure 4 illustrates selective protection in a radial feeder with autoreclosing functionality and advanced admittance-based earth-fault protection. Additionally, directional overcurrent protection for distributed generation applications is included.

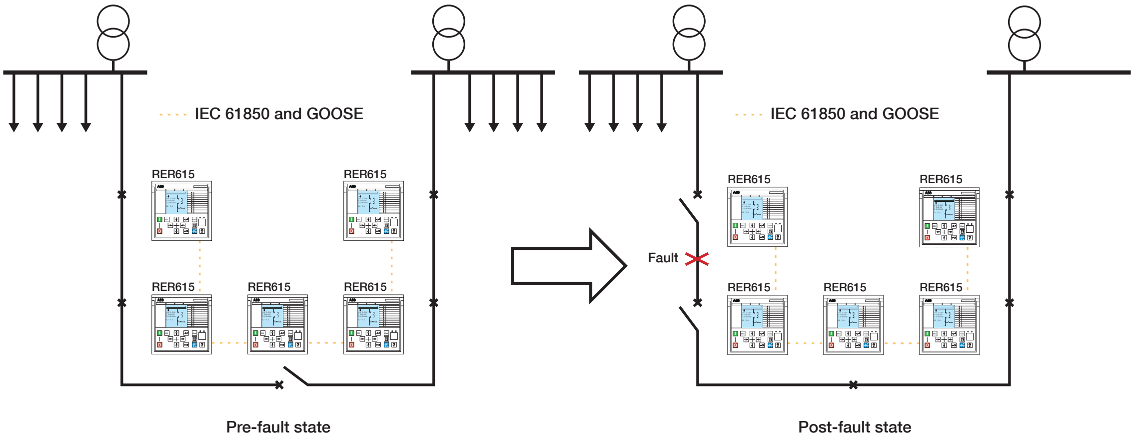


**Figure 5. Fault detection, isolation and restoration in radial feeder**

Exact earth-fault and overcurrent protection enables autonomous fault detection, isolation and restoration, and can be achieved through IEC 61850 and GOOSE communication as illustrated in Figure 5. In the pre-fault state, the closed loop network is of radial type with one normal open point (NOP). The fault is accurately located between two circuit breakers, isolating the faulty part and allowing NOP to be closed.

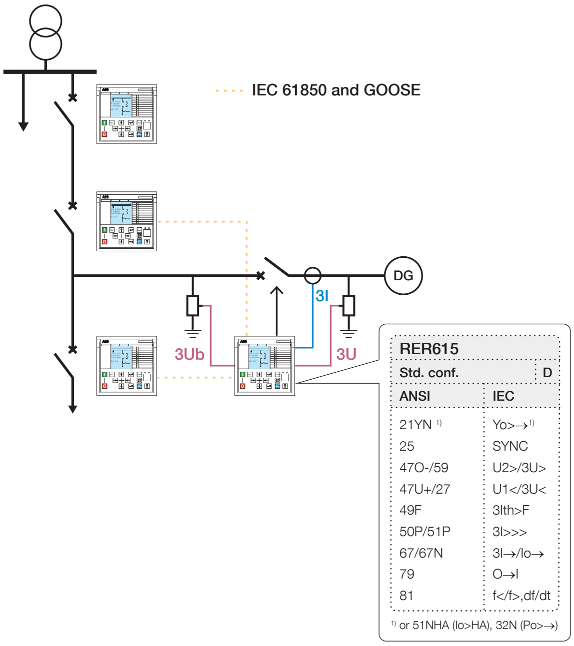


**Figure 6. Protection of distributed generation plant**

The advanced protection functionality of RER615 ensures secure protection of distributed generation against faults, and early indication of loss-of-mains through IEC 61850 and GOOSE communication as seen in Figure 6. Safe reconnection is enabled by using the synchrocheck functionality.

## 5. Supported ABB solutions

RER615 integrates fully with other ABB products such as COM600S, MicroSCADA, SYS600, DMS600, and with ABB's secure, reliable and tested communication solutions, ARG600 and the ARM600 gateway. ABB offers a solution which meets the demanding customer requirements regarding smart grids, and which also contributes to faster engineering.

To facilitate the system engineering, ABB's relays are supplied with connectivity packages. The connectivity packages include a compilation of software and relay-specific information, including single-line diagram templates and a full relay data model. The data model includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with COM600S or the network control and management system MicroSCADA Pro.

Compared to 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. Among the distinctive features of the protection system approach, enabled by the full implementation of the IEC 61850 substation automation standard, are fast communication capability, continuous supervision of the protection and communication system's integrity, and an inherent flexibility regarding reconfiguration and upgrades.

At substation level, COM600S uses the data content of the bay-level devices to enhance substation level functionality. COM600S features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The Web HMI of COM600S also provides an overview of the whole substation, including relay-specific single-line diagrams, which makes information easily accessible. Substation devices and processes can also be remotely accessed through the Web HMI, which improves personnel safety.

In addition, COM600S can be used as a local data warehouse for the substation's technical documentation and for the network data collected by the devices. The collected network data facilitates extensive reporting and analyzing of network fault situations by using the data historian and event handling features of COM600S. The historical data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and historical values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

COM600S can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems, such as MicroSCADA Pro and System 800xA.

Table 3. Supported ABB solutions

| Product | Version |
|---|---|
| Substation Management Unit COM600S | 4.0 SP1 or later |
| MicroSCADA Pro SYS 600 | 9.4 or later |
| System 800xA | 5.1 or later |

## 6. Control

Two circuit breakers can be controlled via the front panel HMI of RER615 or via a remote system.The relay also provides position indication for two disconnectors and two earthing switches.

If the amount of available binary inputs or outputs of the chosen standard configuration is not sufficient, the configuration can be modified to release some binary inputs or outputs originally configured for other purposes. In this case, an external input/ output module, for example, RIO600, can be integrated with the relay and its binary inputs and outputs used for the less time-critical binary signals of the application.

The suitability of the relay's binary outputs selected for controlling primary devices should be carefully verified, for example, regarding the make and carry and the breaking capacity. If the requirements for the control circuit of the primary device are not met, the use of external auxiliary relays should be considered.

The optional, large, graphical LCD of the relay's HMI includes a single-line diagram with position indication for the relevant primary devices. Interlocking schemes required by the application are configured using the signal matrix or the application configuration function of PCM600. Depending on the standard configuration, the relay also has a synchrocheck function to ensure that the voltage, phase angle and frequency on either side of an open circuit breaker meet the conditions for a safe interconnection of two networks.

## 7. Measurement

The relay continuously measures the phase currents and voltages, the symmetrical components of the currents, and the residual current. The relay additionally offers frequency measurement. The relay also calculates the demand value of the current over a user-selectable, pre-set time frame, the thermal overload of the protected object, and the phase unbalance based on the ratio between the negative-sequence and positive-sequence current. Active and reactive power as well as residual voltage are also calculated.

Power quality measurement, such as total harmonic values for both current and voltage, voltage sags and swells, and voltage unbalance, is supported.

Furthermore, the relay offers three-phase power and energy measurement including power factor.

The measured values can be accessed via the local HMI or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the Web HMI.

## 8. Fault location

The relay features an optional impedance-measuring fault location function suitable for locating short-circuits in radial distribution systems. Earth faults can be located in effectively and low-resistance earthed networks. Under circumstances where the fault current magnitude is at least of the same order of magnitude or higher than the load current, earth faults can also be located in isolated neutral distribution networks. The fault location function identifies the type of the fault and then calculates the distance to the fault point. An estimate of the fault resistance value is also calculated. The estimate provides information about the possible fault cause and the accuracy of the estimated distance to the fault point.

## 9. Disturbance recorder

The relay 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 voltages 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 either on the rising or the falling edge of the binary signal or on both.

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

## 10. Event log

To collect sequence-of-events information, the relay has a non-volatile memory capable of storing 1024 events with the associated time stamps. The non-volatile memory retains its data even if the relay temporarily loses its auxiliary supply. The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances. The considerable capacity to process and store data and events in the relay facilitates meeting the growing information demand of future network configurations.

The sequence-of-events information can be accessed either via local HMI or remotely via the communication interface of the relay. The information can also be accessed locally or remotely using the Web HMI.

## 11. Fault recorder

The relay has the capacity to store the records of the 128 latest fault events. The records can be used to analyze the power system events. The fault recording can be triggered by the start or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. Fault records store relay measurement values at the moment when any protection function starts. In addition, the maximum demand current with time stamp is separately recorded. The records are stored in the non-volatile memory.

Furthermore, the relay includes a load profile recorder capable of storing measurement values into the relay's memory. The selected measurement values averaged over the selected period, ranging from one minute to three hours, are stored in a non-volatile memory. Depending on the selected measurements and averaging period, the overall length of the load profile recording ranges from some days to several months, even a year, making this feature suitable for monitoring long-time load behavior for the interested loads.

## 12. Condition monitoring

The condition monitoring functions of the relay constantly monitor 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 circuit breaker history data, which can be used for scheduling preventive circuit breaker maintenance.

## 13. 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.

## 14. Self-supervision

The relay’s built-in self-supervision system continuously monitors the state of the relay hardware and the operation of the relay software. Any fault or malfunction detected is used for alerting the operator.

A permanent relay fault blocks the protection functions to prevent incorrect operation.

## 15. Fuse failure supervision

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

## 16. Autoreclosing

The relay includes a powerful and flexible multi-shot autoreclosing function. The autoreclosing function provides up to five programmable autoreclosing sequences, which can perform one to five successive autoreclosing shots of desired type and duration.

## 17. Hot line tag

Standard configurations of the RER615 are delivered with the hot line tag security functionality that will block the close operation of recloser or breaker when enabled. Hot line tag functionality can be enabled either from the local HMI of the RER615 or from the external signal.

## 18. Access control

To protect the relay from unauthorized access and to maintain information integrity, the relay is provided with a four-level, role-based authentication system with administrator-programmable individual passwords for the viewer, operator, engineer and administrator levels. The access control applies to the local HMI, the Web HMI and PCM600.

## 19. Inputs and outputs

Depending on the selected standard configuration, the relay is equipped with different analog input channels. Standard configuraton A provides three phase-current inputs, one residual current input and three voltage inputs. Standard configuration D provides three phase-current inputs, one residual current input and six sensor voltage inputs or voltage transformers.

The phase-current inputs are rated 1/5 A and the residual current input 0.2/1 A. The residual current is suitable for applications requiring sensitive earth-fault protection and which have core balance current transformers. As the residual current is usually limited to small values, it can also be used in applications where even the phase current is 5A. The three phase voltage inputs and the residual voltage input cover the rated voltages 60...210 V. Both phase-to-phase voltages and phase-to-earth voltages can be connected.

The nominal secondary voltage of voltage sensor inputs is user-programmable, supporting both capacitive and resistive voltage sensors from 5 kV up to 38 kV.

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

All the binary input and output contacts are freely configurable with the Application Configuration or Signal Matrix tool in PCM600.

**Table 4. Number of physical connections in standard configurations**

| Std. conf. | Order code digit | | Analog channels | | | Binary channels | |
|---|---|---|---|---|---|---|---|
| | 5-6 | 7 | CT | VT | Combi-sensor | BI | BO |
| A | AA | N | 4 | 3 | - | 8 | 10 |
| | | A | 4 | 3 | - | 14 | 13 |
| D | AD | N | 4 | 6[1)] | - | 12 | 10 |
| E | AE | N | - | 3[2)] | 3 | 8 | 10 |

1) Support for phase voltage sensors or phase voltage transformer with the SIM0001 module
2) Support for three combi-sensors and three voltage sensors with the SIM0904 module

## 20. Station communication

The relay supports a variety of communication protocols, including IEC 61850 and the most common remote control protocols IEC 60870-5-104, IEC 60870-5-101 Modbus and DNP3. Operational information and controls are available through these protocols. However, some communication functionality, for example horizontal communication between the relays, is only possible through the IEC 61850 communication protocol.

