

RELION® 615 SERIES

Motor Protection and Control REM615

Product Guide



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Conformity

This product complies with following directive and regulations.

Directives of the European parliament and of the council:

- Electromagnetic compatibility (EMC) Directive 2014/30/EU
- Low-voltage Directive 2014/35/EU
- RoHS Directive 2011/65/EU

UK legislations:

- Electromagnetic Compatibility Regulations 2016
- Electrical Equipment (Safety) Regulations 2016
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

These conformities are the result of tests conducted by the third-party testing in accordance with the product standard EN / BS EN 60255-26 for the EMC directive / regulation, and with the product standards EN / BS EN 60255-1 and EN / BS EN 60255-27 for the low voltage directive / safety regulation.

The product is designed in accordance with the international standards of the IEC 60255 series.

1. Description

REM615 is a dedicated motor protection and control relay designed for the protection, control, measurement and supervision of asynchronous motors in manufacturing and process industry. REM615 is a member of ABB's Relion[®] product family and part of its 615 protection and control product series. The 615 series relays are characterized by their compactness and withdrawable-unit design.

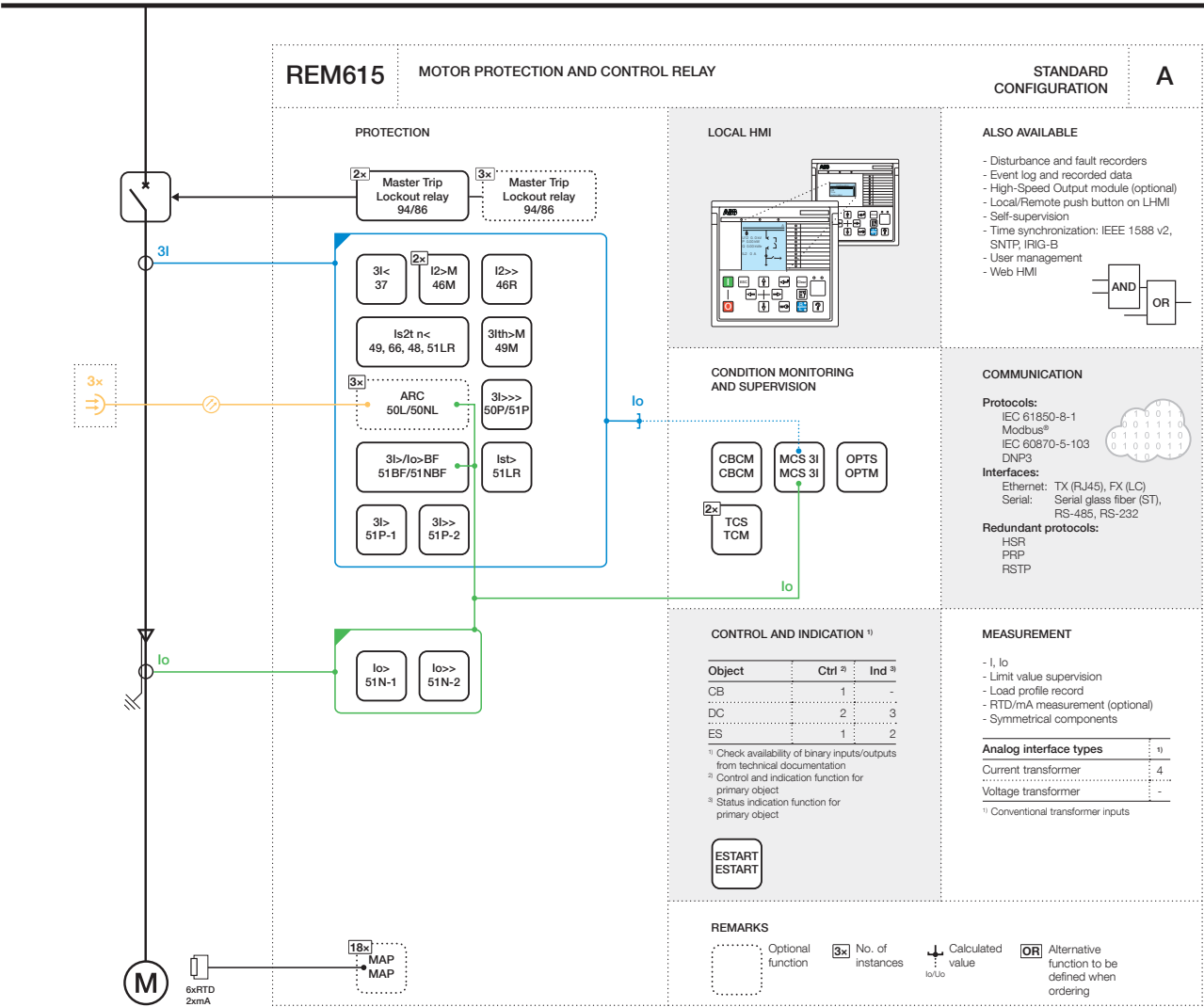
Re-engineered from the ground up, the 615 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices. Once the standard configuration relay has been given the application-specific settings, it can directly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

The 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, IEC 60870-5-103, Modbus[®] and DNP3. Profibus DPV1 communication protocol is supported by using the protocol converter SPA-ZC 302.

2. Standard configuration

REM615 is available with four alternative standard configurations. The standard signal configuration can be altered by means of the graphical signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Further, the application configuration functionality of the relay 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 user-specific application requirements.

The 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 REM615 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 outgoing feeder.



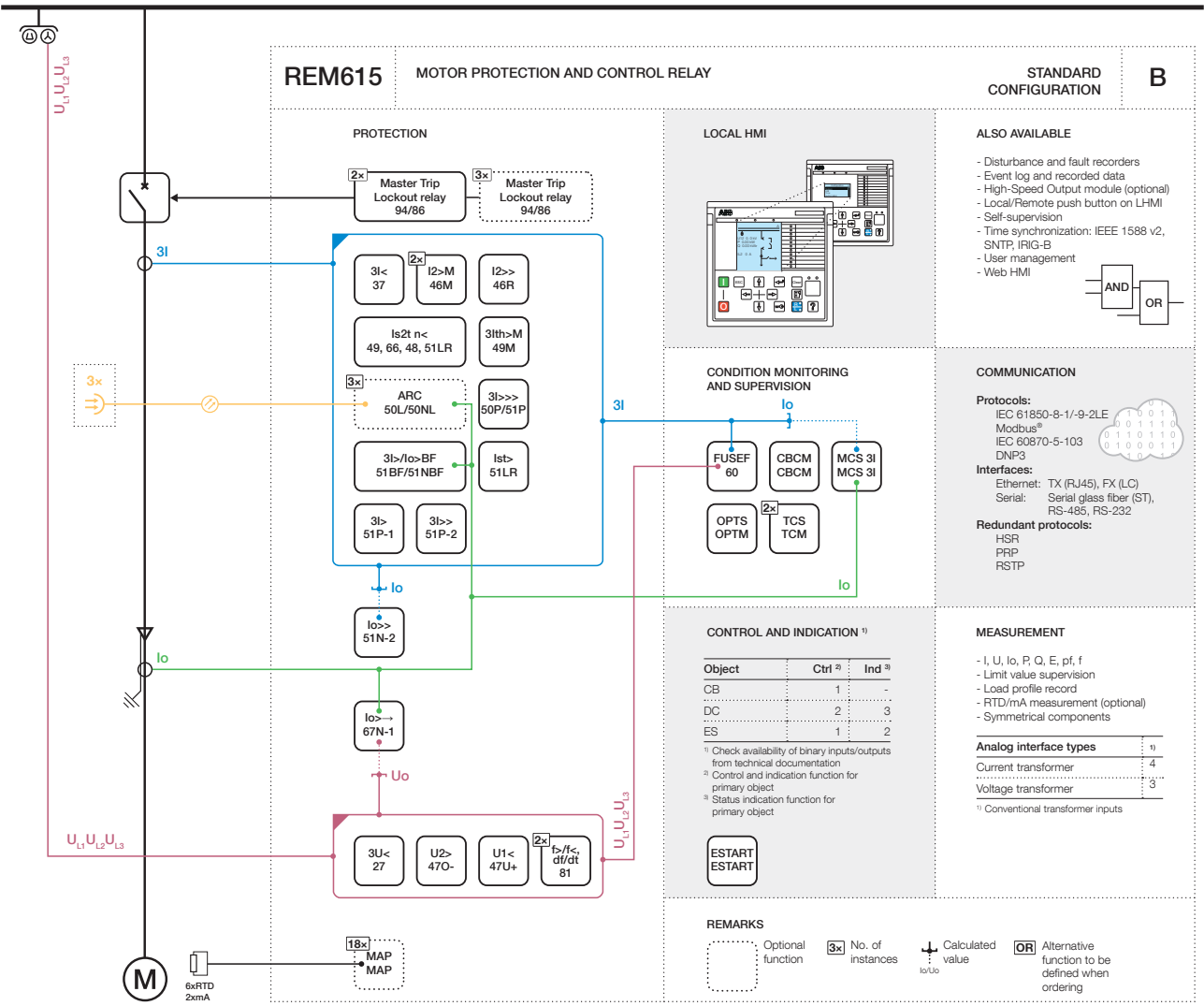
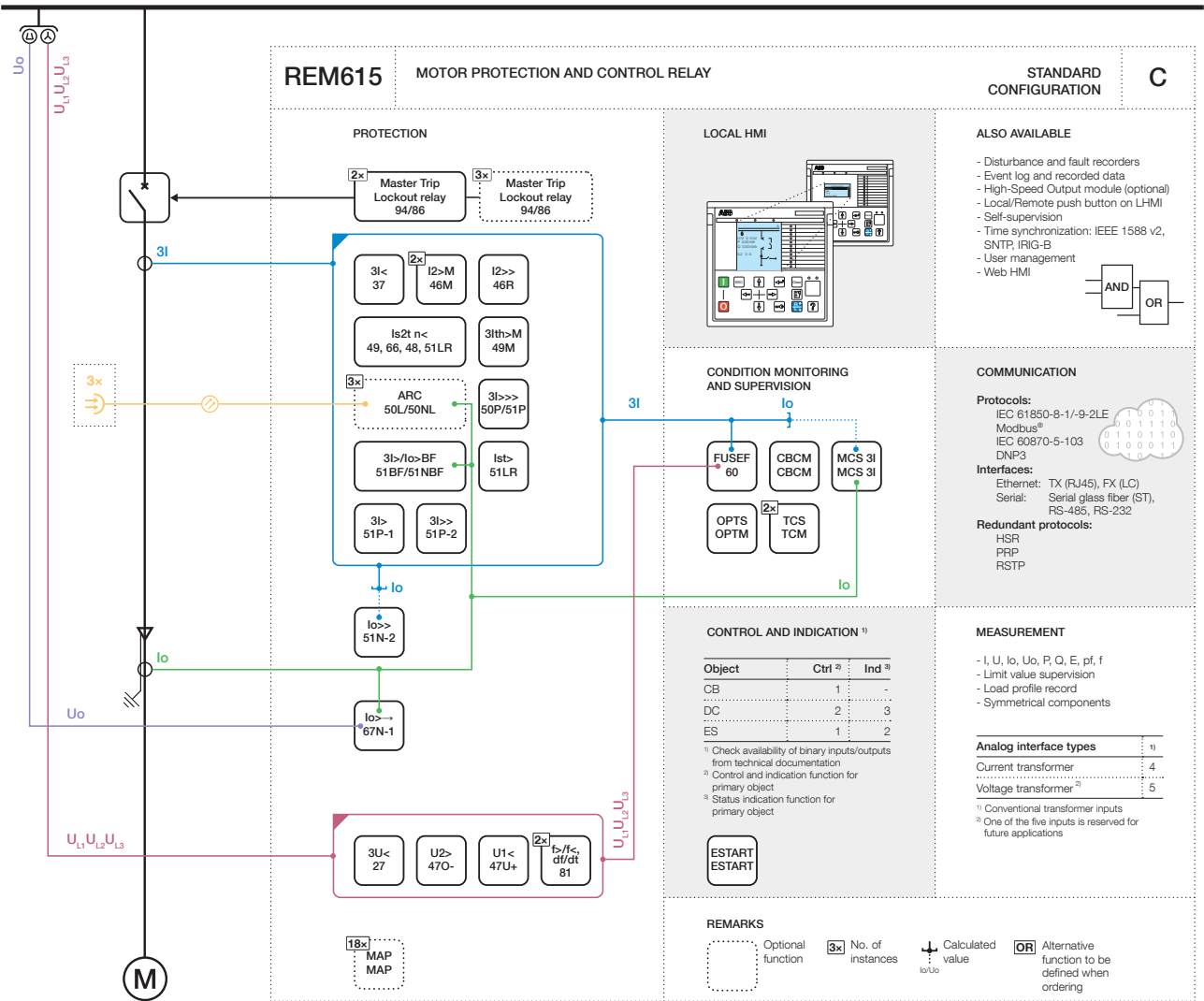


