PRODUCT GUIDE

REG615

Generator protection and control

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REG615
Generator protection and control

1. Description
REG615 is a dedicated generator protection relay designed for the different power generation applications. REG615 is available in two standard configurations denoted C and D. Standard configurations C and D are designed for the protection, control, measurement and supervision of small or medium size generators used in diesel, gas, hydroelectric, combined heat and power (CHP), and steam power plants. REG615 is a member of ABB's Relion® product family and part of its 615 protection and control product series. The 615 series protection relays are characterized by their compactness and withdrawable unit design.

Re-engineered from the ground up, the 615 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices. Once the standard configuration relay has been given the application-specific settings, it can directly be put into service.

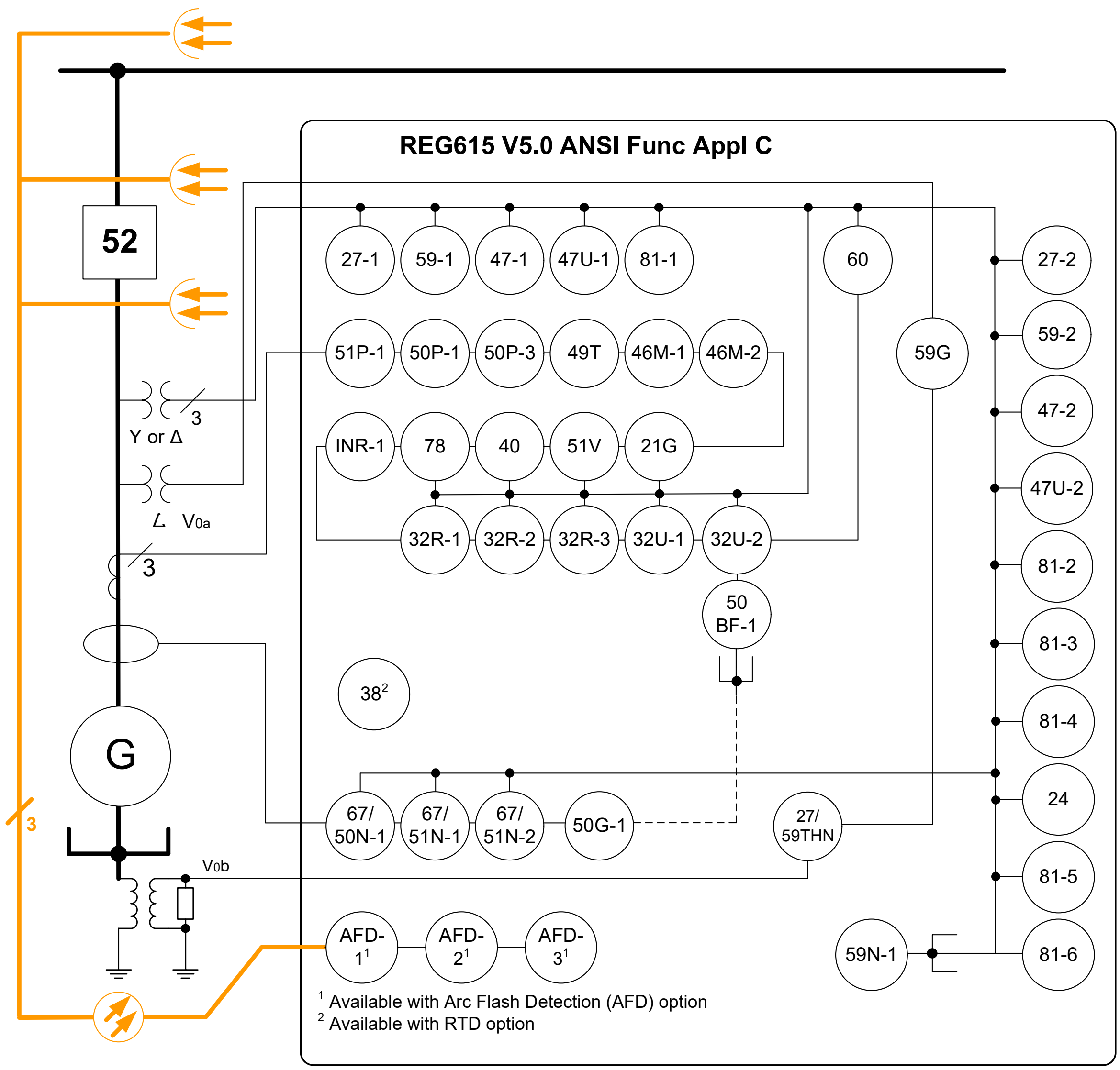
The generator protection relay provides main protection for small size power generators. The generator protection relay is also used as back-up protection for medium size generators in power applications, where an independent and redundant protection system is required.

The 615 series relays support a range of communication protocols including IEC 61850 with Edition 2 support, process bus according to IEC 61850-9-2 LE, Modbus® and DNP3.

2. Standard configurations
REG615 is available in two alternative standard configurations. The standard signal configuration can be altered by means of the signal matrix or the graphical application functionality of the Protection and Control Relay Manager PCM600. Further, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions using various logical elements, including timers and flip-flops. By combining protection functions with logic function blocks, the relay configuration can be adapted to userspecific application requirements.

The protection relay is delivered from the factory with default connections described in the functional diagrams for binary inputs, binary outputs, function-to-function connections and alarm LEDs. Some of the supported functions in REG615 must be added with the Application Configuration tool to be available in the Signal Matrix tool and in the relay. The positive measuring direction of directional protection functions is towards the busbar.

Figure 1. Functionality overview for standard configuration C



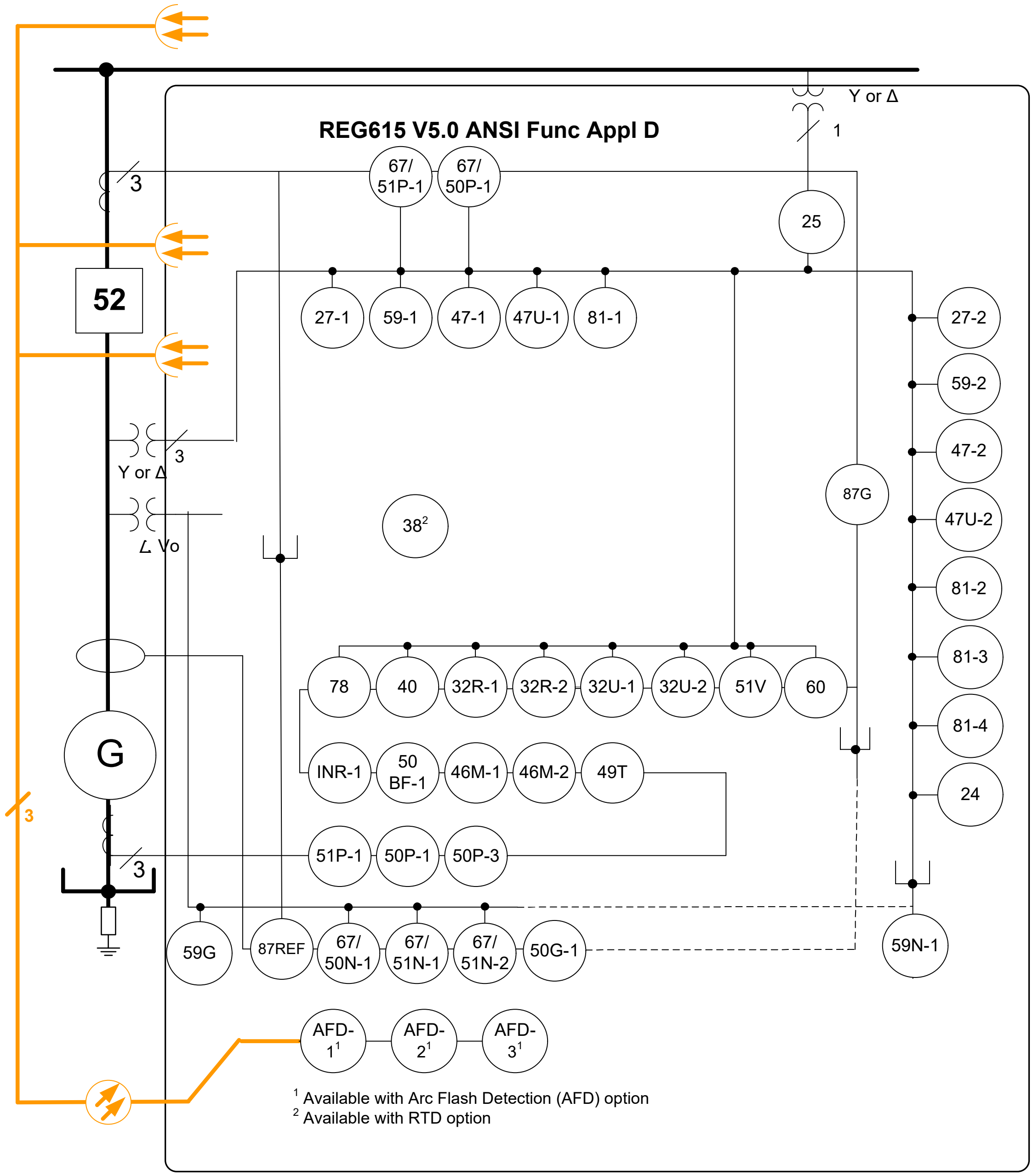


Figure 2. Functionality overview for standard configuration D

Table 1. Standard configurations

Description	Std. conf.
Generator protection with 100% stator ground-fault protection	C
Generator protection with generator differential and directional overcurrent protection and synchro-check	D

Table 2. Supported functions

Function	IEC 61850	ANSI	C	D
Protection				
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	51P	1	1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	50P	1	1
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	50P	1	1
Three-phase directional overcurrent protection, low stage	DPHLPDOC	67/51P		1 TR
Three-phase directional overcurrent protection, high stage	DPHHPDOC	67/50P		1 TR
Three-phase voltage-dependent overcurrent protection	PHPVOC	51V	1	1
Non-directional ground-fault protection, high stage	EFHPTOC	50G	1	1
Directional ground-fault protection, low stage	DEFLPDEF	67/51N	2	2
Directional ground-fault protection, high stage	DEFHPDEF	67/50N	1	1
Transient/intermittent ground-fault protection	INTRPTEF	-		
Negative-sequence overcurrent protection	NSPTOC	-		
Negative-sequence overcurrent protection for machines	MNSPTOC	46M	2	2
Residual overvoltage protection	ROVPTOV	59G, 59N	2	2
Three-phase undervoltage protection	PHPTUV	27	2	2
Three-phase overvoltage protection	PHPTOV	59	2	2
Positive-sequence undervoltage protection	PSPTUV	47U	2	2
Negative-sequence overvoltage protection	NSPTOV	47	2	2
Frequency protection	FRPFRQ	81	6	4
Overexcitation protection	OEPVPH	24	1	1
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	-		
Three-phase thermal overload protection, two time constants	T2PTTR	49T	1	1
Circuit breaker failure protection	CCBRBRF	50BF	1 [2)]	1 [2)]
Three-phase inrush detector	INRPHAR	INR	1	1
Master trip	TRPPTRC	86/94	3(6) [3)]	3(6) [3)]
Arc protection	ARCSARC	AFD	2	2
Multipurpose protection	MAPGAPC	MAP	18	18
Stabilized and instantaneous differential protection for machines	MPDIF	87G		1
Numerical stabilized low-impedance restricted ground-fault protection	LREFPNDF	87LOZREF		1
Third harmonic-based stator ground-fault protection	H3EFPSEF	27/59THN	1	
Underpower protection	DUPPDPR	32U	2	2
Reverse power/directional overpower protection	DOPPDPR	32R-32O	3	2
Three-phase underexcitation protection	UEXPDIS	40	1	1
Three-phase underimpedance protection	UZPDIS	21G	1	
Out-of-step protection	OOSRPSB	78	1	1
Interconnection functions				
Directional reactive power undervoltage protection	DQPTUV	-		
Low-voltage ride-through protection	LVRTPTUV	-		
Voltage vector shift protection	VVSPPAM	-		
Power quality				
Current total demand distortion	CMHAI	PQI	(1) [4)]	(1) [4)]
Voltage total harmonic distortion	VMHAI	PQVPH	(1) [4)]	(1) [4)]
Voltage variation	PHQVVR	PQSS	(1) [4)]	(1) [4)]
Voltage unbalance	VSQVUB	PQVUB	(1) [4)]	(1) [4)]
Control				
Circuit-breaker control	CBXCBR	52	1	1
Disconnector control	DCXSWI	29DS	2	2
Grounding switch control	ESXSWI	29GS	1	1
Disconnector position indication	DCSXSWI	52-TOC	3	3
Grounding switch indication	ESSXSWI	29GS	2	2