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

The relay can send binary signals to other devices (so-called horizontal communication) using the IEC 61850-8-1 GOOSE profile. Binary GOOSE messaging can, for example, be used for protection and interlocking-based protection schemes. The relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. Furthermore, the relay supports the sending and receiving of analog values using GOOSE messaging. Analog GOOSE messaging enables fast transfer of the analog measurement values over the station bus. This facilitates, for example, the sharing of RTD input values, such as surrounding temperature, with other relay applications.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. Modbus implementation supports RTU, ASCII and TCP modes. In addition to the standard Modbus functionality, the relay supports retrieval of timestamped events, changing the active setting group and uploading the latest fault records. If a Modbus TCP connection is used, four clients can be connected to the relay at the same time. Modbus serial and Modbus TCP can also be used in parallel and IEC 61850 and Modbus simultaneously, if required. In addition to the basic standard functionality, the relay supports changing of the active setting group and uploading of disturbance recordings in the IEC 60870-5-101/104 format. DNP3 supports both serial and TCP modes for connection to one master. Changing of the active setting group is also supported. When the relay uses the RS-485 bus for serial communication, both 2-wire and 4-wire connections are supported. Termination and pull-up/down resistors can be configured with jumpers on the communication card, therefore no external resistors are required.

The relay supports several time synchronization methods with a time-stamping resolution of 1 ms. SNTP and IEC 60870-5-104 can be used in Ethernet based time synchronization and IRIG-B is available with special time synchronization wiring. In addition, the relay supports time synchronization via the serial communication protocols Modbus, DNP3 and IEC 60870-5-101.

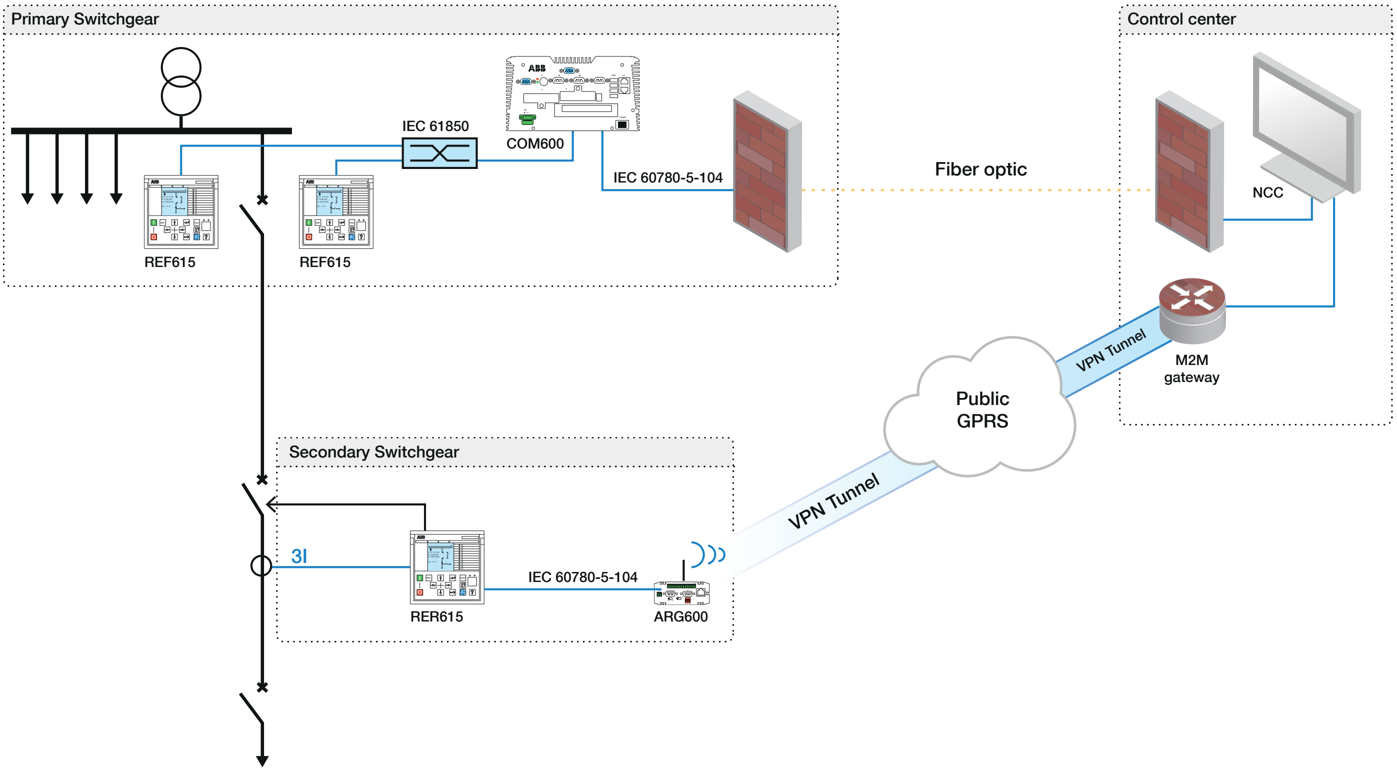


Figure 7. System overview of utility communication

Table 5. Supported station communication interfaces and protocols

| Interfaces/Protocols | Ethernet | | Serial | |
|---|---|---|---|---|
| | 100BASE-TX RJ-45 | 100BASE-FX LC | RS-232/RS-485 | Fibre-optic ST |
| IEC 61850 | • | • | - | - |
| MODBUS RTU/ASCII | - | - | • | • |
| MODBUS TCP/IP | • | • | - | - |
| DNP3 (serial) | - | - | • | • |
| DNP3 TCP/IP | • | • | - | - |
| IEC 60870-5-101 | - | - | • | • |
| IEC 60870-5-104 | • | • | - | - |

• = Supported

## 21. Technical data

Table 6. Dimensions

| Description | Value | |
|---|---|---|
| Width | Frame | 177 mm |
| | Case | 164 mm |
| Height | Frame | 177 mm (4U) |
| | Case | 160 mm |
| Depth | | 201 mm (153 + 48 mm) |
| Weight | Complete protection relay | 4.1 kg |
| | Plug-in unit only | 2.1 kg |

Table 7. Power supply

| Description | Type 1 | Type 2 |
|---|---|---|
| Nominal auxiliary voltage $U_n$ | 100, 110, 120, 220, 240 V AC, 50 and 60 Hz | 24, 30, 48, 60 V DC |
| | 48, 60, 110, 125, 220, 250 V DC | |
| Maximum interruption time in the auxiliary DC voltage without resetting the relay | 50 ms at $U_n$ | |
| Auxiliary voltage variation | 38...110% of $U_n$ (38...264 V AC) | 50...120% of $U_n$ (12...72 V DC) |
| | 80...120% of $U_n$ (38.4...300 V DC) | |
| Start-up threshold | | 19.2 V DC (24 V DC × 80%) |
| Burden of auxiliary voltage supply under quiescent ($P_q$)/operating condition | DC <13.0 W (nominal)/<18.0 W (max.)<br>AC <16.0 W (nominal)/<21.0 W (max.) | DC <13.0 W (nominal)/<18.0 W (max.) |
| Ripple in the DC auxiliary voltage | Max 15% of the DC value (at frequency of 100 Hz) | |
| Fuse type | T4A/250 V | |

The protection relay does not include any batteries as backup power when the auxiliary power goes down. However, the relay configuration and settings, events, disturbance recordings and any critical data stay in the relay's memory because those are saved to a nonvolatile memory. Also, the relay's real-time clock is kept running via a 48-hour capacitor backup.

Table 8. Energizing inputs

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

1) Ordering option for residual current input
2) Residual current and/or phase current

Table 9. Energizing inputs of SIM0001

| Description | | Value |
|---|---|---|
| Voltage sensor input | Rated voltage | 5 kV...38 kV[1] |
| | Continuous voltage withstand | 125 V AC[2] |
| | Input impedance at 50/60 Hz | 1 MΩ[3] |
| Voltage inputs | Rated voltage | 60...210 V AC |
| | Voltage withstand<br>• Continuous<br>• For 10 s | <br>240 V AC<br>360 V AC |
| | Burden at rated voltage | <0.05 VA |

1) This range is covered with a sensor division ratio of 10 000:1 if the input type is set as CVD sensor.
2) Test to this voltage
3) Neutral input impedance is close to zero

Table 10. Energizing inputs of SIM0002/SIM0904

| Description | | Value |
|---|---|---|
| Current sensor input | Rated current voltage (in secondary side) | 75 mV...9000 mV[1)] |
| | Continuous voltage withstand | 125 V |
| | Input impedance at 50/60 Hz | 2...3 MΩ[2)] |
| Voltage sensor input | Rated voltage | 6 kV...30 kV[3)] |
| | Continuous voltage withstand | 50 V |
| | Input impedance at 50/60 Hz | 3 MΩ |

1) Equals the current range of 40...4000 A with a 80 A, 3 mV/Hz Rogowski
2) Depending on the used nominal current (hardware gain)
3) This range is covered (up to 2*rated) with sensor division ratio of 10 000:1

Table 11. Binary inputs

| Description | Value |
|---|---|
| Operating range | ±20% of the rated voltage |
| Rated voltage | 24...250 V DC |
| Current drain | 1.6...1.9 mA |
| Power consumption | 31.0...570.0 mW |
| Threshold voltage | 16...176 V DC |
| Reaction time | 3 ms |

Table 12. Signal output with high make and carry

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

1) X100: SO1
X110: SO1, SO2

Table 13. Signal outputs and IRF output

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

1) X100: IRF,SO2
X110: SO3, SO4

Table 14. Double-pole power outputs with TCS function X100: PO3 and PO4

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

Table 15. Single-pole power output relays X100: PO1 and PO2

| Description | Value |
|---|---|
| Rated voltage | 250 V AC/DC |
| Continuous contact carry | 8 A |
| Make and carry for 3.0 s | 15 A |
| Make and carry for 0.5 s | 30 A |
| Breaking capacity when the control-circuit time constant L/R <40 ms, at 48/110/220 V DC | 5 A/3 A/1 A |
| Minimum contact load | 100 mA at 24 V AC/DC |

Table 16. Front port Ethernet interfaces

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

Table 17. Station communication link, fibre-optic

| Connector | Fibre type[1)] | Wave length | Max. distance | Permitted path attenuation[2)] |
|---|---|---|---|---|
| LC | MM 62.5/125 or 50/125 μm glass fibre core | 1300 nm | 2 km | <8 dB |
| ST | MM 62.5/125 or 50/125 μm glass fibre core | 820...900 nm | 1 km | <11 dB |

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

Table 18. IRIG-B

| Description | Value |
|---|---|
| IRIG time code format | B004, B005[1)] |
| Isolation | 500V 1 min |
| Modulation | Unmodulated |
| Logic level | TTL level |
| Current consumption | 2...4 mA |
| Power consumption | 10...20 mW |

1) According to the 200-04 IRIG standard

Table 19. Degree of protection of flush-mounted protection relay

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

Table 20. Environmental conditions

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

1) Degradation in MTBF and HMI performance outside the temperature range of -25...+55 ºC
2) For relays with an LC communication interface the maximum operating temperature is +70 ºC