Figure 2: Functionality overview for standard configuration B



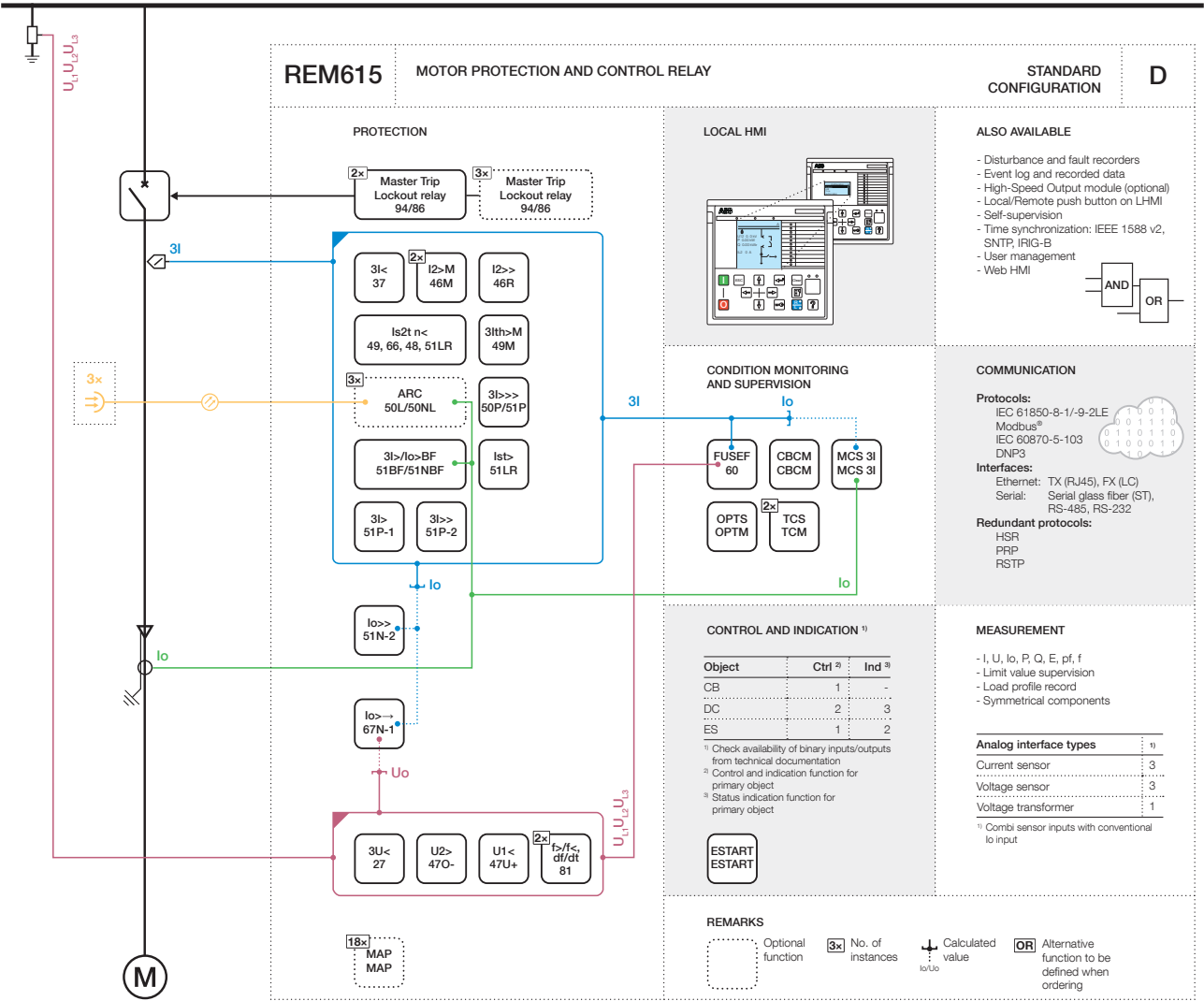


Figure 4: Functionality overview for standard configuration D

Table 1: Standard configuration

Description	Std. conf.
Basic motor protection (RTD option)	A
Motor protection with voltage and frequency based protection and measurements (RTD option)	B
Motor protection with voltage and frequency based protection and measurements	C
Motor protection with voltage and frequency based protection and measurements (sensor inputs)	D

Table 2: Supported functions

Function	IEC 61850	A	B	C	D
Protection					
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1	1	1

Table continues on the next page

Function	IEC 61850	A	B	C	D
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	1	1	1	1
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1	1	1
Non-directional earth-fault protection, low stage	EFLPTOC	1			
Non-directional earth-fault protection, high stage	EFHPTOC	1	1	1	1
Directional earth-fault protection, low stage	DEFLPDEF		1	1	1 ¹
Three-phase undervoltage protection	PHPTUV		1	1	1
Positive-sequence undervoltage protection	PSPTUV		1	1	1
Negative-sequence overvoltage protection	NSPTOV		1	1	1
Frequency protection	FRPFRQ		2	2	2
Negative-sequence overcurrent protection for machines	MNSPTOC	2	2	2	2
Loss of load supervision	LOFLPTUC	1	1	1	1
Motor load jam protection	JAMPTOC	1	1	1	1
Motor start-up supervision	STTPMSU	1	1	1	1
Phase reversal protection	PREVPTOC	1	1	1	1
Thermal overload protection for motors	MPTR	1	1	1	1
Circuit breaker failure protection	CCBRBRF	1	1	1	1
Master trip	TRPPTRC	2 (3)	2 (3) ²	2 (3) ²	2 (3) ²
Arc protection	ARCSARC	(3)	(3)	(3)	(3)
Multipurpose protection	MAPGAPC	18	18	18	18
Control					
Circuit-breaker control	CBXCBR	1	1	1	1
Disconnecter control	DCXSWI	2	2	2	2
Earthing switch control	ESXSWI	1	1	1	1
Disconnecter position indication	DCSXSWI	3	3	3	3
Earthing switch indication	ESSXSWI	2	2	2	2
Emergency start-up	ESMGAPC	1	1	1	1
Condition monitoring and supervision					
Circuit-breaker condition monitoring	SSCBR	1	1	1	1
Trip circuit supervision	TCSSCBR	2	2	2	2
Current circuit supervision	CCSPVC	1	1	1	1

Table continues on the next page

¹ "Uo calculated" is always used.