Table 2. Supported functions

Function	IEC 61850	ANSI	C	D
Synchronism and energizing check	SECRSYN	25		1
Condition monitoring and supervision				
Circuit-breaker condition monitoring	SSCBR	52CM	1	1
Trip circuit supervision	TCSSCBR	TCM	2	2
Current circuit supervision	CCSPVC	-		
Fuse failure supervision	SEQSPVC	60	1	1
Runtime counter for machines and devices	MDSOPT	OPTM	1	1
Measurement				
Disturbance recorder	RDRE	-	1	1
Load profile record	LDPRLRC	LoadProf	1	1
Fault record	FLTRFRC	-	1	1
Three-phase current measurement	CMMXU	IA, IB, IC,	1	2
Sequence current measurement	CSMSQI	I1, I2, I0	1	1
Residual current measurement	RESCMMXU	IG	1	1
Three-phase voltage measurement	VMMXU	VA, VB, VC	1	2
Residual voltage measurement	RESVMMXU	VG	2	1
Sequence voltage measurement	VSMSQI	V1, V2, V0	1	1
Three-phase power and energy measurement	PEMMXU	P, E	1	1
RTD/mA measurement	XRGGIO130	X130 (RTD) (1)	(1)	(1)
Frequency measurement	FMMXU	f	1	1
IEC 61850-9-2 LE sampled value sending 5)6)	SMVSENDER	SMVSENDER	(1)	(1)
IEC 61850-9-2 LE sampled value receiving (voltage sharing) 5)6)	SMVRCV	SMVRECEIVER	(1)	(1)
Other				
Minimum pulse timer (2 pcs)	TPGAPC	62TP	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	62TPS	1	1
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	62TPM	1	1
Pulse timer (8 pcs)	PTGAPC	62PT	2	2
Time delay off (8 pcs)	TOFGAPC	62TOF	4	4
Time delay on (8 pcs)	TONGAPC	62TON	4	4
Set-reset (8 pcs)	SRGAPC	SR	4	4
Move (8 pcs)	MVGAPC	MV	2	2
Generic control point (16 pcs)	SPCGAPC	SPC	2	2
Analog value scaling (4 pcs)	SCA4GAPC	SCA4	4	4
Integer value move (4 pcs)	MVI4GAPC	MV14	1	1

1, 2, ... = Number of included instances. The instances of a protection function represent the number of identical protection function blocks available in the standard configuration.
() = option
TR = The function block is to be used on the terminal side in the application

1) "Io measured" is always used.
2) "Io calculated" is always used.
3) Master trip is included and connected to the corresponding HSO in the configuration only when the BIO0007 module is used. If additionally the ARC option is selected, ARCSARC is connected in the configuration to the corresponding master trip input.
4) Power quality option includes current total demand distortion, voltage total harmonic distortion, voltage variation and voltage unbalance.
5) Available only with IEC 61850-9-2
6) Available only with COM0031...0037

3. Protection functions

The generator protection relay offers protection functionality for synchronous generators and their prime mover against internal faults and abnormal conditions of external systems. The main feature in the standard configuration D is the differential protection. The main feature in the standard configuration C is the 3rd harmonic-based stator ground-fault protection completing the detection coverage with the other ground-fault protection provided. The generator protection relay also features reverse power and directional overpower protection against delivering excessive power beyond the generator's capacity and against the generator running like a motor. The underpower protection protects generators and prime movers against the effects of very low power outputs. A dedicated protection function detects any loss of synchronism (out-ofstep condition) between the generator and the rest of the power system. The generator relay also includes back-up overcurrent protection featuring voltage dependent overcurrent and, in the standard configuration D, directional overcurrent protection and, in the standard configuration C, underimpedance protection. Overexcitation protection (24) protects the generators against excessive flux density. Underexcitation (40) protects the synchronous machine against the underexcitation or loss of excitation condition. Frequency and voltage based protection, thermal overload and unbalance protection are also included in both standard configurations C and D intended for generator protection.

The RTD/mA inputs are offered as an option for the default configuration. They can be used with multipurpose protection function for tripping and alarm purposes. Multipurpose protection function uses RTD/mA measuring data or analog values via GOOSE messages.

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

The arc-fault protection sensor interface is available on the optional communication module. Fast tripping increases staff safety and security and limits material damage in an arc fault situation. A binary input and output module can be selected as an option - having three high speed binary outputs (HSO) it further decreases the total operate time with typically 4...6 ms compared to the normal power outputs.

4. Application

Standard configurations C and D are intended to be used in synchronous power generator application where the protection coverage is a generator, field excitation system and primary mover. A typical application example is parallel connected diesel or gas generators with a common step-up transformer but it can also be a generator in block connection with a transformer. In medium-size power generator applications independent and redundant protection system can be a requirement or the protection system as a whole may require more than one protection relay in one set-up. Various recognized grounding principles exist and typically grounding selection depends on the complete system requirements where the generator is located. The ground-fault protection depends mainly on the used grounding principle.

Figure 3. Application example for parallel with common step-up transformer connected Diesel/Gas generators protected with standard configuration C

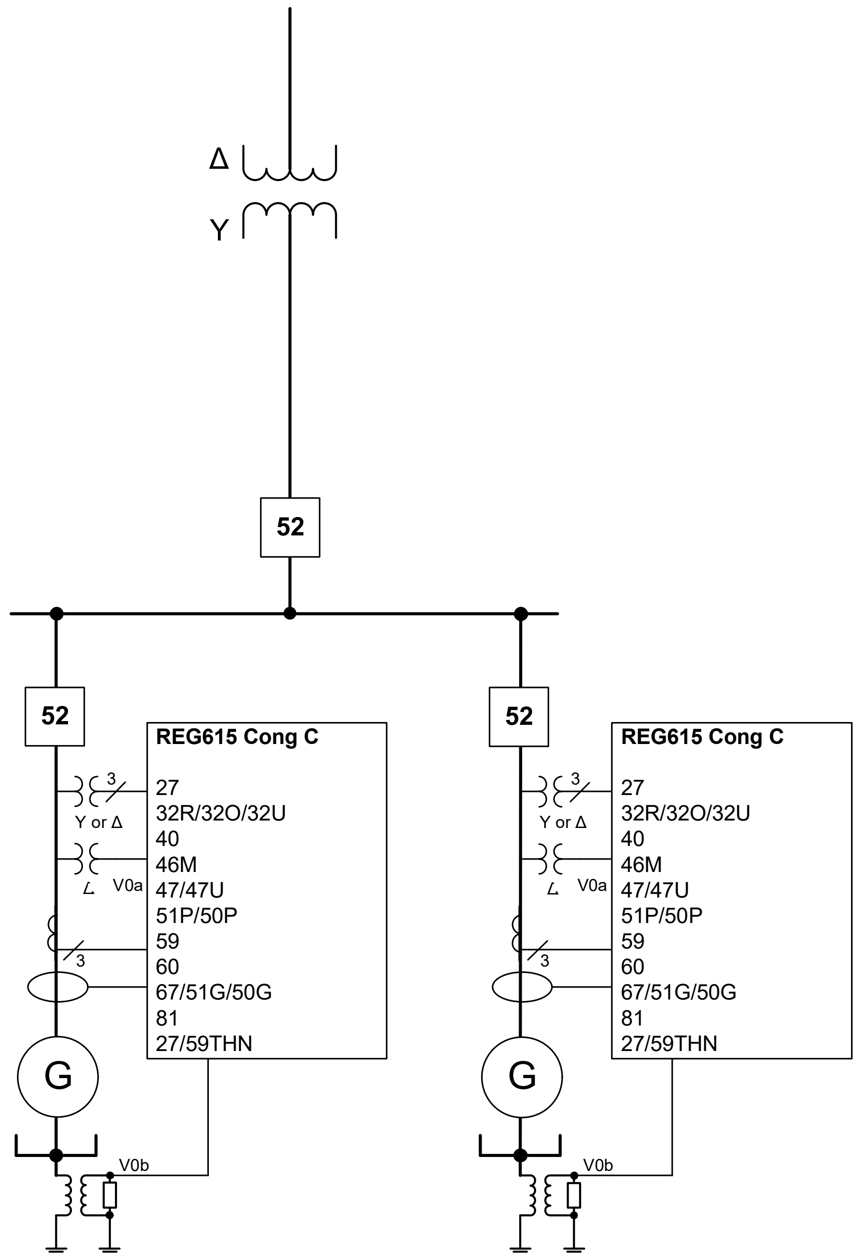
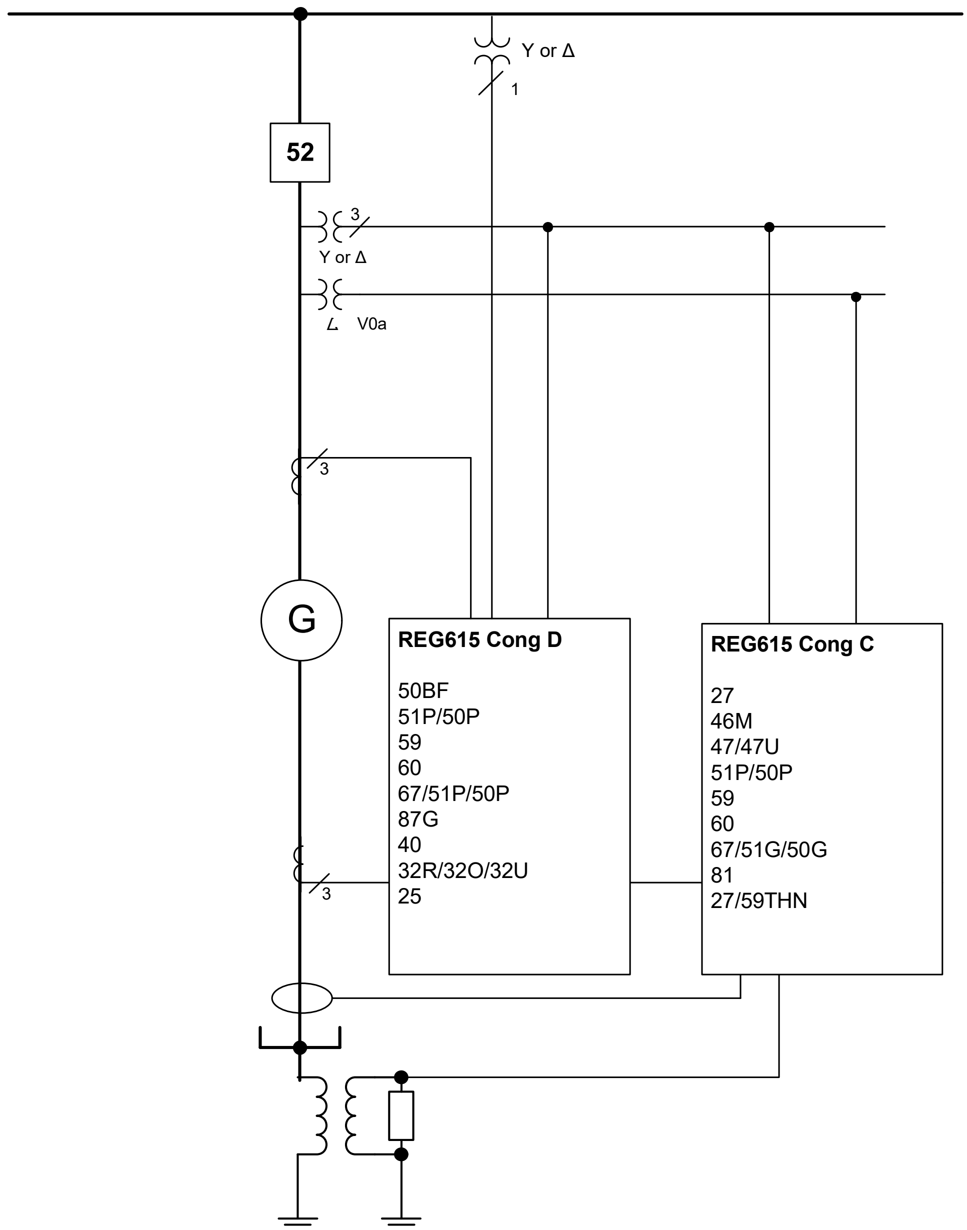


Figure 3 illustrates several generator units connected in parallel. Each unit is individually high resistance Grounded. Ground-fault current is small, typically 3...5 A.

