RELION® PRODUCT FAMILY

Grid Automation
Remote Monitoring and Control
REC615
Product Guide

Contents

1. Description

REC615 is a dedicated grid automation relay designed for remote control and monitoring, protection, fault indication, power quality analysis and automation in medium-voltage secondary distribution systems, including networks with distributed power generation, with secondary equipment such as medium-voltage disconnectors, switches and ring-main units.

REC615 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 REC615, grid reliability can be enhanced, ranging from basic, non-directional overload protection to extended protection functionality with power quality analyses. REC615 meets today’s requirements for smart grids and supports the protection of cable feeders in isolated neutral, resistance-earthed, compensated and solidly earthed networks. REC615 is freely programmable with horizontal GOOSE communication, thus enabling sophisticated interlocking functions. REC615 includes sophisticated protection functionality to detect, isolate and restore power in all types of networks but especially in compensated networks. 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. The relay's existing I/O is further extendable with RIO600. REC615 supports the same configuration tools as the other relays in the Relion product family. The freely programmable relay contains six easily manageable setting groups.

Two breakers and up to eight load-break switches can be controlled via the relay's front panel HMI or a remote system. 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.

REC615 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

REC615 is available in three standard configurations. An example configuration suitable for the SECTOS type load-break switch applications with specific application, such as the current based sectionalizing logic and load limiting functionality, is delivered with each standard configuration. This minimizes the required amount of engineering, allowing fast commissioning by just parameterizing 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 B 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.

Standard configuration C supports combined voltage and current sensors which support traditional residual current inputs in sensitive earth-fault applications. The sensor inputs fully support both ABB's voltage and current medium-voltage sensors. The wide characteristics of the current sensor inputs allow standardization of the primary equipment.