² 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.

Function	IEC 61850	A	B	C	D
Fuse failure supervision	SEQSPVC		1	1	1
Runtime counter for machines and devices	MDSOPT	1	1	1	1
Measurement					
Disturbance recorder	RDRE	1	1	1	1
Load profile record	LDPRLC	1	1	1	1
Fault record	FLTRFRC	1	1	1	1
Three-phase current measurement	CMMXU	1	1	1	1
Sequence current measurement	CSMSQI	1	1	1	1
Residual current measurement	RESCMMXU	1	1	1	1
Three-phase voltage measurement	VMMXU		1	1	1
Residual voltage measurement	RESVMMXU			1	
Sequence voltage measurement	VSMSQI		1	1	1
Three-phase power and energy measurement	PEMMXU		1	1	1
RTD/mA measurement	XRGGIO130	(1)	(1)		
Frequency measurement	FMMXU1		1	1	1
IEC 61850-9-2 LE sampled value sending	SMVSENDER		(1)	(1)	(1)
IEC 61850-9-2 LE sampled value receiving (voltage sharing) ^{3, 4}	SMVRCV		(1)	(1)	(1)
Other					
Minimum pulse timer (2 pcs)	TPGAPC	4	4	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	1	1	1	1
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	1	1	1	1
Pulse timer (8 pcs)	PTGAPC	2	2	2	2
Time delay off (8 pcs)	TOFGAPC	4	4	4	4
Time delay on (8 pcs)	TONGAPC	4	4	4	4
Set-reset (8 pcs)	SRGAPC	4	4	4	4
Move (8 pcs)	MVGAPC	2	2	2	2
Generic control point (16 pcs)	SPCGAPC	2	2	2	2
Analog value scaling (4 pcs)	SCA4GAPC	4	4	4	4
Integer value move (4 pcs)	MVI4GAPC	1	1	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.

() = optional

³ Available only with IEC 61850-9-2

⁴ Available only with COM0031-0037

3. Protection functions

The relay offers all the functionality needed to manage motor start-ups and normal operation, also including protection and fault clearance in abnormal situations. The main features of the relay include thermal overload protection, motor start-up supervision, locked rotor protection and protection against too frequent motor start-ups. The relay also incorporates non-directional earth-fault protection, negative phase-sequence current unbalance protection and backup overcurrent protection. Furthermore, the relay offers motor running stall protection, loss-of-load supervision and phase reversal protection.

Standard configurations B, C and D additionally offer directional earth-fault protection, three-phase undervoltage protection, negative-sequence overvoltage and positive-sequence undervoltage protection. Further, the B, C and D configurations offer frequency protection including overfrequency, underfrequency and rate-of-change frequency protection modes.

The RTD/mA module offered as an option for standard configurations A and B enables the use of the optional multipurpose protection function for tripping and alarm purposes using RTD/mA measuring data or analog values via GOOSE messages.

In certain motor drives of special importance there must be a possibility to override the motor thermal overload protection to perform an emergency start of a hot motor. To enable an emergency hot start, REM615 offers a forced start execution feature.

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 metalenclosed 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

REM615 constitutes main protection for asynchronous motors and the associated drives. Typically, the motor relay is used with circuit breaker or contactor controlled HV motors, and contactor controlled medium sized and large LV motors in a variety of drives, such as pumps and conveyors, crushers and choppers, mixers and agitators, fans and aerators.

The motor relay is thoroughly adapted for earth-fault protection. Using cable current transformers sensitive and reliable earthfault protection can be achieved. Phase current transformers in Holmgreen (summation) connection can also be used for earthfault protection. In that case possible unwanted operations of the earth-fault protection at motor start-up due to CT saturation can be prevented using the relay's internal interlocking features or a suitable stabilizing resistor in the common neutral return.

The optional RTD/mA module offered for standard configurations A and B facilitates the measurement of up to eight analog signals via the six RTD inputs or the two mA inputs using transducers. The RTD and mA inputs can be used for temperature monitoring of motor bearings and stator windings, thus expanding the functionality of the thermal overload protection and preventing premature aging of the motor. Furthermore, the RTD/mA inputs can be used for measuring the ambient cooling air temperature. The analog temperature values can, if required, be sent to other devices using analog horizontal GOOSE messaging. Temperature values can also be received from other devices over the station bus, thus increasing the extent of relevant information.

The standard configuration D includes one conventional residual current (Io) input and three combi-sensor inputs for phase currents and phase voltages. The connection of the three combi-sensors is made with RJ-45 type of connectors.

Sensors offer certain benefits compared to conventional current and voltage instrument transformers, for example, current sensors do not saturate at high currents, they consume less energy and they weigh less. In voltage sensors the risk of ferro-resonance is

eliminated. The sensor inputs also enable the use of the relay in compact medium voltage switchgears, such as ABB's UniGear Digital, SafeRing and SafePlus, with limited space

for conventional measuring transformers, thus requiring the use of sensor technology. Further, the adapters also enable the use of sensors with Twin-BNC connectors.

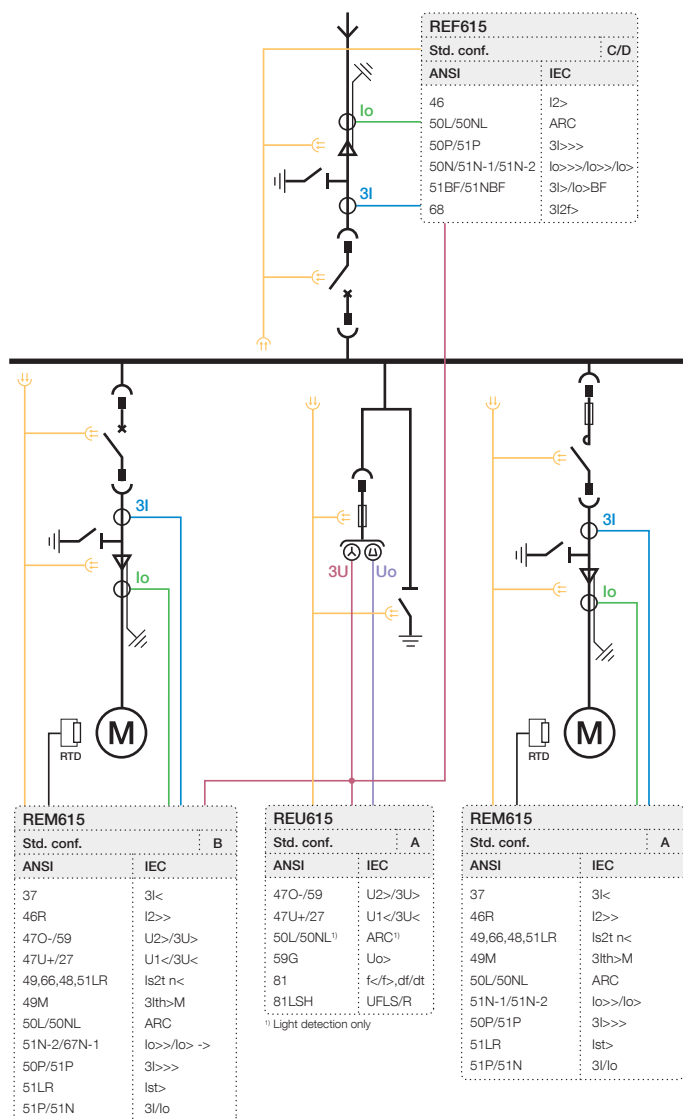


Figure 5: Motor protection and control of contactor and circuit breaker controlled motors using standard configurations A and B

Figure 5 illustrates an example of motor protection and control of contactor and circuit breaker controlled motors using standard configurations A and B. To prevent possible power system instability due to busbar voltage

collapse, the simultaneous starting of several motors can be inhibited with the "restart inhibit" input of REM615. The optional RTD/mA inputs are utilized for motor winding and bearing temperature supervision.