Table 21. Electromagnetic compatibility tests

| Description | Type test value | Reference |
| --- | --- | --- |
| 1 MHz/100 kHz burst disturbance test | | IEC 61000-4-18<br>IEC 60255-26<br>IEEE C37.90.1-2012 |
| • Common mode | 2.5 kV | |
| • Differential mode | 2.5 kV | |
| 3 MHz, 10 MHz and 30 MHz burst disturbance test | | IEC 61000-4-18<br>IEC 60255-26, class III |
| • Common mode | 2.5 kV | |
| Electrostatic discharge test | | IEC 61000-4-2<br>IEC 60255-26<br>IEEE C37.90.3-2001 |
| • Contact discharge | 8 kV | |
| • Air discharge | 15 kV | |
| Radio frequency interference test | | |
| | 10 V (rms)<br>f = 150 kHz...80 MHz | IEC 61000-4-6<br>IEC 60255-26, class III |
| | 10 V/m (rms)<br>f = 80...2700 MHz | IEC 61000-4-3<br>IEC 60255-26, class III |
| | 10 V/m<br>f = 900 MHz | ENV 50204<br>IEC 60255-26, class III |
| | 20 V/m (rms)<br>f = 80...1000 MHz | IEEE C37.90.2-2004 |
| Fast transient disturbance test | | IEC 61000-4-4<br>IEC 60255-26<br>IEEE C37.90.1-2012 |
| • All ports | 4 kV | |
| Surge immunity test | | IEC 61000-4-5<br>IEC 60255-26 |
| • Communication | 1 kV, line-to-earth | |
| • Other ports | 4 kV, line-to-earth<br>2 kV, line-to-line | |
| Power frequency (50 Hz) magnetic field immunity test | | IEC 61000-4-8 |
| • Continuous<br>• 1...3 s | 300 A/m<br>1000 A/m | |
| Pulse magnetic field immunity test | 1000 A/m<br>6.4/16 μs | IEC 61000-4-9 |
| Damped oscillatory magnetic field immunity test | | IEC 61000-4-10 |
| • 2 s | 100 A/m | |
| • 1 MHz | 400 transients/s | |
| Power frequency immunity test | Binary inputs only | IEC 61000-4-16<br>IEC 60255-26, class A |
| • Common mode | 300 V rms | |
| • Differential mode | 150 V rms | |

Table 21. Electromagnetic compatibility tests, continued

| Description | Type test value | Reference |
|---|---|---|
| Emission tests | | EN 55011, class A<br>IEC 60255-26<br>CISPR 11<br>CISPR 22 |
| • Conducted | | |
| 0.15...0.50 MHz | <79 dB (μV) quasi peak<br><66 dB (μV) average | |
| 0.5...30 MHz | <73 dB (μV) quasi peak<br><60 dB (μV) average | |
| • Radiated | | |
| 30...230 MHz | <40 dB (μV/m) quasi peak, measured at 10 m distance | |
| 230...1000 MHz | <47 dB (μV/m) quasi peak, measured at 10 m distance | |

Table 22. Insulation tests

| Description | Type test value | Reference |
|---|---|---|
| Dielectric tests | 2 kV, 50 Hz, 1 min<br>500 V, 50 Hz, 1 min, communication | IEC 60255-27 |
| Impulse voltage test | 5 kV, 1.2/50 μs, 0.5 J<br>1 kV, 1.2/50 μs, 0.5 J, communication | IEC 60255-27 |
| Insulation resistance measurements | >100 MΩ, 500 V DC | IEC 60255-27 |
| Protective bonding resistance | <0.1 Ω, 4 A, 60 s | IEC 60255-27 |

Table 23. Mechanical tests

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

Table 24. Environmental tests

| Description | Type test value | Reference |
|---|---|---|
| Dry heat test | • 96 h at +55ºC<br>• 16 h at +85ºC[1)] | IEC 60068-2-2 |
| Cold test | • 96 h at -25ºC<br>• 16 h at -40ºC | IEC 60068-2-1 |
| Damp heat test | • 6 cycles (12 h + 12 h) at +25°C…+55°C, humidity >93% | IEC 60068-2-30 |
| Change of temperature test | • 5 cycles (3 h + 3 h) at -25°C...+55°C | IEC60068-2-14 |
| Storage test | • 96 h at -40ºC<br>• 96 h at +85ºC | IEC 60068-2-1<br>IEC 60068-2-2 |
| Mixed gas corrosion[2)] | Test parameters according to GR-63-CORE (outdoor):<br>• Temp: 30°C ±1<br>• RH: 70% ±2<br>• H2S: 100 ±15 ppb<br>• Cl2: 20 ±3 ppb<br>• NO2: 200 ±30 ppb<br>• SO2: 200 ±30 ppb | IEC 60068-2-60, test procedure 2 |
| Salt mist test[2)] | Severity level 2 | IEC 60068-2-52, Test Kb |

1) For relays with an LC communication interface the maximum operating temperature is +70ºC
2) For relays with optional conformal coating (the chosen coating is recognized by Underwriters Laboratories (UL) and compliant with the US military specification MIL-I-46058C, IPC-CC-830 (Institute of Printed Circuits) and the RoHS (Restriction of Hazardous Substances) directive 2002/95/EC)

Table 25. Product safety

| Description | Reference |
|---|---|
| LV directive | 2006/95/EC |
| Standard | EN 60255-27 (2013)<br>EN 60255-1 (2009) |

Table 26. EMC compliance

| Description | Reference |
|---|---|
| EMC directive | 2004/108/EC |
| Standard | EN 60255-26 (2013) |

Table 27. RoHS compliance

| Description |
|---|
| Complies with RoHS directive 2002/95/EC |

## Protection functions

Table 28. Three-phase non-directional overcurrent protection ((F)PHxPTOC)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | (F)PHLPTOC | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| | PHHPTOC and PHIPTOC | ±1.5% of set value or ±0.002 × $I_n$ (at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value (at currents in the range of 10…40 × $I_n$) | | |
| Start time [1)2)] | | Minimum | Typical | Maximum |
| | PHIPTOC:<br>$I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 16 ms<br>11 ms | 19 ms<br>12 ms | 23 ms<br>14 ms |
| | PHHPTOC and (F)PHLPTOC:<br>$I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3)]<br>±5.0% of the theoretical value or ±40 ms [3)4)] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression<br>P-to-P+backup: No suppression | | |

1) Set *Operate delay time* = 0,02 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × In, 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
4) Valid for FPHLPTOC

Table 29. Three-phase non-directional overcurrent protection ((F)PHxPTOC) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | (F)PHLPTOC | 0.05...5.00 × $I_n$ | 0.01 |
| | PHHPTOC | 0.10...40.00 × $I_n$ | 0.01 |
| | PHIPTOC | 1.00...40.00 × $I_n$ | 0.01 |
| Time multiplier | (F)PHLPTOC | 0.05...15.00 | 0.01 |
| | PHHPTOC | 0.05...15.00 | 0.01 |
| Operate delay time | (F)PHLPTOC | 40...200000 ms | 10 |
| | PHHPTOC | 40...200000 ms | 10 |
| | PHIPTOC | 20...200000 ms | 10 |
| Operating curve type[1)] | (F)PHLPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35, -36, -37, -38, -39 | |
| | PHHPTOC | Definite or inverse time<br>Curve type: 1, 3, 5, 9, 10, 12, 15, 17 | |
| | PHIPTOC | Definite time | |

1) For further reference, see the Operation characteristics table

Table 30. Three-phase directional overcurrent protection ((F)DPHxPDOC)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the current/voltage measured: $f_n$ ±2 Hz | | |
| | (F)DPHLPDOC | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle: ±2° | | |
| | DPHHPDOC | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle: ±2° | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2.0 × set *Start value* | 39 ms | 43 ms | 47 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3)]<br>±5.0% of the theoretical value or ±40 ms [3)4)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

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

Table 31. Three-phase directional overcurrent protection ((F)DPHxPDOC) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | (F)DPHLPDOC | 0.05...5.00 × $I_n$ | 0.01 |
| | DPHHPDOC | 0.10...40.00 × $I_n$ | 0.01 |
| Time multiplier | DPHxPDOC | 0.05...15.00 | 0.01 |
| Operate delay time | DPHxPDOC | 40...200000 ms | 10 |
| Directional mode | DPHxPDOC | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Characteristic angle | DPHxPDOC | -179...180° | 1 |
| Operating curve type[1] | (F)DPHLPDOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35, -36, -37, -38, -39 | |
| | DPHHPDOC | Definite or inverse time<br>Curve type: 1, 3, 5, 9, 10, 12, 15, 17 | |

1) For further reference, see the Operating characteristics table

Table 32. Non-directional earth-fault protection ((F)EFxPTOC)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | (F)EFLPTOC | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| | EFHPTOC<br>and<br>EFIPTOC | ±1.5% of set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$) | | |
| Start time [1)2)] | | Minimum | Typical | Maximum |
| | EFIPTOC:<br>$I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 16 ms<br>11 ms | 19 ms<br>12 ms | 23 ms<br>14 ms |
| | EFHPTOC and (F)EFLPTOC:<br>$I_{Fault}$ = 2 × set *Start value* | 23 ms | 26 ms | 29 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3)]<br>±5.0% of the theoretical value or ±40 ms [3)4)] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 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 × $I_n$, *Start value* multiples in range of 1.5...20
4) Valid for FEFLPTOC

Table 33. Non-directional earth-fault protection ((F)EFxPTOC) main settings

| Parameter | Function | Value (Range) | Step |
| --- | --- | --- | --- |
| Start value | (F)EFLPTOC | 0.010...5.000 × $I_n$ | 0.005 |
| | EFHPTOC | 0.10...40.00 × $I_n$ | 0.01 |
| | EFIPTOC | 1.00...40.00 × $I_n$ | 0.01 |
| Time multiplier | (F)EFLPTOC and EFHPTOC | 0.05...15.00 | 0.01 |
| Operate delay time | (F)EFLPTOC and EFHPTOC | 40...200000 ms | 10 |
| | EFIPTOC | 40...200000 ms | 10 |
| Operating curve type[1)] | (F)EFLPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35, -36, -37, -38, -39 | |
| | EFHPTOC | Definite or inverse time<br>Curve type: 1, 3, 5, 9, 10, 12, 15, 17 | |
| | EFIPTOC | Definite time | |

1) For further reference, see the Operation characteristics table

Table 34. Directional earth-fault protection ((F)DEFxPDEF)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ ±2 Hz | | |
| | (F)DEFLPDEF | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Voltage<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| | DEFHPDEF | Current:<br>±1.5% of the set value or ±0.002 × $I_n$<br>(at currents in the range of 0.1…10 × $I_n$)<br>±5.0% of the set value<br>(at currents in the range of 10…40 × $I_n$)<br>Voltage:<br>±1.5% of the set value or ±0.002 × $U_n$<br>Phase angle:<br>±2° | | |
| Start time [1)2)] | | Minimum | Typical | Maximum |
| | DEFHPDEF<br>$I_{Fault}$ = 2 × set *Start value* | 42 ms | 46 ms | 49 ms |
| | (F)DEFLPDEF<br>$I_{Fault}$ = 2 × set *Start value* | 58 ms | 62 ms | 66 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <30 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms [3)]<br>±5.0% of the theoretical value or ±40 ms [3)4)] | | |
| Suppression of harmonics | | RMS: No suppression<br>DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>Peak-to-Peak: No suppression | | |

1) Set *Operate delay time* = 0.06 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × $I_n$, $f_n$ = 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 × $I_n$, *Start value* multiples in range of 1.5...20
4) Valid for FDEFLPDEF

Table 35. Directional earth-fault protection ((F)DEFxPDEF) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | (F)DEFLPDEF | 0.010...5.000 × $I_n$ | 0.005 |
| | DEFHPDEF | 0.10...40.00 × $I_n$ | 0.01 |
| Directional mode | (F)DEFxPDEF | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Time multiplier | (F)DEFLPDEF | 0.05...15.00 | 0.01 |
| | DEFHPDEF | 0.05...15.00 | 0.01 |
| Operate delay time | (F)DEFLPDEF | 60...200000 ms | 10 |
| | DEFHPDEF | 40...200000 ms | 10 |
| Operating curve type[1)] | (F)DEFLPDEF | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35, -36, -37, -38, -39 | |
| | DEFHPDEF | Definite or inverse time<br>Curve type: 1, 3, 5, 15, 17 | |
| Operation mode | (F)DEFxPDEF | 1 = Phase angle<br>2 = IoSin<br>3 = IoCos<br>4 = Phase angle 80<br>5 = Phase angle 88 | - |

1) For further reference, see the Operating characteristics table

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

| Characteristic | Value |
|---|---|
| Operation accuracy (Uo criteria with transient protection) | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × Uo |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5 |