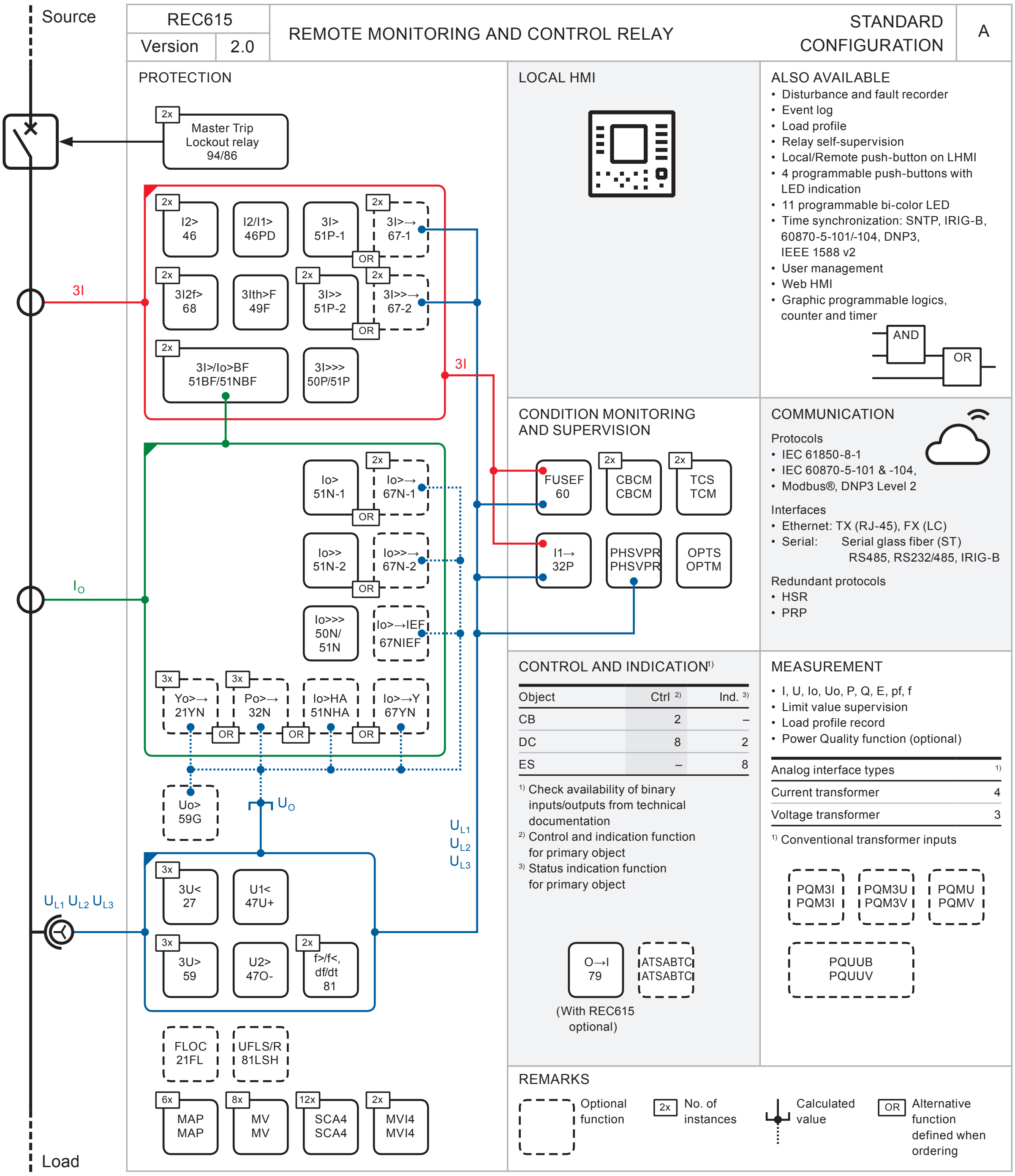


Figure 1. Functionality overview of standard configuration A

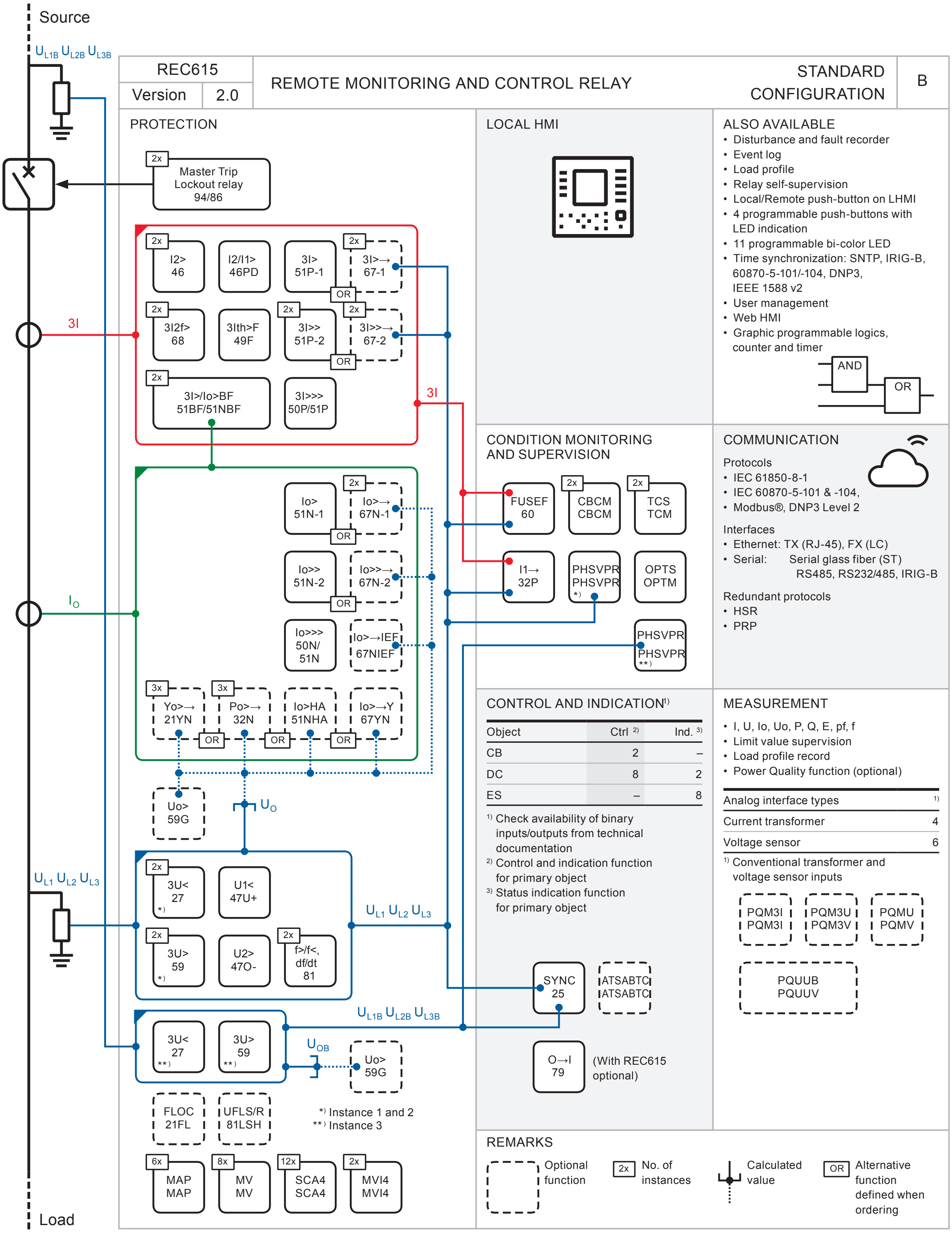


Figure 2. Functionality overview of standard configuration B

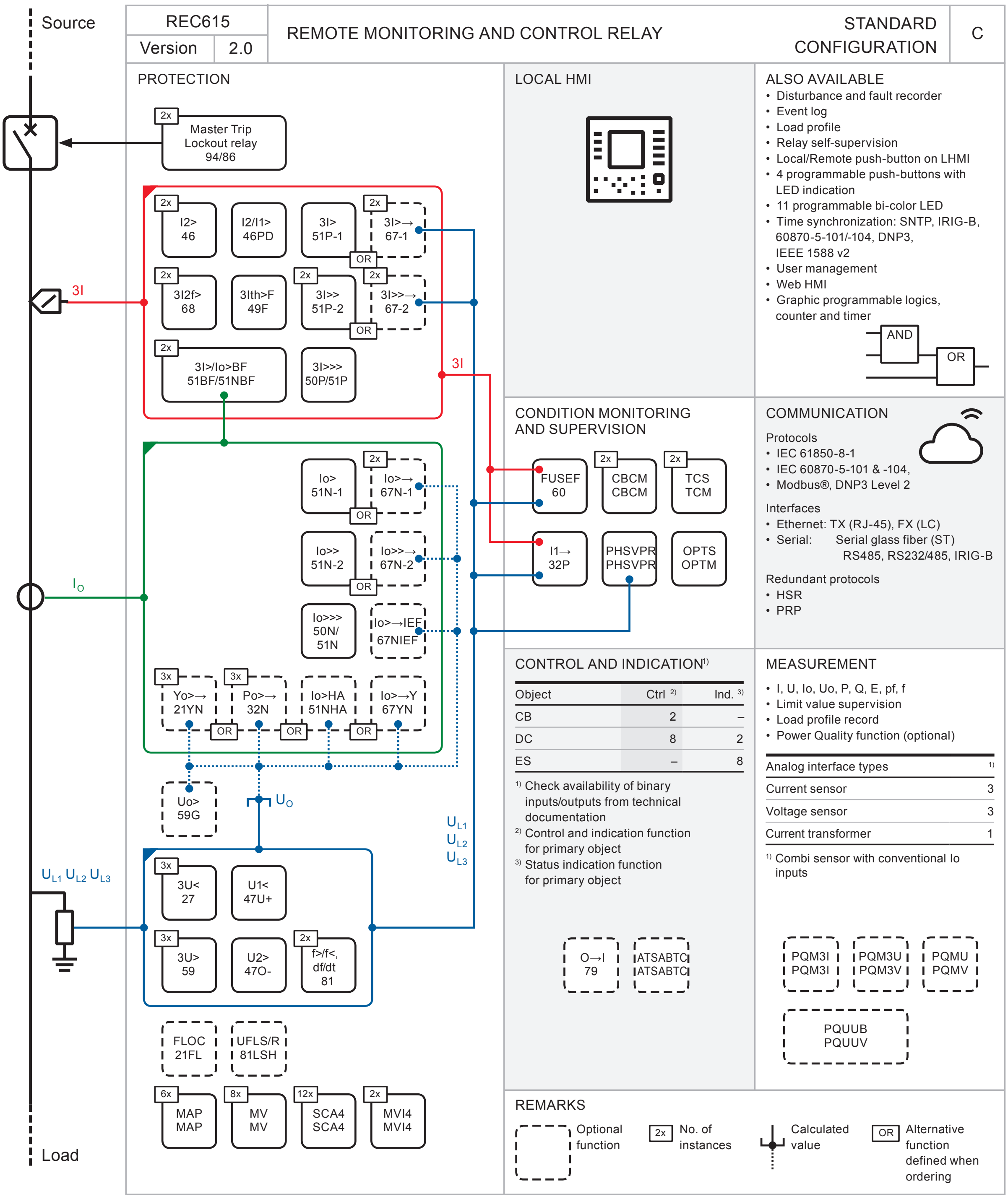


Figure 3. Functionality overview of standard configuration C

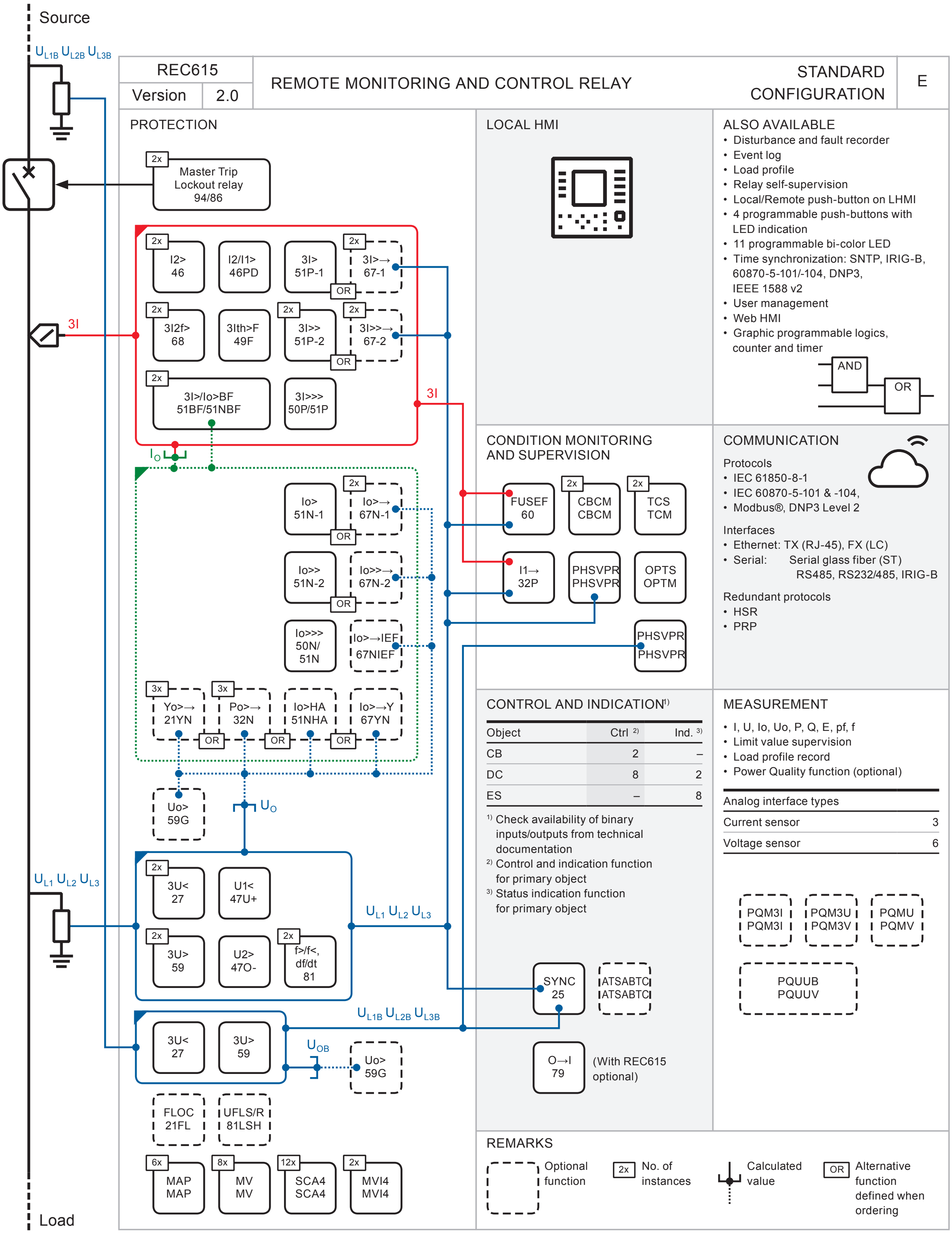


Figure 4. Functionality overview of standard configuration E

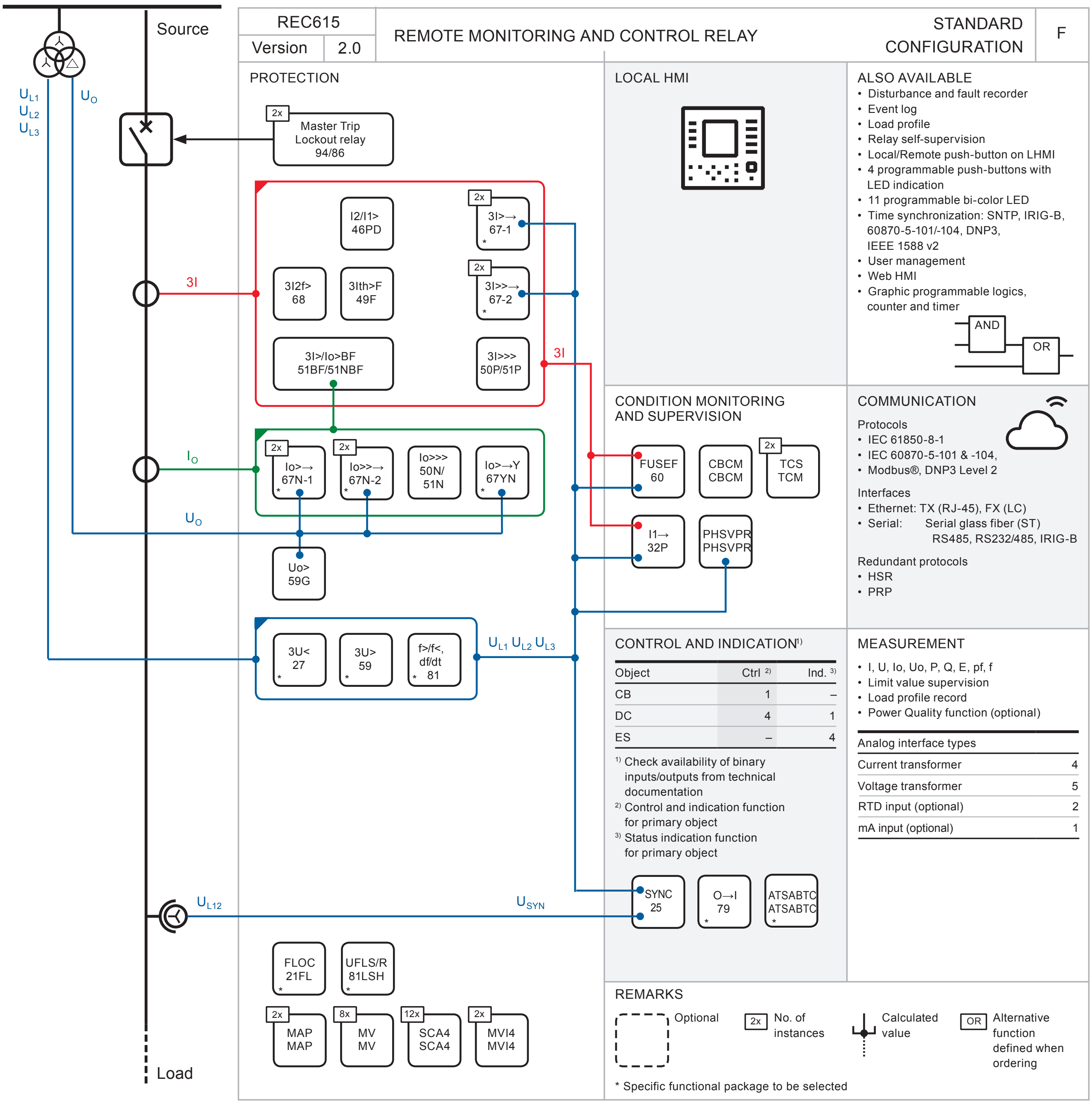


Figure 5. Functionality overview of standard configuration F

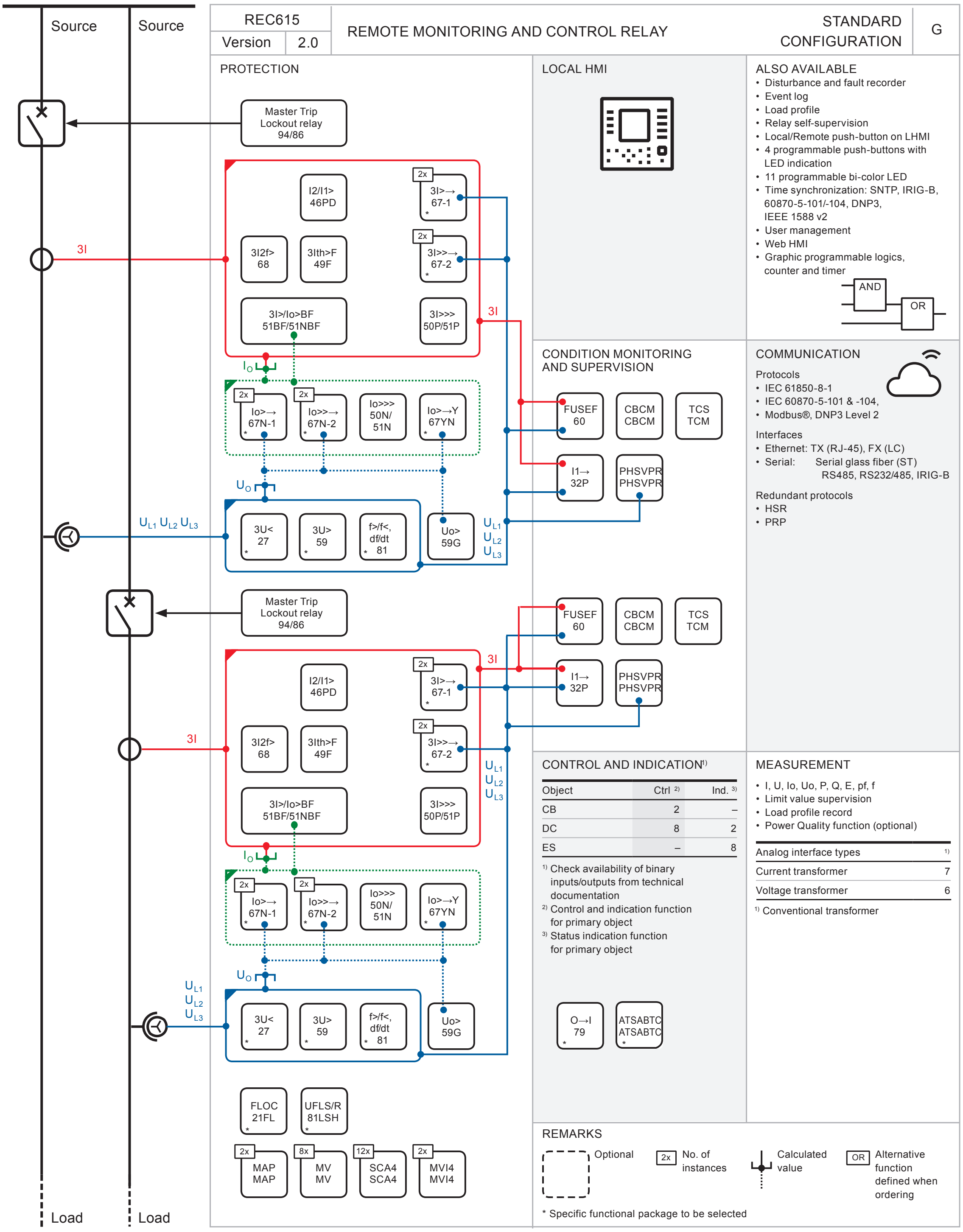
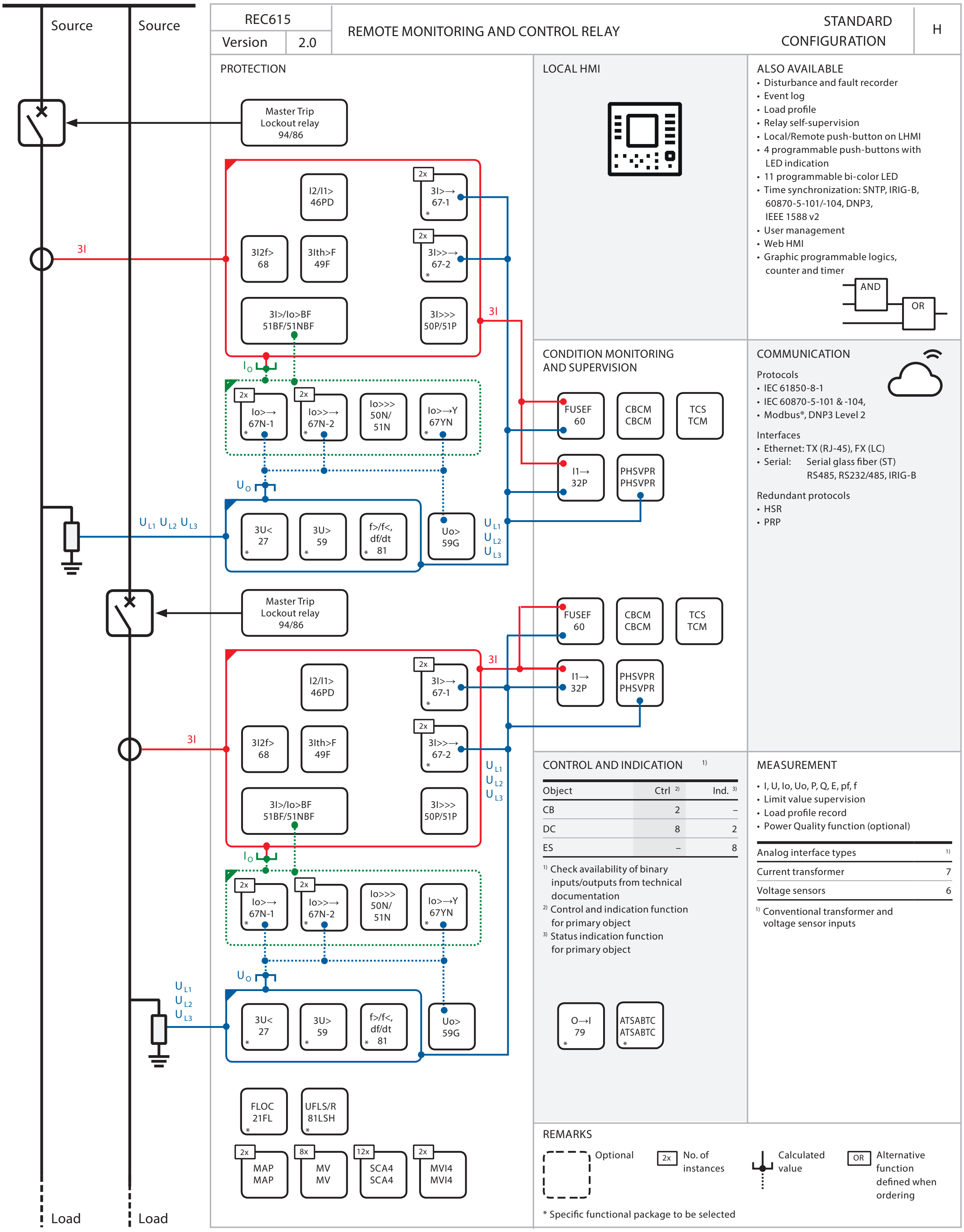


Figure 6. Functionality overview of standard configuration G



Object	Ctrl 2)	Ind. 3)
CB	2	–
DC	8	2
ES	–	8

Analog interface types 1)	
Current transformer	7
Voltage sensors	6

Figure 7. Functionality overview of standard configuration H

Table 1. Standard configurations

Description	Std. conf.
Remote monitoring and control to be used with conventional transformers supporting directional overcurrent and directional earth-fault protection with phase voltage-based protection and measurement functions, voltage protection, frequency and load-shedding protection, condition monitoring, disconnector (switch) control, combi-sensor and voltage sensor inputs, counter logic • Phase voltage inputs based on conventional VTs • Phase current inputs based on conventional CTs • Residual current input based on conventional CT	A
Remote monitoring and control to be used with mixed transformers supporting 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, disconnector (switch) control, voltage sensor inputs, counter logic • Phase voltage inputs based on conventional VTs or voltage sensors • Phase current inputs based on conventional CTs • Residual current input based on conventional CT	B
Remote monitoring and control to be used with combi-sensors supporting directional overcurrent and directional earth-fault protection with phase voltage-based protection and measurement functions, voltage protection, frequency and load-shedding protection, condition monitoring, disconnector (switch) control, combi-sensor and voltage sensor inputs, counter logic • Phase voltage inputs based on voltage sensors • Phase current inputs based on current sensors (Rogowsky coil) • Residual current input based on conventional CT	C
Remote monitoring and control to be used with combi-sensor and additional voltage sensor supporting 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, disconnector (switch) control, combi-sensor and voltage sensor inputs, counter logic • Phase voltage inputs based on voltage sensors • Phase current inputs based on current sensors (Rogowsky coil)	E
Remote monitoring and control to be used with conventional transformers and optional RTD input, supporting 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, disconnector (switch) control, combi-sensor and voltage sensor inputs, counter logic • Phase voltage inputs based on conventional VTs • Residual voltage input based on conventional VT • Phase current inputs based on conventional CTs • Residual current input based on conventional CT • Optional with RTD inputs or binary inputs	F