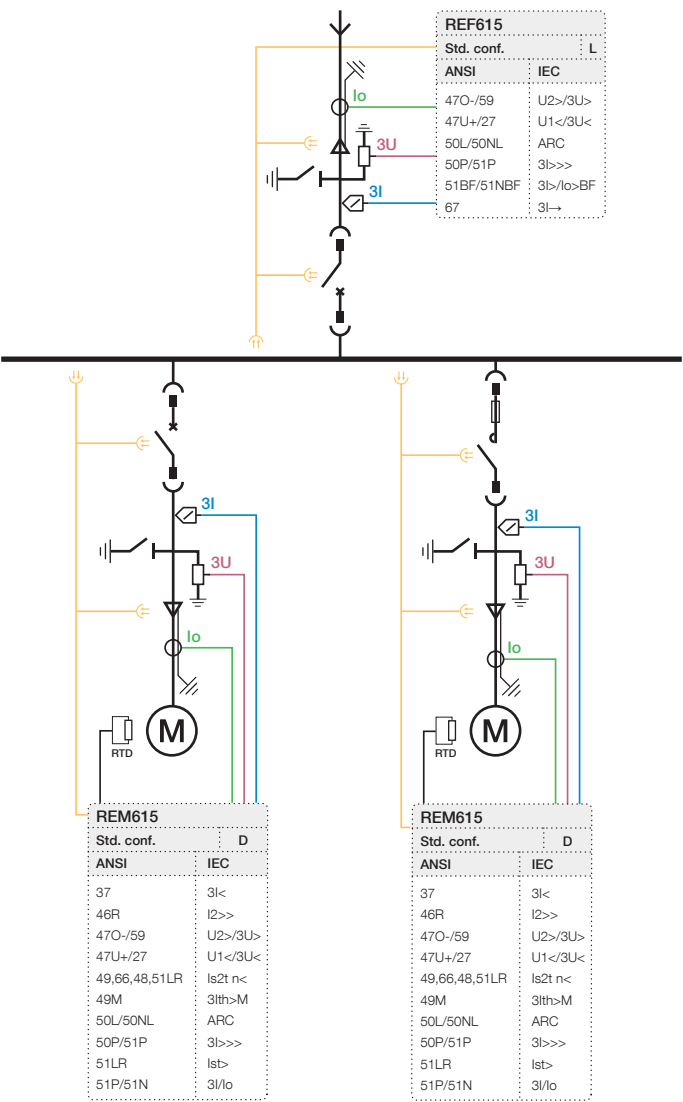


Figure 6: Motor protection and control of contactor and circuit breaker controlled motors using standard configuration D

Example of motor protection and control of contactor and circuit breaker controlled motors using standard configuration D is shown in [Figure 6](#). In this configuration current sensors (Rogowski coil) and voltage sensors (voltage divider) are used for the measurements. To prevent possible power system instability due to busbar voltage collapse, the simultaneous starting of several motors can be inhibited with the "restart inhibit" input of REM615. The optional RTD/mA inputs are utilized for motor winding and bearing temperature supervision.

The standard configuration D has been pre-configured especially for ABB switchgears, for example, UniGear Digital. The use of this configuration is not restricted for that purpose only.

5. Supported ABB solutions

The 615 series protection relays together with the Substation Management Unit COM600S 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 COM600S 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, COM600S uses the data content of the bay level devices to enhance substation level functionality. COM600S features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The SLD feature is especially useful when 615 series relays without the optional single-line diagram feature are used. The Web HMI of COM600S also

provides an overview of the whole substation, including relay-specific single-line diagrams, which makes information easily accessible. Substation devices and processes can also be remotely accessed through the Web HMI, which improves personnel safety.

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

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

GOOSE Analyzer interface in COM600S 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.

Table 3: Supported ABB solutions

Product	Version
Substation Management Unit COM600S	4.0 SP1 or later
	4.1 or later (Edition 2)
MicroSCADA Pro SYS 600	9.3 FP2 or later
	9.4 or later (Edition 2)
System 800xA	5.1 or later

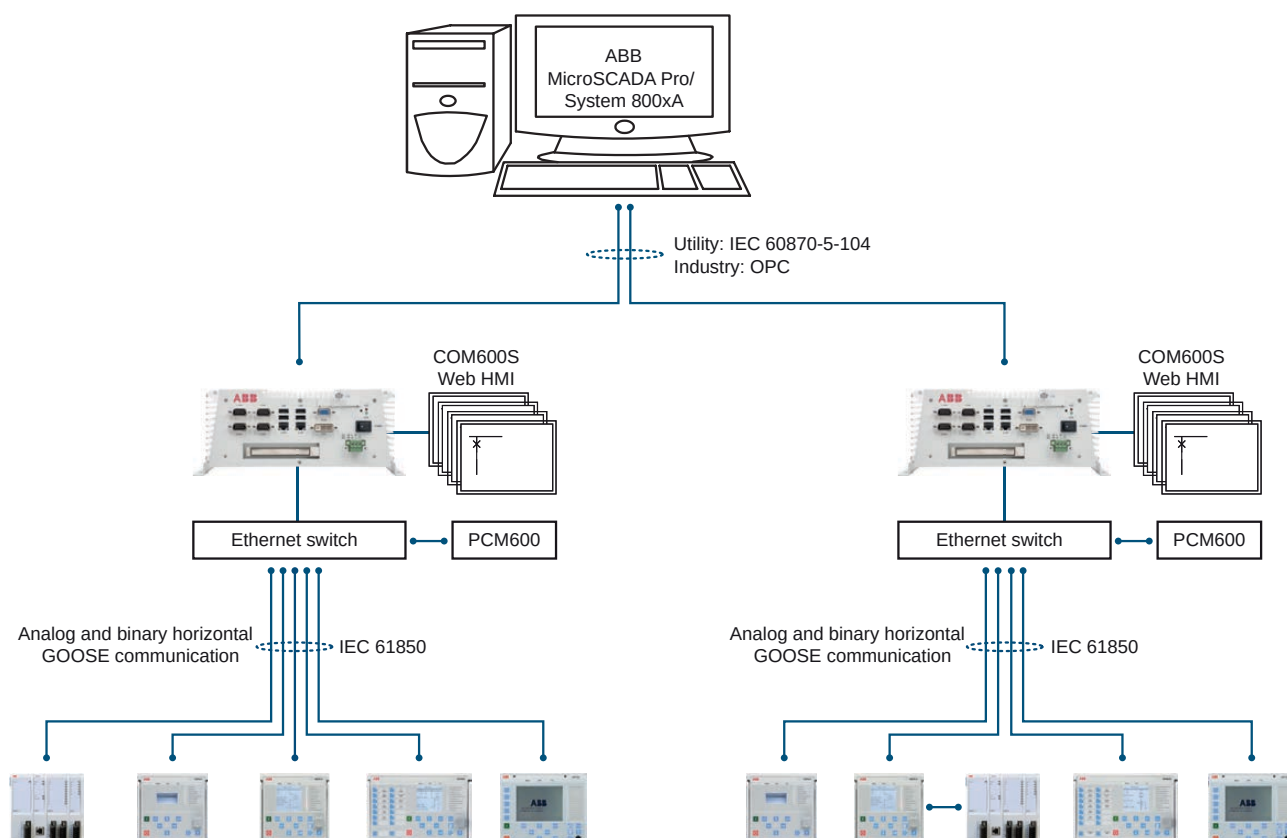


Figure 7: ABB power system example using Relion relays, COM600S and MicroSCADA Pro/System 800xA

6. Control

REM615 integrates functionality for the control of a circuit breaker via the front panel HMI or by means of remote controls. In addition to the circuit 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 earthing 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. 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 be considered.

The optional large graphical LCD of the relay's HMI includes a single-line diagram (SLD) with position indication for the relevant

primary devices. Interlocking schemes required by the application are configured using the signal matrix or the application configuration functionality of PCM600.

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.

7. Measurement

The relay continuously measures the phase currents and the neutral current. Furthermore, the relay measures the phase voltages and the residual voltage. Depending on the standard configuration, the relay also offers frequency measurement. In addition, the relay calculates the symmetrical components of the currents and voltages, maximum current demand value over a user-selectable pre-set time frame, the active and reactive power, the power factor and the active and reactive energy values. Calculated values are also obtained from the protection and condition monitoring functions of the relay.

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. Disturbance recorder

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

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

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

9. 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.

10. 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.