Table 37. Transient/intermittent earth-fault protection (INTRPTEF) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Directional mode | INTRPTEF | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Operate delay time | INTRPTEF | 40...1200000 ms | 10 |
| Voltage start value | INTRPTEF | 0.05...0.50 × $U_n$ | 0.01 |
| Operation mode | INTRPTEF | 1 = Intermittent EF<br>2 = Transient EF | - |
| Peak counter limit | INTRPTEF | 2...20 | 1 |
| Min operate current | INTRPTEF | 0.01...1.00 × $I_n$ | 0.01 |

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

| Characteristic | Value | | |
|---|---|---|---|
| Operation accuracy[1)] | At the frequency $f = f_n$ | | |
| | ±1.0% or ±0.01 mS<br>(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) Uo = 1.0 × Un
2) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

Table 39. Admittance-based earth-fault protection (EFPADM) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Voltage start value | EFPADM | 0.01...2.00 × $U_n$ | 0.01 |
| Directional mode | EFPADM | 1 = Non-directional<br>2 = Forward<br>3 = Reverse | - |
| Operation mode | EFPADM | 1 = Yo<br>2 = Go<br>3 = Bo<br>4 = Yo, Go<br>5 = Yo, Bo<br>6 = Go, Bo<br>7 = Yo, Go, Bo | - |
| Operate delay time | EFPADM | 60...200000 ms | 10 |
| Circle radius | EFPADM | 0.05...500.00 mS | 0.01 |
| Circle conductance | EFPADM | -500.00...500.00 mS | 0.01 |
| Circle susceptance | EFPADM | -500.00...500.00 mS | 0.01 |
| Conductance forward | EFPADM | -500.00...500.00 mS | 0.01 |
| Conductance reverse | EFPADM | -500.00...500.00 mS | 0.01 |
| Susceptance forward | EFPADM | -500.00...500.00 mS | 0.01 |
| Susceptance reverse | EFPADM | -500.00...500.00 mS | 0.01 |
| Conductance tilt Ang | EFPADM | -30...30° | 1 |
| Susceptance tilt Ang | EFPADM | -30...30° | 1 |

**Table 40. Wattmetric-based earth-fault protection (WPWDE)**

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current and voltage:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Power:<br>±3% of the set value or ±0.002 × $P_n$ |
| Start time [1)2)] | Typically 63 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = n × $f_n$, where n = 2,3,4,5,… |

1) Io varied during the test, Uo = 1.0 × $U_n$ = phase-to-earth voltage during earth fault in compensated or unearthed network, the residual power value before fault = 0.0 pu, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

**Table 41. Wattmetric-based earth-fault protection (WPWDE) main settings**

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Directional mode | WPWDE | 2 = Forward<br>3 = Reverse | - |
| Current start value | WPWDE | 0.010...5.000 × $I_n$ | 0.001 |
| Voltage start value | WPWDE | 0.010...1.000 × $U_n$ | 0.001 |
| Power start value | WPWDE | 0.003...1.000 × $P_n$ | 0.001 |
| Reference power | WPWDE | 0.050...1.000 × $P_n$ | 0.001 |
| Characteristic angle | WPWDE | -179...180° | 1 |
| Time multiplier | WPWDE | 0.05...2.00 | 0.01 |
| Operating curve type[1)] | WPWDE | Definite or inverse time<br>Curve type: 5, 15, 20 | |
| Operate delay time | WPWDE | 60...200000 ms | 10 |
| Min operate current | WPWDE | 0.010...1.000 × $I_n$ | 0.001 |
| Min operate voltage | WPWDE | 0.01...1.00 × $U_n$ | 0.01 |

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

Table 42. Harmonics-based earth-fault protection (HAEFPTOC)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±5% of the set value or ±0.004 × $I_n$ |
| Start time [1)2)] | Typically 77 ms |
| Reset time | Typically 40 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |
| Operate time accuracy in IDMT mode [3)] | ±5.0% of the set value or ±20 ms |
| Suppression of harmonics | -50 dB at f = $f_n$ |
| | -3 dB at f = 13 × $f_n$ |

1) Fundamental frequency current = 1.0 × $I_n$, harmonics current before fault = 0.0 × $I_n$, harmonics fault current 2.0 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 2...20

Table 43. Harmonics-based earth-fault protection (HAEFPTOC) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | HAEFPTOC | 0.05...5.00 × $I_n$ | 0.01 |
| Time multiplier | HAEFPTOC | 0.05...15.00 | 0.01 |
| Operate delay time | HAEFPTOC | 100...200000 ms | 10 |
| Operating curve type[1)] | HAEFPTOC | Definite or inverse time<br>Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 | |
| Minimum operate time | HAEFPTOC | 100...200000 ms | 10 |

1) For further reference, see Operation characteristics table

Table 44. Multifrequency admittance-based earth-fault protection (MFADPSDE)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage:<br>$f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Start time[1)] | Typically 35 ms |
| Reset time | Typically 40 ms |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

1) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

Table 45. Multifrequency admittance-based earth-fault protection (MFADPSDE) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Directional mode | MFADPSDE | 2 = Forward<br>3 = Reverse | - |
| Voltage start value | MFADPSDE | 0.01...1.00 × $U_n$ | 0.01 |
| Operate delay time | MFADPSDE | 60...1200000 ms | 10 |
| Operating quantity | MFADPSDE | 1 = Adaptive<br>2 = Amplitude<br>3 = Resistive | - |
| Min operate current | MFADPSDE | 0.005...5.000 × $I_n$ | 0.001 |
| Operation mode | MFADPSDE | 1 = Intermittent EF<br>3 = General EF<br>4 = Alarming EF | - |
| Peak counter limit | MFADPSDE | 2...20 | 1 |

Table 46. Negative-sequence overcurrent protection (NSPTOC)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured current: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 × $I_n$ | | |
| Start time 1)2) | | Minimum | Typical | Maximum |
| | $I_{Fault}$ = 2 × set *Start value*<br>$I_{Fault}$ = 10 × set *Start value* | 23 ms<br>15 ms | 26 ms<br>18 ms | 28 ms<br>20 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms 3) | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) Negative sequence current before fault = 0.0, $f_n$ = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × $I_n$, *Start value* multiples in range of 1.5...20

Table 47. Negative-sequence overcurrent protection (NSPTOC) main settings

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

1) For further reference, see the Operation characteristics table

Table 48. Phase discontinuity protection (PDNSPTOC)

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

Table 49. Phase discontinuity protection (PDNSPTOC) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PDNSPTOC | 10...100% | 1 |
| Operate delay time | PDNSPTOC | 100...30000 ms | 1 |
| Min phase current | PDNSPTOC | 0.05...0.30 × $I_n$ | 0.01 |

Table 50. Residual overvoltage protection (ROVPTOV)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 2 × set *Start value* | 48 ms | 51 ms | 54 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

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

Table 51. Residual overvoltage protection (ROVPTOV) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | ROVPTOV | 0.010...1.000 × $U_n$ | 0.001 |
| Operate delay time | ROVPTOV | 40...300000 ms | 1 |

Table 52. Three-phase undervoltage protection (PHPTUV)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 0.9 × set *Start value* | 62 ms | 66 ms | 70 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) *Start value* = 1.0 × $U_n$, Voltage before fault = 1.1 × $U_n$, $f_n$ = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

Table 53. Three-phase undervoltage protection (PHPTUV) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PHPTUV | 0.05...1.20 × $U_n$ | 0.01 |
| Time multiplier | PHPTUV | 0.05...15.00 | 0.01 |
| Operate delay time | PHPTUV | 60...300000 ms | 10 |
| Operating curve type[1)] | PHPTUV | Definite or inverse time<br>Curve type: 5, 15, 21, 22, 23 | |

1) For further reference, see the Operation characteristics table

Table 54. Three-phase overvoltage protection (PHPTOV)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 1.1 × set *Start value* | 23 ms | 27 ms | 31 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Operate time accuracy in inverse time mode | | ±5.0% of the theoretical value or ±20 ms[3)] | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

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

Table 55. Three-phase overvoltage protection (PHPTOV) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PHPTOV | 0.05...1.60 × $U_n$ | 0.01 |
| Time multiplier | PHPTOV | 0.05...15.00 | 0.01 |
| Operate delay time | PHPTOV | 40...300000 ms | 10 |
| Operating curve type[1] | PHPTOV | Definite or inverse time<br>Curve type: 5, 15, 17, 18, 19, 20 | |

1) For further reference, see the Operation characteristics table

Table 56. Positive-sequence undervoltage protection (PSPTUV)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 0.99 × set *Start value*<br>$U_{Fault}$ = 0.9 × set *Start value* | 52 ms<br>44 ms | 55 ms<br>47 ms | 58 ms<br>50 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Depends on the set *Relative hysteresis* | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

1) *Start value* = 1.0 × $U_n$, positive-sequence voltage before fault = 1.1 × $U_n$, $f_n$ = 50 Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 57. Positive-sequence undervoltage protection (PSPTUV) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | PSPTUV | 0.010...1.200 × $U_n$ | 0.001 |
| Operate delay time | PSPTUV | 40...120000 ms | 10 |
| Voltage block value | PSPTUV | 0.01...1.00 × $U_n$ | 0.01 |

Table 58. Negative-sequence overvoltage protection (NSPTOV)

| Characteristic | | Value | | |
|---|---|---|---|---|
| Operation accuracy | | Depending on the frequency of the voltage measured: $f_n$ | | |
| | | ±1.5% of the set value or ±0.002 × $U_n$ | | |
| Start time[1)2)] | | Minimum | Typical | Maximum |
| | $U_{Fault}$ = 1.1 × set *Start value*<br>$U_{Fault}$ = 2.0 × set *Start value* | 33 ms<br>24 ms | 35 ms<br>26 ms | 37 ms<br>28 ms |
| Reset time | | Typically 40 ms | | |
| Reset ratio | | Typically 0.96 | | |
| Retardation time | | <35 ms | | |
| Operate time accuracy in definite time mode | | ±1.0% of the set value or ±20 ms | | |
| Suppression of harmonics | | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… | | |

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

Table 59. Negative-sequence overvoltage protection (NSPTOV) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | NSPTOV | 0.010...1.000 × $U_n$ | 0.001 |
| Operate delay time | NSPTOV | 40...120000 ms | 1 |

Table 60. Frequency protection (FRPFRQ)

| Characteristic | | Value |
|---|---|---|
| Operation accuracy | f>/f< | ±5 mHz |
| | df/dt | ±50 mHz/s (in range \|df/dt\| <5 Hz/s)<br>±2.0% of the set value (in range 5 Hz/s < \|df/dt\| < 15 Hz/s) |
| Start time | f>/f< | <80 ms |
| | df/dt | <120 ms |
| Reset time | | <150 ms |
| Operate time accuracy | | ±1.0% of the set value or ±30 ms |

Table 61. Frequency protection (FRPFRQ) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation mode | FRPFRQ | 1 = Freq<<br>2 = Freq><br>3 = df/dt<br>4 = Freq< + df/dt<br>5 = Freq> + df/dt<br>6 = Freq< OR df/dt<br>7 = Freq> OR df/dt | - |
| Start value Freq> | FRPFRQ | 0.9000...1.2000 × $f_n$ | 0.0001 |
| Start value Freq< | FRPFRQ | 0.8000...1.1000 × $f_n$ | 0.0001 |
| Start value df/dt | FRPFRQ | -0.2000...0.2000 × $f_n$/s | 0.0001 |
| Operate Tm Freq | FRPFRQ | 80...200000 ms | 10 |
| Operate Tm df/dt | FRPFRQ | 120...200000 ms | 10 |

Table 62. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | Current measurement: ±1.5% of the set value or ±0.002 × $I_n$ (at currents in the range of 0.01...4.00 × $I_n$) |
| Operate time accuracy[1)] | ±2.0% of the theoretical value or ±0.50 s |