Figure 4. Medium-sized generator protection application example with standard configuration C and D



In **Figure 4** protection is implemented with two REG615 generator protection relays. One REG615 takes care of the generator protection with 100% stator ground-fault protection and the other REG615 provides the generator differential protection.

Standard configuration D is not designed for using all the available functionality content in one relay at the same time. Three-phase directional overcurrent protection, three-phase voltage protection, positive-sequence and negative-sequence voltage protection functions must be added with the Application Configuration tool. In order to ensure the performance of the relay, the user specific configuration load is verified with the Application Configuration tool in PCM600.

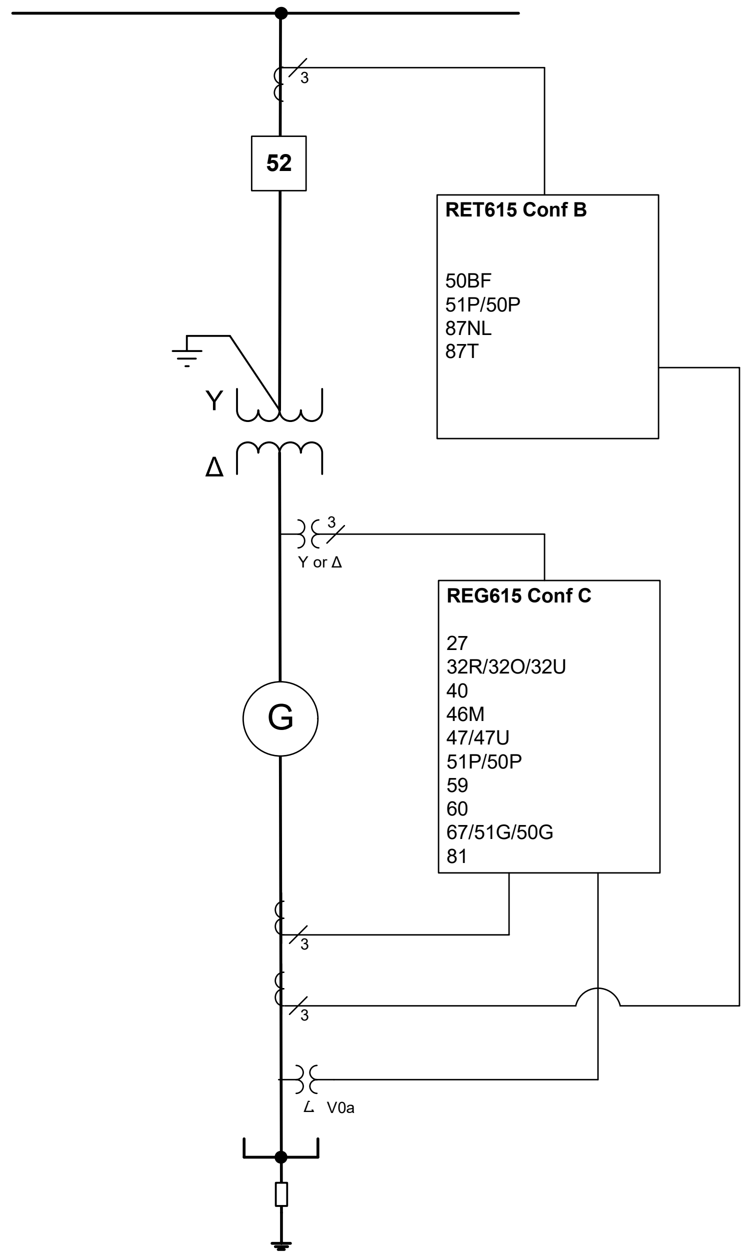


Figure 5. Medium-sized generator in block connection with a transformer protection application example with standard configuration C and RET615

In **Figure 5** generator protection is implemented with REG615 generator protection relay. Transformer protection is implemented with the RET615 transformer differential protection relay covering the generator in block connection with a transformer. A single-phase voltage transformer is connected to the generator neutral for the residual overvoltage protection. On the terminal side phase-to-ground voltages are connected to the generator protection relay.

5. Supported solutions

The 615 series protection relays together with the Substation Management Unit COM600F constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. 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 COM600F or the network control and management system MicroSCADA Pro.

The 615 series relays offer native support for IEC 61850 Edition 2 also including binary and analog horizontal GOOSE messaging. In addition, process bus with the sending of sampled values of analog currents and voltages and the receiving of sampled values of voltages is supported. 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.This protection relay series is able to optimally utilize interoperability provided by the IEC 61850 Edition 2 features.

At substation level, COM600F uses the data content of the baylevel devices to enhance substation level functionality.

COM600F features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The SLD feature is especially useful when 615 series relays without the optional single-line diagram feature are used. The Web HMI of COM600F 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, COM600F 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 COM600F. 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. COM600F 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.

GOOSE Analyzer interface in COM600F enables the following and analyzing the horizontal IEC 61850 application during commissioning and operation at station level. It logs all GOOSE events during substation operation to enable improved system supervision.

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Table 3. Supported ABB solutions

Title	Version
Substation Management Unit COM600F	5.0 SP1 or later (Edition 2)
	5.0 or later (Edition 2)
MicroSCADA Pro SYS 600	9.4 or later (Edition 2)
System 800xA	5.1 or later

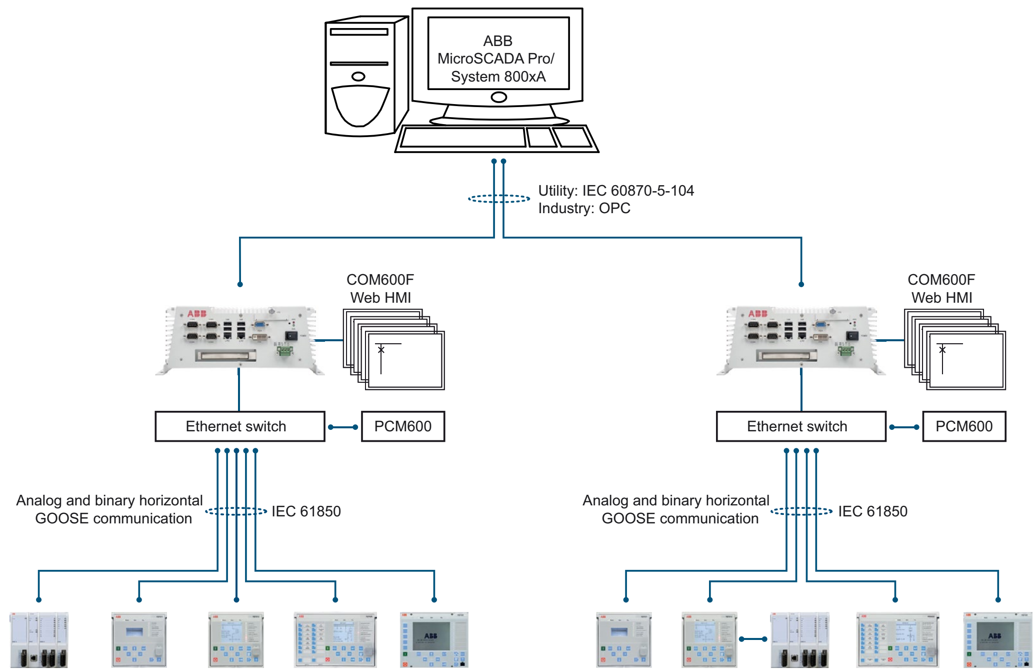


Figure 6. ABB power system example using Relion relays, COM600F and MicroSCADA Pro/ System 800xA

6. Control

REG615 integrates functionality for the control of a circuit breaker via the front panel HMI or by means of remote controls. In addition to the cicuit-breaker control the relay features two control blocks which are intended for motor-operated control of disconnectors or circuit breaker truck and for their position indications. Further, the relay offers one control block which is intended for motor-operated control of one grounding switch control and its position indication.

Two physical binary inputs and two physical binary outputs are needed in the relay for each controllable primary device taken into use. By default, the circuit breaker closing is not connected in the generator protection relay's standard configurations as the generator circuit breaker is typically closed by an external synchronizer. Depending on the chosen standard configuration of the relay the number of unused binary inputs and binary outputs varies. Further, some standard configurations also offer optional hardware modules that increase the number of available binary inputs and outputs. If the amount of available binary inputs or outputs of the chosen standard configuration is not sufficient, the standard configuration can be modified to release some binary inputs or outputs which have originally been configured for other purposes, when applicable, or an external input or output module, for example, RIO600 can be integrated to the relay. The binary inputs and outputs of the external I/O module can be used for the less time critical binary signals of the application. The integration enables releasing of some initially reserved binary inputs and outputs of the relay in the standard configuration.

The suitability of the binary outputs of the relay which have been selected for controlling of primary devices should be carefully verified, for example the make and carry as well as the breaking capacity. In case the requirements for the control-circuit of the primary device are not met, the use of external auxiliary relays should to be considered.

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

7. Measurements

The relay continuously measures the phase currents and voltages, the symmetrical components of the currents and voltages and the residual current and voltage. The relay also calculates the demand value of the current over a user selectable, preset 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. Furthermore, the relay offers three-phase power and energy measurement including power factor.

The generator relay is provided with frequency adaptability support that can be enabled with a setting parameter. Frequency adaptability enables protection and measurement operation over a wide frequency range of 0.2...1.4 × F_n by using three phase-voltage inputs to track the network frequency.

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.

The relay is provided with a load profile recorder. The load profile feature stores the historical load data captured at a periodical time interval (demand interval). The records are in COMTRADE format.

8. Power quality

In the EN standards, power quality is defined through the characteristics of the supply voltage. Transients, short-duration and long-duration voltage variations and unbalance and waveform distortions are the key characteristics describing power quality. The distortion monitoring functions are used for monitoring the current total demand distortion and the voltage total harmonic distortion.

Power quality monitoring is an essential service that utilities can provide for their industrial and key customers. A monitoring system can provide information about system disturbances and their possible causes. It can also detect problem conditions throughout the system before they cause customer complaints, equipment malfunctions and even equipment damage or failure. Power quality problems are not limited to the utility side of the system. In fact, the majority of power quality problems are localized within customer facilities. Thus, power quality monitoring is not only an effective customer service strategy but also a way to protect a utility's reputation for quality power and service.

The protection relay has the following power quality monitoring functions.

- Voltage variation
- Voltage unbalance
- Current harmonics
- Voltage harmonics

The voltage unbalance and voltage variation functions are used for measuring short-duration voltage variations and monitoring voltage unbalance conditions in power transmission and distribution networks.

The voltage and current harmonics functions provide a method for monitoring the power quality by means of the current waveform distortion and voltage waveform distortion. The functions provides a short-term three-second average and a long-term demand for total demand distortion TDD and total harmonic distortion THD.

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 non-volatile 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 non-volatile memory retains its data even if the relay temporarily loses its auxiliary supply. The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances. The considerable capacity to process and store data and events in the relay facilitates meeting the growing information demand of future network configurations.

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

11. Recorded data
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. Each record includes, for example, current, voltage and angle values and a time stamp. The fault recording can be triggered by the start or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. Fault records store relay measurement values at the moment when any protection function starts. In addition, the maximum demand current with time stamp is separately recorded. The records are stored in the non-volatile memory.