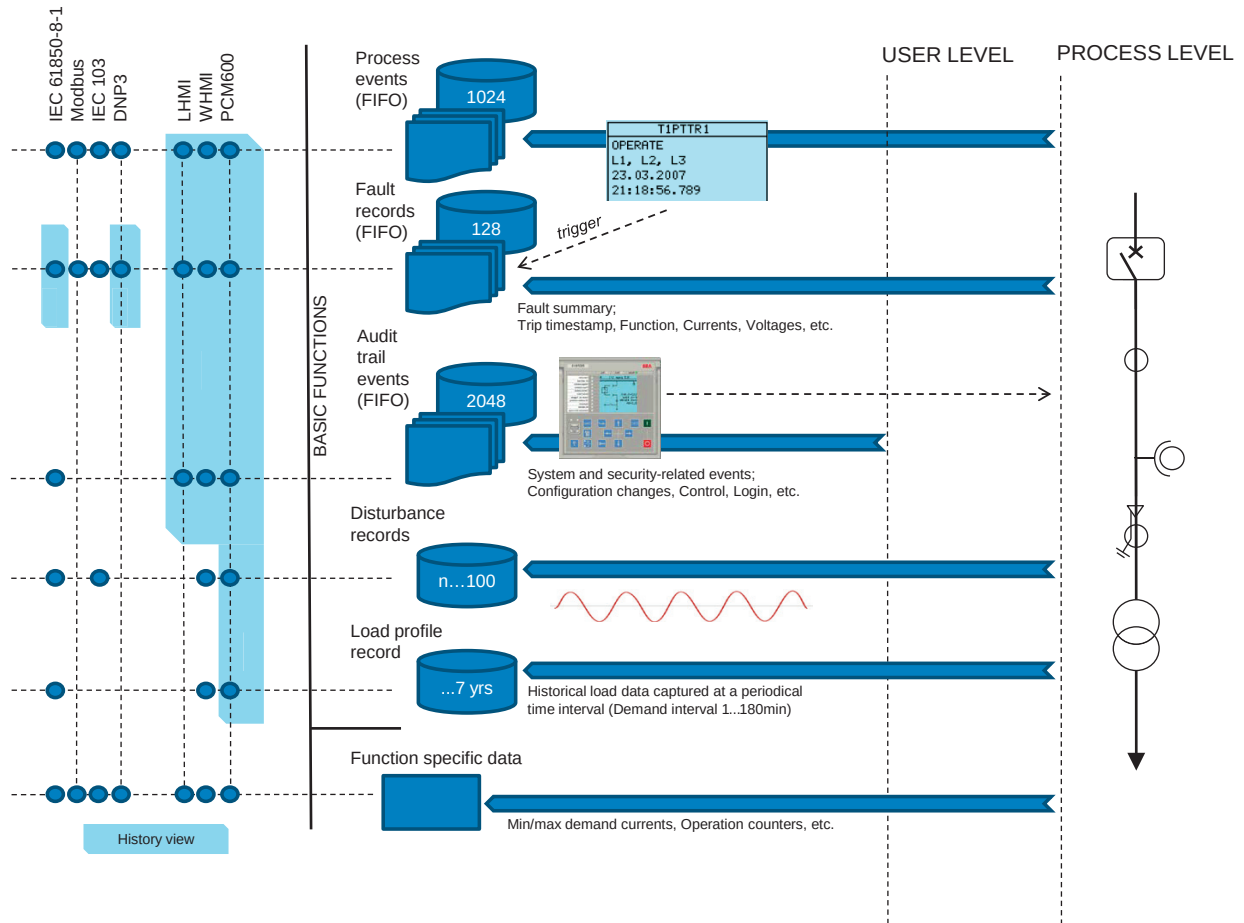


Figure 8: Recording and event capabilities overview

11. 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 the motor has been in operation thus enabling scheduling of time-based preventive maintenance of the motor.

12. 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.

13. 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.

14. Fuse failure supervision

The relay includes fuse failure supervision functionality. 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.

15. Current circuit supervision

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

16. Access control

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

17. Inputs and outputs

The relay is equipped with three phase-current inputs, one residual-current input, three phase-voltage inputs and one residual voltage input. The phase-current inputs and the residual current inputs are rated 1/5 A, that is, the

inputs allow connection of either 1 A or 5 A secondary current transformers. The optional residual-current input 0.2/1 A is normally used in applications requiring sensitive earth-fault protection and featuring core-balance current transformers. The three phase-voltage inputs and the residual-voltage input covers the rated voltages 60-210 V. Both phase-to-phase voltages and phase-to-earth voltages can be connected.

The standard configuration D includes one conventional residual current (I_0 0.2/1 A) input and three sensor inputs for the direct connection of three combi-sensors with RJ-45 connectors. As an alternative to combi-sensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors.

The rated values of the current and voltage inputs are settable parameters of the relay. In addition, the binary input thresholds are selectable within the range of 16...176 V DC by adjusting the relay's parameter settings.

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

As an option for standard configurations A and B, the relay offers six RTD inputs and two mA inputs. By means of the optional RTD/mA module the relay can measure up to eight analog signals such as temperature, pressure and tap changer position values via the six RTD inputs or the two mA inputs using transducers. The values can, apart from measuring and monitoring purposes, be used for tripping and alarm purposes using the offered optional multipurpose protection functions.

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.

See the Input/output overview table and the terminal diagrams for more information about the inputs and outputs.

Table 4: Input/output overview

Std. conf.	Order code digit		Analog channels			Binary channels			
	5-6	7-8	CT	VT	Combi sensor	BI	BO	RTD	mA
A	AC / AD	AB	4	–	–	4	4 PO + 2 SO	–	–
		AD	4	–	–	12	4 PO + 6 SO	–	–
		FE	4	–	–	12	4 PO + 2 SO + 3 HSO	–	–
	AG / AH	AB	4	–	–	4	4 PO + 2 SO	6	2
B	CA / CB	AH	4	3	–	8	4 PO + 6 SO	–	–
		AJ	4	3	–	14	4 PO + 9 SO	–	–
		FD	4	3	–	8	4 PO + 2 SO + 3 HSO	–	–
		FF	4	3	–	14	4 PO + 5 SO + 3 HSO	–	–
	CC / CD	AH	4	3	–	8	4 PO + 6 SO	6	2
		FD	4	3	–	8	4 PO + 2 SO + 3 HSO	6	2
C	AE / AF	AG	4	5	–	16	4 PO + 6 SO	–	–
		FC	4	5	–	16	4 PO + 2 SO + 3 HSO	–	–
D	DA / DB	AH	1	–	3	8	4 PO + 6 SO	–	–
		FD	1	–	3	8	4 PO + 2 SO + 3 HSO	–	–

18. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Profibus DPV1 communication protocol is supported with using the protocol converter SPA-ZC 302. 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.

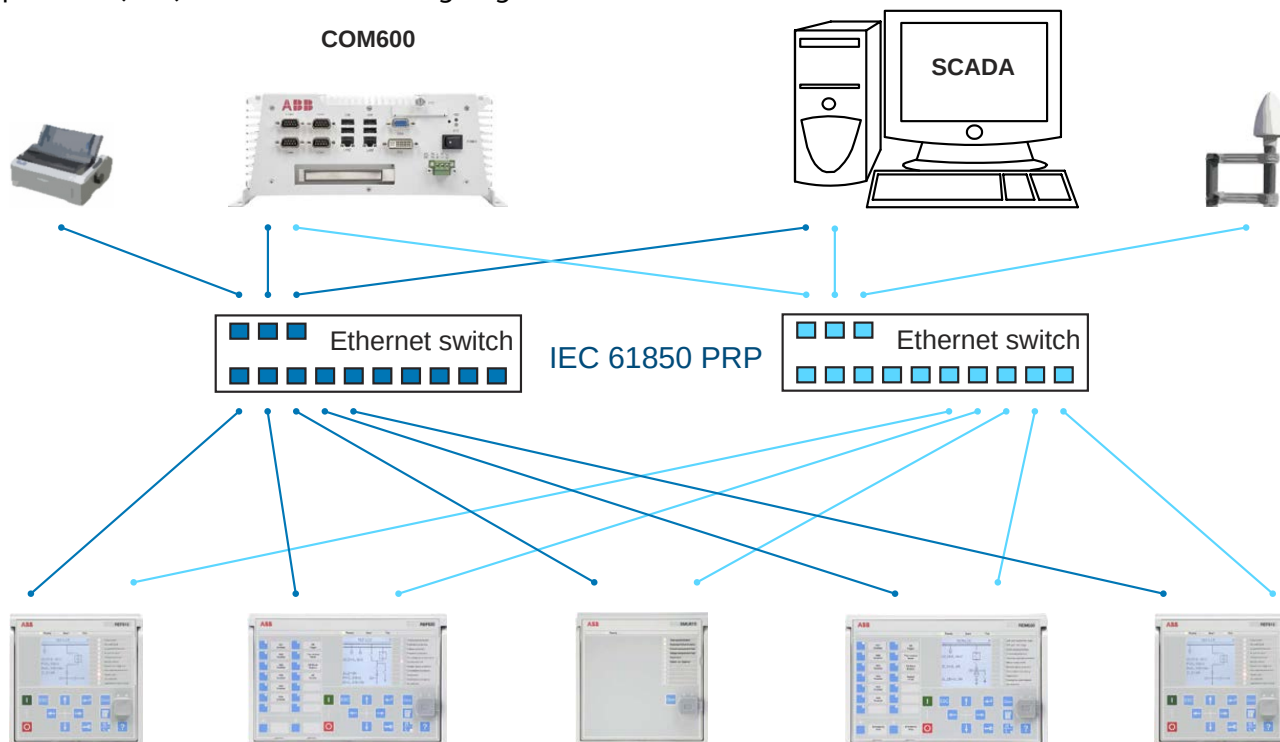


Figure 9: Parallel redundancy protocol (PRP) solution

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.

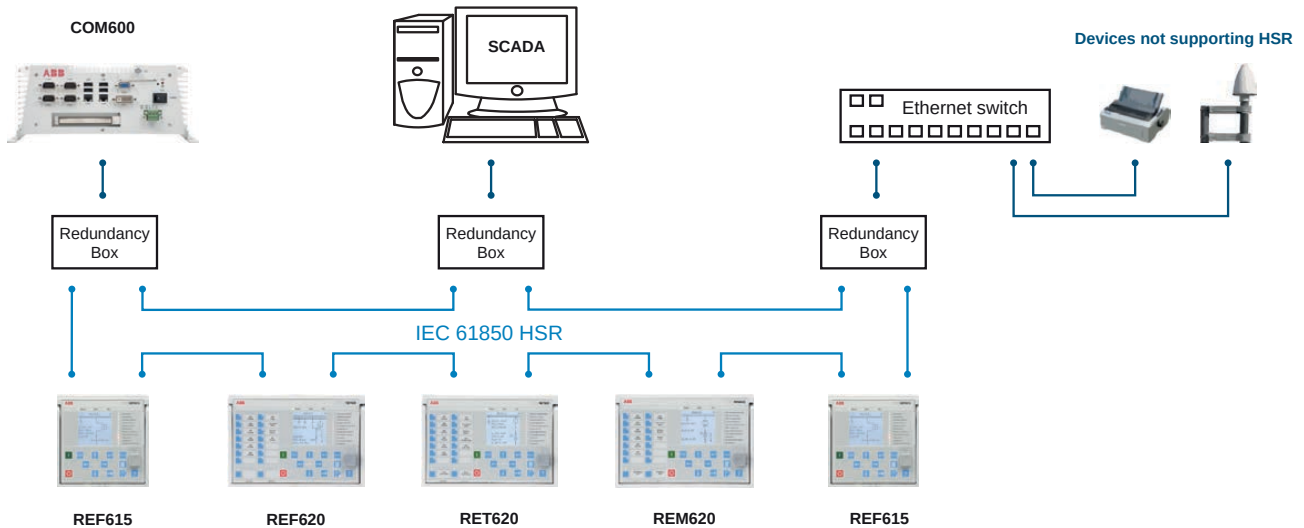


Figure 10: High availability seamless redundancy (HSR) solution

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.