1) Overload current > 1.2 × Operate level temperature

Table 63. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Env temperature Set | T1PTTR | -50...100°C | 1 |
| Current reference | T1PTTR | 0.05...4.00 × $I_n$ | 0.01 |
| Temperature rise | T1PTTR | 0.0...200.0°C | 0.1 |
| Time constant | T1PTTR | 60...60000 s | 1 |
| Maximum temperature | T1PTTR | 20.0...200.0°C | 0.1 |
| Alarm value | T1PTTR | 20.0...150.0°C | 0.1 |
| Reclose temperature | T1PTTR | 20.0...150.0°C | 0.1 |
| Current multiplier | T1PTTR | 1...5 | 1 |
| Initial temperature | T1PTTR | -50.0...100.0°C | 0.1 |

Table 64. Circuit breaker failure protection (CCBRBRF)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $I_n$ |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Reset time | Typically 40 ms |
| Retardation time | <20 ms |

Table 65. Circuit breaker failure protection (CCBRBRF) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Current value | CCBRBRF | 0.05...2.00 × $I_n$ | 0.01 |
| Current value Res | CCBRBRF | 0.05...2.00 × $I_n$ | 0.01 |
| CB failure mode | CCBRBRF | 1 = Current<br>2 = Breaker status<br>3 = Both | - |
| CB fail trip mode | CCBRBRF | 1 = Off<br>2 = Without check<br>3 = Current check | - |
| Retrip time | CCBRBRF | 0...60000 ms | 10 |
| CB failure delay | CCBRBRF | 0...60000 ms | 10 |
| CB fault delay | CCBRBRF | 0...60000 ms | 10 |

Table 66. Three-phase inrush detector (INRPHAR)

| Characteristic | Value |
|---|---|
| Operation accuracy | At the frequency f = $f_n$ |
| | Current measurement:<br>±1.5% of the set value or ±0.002 × $I_n$<br>Ratio I2f/I1f measurement:<br>±5.0% of the set value |
| Reset time | +35 ms / -0 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy | +35 ms / -0 ms |

Table 67. Three-phase inrush detector (INRPHAR) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | INRPHAR | 5...100% | 1 |
| Operate delay time | INRPHAR | 20...60000 ms | 1 |

Table 68. Multipurpose protection (MAPGAPC)

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.0% of the set value or ±20 ms |

Table 69. Multipurpose protection (MAPGAPC) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Start value | MAPGAPC | -10000.0...10000.0 | 0.1 |
| Operate delay time | MAPGAPC | 0...200000 ms | 100 |
| Operation mode | MAPGAPC | 1 = Over<br>2 = Under | - |

Table 70. Load-shedding and restoration (LSHDPFRQ)

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

Table 71. Load-shedding and restoration (LSHDPFRQ) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Load shed mode | LSHDPFRQ | 1 = Freq<<br>6 = Freq< OR df/dt<br>8 = Freq< AND df/dt | - |
| Restore mode | LSHDPFRQ | 1 = Disabled<br>2 = Auto<br>3 = Manual | - |
| Start value Freq | LSHDPFRQ | 0.800...1.200 × $f_n$ | 0.001 |
| Start value df/dt | LSHDPFRQ | -0.200...-0.005 × $f_n$/s | 0.005 |
| Operate Tm Freq | LSHDPFRQ | 80...200000 ms | 10 |
| Operate Tm df/dt | LSHDPFRQ | 120...200000 ms | 10 |
| Restore start Val | LSHDPFRQ | 0.800...1.200 × $f_n$ | 0.001 |
| Restore delay time | LSHDPFRQ | 80...200000 ms | 10 |

Table 72. Fault locator (SCEFRFLO)

| Characteristic | Value |
|---|---|
| Measurement accuracy | At the frequency $f = f_n$<br><br>Impedance:<br>±2.5% or ±0.25 Ω<br><br>Distance:<br>±2.5% or ±0.16 km/0.1 mile<br><br>XC0F_CALC:<br>±2.5% or ±50 Ω<br><br>IFLT_PER_ILD:<br>±5% or ±0.05 |

Table 73. Fault locator (SCEFRFLO) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Z Max phase load | SCEFRFLO | 1.0...10000.00 Ω | 0.1 |
| Ph leakage Ris | SCEFRFLO | 20...1000000 Ω | 1 |
| Ph capacitive React | SCEFRFLO | 10...1000000 Ω | 1 |
| R1 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| X1 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| R0 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| X0 line section A | SCEFRFLO | 0.000...1000.000 Ω/pu | 0.001 |
| Line Len section A | SCEFRFLO | 0.000...1000.000 pu | 0.001 |

Table 74. Operation characteristics

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

## Power quality functions

Table 75. Voltage variation (PHQVVR)

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5% of the set value or ±0.2% of reference voltage |
| Reset ratio | Typically 0.96 (Swell), 1.04 (Dip, Interruption) |

Table 76. Voltage variation (PHQVVR) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Voltage dip set 1 | PHQVVR | 10.0...100.0% | 0.1 |
| Voltage dip set 2 | PHQVVR | 10.0...100.0% | 0.1 |
| Voltage dip set 3 | PHQVVR | 10.0...100.0% | 0.1 |
| Voltage swell set 1 | PHQVVR | 100.0...140.0% | 0.1 |
| Voltage swell set 2 | PHQVVR | 100.0...140.0% | 0.1 |
| Voltage swell set 3 | PHQVVR | 100.0...140.0% | 0.1 |
| Voltage Int set | PHQVVR | 0.0...100.0% | 0.1 |
| VVa Dur Max | PHQVVR | 100...3600000 ms | 100 |

Table 77. Voltage unbalance (VSQVUB)

| Characteristic | Value |
|---|---|
| Operation accuracy | ±1.5% of the set value or ±0.002 × $U_n$ |
| Reset ratio | Typically 0.96 |

Table 78. Voltage unbalance (VSQVUB) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Operation | VSQVUB | 1 = on<br>5 = off | - |
| Unb detection method | VSQVUB | 1 = Neg Seq<br>2 = Zero Seq<br>3 = Neg to Pos Seq<br>4 = Zero to Pos Seq<br>5 = Ph vectors Comp | - |

## Control functions

Table 79. Autoreclosing (DARREC)

| Characteristic | Value |
|---|---|
| Operate time accuracy | ±1.0% of the set value or ±20 ms |

Table 80. Synchronism and energizing check (SECRSYN)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±1 Hz |
| | Voltage:<br>±3.0% of the set value or ±0.01 × $U_n$<br>Frequency:<br>±10 mHz<br>Phase angle:<br>±3° |
| Reset time | <50 ms |
| Reset ratio | Typically 0.96 |
| Operate time accuracy in definite time mode | ±1.0% of the set value or ±20 ms |

Table 81. Synchronism and energizing check (SECRSYN) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Live dead mode | SECRSYN | -1 = Off<br>1 = Both Dead<br>2 = Live L, Dead B<br>3 = Dead L, Live B<br>4 = Dead Bus, L Any<br>5 = Dead L, Bus Any<br>6 = One Live, Dead<br>7 = Not Both Live | - |
| Difference voltage | SECRSYN | 0.01...0.50 × $U_n$ | 0.01 |
| Difference frequency | SECRSYN | 0.0002...0.1000 × $f_n$ | 0.0001 |
| Difference angle | SECRSYN | 5...90° | 1 |
| Synchrocheck mode | SECRSYN | 1 = Off<br>2 = Synchronous<br>3 = Asynchronous | - |
| Dead line value | SECRSYN | 0.1...0.8 × $U_n$ | 0.1 |
| Live line value | SECRSYN | 0.2...1.0 × $U_n$ | 0.1 |
| Max energizing V | SECRSYN | 0.50...1.15 × $U_n$ | 0.01 |
| Control mode | SECRSYN | 1 = Continuous<br>2 = Command | - |
| Close pulse | SECRSYN | 200...60000 ms | 10 |
| Phase shift | SECRSYN | -180...180° | 1 |
| Minimum Syn time | SECRSYN | 0...60000 ms | 10 |
| Maximum Syn time | SECRSYN | 100...6000000 ms | 10 |
| Energizing time | SECRSYN | 100...60000 ms | 10 |
| Closing time of CB | SECRSYN | 40...250 ms | 10 |

Table 82. Automatic transfer switch (ATSABTC)

| Characteristic | Value |
| --- | --- |
| Operation time accuracy | ±1.0% of the set value or ±20 ms |

Table 83. Automatic transfer switch (ATSABTC) main settings

| Parameter | Function | Value (Range) | Step |
| --- | --- | --- | --- |
| Operation | ATSABTC | 1=on<br>5=off | |
| Main bus priority | ATSABTC | 1=Bus 1<br>2=Bus 2 | |
| Operate delay CB tr | ATSABTC | 0...120000 ms | 10 ms |
| Transfer dead time | ATSABTC | 0...120000 ms | 10 ms |
| Reconnection delay | ATSABTC | 0...300000 ms | 10 ms |

## Condition monitoring functions

Table 84. Circuit breaker condition monitoring (SSCBR)

| Characteristic | Value |
|---|---|
| Current measuring accuracy | At the frequency $f = f_n$ |
| | ±1.5% or ±0.002 × $I_n$ (at currents in the range of 0.1…10 × $I_n$)<br>±5.0% (at currents in the range of 10…40 × $I_n$) |
| Operate time accuracy | ±1.0% of the set value or ±20 ms |
| Traveling time measurement | ±10 ms |

Table 85. Fuse failure supervision (SEQSPVC)

| Characteristic | | Value | |
|---|---|---|---|
| Operate time[1)] | NPS function | $U_{Fault}$ = 1.1 × set *Neg Seq voltage Lev* | <33 ms |
| | | $U_{Fault}$ = 5.0 × set *Neg Seq voltage Lev* | <18 ms |
| | Delta function | ΔU = 1.1 × set *Voltage change rate* | <30 ms |
| | | ΔU = 2.0 × set *Voltage change rate* | <24 ms |

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

Table 86. Runtime counter for machines and devices (MDSOPT)

| Description | Value |
|---|---|
| Motor runtime measurement accuracy[1)] | ±0.5% |

1) Of the reading, for a stand-alone relay, without time synchronization

Table 87. Voltage presence (PHSVPR)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured voltage: $f_n$ ±2 Hz |
| | ±1.5% of the set value or ±0.002 × $U_n$ |
| Operation time accuracy | ±1.0% of the set value or ±20 ms |

Table 88. Voltage presence (PHSVPR) main settings

| Parameter | Function | Value (Range) | Step |
|---|---|---|---|
| Num of phases | PHSVPR | 1=1 out of 3<br>2=2 out of 3<br>3=3 out of 3 | |
| V live value | PHSVPR | 0.2...1.0 × $U_n$ | 0.1 |
| V live time | PHSVPR | 40...10000 ms | 1 ms |
| V dead value | PHSVPR | 0.1...0.8 × $U_n$ | 0.1 |
| V dead time | PHSVPR | 40...10000 ms | 1 ms |

## Measurement functions

Table 89. Three-phase current measurement (CMMXU)

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

Table 90. Sequence current measurement (CSMSQI)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the measured current: f/$f_n$ = ±2 Hz |
| | ±1.0% or ±0.002 × $I_n$<br>at currents in the range of 0.01...4.00 × $I_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

Table 91. Residual current measurement (RESCMMXU)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the current measured: f/$f_n$ = ±2 Hz |
| | ±0.5% or ±0.002 × $I_n$<br>at currents in the range of 0.01...4.00 × $I_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,…<br>RMS: No suppression |

Table 92. Three-phase voltage measurement (VMMXU)

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

Table 93. Sequence voltage measurement (VSMSQI)

| Characteristic | Value |
|---|---|
| Operation accuracy | Depending on the frequency of the voltage measured: $f_n$ ±2 Hz<br>At voltages in range 0.01…1.15 × $U_n$ |
| | ±1.0% or ±0.002 × $U_n$ |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

Table 94. Three-phase power and energy measurement (PEMMXU)

| Characteristic | Value |
| --- | --- |
| Operation accuracy | At all three currents in range 0.10…1.20 × $I_n$<br>At all three voltages in range 0.50…1.15 × $U_n$<br>At the frequency $f_n$ ±1 Hz |
| | ±1.5% for apparent power S<br>±1.5% for active power P and active energy[1)]<br>±1.5% for reactive power Q and reactive energy[2)]<br>±0.015 for power factor |
| Suppression of harmonics | DFT: -50 dB at f = n × $f_n$, where n = 2, 3, 4, 5,… |

1) |PF| >0.5 which equals |cosφ| >0.5
2) |PF| <0.86 which equals |sinφ| >0.5

Table 95. Single-phase power and energy measurement (SPEMMXU)

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

Table 96. Frequency measurement (FMMXU)

| Characteristic | Value |
| --- | --- |
| Operation accuracy | ±10 mHz<br>(in measurement range 35...75 Hz) |

## 22. Local HMI

The relay is available with one large display. The LCD display offers 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 display includes a user-configurable single line diagram (SLD) with position indication for the associated primary equipment. Depending on the chosen standard configuration, the relay 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 relay. When the relay is in the local mode, it can be operated only by using the local front panel user interface. When the relay is in the remote mode, it can execute commands sent from a remote location. The relay 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 relays are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.