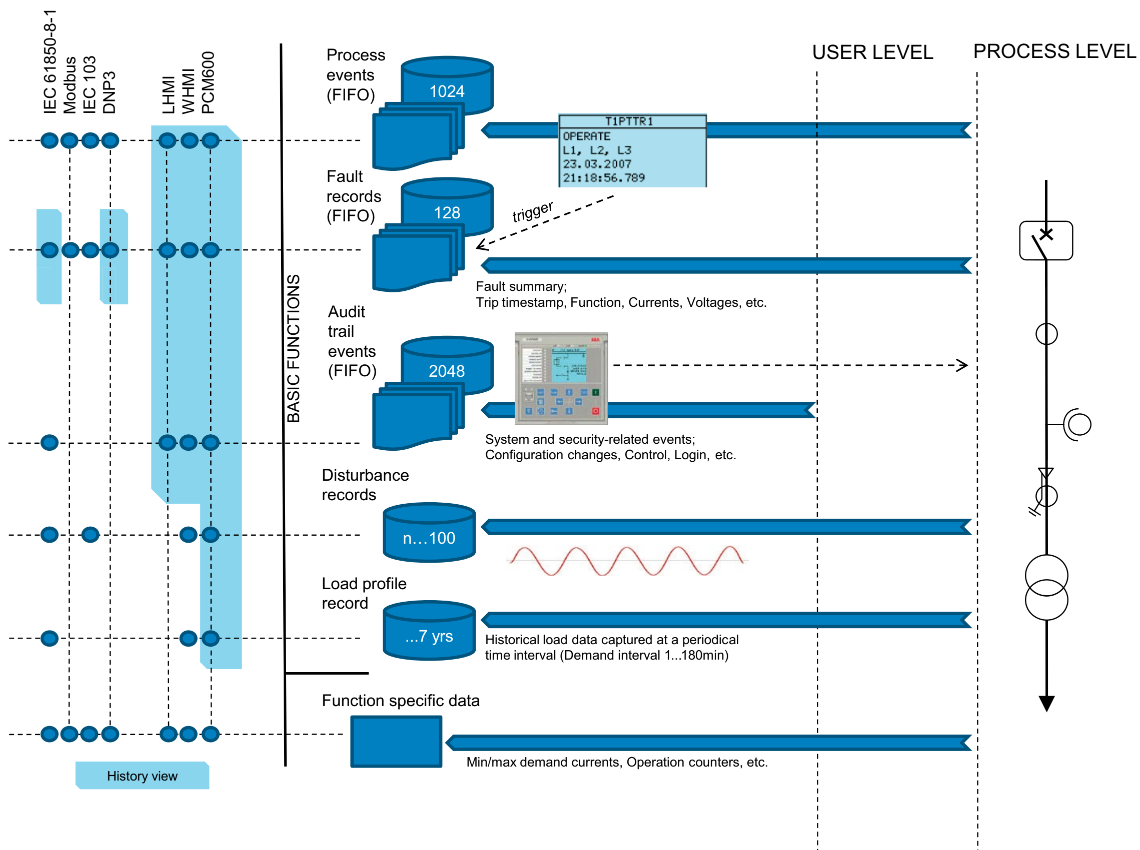


Figure 7. Recording and event capabilities overview 12.

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. In addition, the relay includes a runtime counter for monitoring of how many hours a protected device has been in operation thus enabling scheduling of time-based preventive maintenance of the device.

13. Trip-circuit supervision
The trip-circuit supervision continuously monitors the availability and operability of the trip circuit. It provides opencircuit 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, rolebased 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 standard configuration selected, the relay is equipped either with three or six phase-current inputs and one residual current input, three phase-voltage inputs and one residual voltage input, and one voltage input that is used either for synchro-check or for the 3rd harmonic-based stator groundfault protection depending on the standard configuration.

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

The phase-current input 1 A or 5 A, the residual-current input 1 A or 5 A, alternatively 0.2 A or 1 A, and the rated voltage of the residual voltage input are selected in the relay software. In addition, the binary input thresholds 16…176 V DC are selected by adjusting the relay's parameter settings. All binary inputs and outputs contacts are freely configurable with the signal matrix or application configuration functionality of PCM600.

See the Input/output overview table and the terminal diagrams for more information about the inputs and outputs. Optionally, a binary input and output module can be selected. It has three high speed binary outputs (HSO) and it decreases the total operate time with typically 4...6 ms compared to the normal power outputs.

Table 4. Input/output overview

Std. conf.	Order code digit		Analog channels		Binary channels			
	5-6	7-8	CT	VT	BI	BO	RTD	mA
C	AE/AF	AG	4	5	16	4 PO + 6 SO	-	-
		FC	4	5	16	4 PO + 2 SO + 3 HSO	-	-
	FE/FF	AD	4	5	12	4 PO + 6 SO	2	1
		FE	4	5	12	4 PO + 2 SO + 3 HSO	2	1
D	BC/BD	AD	7	5	12	4 PO + 6 SO	-	-
		FE	7	5	12	4 PO + 2 SO + 3 HSO	-	-
	BE/BF	BA	7	5	8	4 PO + 6 SO	2	1
		FD	7	5	8	4 PO + 2 SO + 3 HSO	2	1

18. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, 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 enabled by the IEC 61850 communication protocol.

The IEC 61850 protocol is a core part of the relay as the protection and control application is fully based on standard modelling. The relay supports Edition 2 and Edition 1 versions of the standard. With Edition 2 support, the relay has the latest functionality modelling for substation applications and the best interoperability for modern substations. It incorporates also the full support of standard device mode functionality supporting different test applications. Control applications can utilize the new safe and advanced station control authority feature.

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

The relay can send binary and analog signals to other devices using the IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) profile. Binary GOOSE messaging can, for example, be employed for protection and interlocking-based protection schemes. The relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard (<10 ms data exchange between the devices). The relay also supports the sending and receiving of analog values using GOOSE messaging. Analog GOOSE messaging enables easy transfer of analog measurement values over the station bus, thus facilitating for example the sending of measurement values between the relays when controlling parallel running transformers.

The relay also supports IEC 61850 process bus by sending sampled values of analog currents and voltages and by receiving sampled values of voltages. With this functionality the galvanic interpanel wiring can be replaced with Ethernet communication. The measured values are transferred as sampled values using IEC 61850-9-2 LE protocol. The intended application for sampled values shares the voltages to other 615 series relays, having voltage based functions and 9-2 support.

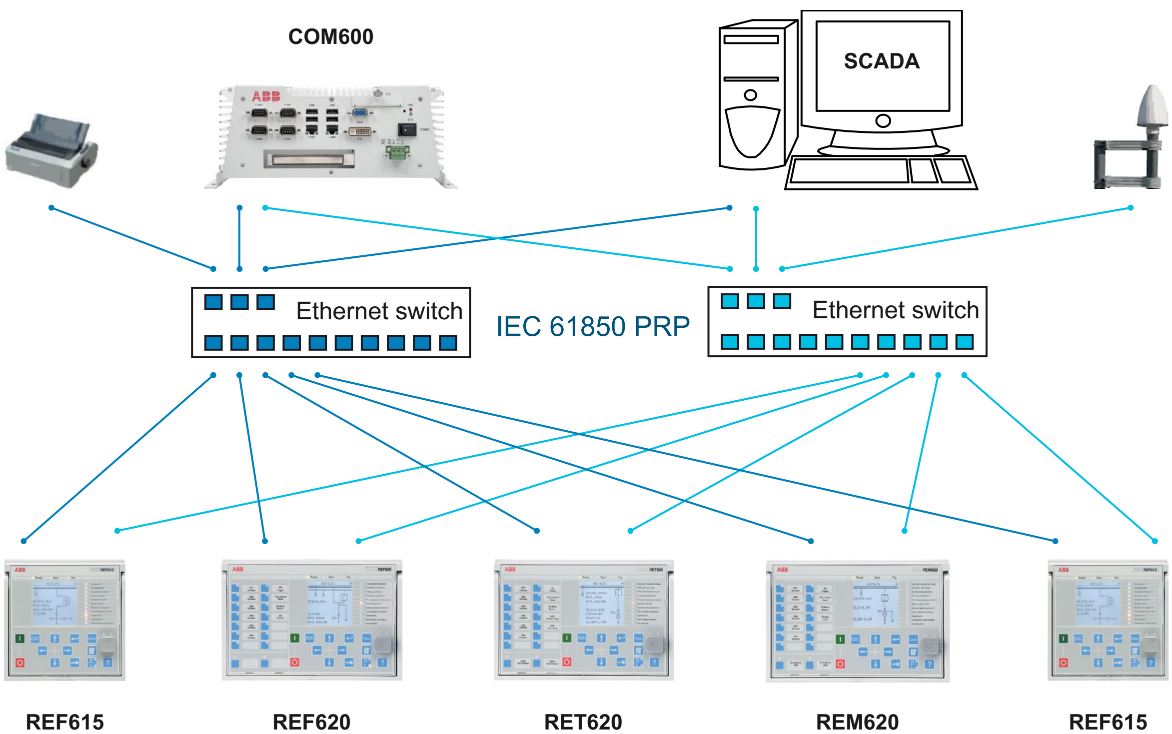
615 relays with process bus based applications use IEEE 1588 for high accuracy time synchronization. For redundant Ethernet communication, the relay offers either two optical or two galvanic Ethernet network interfaces. A third port with galvanic Ethernet network interface is also available. The third Ethernet interface provides connectivity for any other Ethernet device to an IEC 61850 station

bus inside a switchgear bay, for example connection of a Remote I/O. Ethernet network redundancy can be achieved using the high-availability seamless redundancy (HSR) protocol or the parallel redundancy protocol (PRP) or a with self-healing ring using RSTP in managed switches. Ethernet redundancy can be applied to Ethernet-based IEC 61850, Modbus and DNP3 protocols.

The IEC 61850 standard specifies network redundancy which improves the system availability for the substation communication. The network redundancy is based on two complementary protocols defined in the IEC 62439-3 standard: PRP and HSR protocols. Both the protocols are able to overcome a failure of a link or switch with a zero switch-over time. In both the protocols, each network node has two identical Ethernet ports dedicated for one network connection. The protocols rely on the duplication of all transmitted information and provide a zero switch-over time if the links or switches fail, thus fulfilling all the stringent real-time requirements of substation automation.

In PRP, each network node is attached to two independent networks operated in parallel. The networks are completely separated to ensure failure independence and can have different topologies. The networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid failures.

Figure 8. Parallel redundancy protocol (PRP) solution



HSR applies the PRP principle of parallel operation to a single ring. For each message sent, the node sends two frames, one through each port. Both the frames circulate in opposite directions over the ring. Every node forwards the frames it receives from one port to another to reach the next node. When the originating sender node receives the frame it sent, the sender node discards the frame to avoid loops. The HSR ring with 615 series relays supports the connection of up to 30 relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

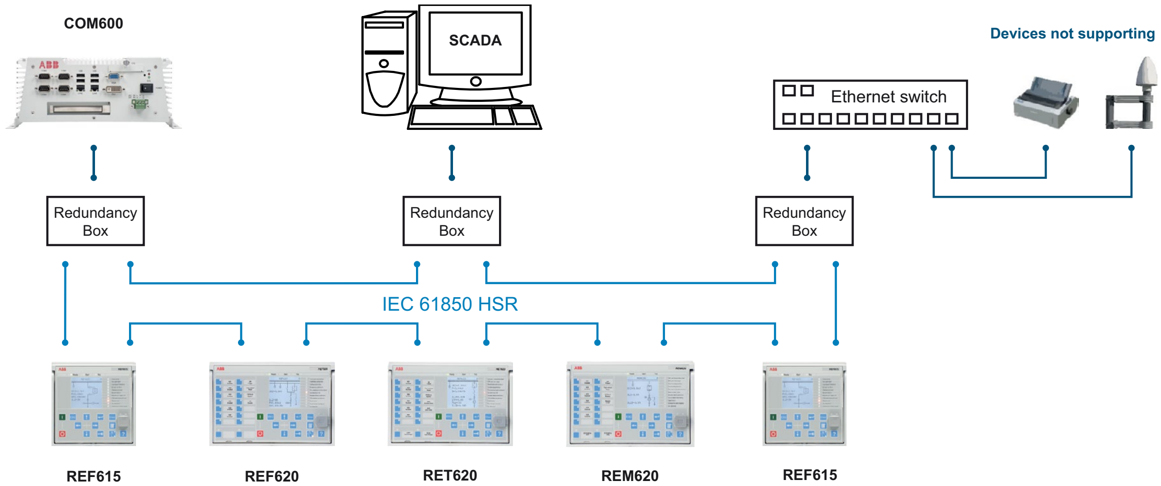


Figure 9. High availability seamless redundancy (HSR) solution

The choice between the HSR and PRP redundancy protocols depends on the required functionality, cost and complexity.