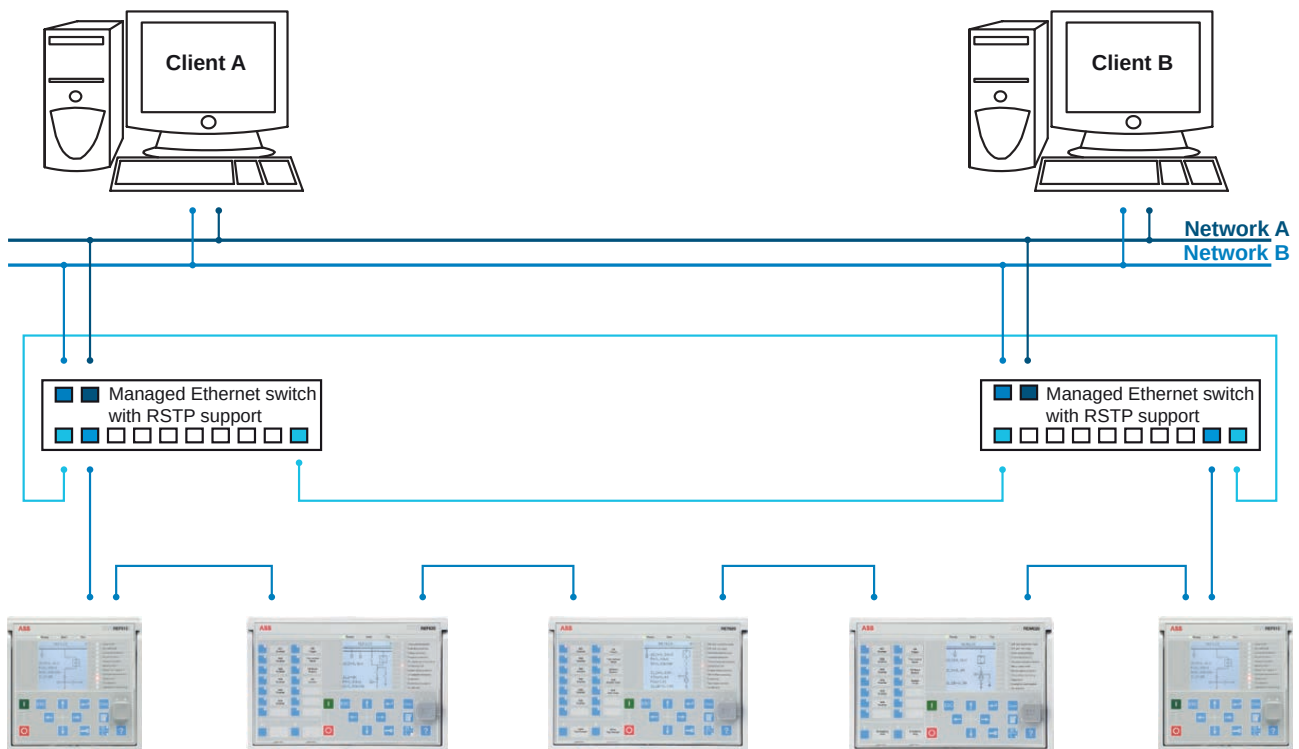


Figure 11: Self-healing Ethernet ring solution

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.

The IEC 60870-5-103 implementation supports two parallel serial bus connections to two different masters. Besides basic standard functionality, the relay supports changing of the active setting group and uploading of disturbance recordings in IEC 60870-5-103 format. Further, IEC 60870-5-103 can be used at the same time with the IEC 61850 protocol.

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.

615 series supports Profibus DPV1 with support of SPA-ZC 302 Profibus adapter. If Profibus is required the relay must be ordered with Modbus serial options. Modbus implementation includes SPA-protocol emulation functionality. This functionality enables connection to SPA-ZC 302.

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 μ s required especially in process bus applications.

- PTP (IEEE 1588) v2 with Power Profile

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

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 $\pm 1 \mu$ s. 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, DNP3 and IEC 60870-5-103 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	•	•	-	-
IEC 60870-5-103	-	-	•	•
• = Supported				

19. Technical data

19.1 Dimensions

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

19.2 Power supply

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

19.3 Energizing inputs

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	4 A	20 A
	• For 1 s	100 A	500 A
	Dynamic current withstand:		
	• Half-wave value	250 A	1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	60...210 V AC	
	Voltage withstand:		
	• Continuous	240 V AC	
	• For 10 s	360 V AC	
	Burden at rated voltage	<0.05 VA	

¹ Ordering option for residual current input

² Residual current and/or phase current

19.4 Energizing inputs (sensors)

Table 9: Energizing Inputs (SIM0002)

Description		Value
Current sensor input	Rated current voltage	75 mV ... 9000 mV ¹
	Continuous voltage withstand	125 V
	Input impedance at 50/60Hz	2...3 MΩ ²
Voltage sensor input	Rated secondary voltage	346 mV...1733 mV ³
	Continuous voltage withstand	50 V
	Input impedance at 50/60Hz	3 MΩ

Table 10: Energizing Inputs (SIM0005)

Description		Value
Current sensor input	Rated current voltage	75 mV ... 9000 mV ¹
	Continuous voltage withstand	125 V
	Input impedance at 50/60Hz	2 MΩ
Voltage sensor input	Rated secondary voltage	346 mV...2339 mV ⁴
	Continuous voltage withstand	50 V
	Input impedance at 50/60Hz	2 MΩ

19.5 Binary inputs

Table 11: Binary inputs

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

¹ Equals the current range of 40 ... 4000 A with 80A, 3mV/Hz Rogowski

² Depending on the used nominal current (hardware gain)

³ Covers 6 kV ... 30 kV sensors with division ratio of 10 000:1. Secondary voltages 600mV/√3 ... 3 V / √3. Range up to 2 x Rated.

⁴ Covers 6 kV ... 40.5 kV sensors with division ratio of 10 000:1. Secondary voltages 600mV/√3 ... 4.05V / √3. Range up to 2 x Rated.

19.6 RTD/mA measurement (XRGGIO130)

Table 12: 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 k Ω	
	Maximum lead resistance (three-wire measurement)	25 Ω per lead	
	Isolation	2 kV (inputs to protective earth)	
	Response time	<4 s	
mA inputs	RTD/resistance sensing current	Maximum 0.33 mA rms	
	Operation accuracy	Resistance	Temperature
		$\pm 2.0\%$ or $\pm 1\ \Omega$	$\pm 1^\circ\text{C}$
			10 Ω copper: $\pm 2^\circ\text{C}$
	Supported current range	0...20 mA	
	Current input impedance	44 $\Omega \pm 0.1\%$	
	Operation accuracy	$\pm 0.5\%$ or $\pm 0.01\ \text{mA}$	

19.7 Signal outputs

Table 13: 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, at 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Table 14: 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

19.8 Double-pole power output relays with TCS function

Table 15: Double-pole power output relays with TCS function

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

19.9 Single-pole power output relays

Table 16: 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

19.10 High-speed output HSO with BIO0007

Table 17: 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	5 A/3 A/1 A

Table continues on the next page

Description	Value
Operate time	<1 ms
Reset	<20 ms, resistive load

19.11 Front port Ethernet interfaces

Table 18: Front port Ethernet interfaces

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

19.12 Station communication link, fiber optic

Table 19: Station communication link, fiber optic

Connector	Fiber type ¹	Wave length	Typical max. length ²	Permitted path attenuation ³
LC	MM 62.5/125 or 50/125 µm glass fiber core	1300 nm	2 km	<8 dB
ST	MM 62.5/125 or 50/125 µm glass fiber core	820...900 nm	1 km	<11 dB

19.13 IRIG-B

Table 20: IRIG-B

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

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

² Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path.