Further, it offers four functional user-configurable push buttons. These buttons can be used, for example, to change setting groups and the non-reclose mode or to block protection functions.


**Figure 8. Large display**

**Table 97. Large display**

| Character size[1)] | Rows in the view | Characters per row |
|---|---|---|
| Small, mono-spaced (6 × 12 pixels) | 10 | 20 |
| Large, variable width (13 × 14 pixels) | 7 | 8 or more |

1) Depending on the selected language

## 23. Mounting methods

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

Further, the relays can be mounted in any standard 19” instrument cabinet by means of 19” mounting panels available with cut-outs for one or two relays.

Mounting methods

- Flush mounting
- Semi-flush mounting
- Semi-flush mounting in a 25° tilt
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame

Panel cut-out for flush mounting
- Height: 161.5 ±1 mm
- Width: 165.5 ±1 mm

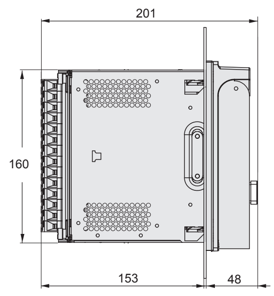


Figure 9. Flush mounting

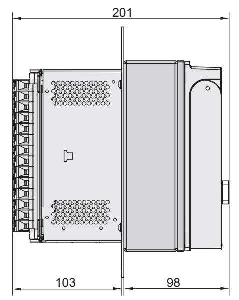


Figure 10. Semi-flush mounting

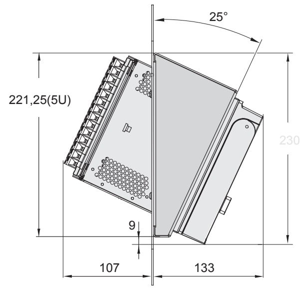


Figure 11. Semi-flush mounting in a 25º tilt

## 24. Relay case and plug-in unit

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

## 25. Selection and ordering data

Use the ABB Library to access the selection and ordering information and to generate the order number.

## 26. Accessories and ordering data

**Table 98. Mounting accessories**

| Item | Order number |
|---|---|
| Semi-flush mounting kit | 1MRS050696 |
| Wall mounting kit | 1MRS050697 |
| Inclined semi-flush mounting kit | 1MRS050831 |
| 19” rack mounting kit with cut-out for one relay | 1MRS050694 |
| 19” rack mounting kit with cut-out for two relays | 1MRS050695 |

## 27. Tools

The protection relay is delivered as a preconfigured unit. The default parameter setting values can be changed from the front-panel user interface (local HMI), the Web browser-based user interface (Web HMI) or Protection and Control IED Manager PCM600 in combination with the relay-specific connectivity package.

PCM600 offers extensive relay configuration functions. For example, depending on the protection relay, the relay signals, application, graphical display and single-line diagram, and IEC 61850 communication, including horizontal GOOSE communication, can be modified with PCM600.

When the Web HMI is used, the protection relay can be accessed either locally or remotely using a Web browser (Internet Explorer). For security reasons, the Web HMI is disabled by default but it can be enabled via the local HMI. The Web HMI functionality can be limited to read-only access.

The relay connectivity package is a collection of software and specific relay information, which enables system products and tools to connect and interact with the protection relay. The connectivity packages reduce the risk of errors in system integration, minimizing device configuration and setup times. Further, the connectivity packages for protection relays of this product series include a flexible update tool for adding one additional local HMI language to the protection relay. The update tool is activated using PCM600, and it enables multiple updates of the additional HMI language, thus offering flexible means for possible future language updates.

Table 99. Tools

| Description | Version |
|---|---|
| PCM600 | 2.9 or later |
| Web browser | IE 8.0, IE 9.0, IE 10.0 or IE 11.0 |
| RER615 Connectivity Package | 2.0 or later |

Table 100. Supported functions

| Function | Web HMI | PCM600 |
|---|---|---|
| Relay parameter setting | ● | ● |
| Saving of relay parameter settings in the relay | ● | ● |
| Signal monitoring | ● | ● |
| Disturbance recorder handling | ● | ● |
| Alarm LED viewing | ● | ● |
| Access control management | ● | ● |
| Relay signal configuration (Signal Matrix) | - | ● |
| Modbus® communication configuration (communication management) | - | ● |
| DNP3 communication configuration (communication management) | - | ● |
| IEC 60870-5-101/104 communication configuration (communication management) | - | ● |
| Saving of relay parameter settings in the tool | - | ● |
| Disturbance record analysis | - | ● |
| XRIO parameter export/import | ● | ● |
| Graphical display configuration | - | ● |
| Application configuration | - | ● |
| IEC 61850 communication configuration, GOOSE (communication configuration) | - | ● |
| Phasor diagram viewing | ● | - |
| Event viewing | ● | ● |
| Saving of event data on the user's PC | ● | ● |
| Online monitoring | - | ● |