Remote monitoring and control to be used with conventional transformers, supporting directional overcurrent and directional earth-fault protection with phase voltage-based protection and measurement functions, voltage protection, frequency and load-shedding protection, condition monitoring, disconnector (switch) control, counter logic • Phase voltage inputs based on conventional VTs • Phase current inputs based on conventional CTs • Residual current input based on conventional CT	G
Remote monitoring and control to be used with mixed transformers, supporting directional overcurrent and directional earth-fault protection with phase voltage-based protection and measurement functions, voltage protection, frequency and load-shedding protection, condition monitoring, disconnector (switch) control, voltage sensor inputs, counter logic • Phase voltage inputs based on conventional VTs or voltage sensors • Phase current inputs based on conventional CTs • Residual current input based on conventional CT	H

Table 2. Supported functions

Function	IEC 61850	A	B	C	E	F	G	H
Protection								
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	(1)	(1)	(1)	(1)			
	FPHLPTOC	(1)	(1)	(1)	(1)			
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	(1)	(1)	(1)	(1)			
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1	1	1	1	2[14)]	2[14)]
Three-phase directional overcurrent protection, low stage	DPHLPDOC	(2)	(2)	(2)	(2)	2[1)]	4[1)2)3)]	4[1)2)3)]
	FDPHLPDOC	(2)	(2)	(2)	(2)			
Three-phase directional overcurrent protection, high stage	DPHHPDOC	(1)	(1)	(1)	(1)	2[1)]	4[1)2)3)]	4[1)2)3)]
Non-directional earth-fault protection, low stage	EFLPTOC	(1)	(1)	(1)	(1)[4)]			
	FEFLPTOC	(1)	(1)	(1)	(1)[4)]			
Non-directional earth-fault protection, high stage	EFHPTOC	(1)	(1)	(1)	(1)[4)]			
Non-directional earth-fault protection, instantaneous stage	EFIPTOC	1	1	1	1[4)]	1	1	1
Directional earth-fault protection, low stage	DEFLPDEF	(2)[5)]	(2)[5)]	(2)[5)]	(2)[4)5)]	2[1)]	4[1)2)3)6)7)8)]	4[1)2)3)6)7)8)]
	FDEFLPDEF	(2)[5)]	(2)[5)]	(2)[5)]	(2)[4)5)]			
Directional earth-fault protection, high stage	DEFHPDEF	(1)[5)]	(1)[5)]	(1)[5)]	(1)[4)5)]	2[1)]	4[1)2)3)6)7)8)]	4[1)2)3)6)7)8)]
Transient / intermittent earth-fault protection	INTRPTEF	(1)[5)]	(1)[5)]	(1)[5)]	(1)[4)5)]			
Admittance-based earth-fault protection[5)]	EFPADM	(3)[5)]	(3)[5)]	(3)[5)]	(3)[4)5)]			
Wattmetric-based earth-fault protection[5)]	WPWDE	(3)[5)]	(3)[5)]	(3)[5)]	(3)[4)5)]			
Harmonics-based earth-fault protection[5)]	HAEFPTOC	(1)	(1)	(1)	(1)[4)]			
Multifrequency admittance-based earth-fault protection	MFADPSDE	(1)[5)]	(1)[5)]	(1)[5)]	(1)[4)5)]	1[1)]	2[1)9)10)11)]	2[1)9)10)11)]
Negative-sequence overcurrent protection	NSPTOC	2	2	2	2			
Phase discontinuity protection	PDNSPTOC	1	1	1	1	1	1	1
Residual overvoltage protection	ROVPTOV	(1)[5)]	(2)[9)10)]	(1)[5)]	(2)[9)10)]	1[1)]	2[1)9)10)]	2[1)9)10)]
Three-phase undervoltage protection	PHPTUV	(3)	(3)[12)]	(3)	(3)[12)]	1[1)]	2[1)13)]	2[1)13)]
Three-phase overvoltage protection	PHPTOV	(3)	(3)[12)]	(3)	(3)[12)]	1[1)]	2[1)13)]	2[1)13)]
Positive-sequence undervoltage protection	PSPTUV	(1)	(1)	(1)	(1)			
Negative-sequence overvoltage protection	NSPTOV	(1)	(1)	(1)	(1)			
Loss of phase (undercurrent)	PHPTUC						2[14)]	2[14)]
Frequency protection	FRPFRQ	(2)	(2)	(2)	(2)	1[1)]	2[1)13)]	2[1)13)]
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	1	1	1	1	1	1	1
Circuit breaker failure protection	CCBRBRF	2	2	2	2[4)]	1	2[11)14)]	2[11)14)]