The self-healing Ethernet ring solution enables a cost-efficient communication ring controlled by a managed switch with standard Rapid Spanning Tree Protocol (RSTP) support. The managed switch controls the consistency of the loop, routes the data and corrects the data flow in case of a communication switch-over. The relays in the ring topology act as unmanaged switches forwarding unrelated data traffic. The Ethernet ring solution supports the connection of up to 30 615 series relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings. The self-healing Ethernet ring solution avoids single point of failure concerns and improves the reliability of the communication.

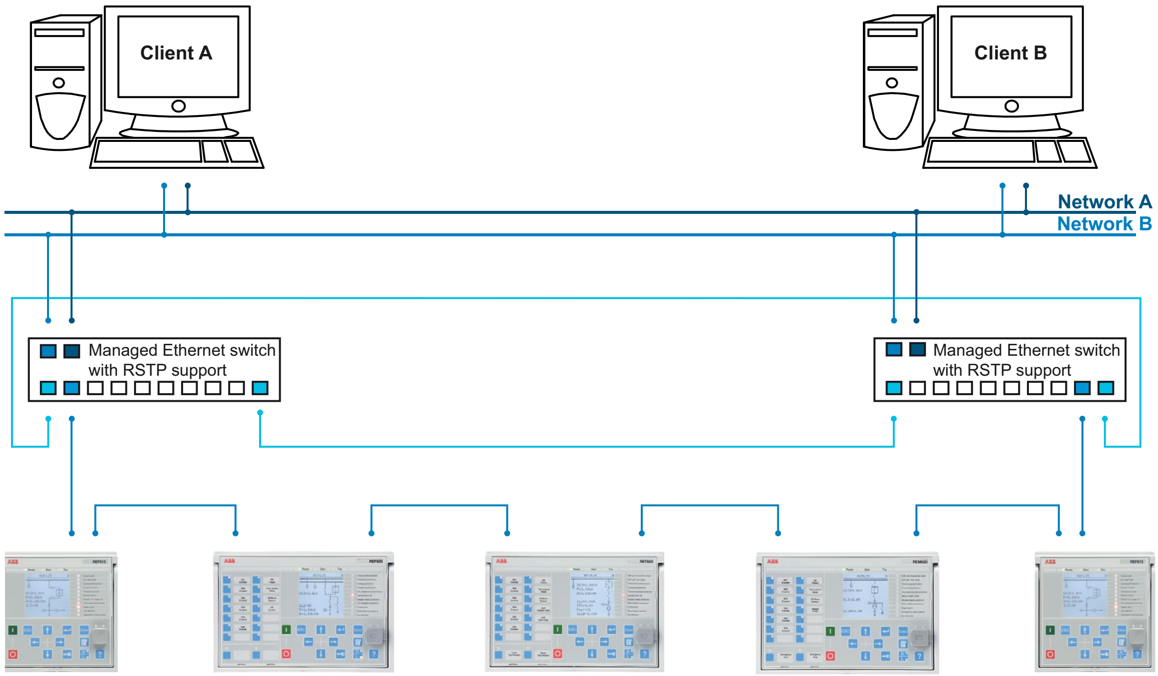


Figure 10. Self-healing Ethernet ring solution

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The relay can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fiber optic LC connector (100Base-FX). If connection to serial bus is required, the 9-pin RS-485 screw-terminal can be used. An optional serial interface is available for RS-232 communication.

Modbus implementation supports RTU, ASCII and TCP modes. Besides standard Modbus functionality, the relay supports retrieval of time-stamped events, changing the active setting group and uploading of the latest fault records. If a Modbus TCP connection is used, five clients can be connected to the relay simultaneously. Further, Modbus serial and Modbus TCP can be used in parallel, and if required both IEC 61850 and Modbus protocols can be run simultaneously.

DNP3 supports both serial and TCP modes for connection up to five masters. Changing of the active setting and reading fault records are supported. DNP serial and DNP TCP can be used in parallel. If required, both IEC 61850 and DNP protocols can be run simultaneously.

When the relay uses the RS-485 bus for the serial communication, both two- and four wire connections are supported. Termination and pull-up/down resistors can be configured with jumpers on the communication card so external resistors are not needed. The relay supports the following time synchronization methods with a time-stamping resolution of 1 ms.

Ethernet-based

- SNTP (Simple Network Time Protocol)

With special time synchronization wiring

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

The relay supports the following high accuracy time synchronization method with a time-stamping resolution of 4 µs required especially in process bus applications.
• PTP (IEEE 1588) v2 with Power Profile

IEEE 1588 v2 features
• Ordinary Clock with Best Master Clock algorithm
• One-step Transparent Clock for Ethernet ring topology
• 1588 v2 Power Profile
• Receive (slave): 1-step/2-step
• Transmit (master): 1-step
• Layer 2 mapping
• Peer to peer delay calculation
• Multicast operation

Required accuracy of grandmaster clock is +/-1 µs. The relay can work as a master clock per BMC algorithm if the external grandmaster clock is not available for short term.

The IEEE 1588 support is included in all variants having a redundant Ethernet communication module.

In addition, the relay supports time synchronization via Modbus and DNP3 serial communication protocols.

Table 5. Supported station communication interfaces and protocols

Interfaces/Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/RS-485	Fiber optic ST
IEC 61850-8-1	•	•	-	-
IEC 61850-9-2 LE	•	•	-	-
MODBUS RTU/ASCII	-	-	•	•
MODBUS TCP/IP	•	•	-	-
DNP3 (serial)	-	-	•	•
DNP3 TCP/IP	•	•	-	-

● = 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	
	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 (Pq)/operating condition	DC <13.0 W (nominal)/<18.0 W (max.)	DC <13.0 W (nominal)/<18.0 W (max.)
	AC <16.0 W (nominal)/<21.0 W (max.)	
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

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 100 A	 20 A 500 A
	Dynamic current withstand: Half-wave value	 250 A	 1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	60...210 V AC	
	Voltage withstand: Continuous 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. 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 10. RTD/mA measurement (XRGGIO130)

Description		Value	
RTD inputs	Supported RTD sensors	100 Ω platinum	TCR 0.00385 (DIN 43760)
		250 Ω platinum	TCR 0.00385
		100 Ω nickel	TCR 0.00618 (DIN 43760)
		120 Ω nickel	TCR 0.00618
		250 Ω nickel	TCR 0.00618
		10 Ω copper	TCR 0.00427
	Supported resistance range	0...2 kΩ	
	Maximum lead resistance (three-wire measurement)	25 Ω per lead	
	Isolation	2 kV (inputs to protective ground)	
	Response time	<4 s	
	RTD/resistance sensing current	Maximum 0.33 mA rms	
	Operation accuracy	Resistance	Temperature
		± 2.0% or ±1 Ω	±1°C
			10 Ω copper: ±2°C
mA inputs	Supported current range	0…20 mA	
	Current input impedance	44 Ω ± 0.1%	
	Operation accuracy	±0.5% or ±0.01 mA	

Table 11. Signal output X100: SO1

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

Table 12. Signal outputs and IRF output

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

Table 13. Double-pole power output relays with TCS function

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit supervision (TCS): 1) Control voltage range 2) Current drain through the supervision circuit 3) Minimum voltage over the TCS contact	 20...250 V AC/DC ~1.5 mA 20 V AC/DC (15...20 V)

Table 14. Single-pole power output relays

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 15. High-speed output HSO with BIO0007

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	6 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Operate time	<1 ms
Reset	<20 ms, resistive load

Table 16. Front port Ethernet interfaces

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

Table 17. IRIG-B

Description	Value
IRIG time code format	B004, B005[1)]
Isolation	500V 1 min
Modulation	Unmodulated
Logic level	5 V TTL
Current consumption	<4 mA
Power consumption	<20 mW

1) According to the 200-04 IRIG standard

Table 18. Degree of protection of flush-mounted protection relay

Description	Value
Front side	IP54
Rear side, connection terminals	IP 20
Left and right side	IP 10
Top and bottom	IP 10

Table 19. 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 20. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test		IEC 61000-4-18
		IEC 60255-26, class III
		IEEE C37.90.1-2002
• 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)	IEC 61000-4-6
	f = 150 kHz...80 MHz	IEC 60255-26, class III
	10 V/m (rms)	IEC 61000-4-3
	f = 80...2700 MHz	IEC 60255-26, class III
	10 V/m	ENV 50204
	f = 900 MHz	IEC 60255-26, class III
	20 V/m (rms)	IEEE C37.90.2-2004
	20 V/m (rms)	
Fast transient disturbance test		IEC 61000-4-4
		IEC 60255-26
		IEEE C37.90.1-2002
• All ports	4 kV	
Surge immunity test		IEC 61000-4-5
		IEC 60255-26
• Communication	1 kV, line-to-ground	
• Other ports	4 kV, line-to-ground	
	2 kV, line-to-line	
Power frequency (50 Hz) magnetic field immunity test		IEC 61000-4-8
• Continuous	300 A/m	
• 1...3 s	1000 A/m	
Pulse magnetic field immunity test	1000 A/m	IEC 61000-4-9
	6.4/16 μs	
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions	30%/10 ms	IEC 61000-4-11
	60%/100 ms	
	60%/1000 ms	
	>95%/5000 ms	
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 20. Electromagnetic compatibility tests

Description	Type test value	Reference
Conducted common mode disturbances	15 Hz...150 kHz Test level 3 (10/1/10 V rms)	IEC 61000-4-16
Emission tests		EN 55011, class A IEC 60255-26 CISPR 11 CISPR 12
• 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	
•		
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	
1…3 GHz	<76 dB (µV/m) peak <56 dB (µV/m) average, measured at 3 m distance	
3…6 GHz	<80 dB (µV/m) peak <60 dB (µV/m) average, measured at 3 m distance	

Table 21. 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 22. Mechanical tests

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

—
Table 23. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55ºC	IEC 60068-2-2
Dry 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

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Table 24. Product safety

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

—
Table 25. EMC compliance Table 24. Product safety

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

—
Table 26. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

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

Description	Type test value	Reference		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	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	16 ms	19 ms	23 ms
	I_{Fault} = 10 × set Start value	11 ms	12 ms	14 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 × set Start value	23 ms	26 ms	29 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)		
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 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

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

Parameter	Function	Value (Range)	Step
Start value	PHLPTOC	0.05...5.00 × I_n	0.01
	PHHPTOC	0.10...40.00 × I_n	0.01
	PHIPTOC	1.00...40.00 × I_n	0.01
Time multiplier	PHLPTOC and PHHPTOC	0.05...15.00	0.01
Operate delay time	PHLPTOC and PHHPTOC	40...200000 ms	10
	PHIPTOC	20...200000 ms	10
Operating curve type[1)]	PHLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

1) For further reference, see the Operation characteristics table

—

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

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current/voltage measured: f_n ±2 Hz		
	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)]		
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

—

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

Parameter	Function	Value (Range)	Step
Start value	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)]	DPHLPDOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	

1) For further reference, see the Operating characteristics table

Table 31. Three-phase voltage-dependent overcurrent protection (PHPVOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	Current: ±1.5% of the set value or ± 0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	Typically 26 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 inverse time 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) Measurement mode = default, current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