³ Maximum allowed attenuation caused by connectors and cable together

⁴ According to the 200-04 IRIG standard

19.14 Lens sensor and optical fiber for arc protection

Table 21: Lens sensor and optical fiber for arc protection

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

19.15 Degree of protection of flush-mounted protection relay

Table 22: Degree of protection of flush-mounted protection relay

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

19.16 Environmental conditions

Table 23: Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+85°C (<16 h) ^{5, 6}
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+85°C

19.17 Electromagnetic compatibility tests

Table 24: 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	

Table continues on the next page

⁵ Degradation in MTBF and HMI performance outside the temperature range of -25...+55 °C

⁶ For relays with an LC communication interface the maximum operating temperature is +70 °C

Description	Type test value	Reference
Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III
Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
Contact discharge	8 kV	
Air discharge	15 kV	
Radio frequency interference test		
	10 V (rms) f = 150 kHz...80 MHz	IEC 61000-4-6 IEC 60255-26, class III
	10 V/m (rms) f = 80...2700 MHz	IEC 61000-4-3 IEC 60255-26, class III
	10 V/m f = 900 MHz	ENV 50204 IEC 60255-26, class III
	20 V/m (rms) f = 80...1000 MHz	IEEE C37.90.2-2004
Fast transient disturbance test		IEC 61000-4-4 IEC 60255-26 IEEE C37.90.1-2002
All ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-26
Communication	1 kV, line-to-earth	
Other ports	4 kV, line-to-earth 2 kV, line-to-line	
Power frequency (50 Hz) magnetic field immunity test		IEC 61000-4-8
Continuous	300 A/m	
1...3 s	1000 A/m	
Pulse magnetic field immunity test	1000 A/m 6.4/16 µs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
2 s	100 A/m	
1 MHz	400 transients/s	

Table continues on the next page

Description	Type test value	Reference
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11
Power frequency immunity test	Binary inputs only	IEC 61000-4-16 IEC 60255-26, class A
- Common mode - Differential mode	300 V rms 150 V rms	
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	
Radiated		
30...230 MHz	<40 dB (μV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	<47 dB (μV/m) quasi peak, measured at 10 m distance	
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	

19.18 Insulation tests

Table 25: Insulation tests

Description	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min, communication 820 V, 50 Hz, 1 min, sensor inputs of SIM0005	IEC 60255-27 IEC 61869-6

Table continues on the next page

Description	Type test value	Reference
Impulse voltage test	5 kV, 1,2/50 μ s, 0.5 J	IEC 60255-27
	1 kV, 1,2/50 μ s, 0.5 J, communication	
	1,5 kV, 1,2/50 μ s, 0,5 J, sensor inputs of SIM0005	IEC 61869-6
Insulation resistance measurements	>100 M Ω , 500 V DC	IEC 60255-27
Protective bonding resistance	<0.1 Ω , 4 A, 60 s	IEC 60255-27

19.19 Mechanical tests

Table 26: Mechanical tests

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

19.20 Environmental tests

Table 27: Environmental tests

Description	Type test value	Reference
Dry heat test	96 h at +55°C 16 h at +85°C ⁷	IEC 60068-2-2
Dry cold test	96 h at -25°C 16 h at -40°C	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 -40°C	IEC 60068-2-1
	96 h at +85°C	IEC 60068-2-2

19.21 Product safety

⁷ For relays with an LC communication interface the maximum operating temperature is +70 °C

Table 28: Product safety

Description	Reference
LV directive	2014/35/EU
Standard	EN / BS EN 60255-27 EN / BS EN 60255-1

19.22 EMC compliance**Table 29: EMC compliance**

Description	Reference
EMC directive	2014/30/EU
Standard	EN / BS EN 60255-26

19.23 RoHS compliance**Table 30: RoHS compliance**

Description
RoHS Directive 2011/65/EU

19.24 Protection functions**19.24.1 Three-phase non-directional overcurrent protection (PHxPTOC)****Table 31: Three-phase non-directional overcurrent protection (PHxPTOC)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \pm 2 \text{ Hz}$
PHLPTOC	$\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
PHHPTOC ⁸	$\pm 1.5\%$ of set value or $\pm 0.002 \times I_n$
and	(at currents in the range of $0.1 \dots 10 \times I_n$)
PHIPTOC	$\pm 5.0\%$ of the set value
	(at currents in the range of $10 \dots 40 \times I_n$)

Table continues on the next page

⁸ Not included in REM615

Characteristic	Value			
Start time ^{9, 10}	PHIPTOC:	Minimum	Typical	Maximum
	$I_{Fault} = 2 \times \text{set Start value}$	16 ms	19 ms	23 ms
	$I_{Fault} = 10 \times \text{set Start value}$	11 ms	12 ms	14 ms
	PHHPTOC ⁸ and PHLPTOC: $I_{Fault} = 2 \times \text{set Start value}$	23 ms	26 ms	29 ms
Reset time	Typically 40 ms			
Reset ratio	Typically 0.96			
Retardation time	<40 ms			
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms			
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ¹¹			
Suppression of harmonics	RMS: No suppression DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression P-to-P+backup: No suppression			

19.24.2 Three-phase non-directional overcurrent protection (PHxPTOC) main settings

Table 32: Three-phase non-directional overcurrent protection (PHxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PHLPTOC	$0.05 \dots 5.00 \times I_n$	0.01
	PHHPTOC ¹²	$0.10 \dots 40.00 \times I_n$	0.01
	PHIPTOC	$1.00 \dots 40.00 \times I_n$	0.01
Time multiplier	PHLPTOC and PHHPTOC ¹²	0.05...15.00	0.01
	PHLPTOC and PHHPTOC ¹²	40...200000 ms	10

Table continues on the next page

⁹ Set *Operate delay time* = 0,02 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = $0.0 \times I_n$, $f_n = 50$ Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

¹⁰ Includes the delay of the signal output contact

¹¹ Includes the delay of the heavy-duty output contact

¹² Not included in this product

Parameter	Function	Value (Range)	Step
Operating curve type ¹³	PHIPTOC	20...200000 ms	10
	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 ¹²	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

19.24.3 Non-directional earth-fault protection (EFxPTOC)

Table 33: Non-directional earth-fault protection (EFxPTOC)

Characteristic	Value		
Operation accuracy	Depending on the frequency of the measured current: $f_n \pm 2$ Hz		
EFLPTOC	$\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$		
EFHPTOC	$\pm 1.5\%$ of set value or $\pm 0.002 \times I_n$		
and	(at currents in the range of $0.1...10 \times I_n$)		
EFIPTOC ¹⁴	$\pm 5.0\%$ of the set value (at currents in the range of $10...40 \times I_n$)		
Start time ^{15, 16}	Minimum	Typical	Maximum
EFIPTOC ¹⁴ :	16 ms	19 ms	23 ms
$I_{Fault} = 2 \times \text{set Start value}$	11 ms		14 ms
$I_{Fault} = 10 \times \text{set Start value}$			
EFHPTOC and EFLP-TOC:	23 ms	26 ms	29 ms
$I_{Fault} = 2 \times \text{set Start value}$			
Reset time	Typically 40 ms		
Reset ratio	Typically 0.96		
Retardation time	<30 ms		
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms		

Table continues on the next page

¹³ For further reference, see the Operation characteristics table

¹⁴ Not included in REM615

¹⁵ *Measurement mode* = default (depends on stage), current before fault = $0.0 \times I_n$, $f_n = 50$ Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

¹⁶ Includes the delay of the signal output contact

Characteristic	Value
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ¹⁷
Suppression of harmonics	RMS: No suppression DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression

19.24.4 Non-directional earth-fault protection (EFxPTOC) main settings

Table 34: Non-directional earth-fault protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010. 5.000 $\times I_n$	0.005
	EFHPTOC	0.10. 40.00 $\times I_n$	0.01
	EFIPTOC ¹⁸	1.00. 40.00 $\times I_n$	0.01
Time multiplier	EFLPTOC and EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC and EFHPTOC	40...200000 ms	10
	EFIPTOC ¹⁸	20...200000 ms	10
Operating curve type ¹⁹	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 ¹⁸	Definite time	

19.24.5 Directional earth-fault protection (DEFxPDEF)

Table 35: Directional earth-fault protection (DEFxPDEF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \pm 2$ Hz
DEFLPDEF	Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$

Table continues on the next page

¹⁷ Maximum *Start value* = $2.5 \times I_n$, *Start value* multiples in range of 1.5...20

¹⁸ Not included in this product

¹⁹ For further reference, see the Operation characteristics table

Characteristic	Value		
DEFHPDEF ²⁰	Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$) $\pm 5.0\%$ of the set value (at currents in the range of $10 \dots 40 \times I_n$) Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$		
Start time ^{21, 22}	Minimum	Typical	Maximum
DEFHPDEF ²⁰ $I_{\text{Fault}} = 2 \times \text{set Start value}$	42	46 ms	49 ms
DEFLPDEF $I_{\text{Fault}} = 2 \times \text{set Start value}$	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	$\pm 1.0\%$ of the set value or ± 20 ms		
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ²³		
Suppression of harmonics	RMS: No suppression DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression		

²⁰ Not included in REM615

²¹ Set *Operate delay time* = 0.06 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = $0.0 \times I_n$, $f_n = 50$ Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

²² Includes the delay of the signal output contact

²³ Maximum *Start value* = $2.5 \times I_n$, *Start value* multiples in range of 1.5...20

19.24.6 Directional earth-fault protection (DEFxPDEF) main settings

Table 36: Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start value	DEFLPDEF	$0.010 \dots 5.000 \times I_n$	0.005
	DEFHPDEF ²⁴	$0.10 \dots 40.00 \times I_n$	0.01
Directional mode	DEFLPDEF and DEFHPDEF	1 = Non-directional 2 = Forward 3 = Reverse	-
Time multiplier	DEFLPDEF	0.05...15.00	0.01
	DEFHPDEF ²⁴	0.05...15.00	0.01
Operate delay time	DEFLPDEF	50...200000 ms	10
	DEFHPDEF ²⁴	40...200000 ms	10
Operating curve type ²⁵	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 ²⁴	Definite or inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFxPDEF	1 = Phase angle 2 = $I_o \sin$ 3 = $I_o \cos$ 4 = Phase angle 80 5 = Phase angle 88	-