Table 2. Supported functions, continued

Function	IEC 61850	A	B	C	E	F	G	H
Three-phase inrush detector	INRPHAR	1	1	1	1	1	1	1
Master trip	TRPPTRC	2	2	2	2	2	2	2
Multipurpose protection[15)]	MAPGAPC	6	6	6	6	2	2	2
Load-shedding and restoration	LSHDPFRQ	(1)	(1)	(1)	(1)	1[1)]	2[1)13)]	2[1)13)]
Fault locator	SCEFRFLO	(1)	(1)	(1)	(1)	1[1)]	1[1)]	1[1)]
Three-phase power directional element	DPSRDIR	1	1	1	1	1	2	2
Power quality								
Current total demand distortion	CMHAI	(1)	(1)	(1)	(1)			
Voltage total harmonic distortion	VMHAI	(1)	(1)	(1)	(1)			
Voltage variation	PHQVVR	(1)	(1)	(1)	(1)			
Voltage unbalance	VSQVUB	(1)	(1)	(1)	(1)			
Control								
Circuit-breaker control	CBXCBR	2	2	2	2	1	2	2
Disconnector control	DCXSWI	8	8	8	8	4	8	8
Disconnector position indication	DCSXSWI	2	2	2	2	1	2	2
Earthing switch indication	ESSXSWI	8	8	8	8	4	8	8
Autoreclosing	DARREC	(1)	(1)	(1)	(1)	1[1)]	2[1)]	2[1)]
Synchronism and energizing check	SECRSYN		1		1	1		
Automatic transfer switch	ATSABTC	(1)	(1)	(1)	(1)	1[1)]	1[1)]	1[1)]
Condition monitoring								
Circuit-breaker condition monitoring	SSCBR	2	2	2	2	1	2[14)]	2[14)]
Trip circuit supervision	TCSSCBR	2	2	2	2	2	2	2
Fuse failure supervision	SEQSPVC	1	1	1	1	1	2[13)14)]	2[13)14)]
Runtime counter for machines and devices	MDSOPT	1	1	1	1			
Voltage presence	PHSVPR	1	2[13)]	1	2[13)]	1	2[13)]	2[13)]
Measurement								
Three-phase current measurement	CMMXU	1	1	1	1	1	2[14)]	2[14)]
Sequence current measurement	CSMSQI	1	1	1	1	1	2[14)]	2[14)]
Residual current measurement	RESCMMXU	1	1	1		1	1	1
Three-phase voltage measurement	VMMXU	1	2[13)]	1	2[13)]	2[13)]	2[13)]	2[13)]
Residual voltage measurement	RESVMMXU					1		
Sequence voltage measurement	VSMSQI	1	2[13)]	1	2[13)]		2[13)]	2[13)]
Three-phase power and energy measurement	PEMMXU	1	1	1	1	1	2[13)14)]	2[13)14)]
Single-phase power and energy measurement	SPEMMXU	1	1	1	1	1	2[13)14)]	2[13)14)]
Frequency measurement	FMMXU	1	2[13)]	1	2[13)]	1	2[13)]	2[13)]
Load profile record	LDPRLRC	1	1	1	1	1	1	1
Other								

Table 2. Supported functions, continued

Function	IEC 61850	A	B	C	E	F	G	H
Minimum pulse timer (2 pcs)	TPGAPC	2	2	2	2	2	2	2
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	1	1	1	1	1	1	1
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	1	1	1	1	1	1	1
Pulse timer (8 pcs)	PTGAPC	2	2	2	2	2	2	2
Time delay off (8 pcs)	TOFGAPC	2	2	2	2	2	2	2
Time delay on (8 pcs)	TONGAPC	2	2	2	2	2	2	2
Set-reset (8 pcs)	SRGAPC	2	2	2	2	2	2	2
Move (8 pcs)	MVGAPC	8	8	8	8	8	8	8
Generic control point (16 pcs)	SPCGAPC	2	2	2	2	2	2	2
Remote generic control points	SPCRGAPC	1	1	1	1	1	1	1
Local generic control points	SPCLGAPC	1	1	1	1	1	1	1
Generic up-down counters	UDFCNT	3	3	3	3	3	3	3
Analog value scaling	SCA4GAPC	12	12	12	12	12	12	12
Integer value move	MVI4GAPC	2	2	2	2	2	2	2
Daily timer function	DTMGAPC	2	2	2	2	2	2	2
Programmable buttons (4 buttons)	FKEY4GGIO	1	1	1	1	1	1	1
Logging functions								
Disturbance recorder	RDRE	1	1	1	1	1	1	1
Fault record	FLTRFRC	1	1	1	1	1	1	1

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

1) Specific functional package to be selected for functional package 1 (G,H), 2 (C,D) and 3 (D)
2) Voltage group B always used with the third and fourth instances
3) Current group B always used with the third and fourth instances
4) Io calculated is always used
5) Uo calculated is always used
6) Uo calculated is always used with the first and second instances
7) UoB calculated is always used with the third and fourth instances
8) IoB calculated is always used with the third and fourth instances
9) Uo calculated is always used with the first instance
10) UoB calculated is always used with the second instance
11) IoB calculated is always used with the second instance
12) Voltage group B always used with the third instance
13) Voltage group B always used with the second instance
14) Current group B always used with the second instance
15) UoB calculated is always used

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 grid automation applications, such as 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 B. 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 REC615.

4. Application

REC615 is a dedicated grid automation relay and suitable for a variety of applications, ranging from basic applications on the line breaker 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.

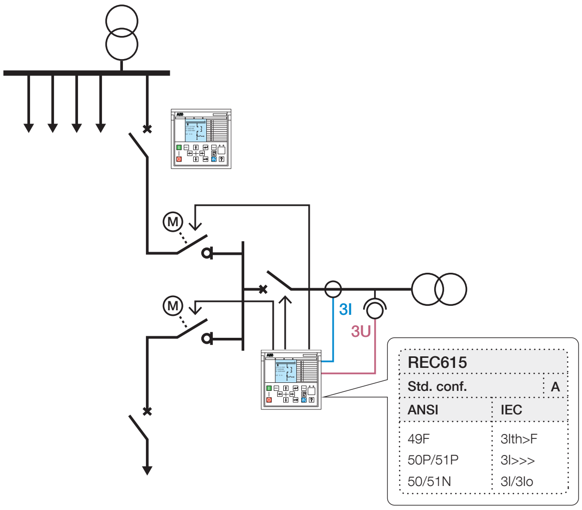


Figure 8. RMU (Ring Main Unit) with an outgoing circuit breaker for a distribution transformer

Figure 8 illustrates remotely controllable load-break switches on cable feeders and current-based protection functions for distribution transformers. Additionally, the application includes embedded communication with SCADA via, for example, IEC 60870-5-104, a graphical local HMI and power measurements P, Q, S and cosφ and power quality functionality.

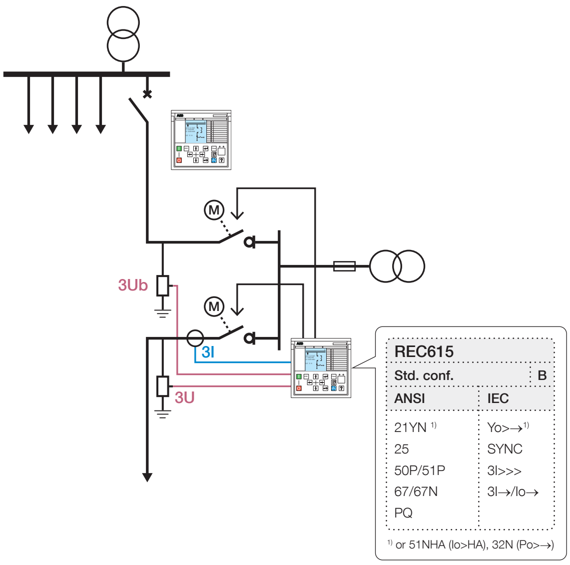


Figure 9. RMU controller with synchrocheck functionality

Figure 9 illustrates remotely controllable load-break switches for cable feeders in radial networks requiring synchrocheck functionality to reliably close the loop. Accurate fault pass indication and disturbance recording on outgoing feeder are also included. Additionally, embedded communication with SCADA via, for example, IEC 60870-5-104, a graphical local HMI and power measurements P, Q, S and cosφ, and power quality functionality are available.

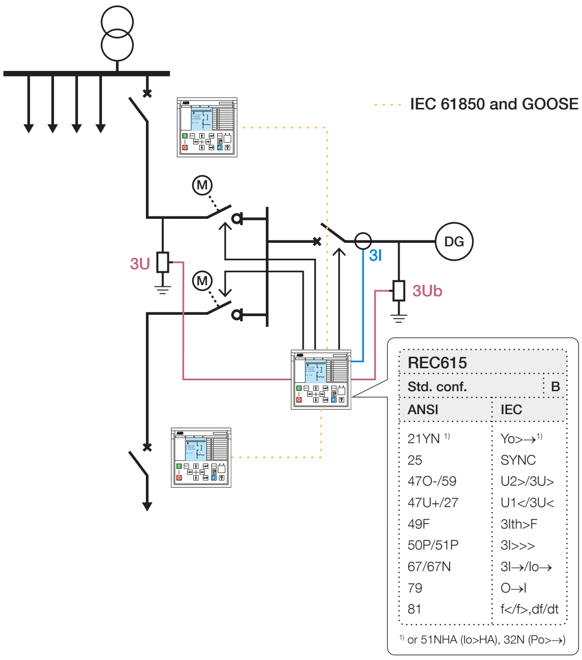


Figure 10. Remote control and protection of distributed generation plant

The advanced protection functionality of REC615 ensures secure protection of distributed generation against faults, and early indication of loss-of-mains through IEC 61850 and GOOSE communication as shown in Figure 10. Safe reconnection is ensured by using the synchrocheck functionality.

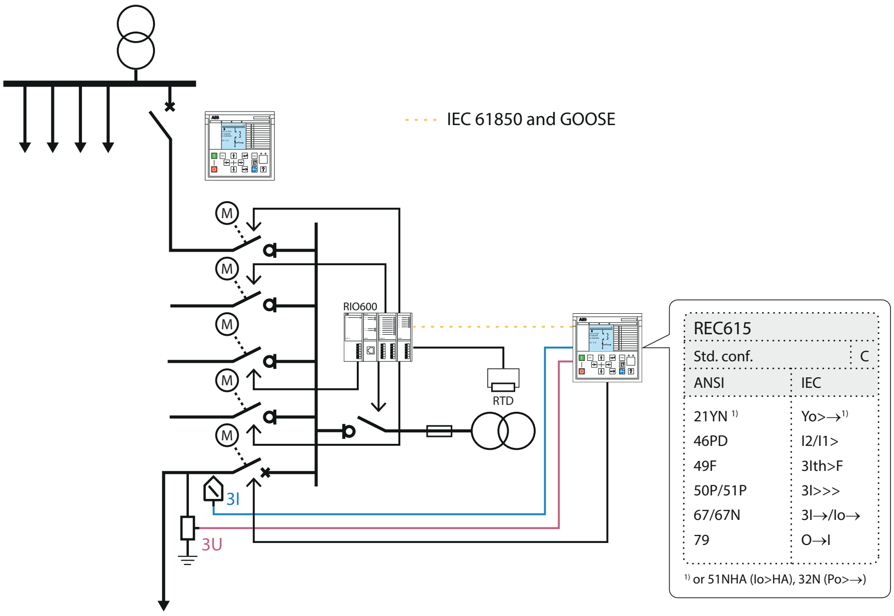


Figure 11. Remote control and protection of RMU station

Remotely controllable load-break switches on cable feeders with sensor measurement enable the selective protection of radial feeders with advanced directional earth-fault and overcurrent protection, and autoreclosing functionality as hown in Figure 11. Additionally, embedded communication with SCADA via, for example, IEC 60870-5-104, a graphical local HMI, energy measurement in all four quadrants, and power quality functionality are available. RIO600 is used to extend the number of I/Os and for temperature measurement of the distribution transformer.

5. Supported ABB solutions

REC615 integrates fully with other ABB products such as RIO600, 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 and up to eight load-break switches can be controlled via the front panel HMI of REC615 or via a remote system. The relay also provides position indication for eight 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 nonvolatile memory capable of storing 1024 events with the associated time stamps. The nonvolatile 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 nonvolatile 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 nonvolatile 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. 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.

17. 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 B provides three phase-current inputs, one residual current input and six sensor voltage inputs or voltage transformers. Standard configuration C supports combi-sensors with sensitive residual current measurement.