Table 32. Three-phase voltage-dependent overcurrent protection (PHPVOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPVOC	0.05...5.00 × I_n	0.01
Start value low	PHPVOC	0.05...1.00 × I_n	0.01
Voltage high limit	PHPVOC	0.01...1.00 × U_n	0.01
Voltage low limit	PHPVOC	0.01...1.00 × U_n	0.01
Start value Mult	PHPVOC	0.8...10.0	0.1
Time multiplier	PHPVOC	0.05...15.00	0.01
Operating curve type[1)]	PHPVOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	PHPVOC	40...200000 ms	10

1) For further reference, see the Operating characteristics table

Table 33. Non-directional ground-fault protection (EFxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	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	16 ms	19 ms	23 ms
	I_{Fault} = 10 × set Start value	11 ms	12 ms	14 ms
	EFHPTOC and 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)		
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 and Pol quantity = default, current before fault = 0.0 × In, 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

Table 34. Non-directional ground-fault protection (EFxPTOC) main settings

	Function	Value (Range)	Step
Start value	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	EFLPTOC and EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC and EFHPTOC	40...200000 ms	10
	EFIPTOC	20...200000 ms	10
Operating curve type[1)]	EFLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further reference, see the Operating characteristics table

Table 35. Directional ground-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	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
	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)]		
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, ground-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

Table 36. Directional ground-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start value	DEFLPDEF	0.010...5.000 × I_n	0.005
	DEFHPDEF	0.10...40.00 × I_n	0.01
Directional mode	DEFLPDEF and DEFHPDEF	1 = Non-directional 2 = Forward 3 = Reverse	-
Time multiplier	DEFLPDEF	0.05...15.00	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFLPDEF	50...200000 ms	10
	DEFHPDEF	40...200000 ms	10
Operating curve type[1)]	DEFLPDEF	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	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 37. Transient/intermittent ground-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 38. Transient/intermittent ground-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		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 39. 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	23 ms	26 ms	28 ms
	I_{Fault} = 10 × set Start value	15 ms	18 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 40. 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 41. Negative-sequence overcurrent protection for machines (MNSPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n		
		±1.5% of the set value or ±0.002 x I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set Start value	23	25 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		
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 = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

3) Start value multiples in range of 1.10...5.00

Table 42. Negative-sequence overcurrent protection for machines (MNSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	MNSPTOC	0.01...0.50 × I_n	0.01
Operating curve type	MNSPTOC	Definite or inverse time Curve type: 5, 15, 17, 18	
Operate delay time	MNSPTOC	100...120000 ms	10
Operation	MNSPTOC	1 = on 5 = off	-
Cooling time	MNSPTOC	5...7200 s	1

Table 43. 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 44. 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 45. 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 46. 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 47. 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

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Table 48. 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

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Table 49. 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	52 ms	55 ms	58 ms
U_{Fault} = 0.9 × set Start value	44 ms	47 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 , positive-sequence voltage b ndom phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

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Table 50. 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

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Table 51. 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	33 ms	35 ms	37 ms
U_{Fault} = 2.0 × set Start value	24 ms	26 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 52. 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 53. Frequency protection (FRPFRQ)

Characteristic		Value
Start value	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 54. 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	0.005
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 55. Overexcitation protection (OEPVPH)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±3.0% of the set value
Start time [1)2)]	Frequency change: Typically 200 ms
	Voltage change: Typically 40 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 ±50 ms

1) fn = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 56. Overexcitation protection (OEPVPH) main settings

Parameter	Function	Value (Range)	Step
Start value	OEPVPH	100...200%	1
Operating curve type	OEPVPH	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	
Time multiplier	OEPVPH	0.1...100.0	0.1
Operate delay time	OEPVPH	200...200000 ms	10
Cooling time	OEPVPH	5...10000 s	1

Table 57. 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 58. 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 59. Three-phase thermal overload protection, two time constants (T2PTTR)

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 x In (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 x Operate level temperature

Table 60. Three-phase thermal overload protection, two time constants (T2PTTR) main settings

Parameter	Function	Value (Range)	Step
Temperature rise	T2PTTR	0.0...200.0°C	0.1
Max temperature	T2PTTR	0.0...200.0°C	0.1
Operate temperature	T2PTTR	80.0...120.0%	0.1
Short time constant	T2PTTR	6...60000 s	1
Weighting factor p	T2PTTR	0.00...1.00	0.01
Current reference	T2PTTR	0.05...4.00 × I_n	0.01
Operation	T2PTTR	1 = on 5 = off	-

Table 61. 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 62. Circuit breaker failure protection (CCBRBRF) main settings

Parameter	Function	Value (Range)	Step
Current value	CCBRBRF	0.05...2.00 × I_n	0.05
Current value Res	CCBRBRF	0.05...2.00 × I_n	0.05
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 63. 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 64. 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 65. Arc protection (ARCSARC)

Characteristic		Value		
Operation accuracy		±3% of the set value or ±0.01 × I_n		
Start time [1)2)]		Minimum	Typical	Maximum
	Operation mode = "Light +current"[1)2)]	9 ms[3)]	12 ms[3)]	15 ms [3)]
		4 ms[4)]	6 ms[4)]	9 ms[4)]
	Operation mode = "Light only"[2)]	9 ms[3)]	10 ms[3)]	12 ms[3)]
		4 ms[4)]	6 ms[4)]	7 ms[4)]
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		

1) Phase start value = 1.0 × I_n, current before fault = 2.0 × set Phase start value, f_n = 50 Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements
2) Includes the delay of the heavy-duty output contact
3) Normal power output
4) High-speed output

Table 66. Arc protection (ARCSARC) main settings

Parameter	Function	Value (Range)	Step
Phase start value	ARCSARC	0.50...40.00 × I_n	0.01
Ground start value	ARCSARC	0.05...8.00 × I_n	0.01
Operation mode	ARCSARC	2 = Light only	-
		3 = BI controlled	

Table 67. Multipurpose protection (MAPGAPC)

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

Table 68. 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 69. Stabilized and instantaneous differential protection for machines (MPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz		
		±3% of the set value or ±0.002 x I_n		
Operation time [1)2)]		Minimum	Typical	Maximum
	Low stage	36 ms	40 ms	42 ms
	High stage	18 ms	22 ms	27 ms
Reset time		<40 ms		
Reset ratio		Typically 0.95		
Retardation time		<20 ms		
Reset ratio		Typically 0.96		

1) F_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the power output contact

Table 70. Stabilized and instantaneous differential protection for machines (MPDIF) main settings

Parameter	Function	Value (Range)	Step
Low operate value	MPDIF	5...30 %Ir	1
High operate value	MPDIF	100...1000 %Ir	10
Slope section 2	MPDIF	10...50%	1
End section 1	MPDIF	0...100 %Ir	1
End section 2	MPDIF	100...300 %Ir	1
DC restrain enable	MPDIF	0 = False 1 = True	-
CT connection type	MPDIF	1 = Type 1 2 = Type 2	-
CT ratio Cor Line	MPDIF	0.40...4.00	0.01
CT ratio Cor Neut	MPDIF	0.40...4.00	0.01

Table 71. Third harmonic-based stator ground-fault protection (H3EFPSEF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz
	±5% of the set value or ±0.004 × U_n
Start time[1)2)]	Typically 35 ms
Reset time	Typically 35 ms
Reset ratio	Typically 0.96 (differential mode) Typically 1.04 (under voltage mode)
Operate time accuracy	±1.0% of the set value of ±20 ms

1) f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 72. Numerical stabilized low-impedance restricted ground fault protection (LREFPNDF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±2.5% of the set value or ±0.002 x I_n		
Pickup time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 x set Trip value	37 ms	41 ms	45 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Trip time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f= n x f_n where n = 2, 3, 4, 5, ...		

1) 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

Table 73. Third harmonic-based stator ground-fault protection (H3EFPSEF) main settings

Parameter	Function	Value (Range)	Step
Beta	H3EFPSEF	0.50...10.00	0.01
Voltage N 3.H Lim	H3EFPSEF	0.005...0.200 × U_n	0.001
Operate delay time	H3EFPSEF	20...300000 ms	10
Voltage selection	H3EFPSEF	1 = No voltage 2 = Measured Uo 3 = Calculated Uo 4 = Phase A 5 = Phase B 6 = Phase C	-
CB open factor	H3EFPSEF	1.00...10.00	0.01

Table 74. Underpower protection (DUPPDPR)

Characteristic	Value
Operation accuracy [1]	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	Power measurement accuracy ±3% of the set value or ±0.002 × Sn Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 1.04
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) Measurement mode = “Pos Seq” (default)

2) U = U_n, f_n = 50 Hz, results based on statistical distribution of 1000 measurements

3) Includes the delay of the signal output contact

Table 75. Underpower protection (DUPPDPR) main settings

Parameter	Function	Value (Range)	Step
Start value	DUPPDPR	0.01...2.00 × S_n	0.01
Operate delay time	DUPPDPR	40...300000 ms	10
Pol reversal	DUPPDPR	0 = False	-
		1 = True	
Disable time	DUPPDPR	0...60000 ms	1000

Table 76. Reverse power/directional overpower protection (DOPPDPR)

Characteristic	Value
Operation accuracy [1]	Depending on the frequency of the measured current and voltage: f = f_n ±2 Hz
	Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 0.94
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) Measurement mode = “Pos Seq” (default)

2) U = U_n, f_n = 50 Hz, results based on statistical distribution of 1000 measurements

3) Includes the delay of the signal output contact

Table 77. Reverse power/directional overpower protection (DOPPDPR) main settings

Parameter	Function	Value (Range)	Step
Start value	DOPPDPR	0.01...2.00 × S_n	0.01
Operate delay time	DOPPDPR	40...300000 ms	10
Operation mode	MAPGAPC	2 = Forward 3 = Reverse	-
Power angle	DOPPDPR	-90...90°	1

Table 78. Three-phase under excitation protection (UEXPDIS)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: $f = f_n \pm 2$ Hz ±3.0% of the set value or ±0.2% Zb
Start time[1)2)]	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 1.04
Retardation time	Total retardation time when the impedance returns from the operating circle <40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

1) f_n= 50Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 79. Three-phase underexcitation protection (UEXPDIS) main settings

Parameter	Function	Value (Range)	Step
Diameter	UEXPDIS	1...6000 %Zn	1
Offset	UEXPDIS	-1000...1000 %Zn	1
Displacement	UEXPDIS	-1000...1000 %Zn	1
Operate delay time	UEXPDIS	60...200000 ms	10
External Los Det Ena	UEXPDIS	0 = Disable 1 = Enable	-

Table 80. Three-phase underimpedance protection (UZPDIS)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz ±3.0% of the set value or ±0.2 %Zb
Start time[1)2)]	Typically 50 ms
Reset time	Typically 40 ms
Reset ratio	Typically 1.04
Retardation time	<40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

1) f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 81. Three-phase underimpedance protection (UZPDIS) main settings

Parameter	Function	Value (Range)	Step
Percentage reach	UZPDIS	1...6000% Zn	1
Operate delay time	UZPDIS	40...200000 ms	10

Table 82. Out-of-step protection OOSRPSB

Characteristic	Value
Impedance reach	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	±3.0% of the reach value or ±0.2% of $U_n/(\sqrt{3}\ I_n)$
Reset time	±1.0% of the set value or ±40 ms
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 83. Out-of-step protection (OOSRPSB) main settings

Parameter	Function	Value (Range)	Step
Oos trip mode	OOSRPSB	1 = Way in	-
		2 = Way out	
		3 = Adaptive	
Forward reach	OOSRPSB	0.00…6000.00 Ω	0.01
Reverse reach	OOSRPSB	0.00…6000.00 Ω	0.01
Inner blinder R	OOSRPSB	1.00…6000.00 Ω	0.01
Outer blinder R	OOSRPSB	1.01…10000.00 Ω	0.01
Impedance angle	OOSRPSB	10.0…90.0°	0.1
Swing time	OOSRPSB	20…300000 ms	10
Trip delay time	OOSRPSB	20…60000 ms	10
Zone 1 reach	OOSRPSB	1…100%	1