● = Supported

## 28. Connection diagrams

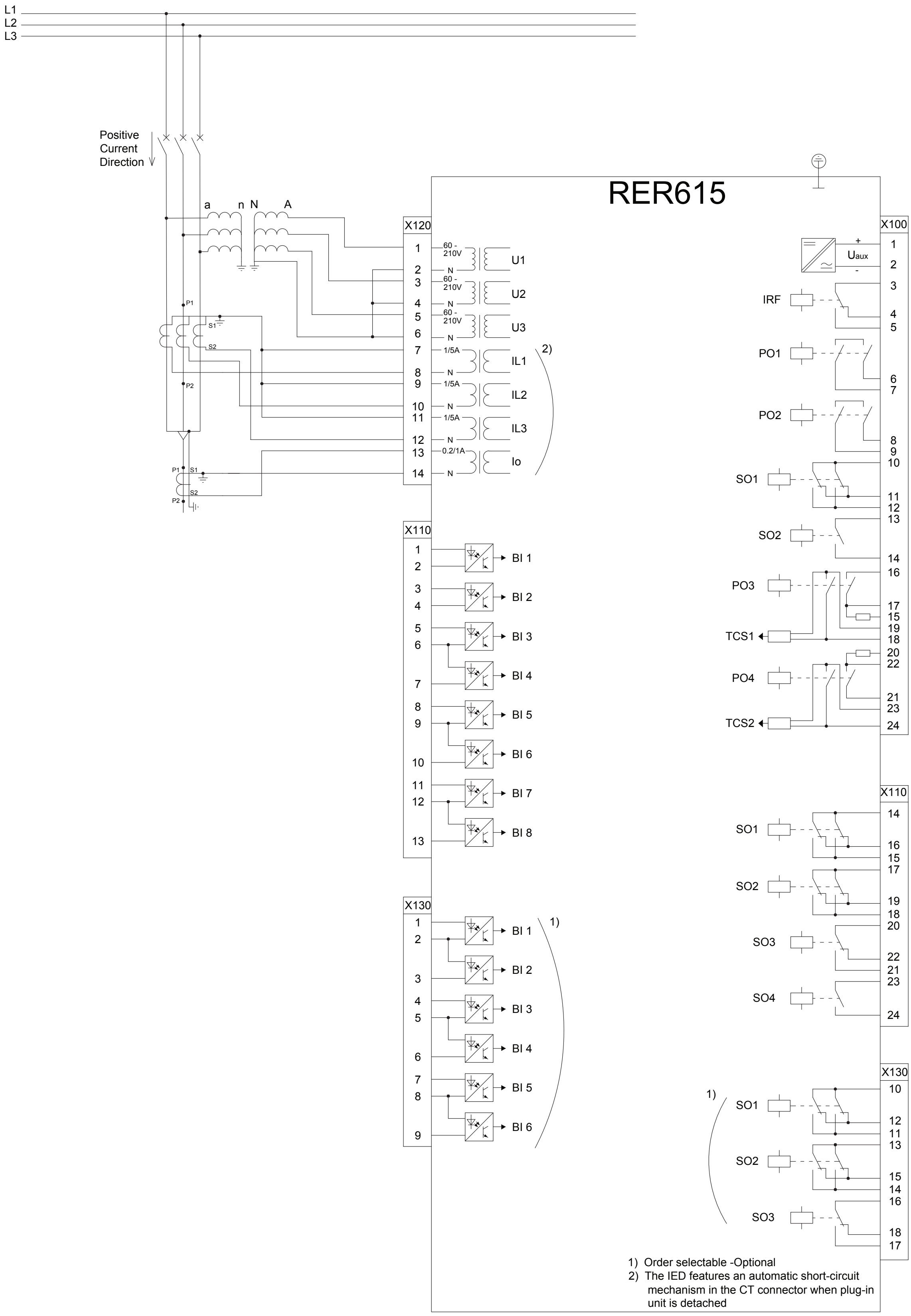


Figure 12. Connection diagram for the A configuration

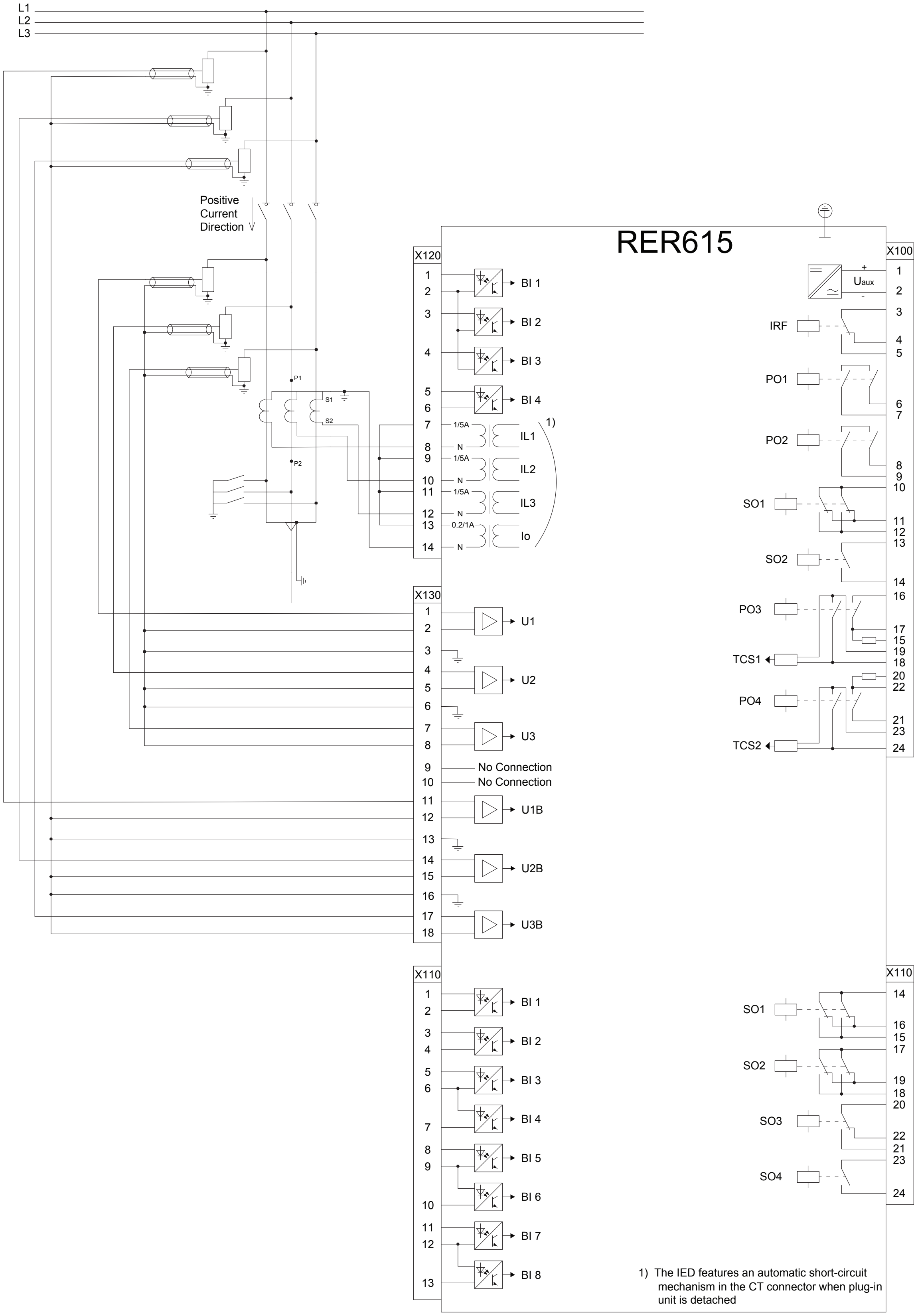


**Figure 13. Connection diagram for the D configuration**

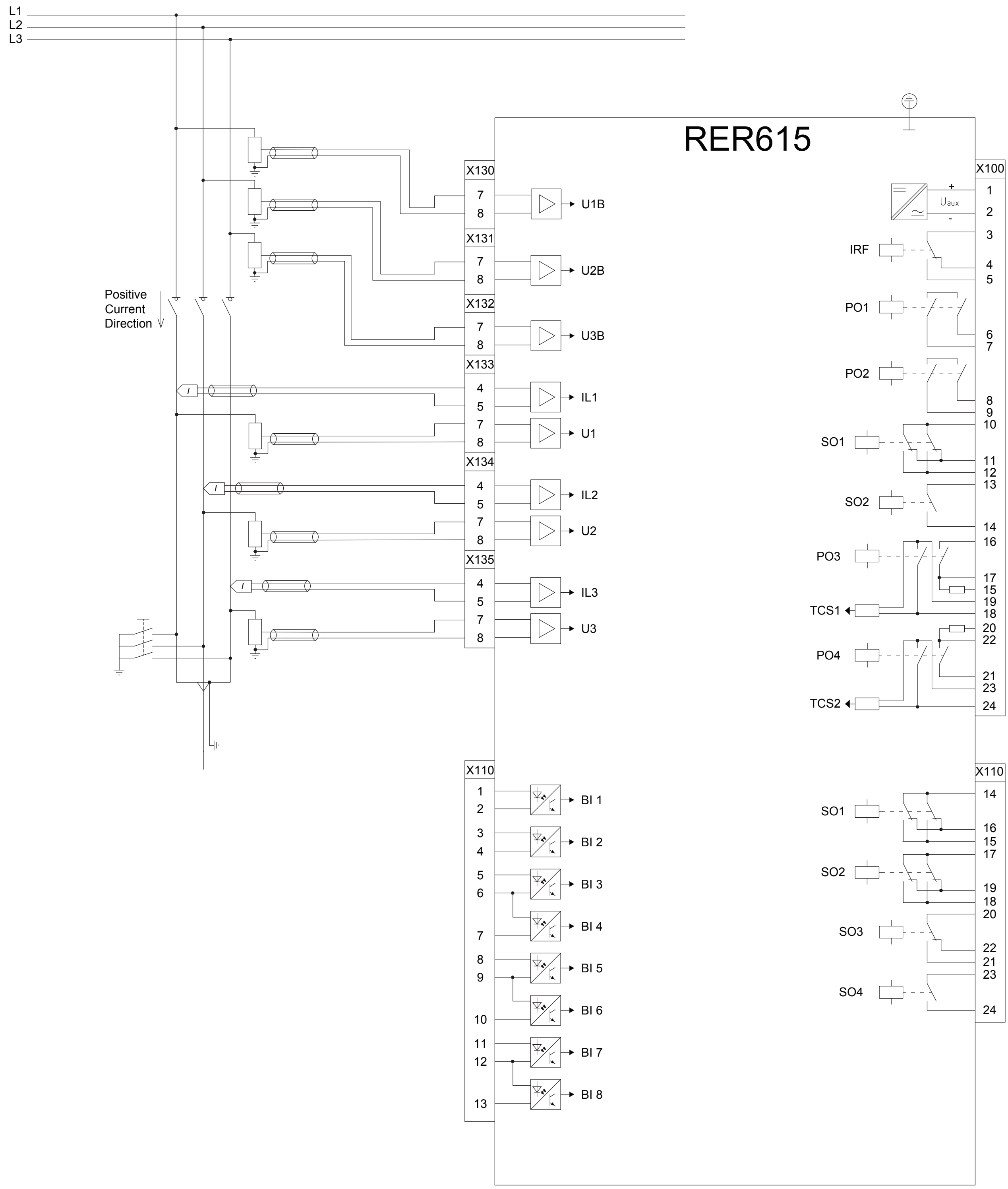


**Figure 14.** Connection diagram for the E configuration

## 29. References

The www.abb.com/substationautomation portal provides information on the entire range of distribution automation products and services.

The latest relevant information on the RER615 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

## 30. Functions, codes and symbols

All available functions are listed in the table. All of them may not be applicable to all products.

Table 101. Functions included in the relay

| Function | IEC 61850 | IEC 60617 | IEC-ANSI |
|---|---|---|---|
| **Protection** | | | |
| Three-phase non-directional overcurrent protection, low stage, instance 1 | PHLPTOC1 | 3I> (1) | 51P-1 (1) |
| | FPHLPTOC1 | F3I> (1) | F51P-1 (1) |
| Three-phase non-directional overcurrent protection, high stage, instance 1 | PHHPTOC1 | 3I>> (1) | 51P-2 (1) |
| Three-phase non-directional overcurrent protection, instantaneous stage, instance 1 | PHIPTOC1 | 3I>>> (1) | 50P/51P (1) |
| Three-phase directional overcurrent protection, low stage, instance 1 | DPHLPDOC1 | 3I> -> (1) | 67-1 (1) |
| | FDPHLPDOC1 | F3I> -> (1) | F67-1 (1) |
| Three-phase directional overcurrent protection, low stage, instance 2 | DPHLPDOC2 | 3I> -> (2) | 67-1 (2) |
| | FDPHLPDOC2 | F3I> -> (2) | F67-1 (2) |
| Three-phase directional overcurrent protection, high stage, instance 1 | DPHHPDOC1 | 3I>> -> (1) | 67-2 (1) |
| Non-directional earth-fault protection, low stage, instance 1 | EFLPTOC1 | Io> (1) | 51N-1 (1) |
| | FEFLPTOC1 | FIo> (1) | F51N-1 (1) |
| Non-directional earth-fault protection, high stage, instance 1 | EFHPTOC1 | Io>> (1) | 51N-2 (1) |
| Non-directional earth-fault protection, instantaneous stage, instance 1 | EFIPTOC1 | Io>>> (1) | 50N/51N (1) |
| Directional earth-fault protection, low stage, instance 1 | DEFLPDEF1 | Io> -> (1) | 67N-1 (1) |
| | FDEFLPDEF1 | FIo> -> (1) | F67N-1 (1) |
| Directional earth-fault protection, low stage, instance 2 | DEFLPDEF2 | Io> -> (2) | 67N-1 (2) |
| | FDEFLPDEF2 | FIo> -> (2) | F67N-1 (2) |
| Directional earth-fault protection, high stage, instance 1 | DEFHPDEF1 | Io>> -> (1) | 67N-2 (1) |
| Transient / intermittent earth-fault protection,instance 1 | INTRPTEF1 | Io> -> IEF (1) | 67NIEF (1) |
| Admittance-based earth-fault protection, instance 1 1) | EFPADM1 | Yo> -> (1) | 21YN (1) |
| Admittance-based earth-fault protection, instance 2 1) | EFPADM2 | Yo> -> (2) | 21YN (2) |
| Admittance-based earth-fault protection, instance 3 1) | EFPADM3 | Yo> -> (3) | 21YN (3) |
| Wattmetric-based earth-fault protection, instance 1 1) | WPWDE1 | Po> -> (1) | 32N (1) |
| Wattmetric-based earth-fault protection, instance 2 1) | WPWDE2 | Po> -> (2) | 32N (2) |
| Wattmetric-based earth-fault protection, instance 3 1) | WPWDE3 | Po> -> (3) | 32N (3) |
| Harmonics-based earth-fault protection, instance 1 1) | HAEFPTOC1 | Io>HA (1) | 51NHA (1) |
| Multifrequency admittance-based earth-fault protection, instance 1 | MFADPSDE1 | Io> -> Y (1) | 67YN (1) |
| Negative-sequence overcurrent protection, instance 1 | NSPTOC1 | I2> (1) | 46 (1) |
| Negative-sequence overcurrent protection, instance 2 | NSPTOC2 | I2> (2) | 46 (2) |
| Phase discontinuity protection, instance 1 | PDNSPTOC1 | I2/I1> (1) | 46PD (1) |
| Residual overvoltage protection, instance 1 | ROVPTOV1 | Uo> (1) | 59G (1) |
| Residual overvoltage protection, instance 2 | ROVPTOV2 | Uo> (2) | 59G (2) |

Table 101. Functions included in the relay, continued

| Function | IEC 61850 | IEC 60617 | IEC-ANSI |
|---|---|---|---|
| Three-phase undervoltage protection, instance 1 | PHPTUV1 | 3U< (1) | 27 (1) |
| Three-phase undervoltage protection, instance 2 | PHPTUV2 | 3U< (2) | 27 (2) |
| Three-phase undervoltage protection, instance 3 | PHPTUV3 | 3U< (3) | 27 (3) |
| Three-phase overvoltage protection, instance 1 | PHPTOV1 | 3U> (1) | 59 (1) |
| Three-phase overvoltage protection, instance 2 | PHPTOV2 | 3U> (2) | 59 (2) |
| Three-phase overvoltage protection, instance 3 | PHPTOV3 | 3U> (3) | 59 (3) |
| Positive-sequence undervoltage protection, instance 1 | PSPTUV1 | U1< (1) | 47U+ (1) |
| Negative-sequence overvoltage protection, instance 1 | NSPTOV1 | U2> (1) | 47O- (1) |
| Frequency protection, instance 1 | FRPFRQ1 | f>/f<,df/dt (1) | 81 (1) |
| Frequency protection, instance 2 | FRPFRQ2 | f>/f<,df/dt (2) | 81 (2) |
| Three-phase thermal protection for feeders, cables and distribution transformers, instance 1 | T1PTTR1 | 3Ith>F (1) | 49F (1) |
| Circuit breaker failure protection, instance 1 | CCBRBRF1 | 3I>/Io>BF (1) | 51BF/51NBF (1) |
| Circuit breaker failure protection, instance 2 | CCBRBRF2 | 3I>/Io>BF (2) | 51BF/51NBF (2) |
| Three-phase inrush detector, instance 1 | INRPHAR1 | 3I2f> (1) | 68 (1) |
| Master trip, instance 1 | TRPPTRC1 | Master Trip (1) | 94/86 (1) |
| Master trip, instance 2 | TRPPTRC2 | Master Trip (2) | 94/86 (2) |
| Multipurpose protection, instance 1 2) | MAPGAPC1 | MAP (1) | MAP (1) |
| Multipurpose protection, instance 2 2) | MAPGAPC2 | MAP (2) | MAP (2) |
| Multipurpose protection, instance 3 2) | MAPGAPC3 | MAP (3) | MAP (3) |
| Multipurpose protection, instance 4 2) | MAPGAPC4 | MAP (4) | MAP (4) |
| Multipurpose protection, instance 5 2) | MAPGAPC5 | MAP (5) | MAP (5) |
| Multipurpose protection, instance 6 2) | MAPGAPC6 | MAP (6) | MAP (6) |
| Load-shedding and restoration, instance 1 | LSHDPFRQ1 | UFLS/R (1) | 81LSH (1) |
| Fault locator, instance 1 | SCEFRFLO1 | FLOC (1) | 21FL (1) |
| Three-phase power directional element, instance 1 | DPSRDIR1 | I1-> (1) | 32P (1) |
| **Power quality** | | | |
| Current total demand distortion, instance 1 | CMHAI1 | PQM3I (1) | PQM3I (1) |
| Voltage total harmonic distortion, instance 1 | VMHAI1 | PQM3U (1) | PQM3V (1) |
| Voltage variation, instance 1 | PHQVVR1 | PQMU (1) | PQMV (1) |
| Voltage unbalance, instance 1 | VSQVUB1 | PQUUB (1) | PQVUB (1) |
| **Control** | | | |
| Circuit-breaker control, instance 1 | CBXCBR1 | I <-> O CB (1) | I <-> O CB (1) |
| Circuit-breaker control, instance 2 | CBXCBR2 | I <-> O CB (2) | I <-> O CB (2) |
| Disconnector control, instance 1 | DCXSWI1 | I <-> O DCC (1) | I <-> O DCC (1) |
| Disconnector control, instance 2 | DCXSWI2 | I <-> O DCC (2) | I <-> O DCC (2) |
| Disconnector control, instance 3 | DCXSWI3 | I <-> O DCC (3) | I <-> O DCC (3) |
| Disconnector control, instance 4 | DCXSWI4 | I <-> O DCC (4) | I <-> O DCC (4) |