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 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.

Current sensor inputs are designed for ABB's Rogowski sensors, and the nominal current is user-programmable. The wide input characteristics allow standardization of the primary equipment, which is why one and the same primary measuring device can be used for both measuring and protection, where the nominal current I_N ranges from 39 A to 4000 A.

The phase current input 1 A or 5 A, the residual current input 0.2 A or 1 A, and the rated 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	RTD	mA
A	AA	N	4	3	-	8	10	-	-
		A	4	3	-	14	13	-	-
B	AB	N	4	6[1)]	-	12	10	-	-
C	AC	N	1	-	3	8	10	-	-
E	AE	N	-	3[2)]	3	8	10	-	-
F	AF	N	4	5	-	12	10	2	1
	BF	N	4	5	-	16	10	-	-
G	AG	N	7	6	-	11	10	-	-
H	AH	N	7	6[1)]	-	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

18. 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.

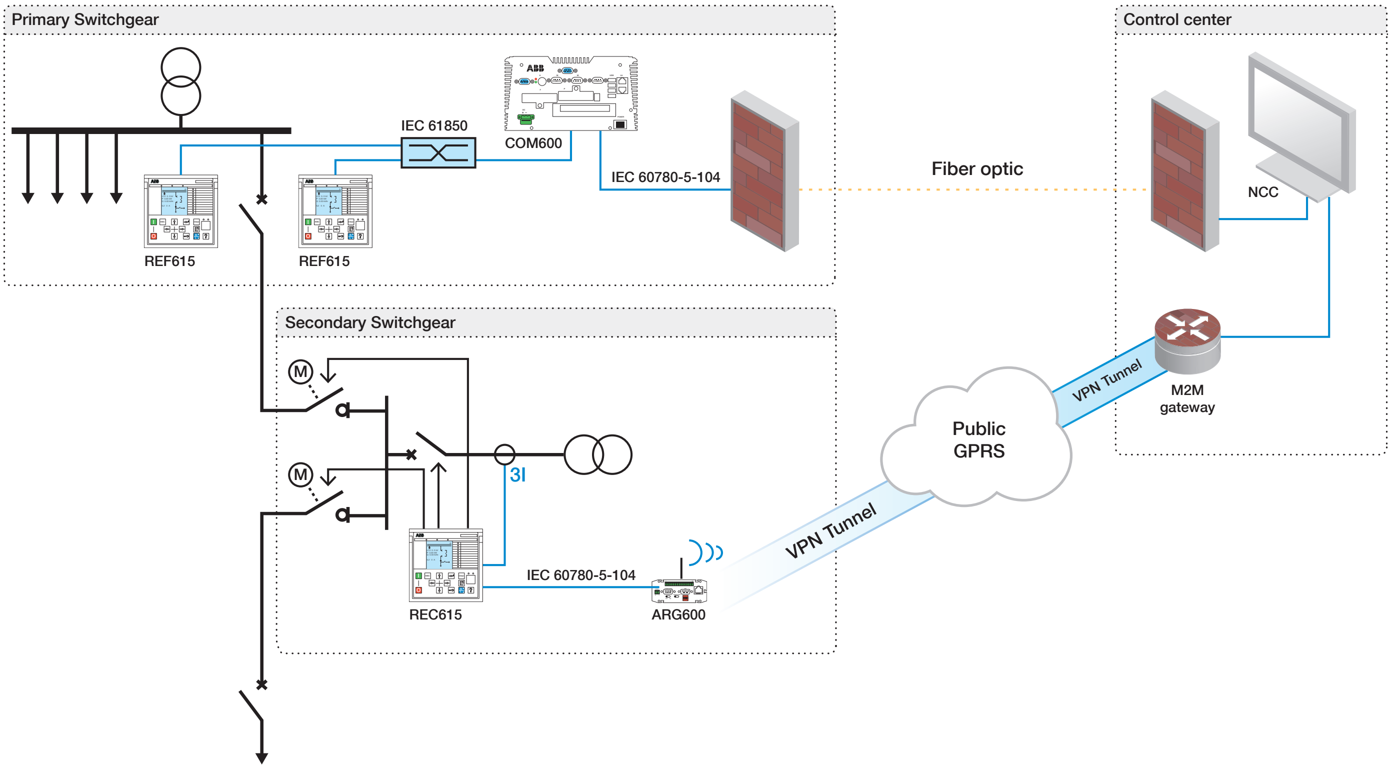


Figure 12. System overview of utility communication

The communication solutions used with secondary substations are typically different from the ones used with primary substations. In the example illustrated in Figure 12, the primary substation communication is established by fibre optics and, for example, a COM600 Grid Automation Controller while the communication to the secondary substation is handled with REC615 as the gateway and a ARG600 communication unit providing an end-to-end intelligent and secure connection.

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

19. Technical data

Table 6. Dimensions

Description	Value	
Width	Frame	177 mm
	Case	164 mm
Height	Frame	177 mm (4U)
	Case	160 mm
Depth		201 mm (153 + 48 mm)
Weight	Complete 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.) 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 • Continuously • For 1 s	 4 A[1] 100 A[1]	 20 A 500 A
	Dynamic current withstand • Half-wave value	 250 A[1]	 1250 A
	Input impedance	<100 mΩ[1]	<20 mΩ
Voltage inputs	Rated voltage	60...210 V AC	
	Voltage withstand • Continuous • For 10 s	 240 V AC 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 • Continuous • For 10 s	 240 V AC 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
X130: SO1, SO2 when REC615 is equipped with BIO0006

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
X130: SO3 when REC615 is equipped with BIO0006

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 IEC 60255-26 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 IEC 60255-26, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test		
	10 V (rms) f = 150 kHz...80 MHz	IEC 61000-4-6 IEC 60255-26, class III
	10 V/m (rms) f = 80...2700 MHz	IEC 61000-4-3 IEC 60255-26, class III
	10 V/m f = 900 MHz	ENV 50204 IEC 60255-26, class III
	20 V/m (rms) f = 80...1000 MHz	IEEE C37.90.2-2004
Fast transient disturbance test		IEC 61000-4-4 IEC 60255-26 IEEE C37.90.1-2012
• All ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-26
• Communication	1 kV, line-to-earth	
• Other ports	4 kV, line-to-earth 2 kV, line-to-line	
Power frequency (50 Hz) magnetic field immunity test		IEC 61000-4-8
• Continuous • 1...3 s	300 A/m 1000 A/m	
Pulse magnetic field immunity test	1000 A/m 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 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 IEC 60255-26 CISPR 11 CISPR 22
• Conducted		
0.15...0.50 MHz	<79 dB (μV) quasi peak <66 dB (μV) average	
0.5...30 MHz	<73 dB (μV) quasi peak <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 500 V, 50 Hz, 1 min, communication	IEC 60255-27
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J 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) IEC 60255-21-1
Shock and bump test	Class 2	IEC 60068-2-27 (test Ea shock) IEC 60068-2-29 (test Eb bump) 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 • 16 h at +85ºC[1)]	IEC 60068-2-2
Cold test	• 96 h at -25ºC • 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 • 96 h at +85ºC	IEC 60068-2-1 IEC 60068-2-2
Mixed gas corrosion[2)]	Test parameters according to GR-63-CORE (outdoor): • Temp: 30°C ±1 • RH: 70% ±2 • H2S: 100 ±15 ppb • Cl2: 20 ±3 ppb • NO2: 200 ±30 ppb • 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) 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) ±5.0% of the set value (at currents in the range of 10…40 × I_n)		
Start time [1)2)]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	16 ms 11 ms	19 ms 12 ms	23 ms 14 ms
	PHHPTOC and (F)PHLPTOC: 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)] ±5.0% of the theoretical value or ±40 ms [3)4)]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression		

1) Set *Operate delay time* = 0,02 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × 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 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 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: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DPHHPDOC	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n 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)] ±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 2 = Forward 3 = Reverse	-
Characteristic angle	DPHxPDOC	-179...180°	1
Operating curve type[1)]	(F)DPHLPDOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, -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 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 and EFIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n)		
Start time [1)2)]		Minimum	Typical	Maximum
	EFIPTOC: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	 16 ms 11 ms	 19 ms 12 ms	 23 ms 14 ms
	EFHPTOC and (F)EFLPTOC: 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)] ±5.0% of the theoretical value or ±40 ms [3)4)]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… 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 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 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: ±1.5% of the set value or ±0.002 × I_n Voltage ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time 1)2)		Minimum	Typical	Maximum
	DEFHPDEF I_{Fault} = 2 × set *Start value*	42 ms	46 ms	49 ms
	(F)DEFLPDEF 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) ±5.0% of the theoretical value or ±40 ms 3)4)		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… 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 2 = Forward 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 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 Curve type: 1, 3, 5, 15, 17	
Operation mode	(F)DEFxPDEF	1 = Phase angle 2 = IoSin 3 = IoCos 4 = Phase angle 80 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 2 = Forward 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 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 (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 × 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 2 = Forward 3 = Reverse	-
Operation mode	EFPADM	1 = Yo 2 = Go 3 = Bo 4 = Yo, Go 5 = Yo, Bo 6 = Go, Bo 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: ±1.5% of the set value or ±0.002 × I_n Power: ±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 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 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 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: 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 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 2 = Amplitude 3 = Resistive	-
Min operate current	MFADPSDE	0.005...5.000 × I_n	0.001
Operation mode	MFADPSDE	1 = Intermittent EF 3 = General EF 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* I_{Fault} = 10 × set *Start value*	23 ms 15 ms	26 ms 18 ms	28 ms 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 type[1)]	NSPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	

1) For further reference, 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 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 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* U_{Fault} = 0.9 × set *Start value*	52 ms 44 ms	55 ms 47 ms	58 ms 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* U_{Fault} = 2.0 × set *Start value*	33 ms 24 ms	35 ms 26 ms	37 ms 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. Loss of phase, undercurrent (PHPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × I_n
Start time	Typically <55 ms
Reset time	<40 ms
Reset ratio	Typically 1.04
Retardation time	<35 ms
Operate time accuracy in definite time mode	mode ±1.0% of the set value or ±20 ms

Table 61. Loss of phase, undercurrent (PHPTUC) main settings

Parameter	Function	Value (Range)	Step
Current block value	PHPTUC	0.00...0.50 × I_n	0.01
Start value	PHPTUC	0.01...1.00 × I_n	0.01
Operate delay time	PHPTUC	50...200000 ms	10

Table 62. Frequency protection (FRPFRQ)

Characteristic		Value
Operation accuracy	f>/f<	±5 mHz
	df/dt	±50 mHz/s (in range |df/dt| <5 Hz/s) ±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 63. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1 = Freq< 2 = Freq> 3 = df/dt 4 = Freq< + df/dt 5 = Freq> + df/dt 6 = Freq< OR df/dt 7 = Freq> OR df/dt	-
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 64. 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 65. 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 66. 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 67. 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 2 = Breaker status 3 = Both	-
CB fail trip mode	CCBRBRF	1 = Off 2 = Without check 3 = Current check	-
Retrip time	CCBRBRF	0...60000 ms	10
CB failure delay	CCBRBRF	0...60000 ms	10
CB fault delay	CCBRBRF	0...60000 ms	10

Table 68. Three-phase inrush detector (INRPHAR)

Characteristic	Value
Operation accuracy	At the frequency f = f_n
	Current measurement: ±1.5% of the set value or ±0.002 × I_n Ratio I2f/I1f measurement: ±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 69. 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 70. Multipurpose protection (MAPGAPC)

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

Table 71. 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 2 = Under	-

Table 72. Load-shedding and restoration (LSHDPFRQ)

Characteristic		Value
Operation accuracy	f<	±5 mHz
	df/dt	±100 mHz/s (in range |df/dt| < 5 Hz/s) ± 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 73. Load-shedding and restoration (LSHDPFRQ) main settings