Table 84. 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

Table 85. Directional reactive power undervoltage protection (DQPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Reactive power range |PF| <0.71
	Power: ±3.0% or ±0.002 × Q_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	Typically 46 ms
Reset time	<50 ms
Reset ratio	Typically 0.96
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,…

1) Start value = 0.05 × S_n, reactive power before fault = 0.8 × Start value, reactive power overshoot 2 times, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 86. Directional reactive power undervoltage protection (DQPTUV) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	DQPTUV	0.20...1.20 × U_n	0.01
Operate delay time	DQPTUV	100...300000 ms	10
Min reactive power	DQPTUV	0.01...0.50 × S_n	0.01
Min Ps Seq current	DQPTUV	0.02...0.20 × I_n	0.01
Pwr sector reduction	DQPTUV	0...10°	1

Table 87. Low-voltage ride-through protection (LVRTPTUV)

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)]	Typically 40 ms
Reset time	Based on maximum value of Recovery time setting
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,…

1) Tested for Number of Start phases = 1 out of 3, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 88. Low-voltage ride-through protection (LVRTPTUV) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	LVRTPTUV	0.05...1.20 × U_n	0.01
Num of start phases	LVRTPTUV	4 = Exactly 1 of 3 5 = Exactly 2 of 3 6 = Exactly 3 of 3	-
Voltage selection	LVRTPTUV	1 = Highest Ph-to-E 2 = Lowest Ph-to-E 3 = Highest Ph-to-Ph 4 = Lowest Ph-to-Ph 5 = Positive Seq	-
Active coordinates	LVRTPTUV	1...10	1
Voltage level 1	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 2	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 3	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 4	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 5	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 6	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 7	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 8	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 9	LVRTPTUV	0.00...1.20 ms	0.01
Voltage level 10	LVRTPTUV	0.00...1.20 ms	0.01
Recovery time 1	LVRTPTUV	0...300000 ms	1
Recovery time 2	LVRTPTUV	0...300000 ms	1
Recovery time 3	LVRTPTUV	0...300000 ms	1
Recovery time 4	LVRTPTUV	0...300000 ms	1
Recovery time 5	LVRTPTUV	0...300000 ms	1
Recovery time 6	LVRTPTUV	0...300000 ms	1
Recovery time 7	LVRTPTUV	0...300000 ms	1
Recovery time 8	LVRTPTUV	0...300000 ms	1
Recovery time 9	LVRTPTUV	0...300000 ms	1
Recovery time 10	LVRTPTUV	0...300000 ms	1

Table 89. Voltage vector shift protection (VVSPPAM)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±1 Hz
	±1°
Operate time[1)2)] Typically 53 ms	23 = Programmable

1) f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 90. Voltage vector shift protection (VVSPPAM) main settings

Parameter	Function	Value (Range)	Step
Start value	VVSPPAM	2.0...30.0°	0.1
Over Volt Blk value	VVSPPAM	0.40...1.50 × U_n	0.01
Under Volt Blk value	VVSPPAM	0.15...1.00 × U_n	0.01
Phase supervision	VVSPPAM	7 = Ph A + B + C 8 = Pos sequence	-

Power quality functions

—

Table 91. 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 92. Voltage unbalance (VSQVUB)

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

Control functions

Table 93. 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 94. 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	0.001...0.100 × f_n	0.001
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 95. Circuit-breaker condition monitoring (SSCBR)

Characteristic	Value
Current measuring accuracy	±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
Travelling time measurement	+10 ms / -0 ms

Table 96. Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time [1]	<30 ms

1) Including the delay of the output contact

Table 97. Current circuit supervision (CCSPVC) main settings

Parameter	Function	Value (Range)	Step
Start value	CCSPVC	0.05...0.20 × I_n	0.01
Max operate current	CCSPVC	1.00...5.00 × I_n	0.01

Table 98. Fuse failure supervision (SEQSPVC)

Parameter	Function	Value (Range)	Step
Operate time[1]	NPS function	UFault = 1.1 × set Neg Seq voltage Lev	<33 ms
		UFault = 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 99. 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

Measurement functions

Table 100. 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 101. 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 102. 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 103. Three-phase voltage measurement (VMMXU)

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

Table 104. Residual voltage measurement (RESVMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: 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 105. 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 106. Single and three-phase power and energy measurement (PEMMXU, SPEMMXU)

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 107. RTD/mA measurement (XRGGIO130)

Parameter	Function	Value (Range)	Step
RTD inputs	Supported RTD sensors	100 Ω platinum	TCR 0.00385 (DIN 43760)
		250 Ω platinum	TCR 0.00385
		100 Ω nickel	TCR 0.00618 (DIN 43760)
		120 Ω nickel	TCR 0.00618
		250 Ω nickel	TCR 0.00618
		10 Ω copper	TCR 0.00427
	Supported resistance range	0...2 kΩ	
	Maximum lead resistance (threewire measurement)	25 Ω per lead	
	Isolation	2 kV (inputs to protective ground)	
	Response time	<4 s	
	RTD/resistance sensing current	Maximum 0.33 mA rms	
	Operation accuracy	Resistance	Temperature
		± 2.0% or ±1 Ω	±1°C
			10 Ω copper: ±2°C
mA inputs	Supported current range	0…20 mA	
	Current input impedance	44 Ω ± 0.1%	
	Operation accuracy	±0.5% or ±0.01 mA	

Table 108. Frequency measurement (FMMXU)

Characteristic	Value
Operation accuracy	±5 mHz
	(in measurement range 35...75 Hz)

Other functions

Table 109. Pulse timer (PTGAPC)

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

Table 110. Time delay off (8 pcs) (TOFPAGC)

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

Table 111. Time delay on (8 pcs) (TONGAPC)

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

20. Local HMI

The relay is available with a large display. The large display is suited for relay installations where the front panel user interface is frequently used and a single line diagram is required.

The LCD display offers front-panel user interface functionality with menu navigation and menu views. The display also offers increased front-panel usability with less menu scrolling and improved information overview. In addition, the large display includes a user-configurable single line diagram (SLD) with position indication for the associated primary equipment. Depending on the chosen standard configuration, the 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 user can create up to 10 SLD pages.

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.

Figure 11. Large display

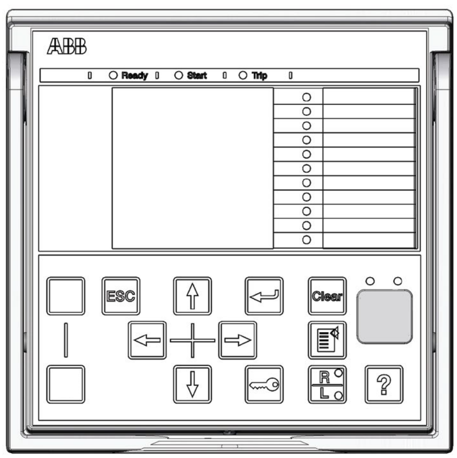


Table 112. Large display

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.

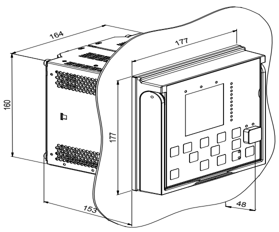
Mounting methods
• Flush mounting
• Semi-flush mounting
• Semi-flush mounting in a 25° tilt
• Rack mounting
• Wall mounting
• Mounting to a 19" equipment frame

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

Figure 12. Flush mounting

Figure 13. Semi-flush mounting

Figure 14. Semi-flush mounting in a 25º tilt



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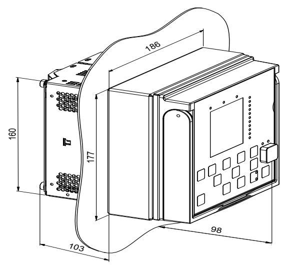

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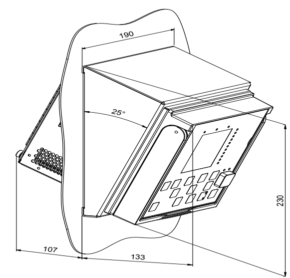

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22. Relay case and plug-in unit
The relay cases are assigned to a certain type of plug-in unit. For safety reasons, the relay cases for current measuring relays are provided with automatically operating contacts for short-circuiting the CT secondary 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 **ABB Library** to access the selection and ordering information and to generate the order number.

Product Selection Tool (PST), a Next-Generation Order Number Tool, supports order code creation for ABB Distribution Automation ANSI products with emphasis on but not exclusively for the Relion product family. PST is an easy to use, online tool always containing the latest product information. The complete order code can be created with detailed specification and the result can be printed and mailed. Registration is required.

24. Accessories and ordering data

Table 113. Cables

Item	Order number
Optical sensor for arc protection, cable length 1.5 m	1MRS120534-1.5
Optical sensor for arc protection, cable length 3.0 m	1MRS120534-3
Optical sensor for arc protection, cable length 5.0 m	1MRS120534-5
Optical sensor for arc protection, cable length 7.0 m	1MRS120534-7
Optical sensor for arc protection, cable length 10.0 m	1MRS120534-10
Optical sensor for arc protection, cable length 15.0 m	1MRS120534-15
Optical sensor for arc protection, cable length 20.0 m	1MRS120534-20
Optical sensor for arc protection, cable length 25.0 m	1MRS120534-25
Optical sensor for arc protection, cable length 30.0 m	1MRS120534-30

Table 114. 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
Functional grounding flange for RTD modules[1)]	2RCA036978A0001

1) Cannot be used when the protection relay is mounted with the Combiflex 19" equipment frame (2RCA032826A0001)

25. Tools

The protection relay is delivered as a preconfigured unit. The default parameter setting values can be changed from the frontpanel user interface (local HMI), the Web browser-based user interface (Web HMI) or Protection and Control Relay 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 115. Tools

Description	Version
PCM600	2.8 or later
Web browser	IE 11.0
REG615 Connectivity Package	5.1 or later

Table 116. 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)	-	•
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. Cyber security

The relay supports role based user authentication and authorization. It can store 2048 audit trail events to a non-volatile memory. The non-volatile memory is based on a memory type which does not need battery backup or regular component exchange to maintain the memory storage. FTP and Web HMI use TLS encryption with a minimum of 128 bit key length protecting the data in transit. In this case the used communication protocols are FTPS and HTTPS. All rear communication ports and optional protocol services can be deactivated according to the required system setup.

27. Terminal diagrams

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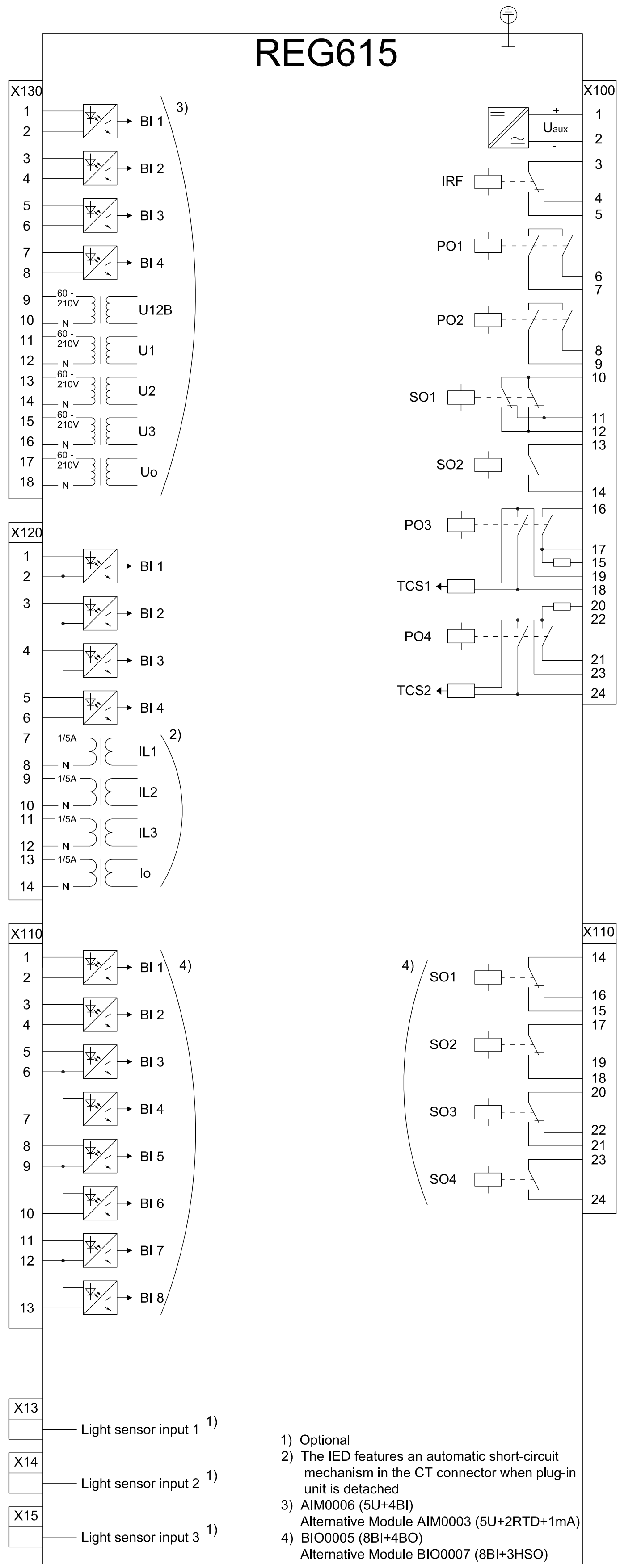
Figure 17. Terminal diagram of standard configuration C