Table 101. Functions included in the relay, continued

| Function | IEC 61850 | IEC 60617 | IEC-ANSI |
|---|---|---|---|
| Disconnector control, instance 5 | DCXSWI5 | I <-> O DCC (5) | I <-> O DCC (5) |
| Disconnector control, instance 6 | DCXSWI6 | I <-> O DCC (6) | I <-> O DCC (6) |
| Disconnector control, instance 7 | DCXSWI7 | I <-> O DCC (7) | I <-> O DCC (7) |
| Disconnector control, instance 8 | DCXSWI8 | I <-> O DCC (8) | I <-> O DCC (8) |
| Disconnector position indication, instance 1 | DCSXSWI1 | I <-> O DC (1) | I <-> O DC (1) |
| Disconnector position indication, instance 2 | DCSXSWI2 | I <-> O DC (2) | I <-> O DC (2) |
| Earthing switch indication, instance 1 | ESSXSWI1 | I <-> O ES (1) | I <-> O ES (1) |
| Earthing switch indication, instance 2 | ESSXSWI2 | I <-> O ES (2) | I <-> O ES (2) |
| Earthing switch indication, instance 3 | ESSXSWI3 | I <-> O ES (3) | I <-> O ES (3) |
| Earthing switch indication, instance 4 | ESSXSWI4 | I <-> O ES (4) | I <-> O ES (4) |
| Earthing switch indication, instance 5 | ESSXSWI5 | I <-> O ES (5) | I <-> O ES (5) |
| Earthing switch indication, instance 6 | ESSXSWI6 | I <-> O ES (6) | I <-> O ES (6) |
| Earthing switch indication, instance 7 | ESSXSWI7 | I <-> O ES (7) | I <-> O ES (7) |
| Earthing switch indication, instance 8 | ESSXSWI8 | I <-> O ES (8) | I <-> O ES (8) |
| Autoreclosing, instance 1 | DARREC1 | O -> I (1) | 79 (1) |
| Synchronism and energizing check, instance 1 | SECRSYN1 | SYNC (1) | 25 (1) |
| Automatic transfer switch,instance1 | ATSABTC1 | ATSABTC1 | ATSABTC1 |
| **Condition monitoring** | | | |
| Circuit-breaker condition monitoring, instance 1 | SSCBR1 | CBCM (1) | CBCM (1) |
| Circuit-breaker condition monitoring, instance 2 | SSCBR2 | CBCM (2) | CBCM (2) |
| Trip circuit supervision, instance 1 | TCSSCBR1 | TCS (1) | TCM (1) |
| Trip circuit supervision, instance 2 | TCSSCBR2 | TCS (2) | TCM (2) |
| Fuse failure supervision, instance 1 | SEQSPVC1 | FUSEF (1) | 60 (1) |
| Runtime counter for machines and devices, instance 1 | MDSOPT1 | OPTS (1) | OPTM (1) |
| Voltage presence, instance 1 | PHSVPR1 | PHSVPR(1) | PHSVPR(1) |
| Voltage presence, instance 2 | PHSVPR2 | PHSVPR(2) | PHSVPR(2) |
| **Measurement** | | | |
| Three-phase current measurement, instance 1 | CMMXU1 | 3I (1) | 3I (1) |
| Sequence current measurement, instance 1 | CSMSQI1 | I1, I2, I0 (1) | I1, I2, I0 (1) |
| Residual current measurement, instance 1 | RESCMMXU1 | Io (1) | In (1) |
| Three-phase voltage measurement, instance 1 | VMMXU1 | 3U (1) | 3V (1) |
| Three-phase voltage measurement, instance 2 | VMMXU2 | 3U (2) | 3V (2) |
| Sequence voltage measurement, instance 1 | VSMSQI1 | U1, U2, U0 (1) | V1, V2, V0 (1) |
| Sequence voltage measurement, instance 2 | VSMSQI2 | U1, U2, U0 (2) | V1, V2, V0 (2) |
| Three-phase power and energy measurement, instance 1 | PEMMXU1 | P, E (1) | P, E (1) |
| Single-phase power and energy measurement, instance 1 | SPEMMXU1 | SP, SE (1) | SP, SE (1) |

Table 101. Functions included in the relay, continued

| Function | IEC 61850 | IEC 60617 | IEC-ANSI |
|---|---|---|---|
| Frequency measurement, instance 1 | FMMXU1 | f (1) | f (1) |
| Frequency measurement, instance 2 | FMMXU2 | f (2) | f (2) |
| Load profile record, instance 1 | LDPRLRC1 | LOADPROF (1) | LOADPROF (1) |
| **Other** | | | |
| Minimum pulse timer (2 pcs), instance 1 | TPGAPC1 | TP (1) | TP (1) |
| Minimum pulse timer (2 pcs), instance 2 | TPGAPC2 | TP (2) | TP (2) |
| Minimum pulse timer (2 pcs, second resolution), instance 1 | TPSGAPC1 | TPS (1) | TPS (1) |
| Minimum pulse timer (2 pcs, minute resolution), instance 1 | TPMGAPC1 | TPM (1) | TPM (1) |
| Pulse timer (8 pcs), instance 1 | PTGAPC1 | PT (1) | PT (1) |
| Pulse timer (8 pcs), instance 2 | PTGAPC2 | PT (2) | PT (2) |
| Time delay off (8 pcs), instance 1 | TOFGAPC1 | TOF (1) | TOF (1) |
| Time delay off (8 pcs), instance 2 | TOFGAPC2 | TOF (2) | TOF (2) |
| Time delay on (8 pcs), instance 1 | TONGAPC1 | TON (1) | TON (1) |
| Time delay on (8 pcs), instance 2 | TONGAPC2 | TON (2) | TON (2) |
| Set-reset (8 pcs), instance 1 | SRGAPC1 | SR (1) | SR (1) |
| Set-reset (8 pcs), instance 2 | SRGAPC2 | SR (2) | SR (2) |
| Move (8 pcs), instance 1 | MVGAPC1 | MV (1) | MV (1) |
| Move (8 pcs), instance 2 | MVGAPC2 | MV (2) | MV (2) |
| Move (8 pcs), instance 3 | MVGAPC3 | MV (3) | MV (3) |
| Move (8 pcs), instance 4 | MVGAPC4 | MV (4) | MV (4) |
| Move (8 pcs), instance 5 | MVGAPC5 | MV (5) | MV (5) |
| Move (8 pcs), instance 6 | MVGAPC6 | MV (6) | MV (6) |
| Move (8 pcs), instance 7 | MVGAPC7 | MV (7) | MV (7) |
| Move (8 pcs), instance 8 | MVGAPC8 | MV (8) | MV (8) |
| Generic control point (16 pcs), instance 1 | SPCGAPC1 | SPC (1) | SPC (1) |
| Generic control point (16 pcs), instance 2 | SPCGAPC2 | SPC (2) | SPC (2) |
| Remote generic control points, instance 1 | SPCRGAPC1 | SPCR (1) | SPCR (1) |
| Local generic control points, instance 1 | SPCLGAPC1 | SPCL (1) | SPCL (1) |
| Generic up-down counters, instance 1 | UDFCNT1 | UDCNT (1) | UDCNT (1) |
| Generic up-down counters, instance 2 | UDFCNT2 | UDCNT (2) | UDCNT (2) |
| Generic up-down counters, instance 3 | UDFCNT3 | UDCNT (3) | UDCNT (3) |
| Analog value scaling, instance 1 | SCA4GAPC1 | SCA4 (1) | SCA4 (1) |
| Analog value scaling, instance 2 | SCA4GAPC2 | SCA4 (2) | SCA4 (2) |
| Analog value scaling, instance 3 | SCA4GAPC3 | SCA4 (3) | SCA4 (3) |
| Analog value scaling, instance 4 | SCA4GAPC4 | SCA4 (4) | SCA4 (4) |
| Analog value scaling, instance 5 | SCA4GAPC5 | SCA4 (5) | SCA4 (5) |

Table 101. Functions included in the relay, continued

| Function | IEC 61850 | IEC 60617 | IEC-ANSI |
| --- | --- | --- | --- |
| Analog value scaling, instance 6 | SCA4GAPC6 | SCA4 (6) | SCA4 (6) |
| Analog value scaling, instance 7 | SCA4GAPC7 | SCA4 (7) | SCA4 (7) |
| Analog value scaling, instance 8 | SCA4GAPC8 | SCA4 (8) | SCA4 (8) |
| Analog value scaling, instance 9 | SCA4GAPC9 | SCA4 (9) | SCA4 (9) |
| Analog value scaling, instance 10 | SCA4GAPC10 | SCA4 (10) | SCA4 (10) |
| Analog value scaling, instance 11 | SCA4GAPC11 | SCA4 (11) | SCA4 (11) |
| Analog value scaling, instance 12 | SCA4GAPC12 | SCA4 (12) | SCA4 (12) |
| Integer value move, instance 1 | MVI4GAPC1 | MVI4 (1) | MVI4 (1) |
| Integer value move, instance 2 | MVI4GAPC2 | MVI4 (2) | MVI4 (2) |
| Daily timer function, instance 1 | DTMGAPC1 | DTMGAPC1 | DTMGAPC1 |
| Daily timer function, instance 2 | DTMGAPC2 | DTMGAPC2 | DTMGAPC2 |
| Programmable buttons (4 buttons) | FKEY4GGIO1 | FKEY4GGIO1 | FKEY4GGIO1 |
| **Logging functions** | | | |
| Disturbance recorder | RDRE1 | DR (1) | DFR (1) |
| Fault record | FLTRFRC1 | FAULTREC (1) | FAULTREC (1) |

## 31. Document revision history

| Document revision/date | Product version | History |
|---|---|---|
| A/2013-09-17 | 1.0 | First release |
| B/2013-11-15 | 1.0 | Content updated |
| C/2015-03-06 | 1.1 | Content updated to correspond to the product version |
| D/2018-08-31 | 2.0 | Content updated to correspond to the product version |
| E/2018-12-10 | 2.0 | Content updated |

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