Parameter	Function	Value (Range)	Step
Load shed mode	LSHDPFRQ	1 = Freq< 6 = Freq< OR df/dt 8 = Freq< AND df/dt	-
Restore mode	LSHDPFRQ	1 = Disabled 2 = Auto 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 74. Fault locator (SCEFRFLO)

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

Table 75. 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 76. Operation characteristics

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

Power quality functions

Table 77. 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 78. 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 79. Voltage unbalance (VSQVUB)

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

Table 80. Voltage unbalance (VSQVUB) main settings

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

Control functions

Table 81. Autoreclosing (DARREC)

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

Table 82. Synchronism and energizing check (SECRSYN)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±1 Hz
	Voltage: ±3.0% of the set value or ±0.01 × U_n Frequency: ±10 mHz Phase angle: ±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 83. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	-1 = Off 1 = Both Dead 2 = Live L, Dead B 3 = Dead L, Live B 4 = Dead Bus, L Any 5 = Dead L, Bus Any 6 = One Live, Dead 7 = Not Both Live	-
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 2 = Synchronous 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 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 84. Automatic transfer switch (ATSABTC)

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

Table 85. Automatic transfer switch (ATSABTC) main settings

Parameter	Function	Value (Range)	Step
Operation	ATSABTC	1=on 5=off	
Main bus priority	ATSABTC	1=Bus 1 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 86. 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) ±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 87. 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 88. 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 89. 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 90. Voltage presence (PHSVPR) main settings

Parameter	Function	Value (Range)	Step
Num of phases	PHSVPR	1=1 out of 3 2=2 out of 3 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 91. 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 (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,… RMS: No suppression

Table 92. 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 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 93. 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 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,… RMS: No suppression

Table 94. Three-phase voltage measurement (VMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz 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,… RMS: No suppression

Table 95. Residual voltage measurement (RESVMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f/f_n = ±2 Hz
	±0.5% or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… RMS: No suppression

Table 96. Sequence voltage measurement (VSMSQI)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz 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 97. Three-phase power and energy measurement (PEMMXU)

Characteristic	Value
Operation accuracy	At all three currents in range 0.10…1.20 × I_n At all three voltages in range 0.50…1.15 × U_n At the frequency f_n ±1 Hz
	±1.5% for apparent power S ±1.5% for active power P and active energy[1)] ±1.5% for reactive power Q and reactive energy[2)] ±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 98. Single-phase power and energy measurement (SPEMMXU)

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

Table 99. Frequency measurement (FMMXU)

Characteristic	Value
Operation accuracy	±10 mHz (in measurement range 35...75 Hz)

20. 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 13. Large display

Table 100. 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

21. 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

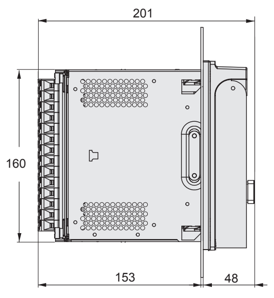


Figure 14. Flush mounting

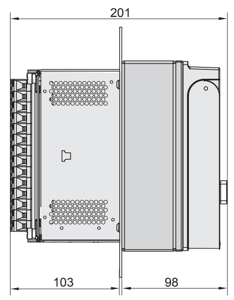


Figure 15. Semi-flush mounting

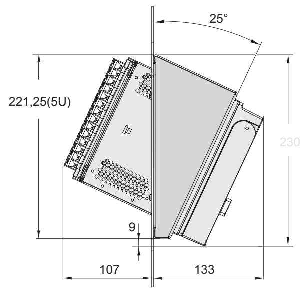


Figure 16. Semi-flush mounting in a 25º tilt

22. 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.

23. Selection and ordering data

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

24. Accessories and ordering data

Table 101. 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

25. 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 102. Tools

Description	Version
PCM600	2.9 or later
Web browser	IE 8.0, IE 9.0, IE 10.0 or IE 11.0
REC615 Connectivity Package	2.0 or later