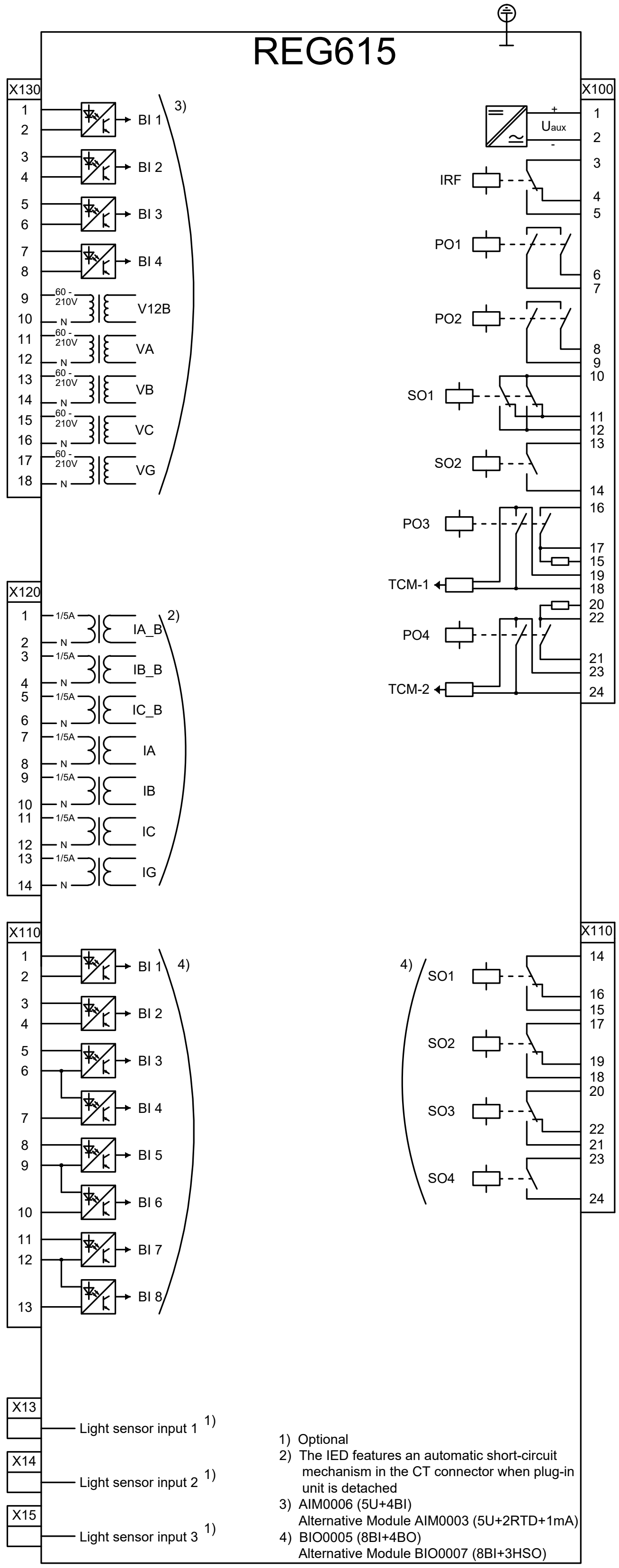


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Figure 18. Terminal diagram of standard configuration D

28. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Relion® 615 series. Certificate number: 7410570I-OPE/INC 15-1136.

DNV GL has issued an IEC 61850 Edition 1 Certificate Level A1 for Relion® 615 series. Certificate number: 74105701-OPE/INC 15-1145.

Additional certificates can be found on the **product page.**

29. References

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

The latest relevant information on the REG615 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

30. Functions, codes and symbols

Table 117. Functions included in the relay

Function	IEC 61850	ANSI
Protection		
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	51P-2 (1)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	50P/51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	67-1 (1)
	DPHLPDOC2	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	67-2 (1)
Three-phase voltage-dependent overcurrent protection	PHPVOC1	51V (1)
Non-directional ground-fault protection, high stage	EFHPTOC1	51N-2 (1)
Directional ground-fault protection, low stage	DEFLPDEF1	67N-1 (1)
	DEFLPDEF2	67N-1 (2)
Directional ground-fault protection, high stage	DEFHPDEF1	67N-2 (1)
Transient/intermittent ground-fault protection	INTRPTEF1	67NIEF (1)
Negative-sequence overcurrent protection	NSPTOC1	46 (1)
	NSPTOC2	46 (2)
Negative-sequence overcurrent protection for machines	MNSPTOC1	46M (1)
	MNSPTOC2	46M (2)
Residual overvoltage protection	ROVPTOV1	59G (1)
	ROVPTOV2	59G (2)
Three-phase undervoltage protection	PHPTUV1	27 (1)
	PHPTUV2	27 (2)
Three-phase overvoltage protection	PHPTOV1	59 (1)
	PHPTOV2	59 (2)
Positive-sequence undervoltage protection	PSPTUV1	47U+ (1)
	PSPTUV2	47U+ (2)
Negative-sequence overvoltage protection	NSPTOV1	47O- (1)
	NSPTOV2	47O- (2)
Frequency protection	FRPFRQ1	81 (1)
	FRPFRQ2	81 (2)
	FRPFRQ3	81 (3)
	FRPFRQ4	81 (4)
	FRPFRQ5	81 (5)
	FRPFRQ6	81 (6)
Overexcitation protection	OEPVPH1	24 (1)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	49F (1)
Three-phase thermal overload protection, two time constants	T2PTTR1	49T/G/C (1)
Circuit breaker failure protection	CCBRBRF1	51BF/51NBF (1)
Three-phase inrush detector	INRPHAR1	68 (1)
Numerical stabilized low-impedance restricted ground fault protection	LREFPNDF1	87LOZREF
Master trip	TRPPTRC1	94/86 (1)
	TRPPTRC2	94/86 (2)
	TRPPTRC3	94/86 (3)
	TRPPTRC4	94/86 (4)
	TRPPTRC5	94/86 (5)
	TRPPTRC6	94/86 (6)
Arc protection	ARCSARC1	50L/50NL (1)
	ARCSARC2	50L/50NL (2)
	ARCSARC3	50L/50NL (3)
Multipurpose protection	MAPGAPC1	MAP (1)

Table 117. Functions included in the relay

Function	IEC 61850	ANSI
Multipurpose protection	MAPGAPC2	MAP (2)
	MAPGAPC3	MAP (3)
	MAPGAPC4	MAP (4)
	MAPGAPC5	MAP (5)
	MAPGAPC6	MAP (6)
	MAPGAPC7	MAP (7)
	MAPGAPC8	MAP (8)
	MAPGAPC9	MAP (9)
	MAPGAPC10	MAP (10)
	MAPGAPC11	MAP (11)
	MAPGAPC12	MAP (12)
	MAPGAPC13	MAP (13)
	MAPGAPC14	MAP (14)
	MAPGAPC15	MAP (15)
	MAPGAPC16	MAP (16)
	MAPGAPC17	MAP (17)
	MAPGAPC18	MAP (18)
Stabilized and instantaneous differential protection for machines	MPDIF1	87G/M (1)
Numerically stabilized low-impedance restricted ground-fault protection	LREFPNDF1	87LOZREF
Third harmonic-based stator ground-fault protection	H3EFPSEF1	27/59THD (1)
Underpower protection	DUPPDPR1	32U (1)
	DUPPDPR2	32U (2)
Reverse power/directional overpower protection	DOPPDPR1	32R/32O (1)
	DOPPDPR2	32R/32O (2)
	DOPPDPR3	32R/32O (3)
Three-phase underexcitation protection	UEXPDIS1	40 (1)
Three-phase underimpedance protection	UZPDIS1	21G (1)
Out-of-step protection	OOSRPSB1	78 (1)
Interconnection functions		
Directional reactive power undervoltage protection	DQPTUV1	32Q,27 (1)
Low-voltage ride-through protection	LVRTPTUV1	27RT (1)
	LVRTPTUV2	27RT (2)
	LVRTPTUV3	27RT (3)
Voltage vector shift protection	VVSPPAM1	78V (1)
Power quality		
Current total demand distortion	CMHAI1	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3V (1)
Voltage variation	PHQVVR1	PQMV (1)
Voltage unbalance	VSQVUB1	PQVUB (1)
Control		
Circuit-breaker control	CBXCBR1	I <-> O CB (1)
Disconnector control	DCXSWI1	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)
Grounding switch indication	ESSXSWI1	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)
Synchronism and energizing check	SECRSYN1	25 (1)
Condition monitoring and supervision		
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)
Trip circuit supervision	TCSSCBR1	TCM (1)
	TCSSCBR2	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)

Table 117. Functions included in the relay

Function	IEC 61850	ANSI
Fuse failure supervision	SEQSPVC1	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTM (1)
Measurement		
Disturbance recorder	RDRE1	DFR (1)
Load profile record	LDPRLRC1	LOADPROF (1)
Fault record	FLTRFRC1	FAULTREC (1)
Single-phase power and energy measurement	SPEMMXU1	SP, SE-1
Three-phase current measurement	CMMXU1	3I (1)
	CMMXU2	3I (2)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	In (1)
Three-phase voltage measurement	VMMXU1	3V (1)
	VMMXU2	3V (2)
Residual voltage measurement	RESVMMXU1	Vn (1)
	RESVMMXU2	Vn (2)
Sequence voltage measurement	VSMSQI1	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)
RTD/mA measurement	XRGGIO130	X130 (RTD) (1)
Frequency measurement	FMMXU1	f (1)
IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER
IEC 61850-9-2 LE sampled value receiving (voltage sharing)	SMVRCV	SMVRCV
Other		
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)
	TPGAPC2	TP (2)
	TPGAPC3	TP (3)
	TPGAPC4	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)
Pulse timer (8 pcs)	PTGAPC1	PT (1)
Pulse timer (8 pcs), instance 2	PTGAPC2	PT (2)
Time delay off (8 pcs)	TOFGAPC1	TOF (1)
	TOFGAPC2	TOF (2)
	TOFGAPC3	TOF (3)
	TOFGAPC4	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)
	TONGAPC2	TON (2)
	TONGAPC3	TON (3)
	TONGAPC4	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)
	SRGAPC2	SR (2)
	SRGAPC3	SR (3)
	SRGAPC4	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)
	MVGAPC2	MV (2)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)
	SPCGAPC2	SPC (2)
Analog value scaling	SCA4GAPC1	SCA4 (1)
	SCA4GAPC2	SCA4 (2)
	SCA4GAPC3	SCA4 (3)
	SCA4GAPC4	SCA4 (4)
Integer value move	MVI4GAPC1	MVI4 (1)

31. Document revision history

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Table 118. Functions included in the relay

Document revision/date	Product version	History
D/2019-10-17	5.0 FP1	First release

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