Table 103. 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

26. Connection diagrams

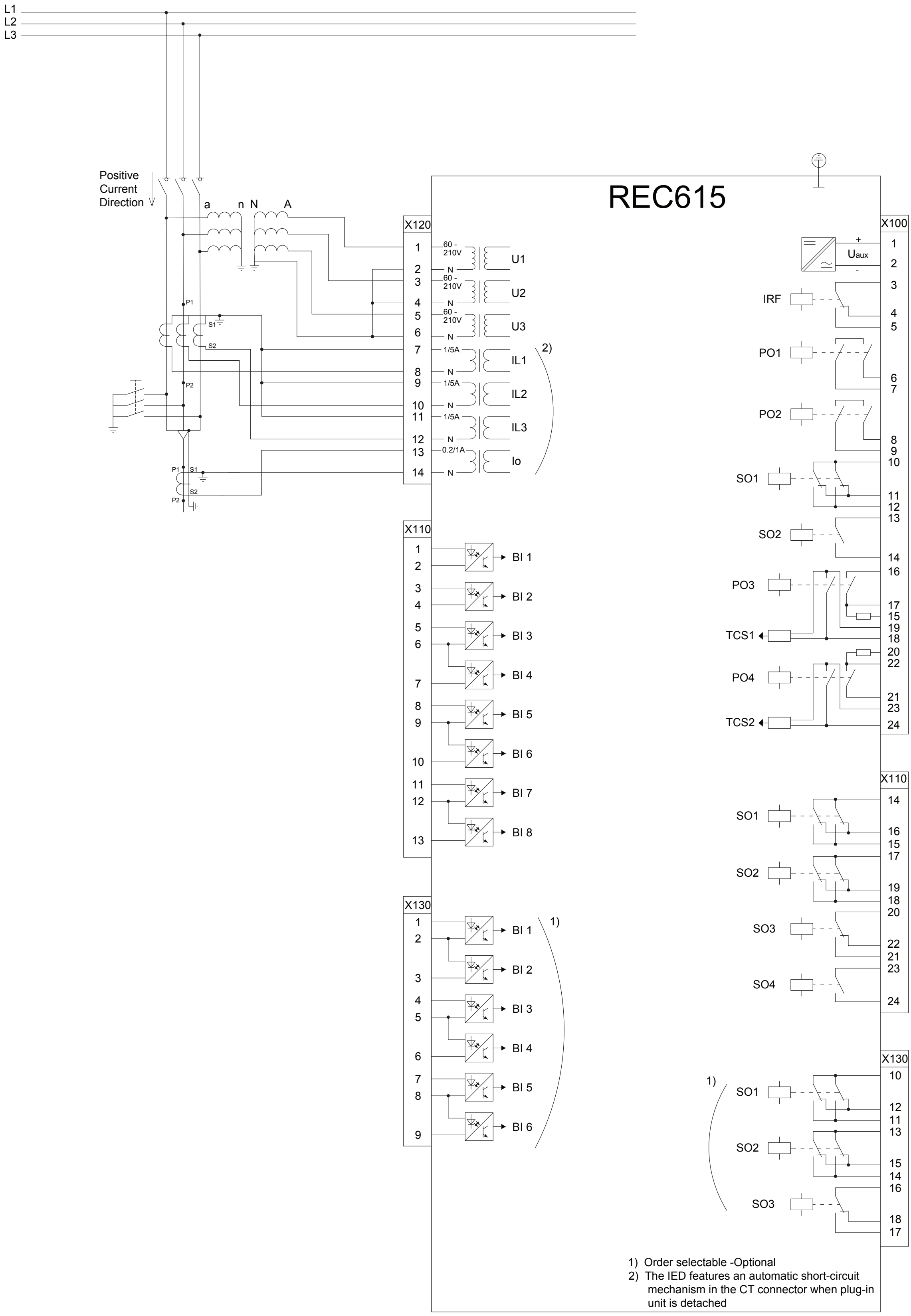


Figure 17. Connection diagram for the A configuration

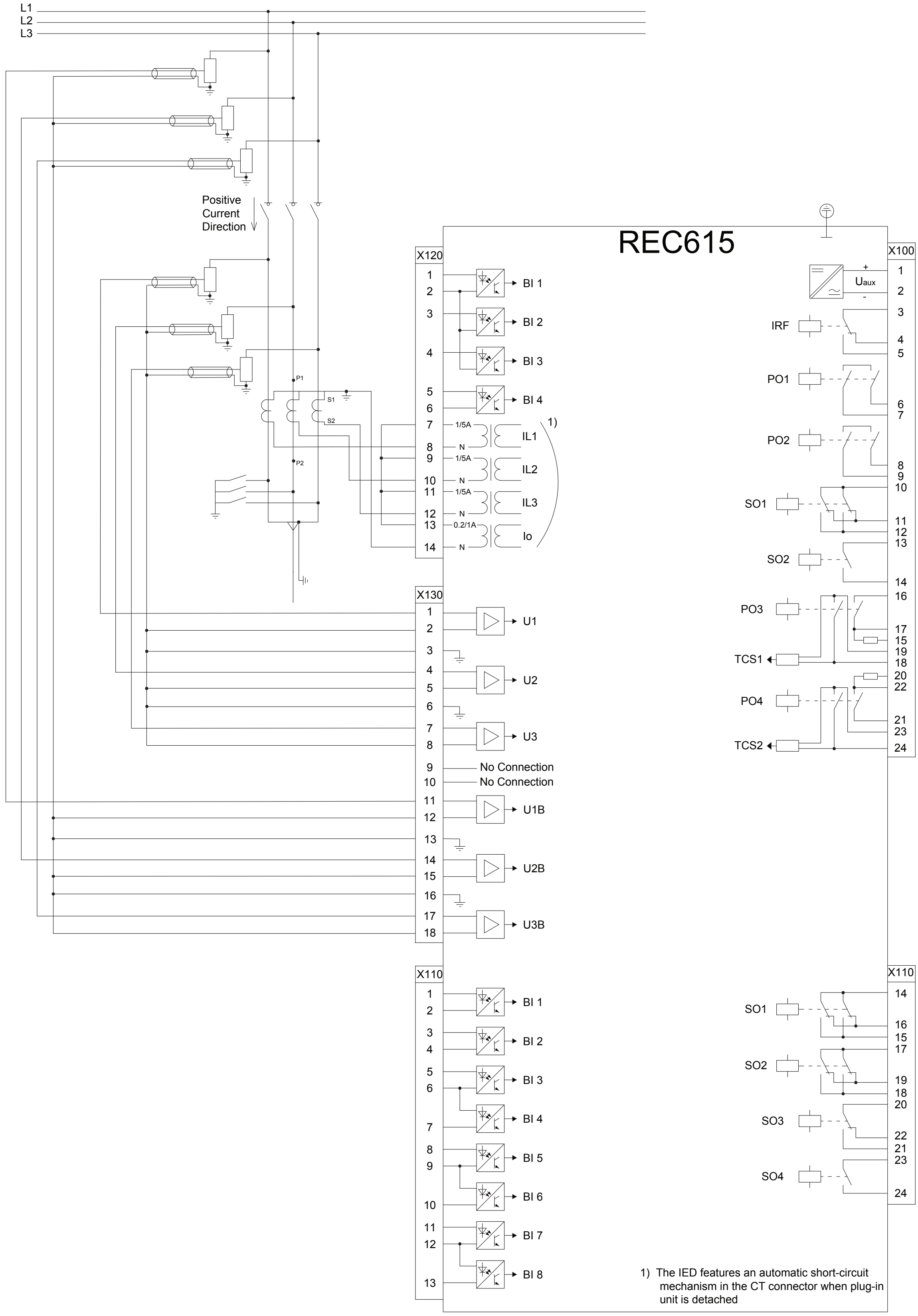


Figure 18. Connection diagram for the B configuration

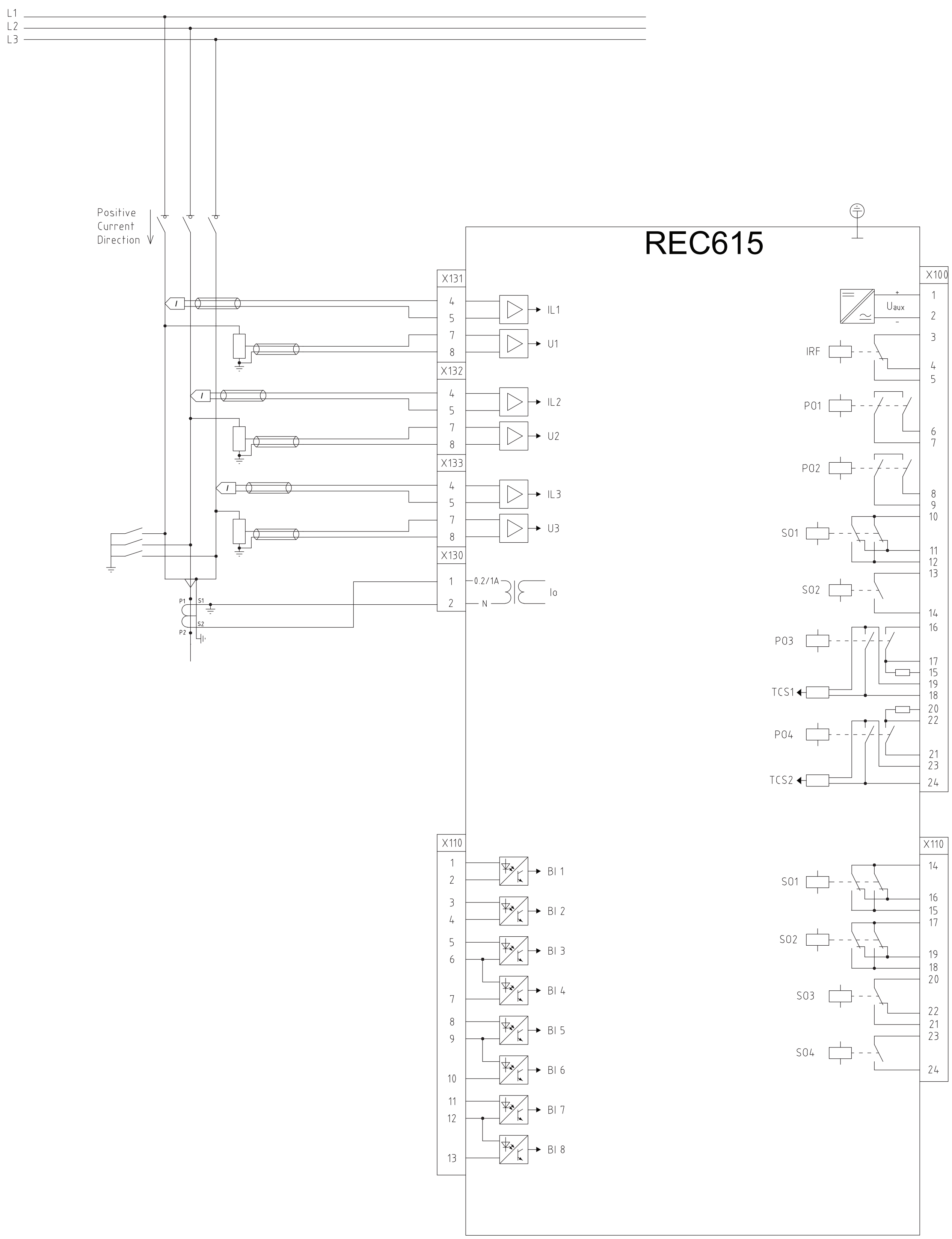


Figure 19. Connection diagram for the C configuration

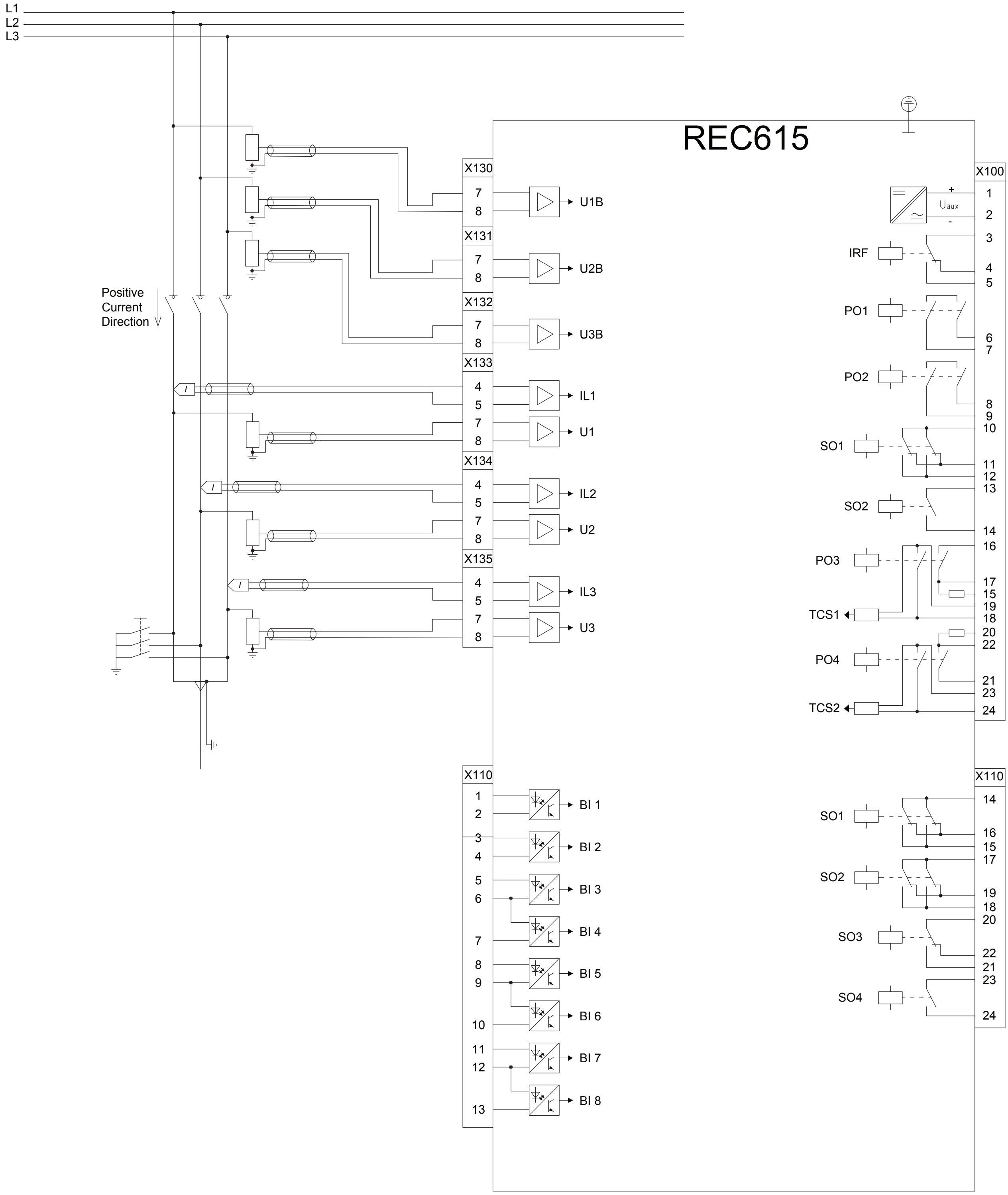


Figure 20. Connection diagram for the E configuration

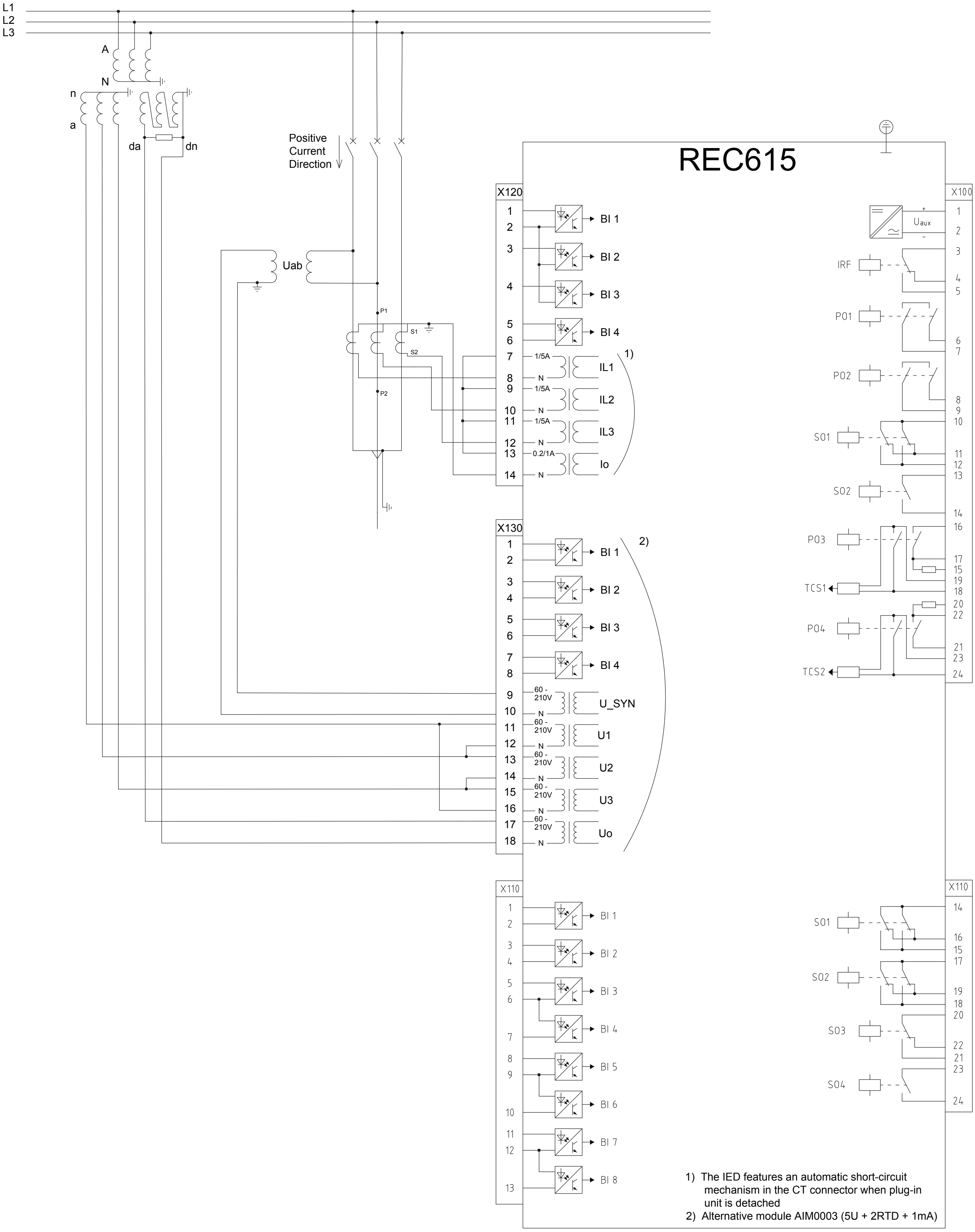


Figure 21. Connection diagram for the F configuration

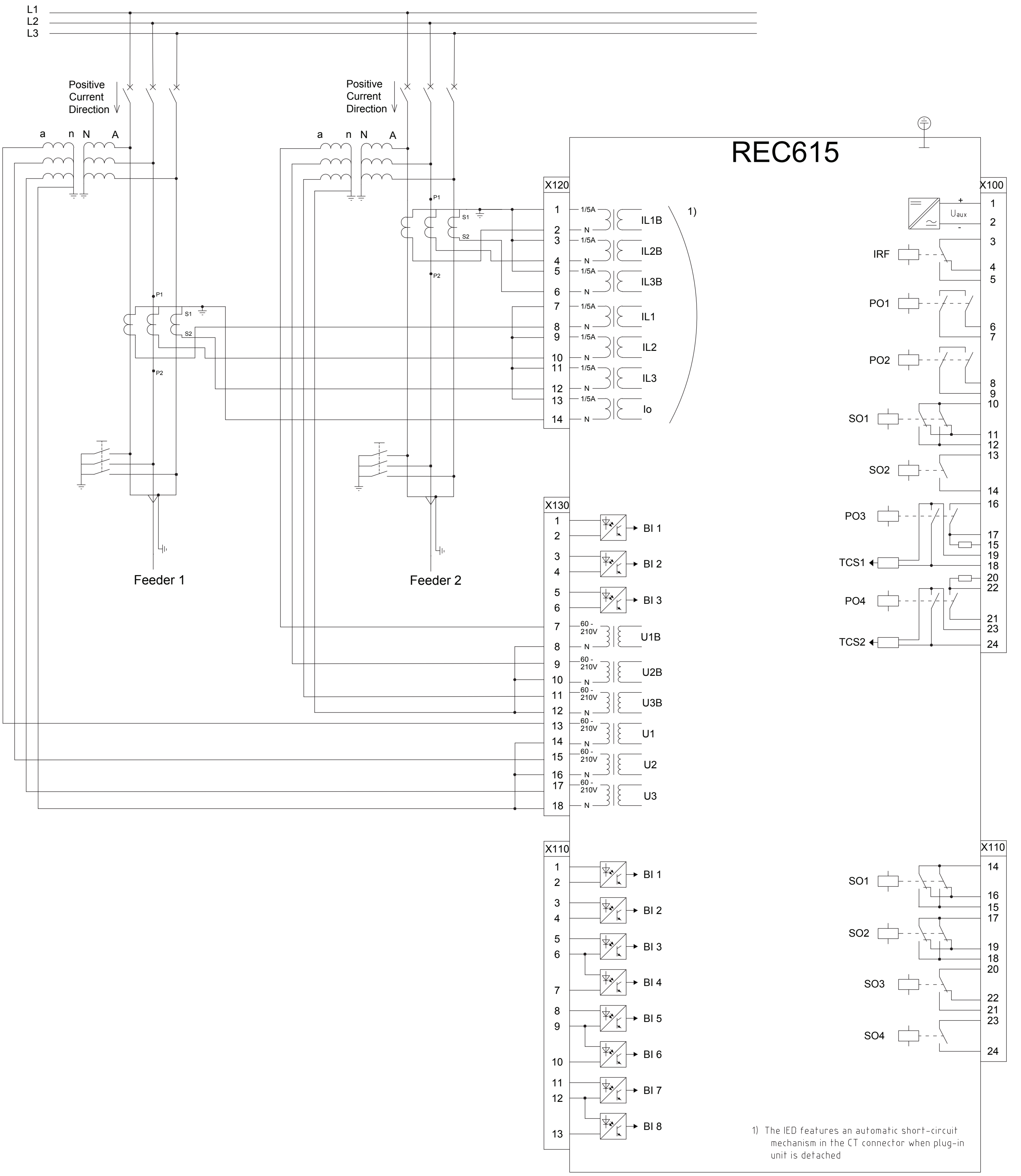


Figure 22. Connection diagram for the G configuration

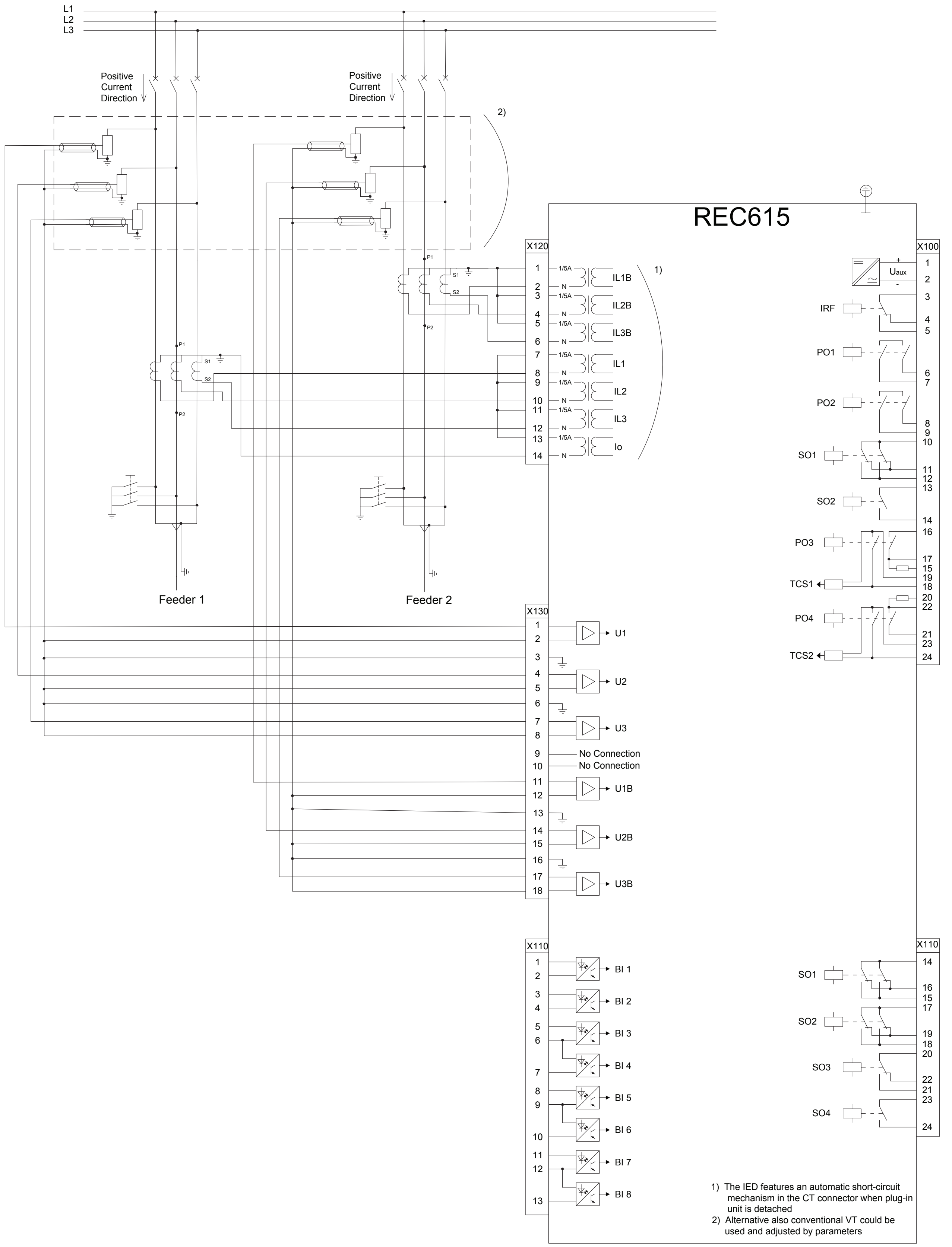


Figure 23. Connection diagram for the H configuration

27. 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 REC615 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

28. Functions, codes and symbols

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

Table 104. 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 non-directional overcurrent protection, instantaneous stage, instance 2	PHIPTOC2	3I>>> (2)	50P/51P (2)
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, low stage, instance 3	DPHLPDOC3	3I> -> (3)	67-1 (3)
Three-phase directional overcurrent protection, low stage, instance 4	DPHLPDOC4	3I> -> (4)	67-1 (4)
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Three-phase directional overcurrent protection, high stage, instance 3	DPHHPDOC3	3I>> -> (3)	67-2 (3)
Three-phase directional overcurrent protection, high stage, instance 4	DPHHPDOC4	3I>> -> (4)	67-2 (4)
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, low stage, instance 3	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, low stage, instance 4	DEFLPDEF4	Io> -> (4)	67N-1 (4)
Directional earth-fault protection, high stage, instance 1	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Directional earth-fault protection, high stage, instance 2	DEFHPDEF2	Io>> -> (2)	67N-2 (2)
Directional earth-fault protection, high stage, instance 3	DEFHPDEF3	Io>> -> (3)	67N-2 (3)
Directional earth-fault protection, high stage, instance 4	DEFHPDEF4	Io>> -> (4)	67N-2 (4)

Table 104. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Transient / intermittent earth-fault protection,instance 1	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Admittance-based earth-fault protection, instance 1	EFPADM1	Yo> -> (1)	21YN (1)
Admittance-based earth-fault protection, instance 2	EFPADM2	Yo> -> (2)	21YN (2)
Admittance-based earth-fault protection, instance 3	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric-based earth-fault protection, instance 1	WPWDE1	Po> -> (1)	32N (1)
Wattmetric-based earth-fault protection, instance 2	WPWDE2	Po> -> (2)	32N (2)
Wattmetric-based earth-fault protection, instance 3	WPWDE3	Po> -> (3)	32N (3)
Harmonics-based earth-fault protection, instance 1	HAEFPTOC1	Io>HA (1)	51NHA (1)
Multifrequency admittance-based earth-fault protection, instance 1	MFADPSDE1	Io> -> Y (1)	67YN (1)
Multifrequency admittance-based earth-fault protection, instance 2	MFADPSDE2	Io> -> Y (2)	67YN (2)
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)
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)
Loss of phase (undercurrent), instance 1	PHPTUC1	3I< (1)	37 (1)
Loss of phase (undercurrent), instance 2	PHPTUC2	3I< (2)	37 (2)
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	MAPGAPC1	MAP (1)	MAP (1)
Multipurpose protection, instance 2	MAPGAPC2	MAP (2)	MAP (2)
Multipurpose protection, instance 3	MAPGAPC3	MAP (3)	MAP (3)

Table 104. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Multipurpose protection, instance 4	MAPGAPC4	MAP (4)	MAP (4)
Multipurpose protection, instance 5	MAPGAPC5	MAP (5)	MAP (5)
Multipurpose protection, instance 6	MAPGAPC6	MAP (6)	MAP (6)
Load-shedding and restoration, instance 1	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
Load-shedding and restoration, instance 2	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
Fault locator, instance 1	SCEFRFLO1	FLOC (1)	21FL (1)
Three-phase power directional element, instance 1	DPSRDIR1	I1-> (1)	32P (1)
Three-phase power directional element, instance 2	DPSRDIR2	I1-> (2)	32P (2)
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)
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)
Autoreclosing, instance 2	DARREC2	O -> I (2)	79 (2)
Synchronism and energizing check, instance 1	SECRSYN1	SYNC (1)	25 (1)
Automatic transfer switch,instance1	ATSABTC1	ATSABTC1	ATSABTC1

Table 104. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
Fuse failure supervision, instance 2	SEQSPVC2	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)
Three-phase current measurement, instance 2	CMMXU2	3I (2)	3I (2)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Sequence current measurement, instance 2	CSMSQI2	I1, I2, I0 (2)	I1, I2, I0 (2)
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)
Residual voltage measurement, instance 1	RESVMMXU1	Uo (1)	Vn (1)
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)
Three-phase power and energy measurement, instance 2	PEMMXU2	P, E (2)	P, E (2)
Single-phase power and energy measurement, instance 1	SPEMMXU1	SP, SE (1)	SP, SE (1)
Single-phase power and energy measurement, instance 2	SPEMMXU2	SP, SE (2)	SP, SE (2)
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)

Table 104. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
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

Table 104. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Programmable buttons (4 buttons)	FKEY4GGIO1	FKEY4GGIO1	FKEY4GGIO1
Logging functions			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Fault record	FLTRFRC1	FAULTREC (1)	FAULTREC (1)

29. 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
F/2019-05-31	2.0.3	Content updated to correspond to the product version

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ABB Distribution Solutions
Distribution Automation
P.O. Box 699
FI-65101 VAASA, Finland
Phone +358 10 22 11

www.abb.com/mediumvoltage
www.abb.com/relion

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