19.24.7 Three-phase undervoltage protection (PHPTUV)

Table 37: Three-phase undervoltage protection (PHPTUV)

Characteristic	Value		
Operation accuracy	Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$		
Start time ^{26, 27}		Minimum	Typical
	$U_{\text{Fault}} = 0.9 \times \text{set Start value}$	62 ms	66 ms
Reset time	Typically 40 ms		
Reset ratio	Depends on the set <i>Relative hysteresis</i>		

Table continues on the next page

²⁴ Not included in REM615

²⁵ For further reference, see the Operating characteristics table

²⁶ *Start value* = $1.0 \times U_n$, Voltage before fault = $1.1 \times U_n$, $f_n = 50$ Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

²⁷ Includes the delay of the signal output contact

Characteristic	Value
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ²⁸
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

19.24.8 Three-phase undervoltage protection (PHPTUV) main settings

Table 38: Three-phase undervoltage protection (PHPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	$0.05 \dots 1.20 \times U_n$	0.01
Time multiplier	PHPTUV	0.05...15.00	0.01
Operate delay time	PHPTUV	60...300000 ms	10
Operating curve type ²⁹	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

19.24.9 Positive-sequence undervoltage protection (PSPTUV)

Table 39: Positive-sequence undervoltage protection (PSPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: $f_n \pm 2$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{30, 31}	Minimum
	Typical
	Maximum
$U_{\text{Fault}} = 0.99 \times \text{set Start value}$	52 ms
$U_{\text{Fault}} = 0.9 \times \text{set Start value}$	44 ms
Reset time	Typically 40 ms
Reset ratio	Depends on the set <i>Relative hysteresis</i>
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

²⁸ Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

²⁹ For further reference, see the Operation characteristics table

³⁰ *Start value* = $1.0 \times U_n$, positive-sequence voltage before fault = $1.1 \times U_n$, $f_n = 50$ Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

³¹ Includes the delay of the signal output contact

19.24.10 Positive-sequence undervoltage protection (PSPTUV) main settings

Table 40: Positive-sequence undervoltage protection (PSPTUV) main settings

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

19.24.11 Negative-sequence overvoltage protection (NSPTOV)

Table 41: Negative-sequence overvoltage protection (NSPTOV)

Characteristic	Value		
Operation accuracy	Depending on the frequency of the voltage measured: f_n $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$		
Start time ^{32, 33}		Minimum	Typical
	$U_{\text{Fault}} = 1.1 \times \text{set Start value}$	33 ms	35 ms
	$U_{\text{Fault}} = 2.0 \times \text{set Start value}$	24 ms	26 ms
Reset time	Typically 40 ms		
Reset ratio	Typically 0.96		
Retardation time	<35 ms		
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms		
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$		

19.24.12 Negative-sequence overvoltage protection (NSPTOV) main settings

Table 42: Negative-sequence overvoltage protection (NSPTOV) main settings

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

19.24.13 Frequency protection (FRPFRQ)

Table 43: Frequency protection (FRPFRQ)

Characteristic	Value	
Operation accuracy	$f > / f <$	± 5 mHz
	df/dt	± 50 mHz/s (in range $ df/dt < 5$ Hz/s)
		$\pm 2.0\%$ of the set value (in range $5 \text{ Hz/s} < df/dt < 15 \text{ Hz/s}$)

Table continues on the next page

³² Negative-sequence voltage before fault = $0.0 \times U_n$, $f_n = 50$ Hz, negative-sequence overvoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

³³ Includes the delay of the signal output contact

Characteristic	Value
Start time	$f > / f <$ <80 ms
	df/dt <120 ms
Reset time	<150 ms
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 30 ms

19.24.14 Frequency protection (FRPFRQ) main settings

Table 44: 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	$0.9000 \dots 1.2000 \times f_n$	0.0001
Start value Freq<	FRPFRQ	$0.8000 \dots 1.1000 \times f_n$	0.0001
Start value df/dt	FRPFRQ	$-0.2000 \dots 0.2000 \times f_n/s$	0.005
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

19.24.15 Negative-sequence overcurrent protection for machines (MNSPTOC)

Table 45: Negative-sequence overcurrent protection for machines (MNSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
Start time ^{34, 35}	Minimum Typical Maximum
$I_{Fault} = 2.0 \times \text{set Start value}$	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	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁶
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

³⁴ Negative-sequence current before = 0.0, $f_n = 50$ Hz, results based on statistical distribution of 1000 measurements

³⁵ Includes the delay of the signal output contact

³⁶ *Start value* multiples in range of 1.10...5.00

19.24.16 Negative-sequence overcurrent protection for machines (MNSPTOC) main settings**Table 46: Negative-sequence overcurrent protection for machines (MNSPTOC) main settings**

Parameter	Function	Value (Range)	Step
Start value	MNSPTOC	$0.01...0.50 \times I_n$	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

19.24.17 Loss of load supervision (LOFLPTUC)**Table 47: Loss of load supervision (LOFLPTUC)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \pm 2$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
Start time	Typically 300 ms
Reset time	Typically 40 ms
Reset ratio	Typically 1.04
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms

19.24.18 Loss of load supervision (LOFLPTUC) main settings**Table 48: Loss of load supervision (LOFLPTUC) main settings**

Parameter	Function	Value (Range)	Step
Start value low	LOFLPTUC	$0.01...0.50 \times I_n$	0.01
Start value high	LOFLPTUC	$0.01...1.00 \times I_n$	0.01
Operate delay time	LOFLPTUC	400...600000 ms	10
Operation	LOFLPTUC	1 = on 5 = off	-

19.24.19 Motor load jam protection (JAMPTOC)**Table 49: Motor load jam protection (JAMPTOC)**

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

Table continues on the next page

Characteristic	Value
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

19.24.20 Motor load jam protection (JAMPTOC) main settings

Table 50: Motor load jam protection (JAMPTOC) main settings

Parameter	Function	Value (Range)	Step
Operation	JAMPTOC	1 = on 5 = off	-
Start value	JAMPTOC	0.10...10.00 × I _n	0.01
Operate delay time	JAMPTOC	100...120000 ms	10

19.24.21 Motor start-up supervision (STTPMSU)

Table 51: Motor start-up supervision (STTPMSU)

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
Start time ^{37, 38}	Minimum Typical Maximum
$I_{Fault} = 1.1 \times \text{set } Start\ detection$ A	27 ms 30 ms 34 ms
Operate time accuracy	±1.0% of the set value or ±20 ms
Reset ratio	Typically 0.90

19.24.22 Motor start-up supervision (STTPMSU) main settings

Table 52: Motor start-up supervision (STTPMSU) main settings

Parameter	Function	Value (Range)	Step
Motor start-up A	STTPMSU	1.0...10.0 × I _n	0.1
Motor start-up time	STTPMSU	1...80 s	1
Lock rotor time	STTPMSU	2...120 s	1
Operation	STTPMSU	1 = on 5 = off	-

Table continues on the next page

³⁷ Current before = 0.0 × I_n, f_n = 50 Hz, overcurrent in one phase, results based on statistical distribution of 1000 measurements

³⁸ Includes the delay of the signal output contact

Parameter	Function	Value (Range)	Step
Operation mode	STTPMSU	1 = Ilt 2 = Ilt, CB 3 = Ilt + stall 4 = Ilt + stall, CB	-
Restart inhibit time	STTPMSU	0...250 min	1

19.24.23 Phase reversal protection (PREVPTOC)

Table 53: Phase reversal protection (PREVPTOC)

Characteristic	Value			
Operation accuracy	Depending on the frequency of the measured current: $f_n \pm 2$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$			
Start time ^{39, 40}	$I_{Fault} = 2.0 \times \text{set } Start \text{ value}$	Minimum	Typical	Maximum
		23 ms	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	$\pm 1.0\%$ of the set value or ± 20 ms			
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$			

19.24.24 Phase reversal protection (PREVPTOC) main settings

Table 54: Phase reversal protection (PREVPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PREVPTOC	$0.05 \dots 1.00 \times I_n$	0.01
Operate delay time	PREVPTOC	100...60000 ms	10
Operation	PREVPTOC	1 = on 5 = off	-

³⁹ Negative-sequence current before = 0.0, $f_n = 50$ Hz, results based on statistical distribution of 1000 measurements

⁴⁰ Includes the delay of the signal output contact

19.24.25 Thermal overload protection for motors (MPTTR)**Table 55: Thermal overload protection for motors (MPTTR)**

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \pm 2$ Hz Current measurement: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.01 \dots 4.00 \times I_n$)
Operate time accuracy ⁴¹	$\pm 2.0\%$ of the theoretical value or ± 0.50 s

19.24.26 Thermal overload protection for motors (MPTTR) main settings**Table 56: Thermal overload protection for motors (MPTTR) main settings**

Parameter	Function	Value (Range)	Step
Overload factor	MPTTR	1.00...1.20	0.01
Alarm thermal value	MPTTR	50.0...100.0%	0.1
Restart thermal Val	MPTTR	20.0...80.0%	0.1
Weighting factor p	MPTTR	20.0...100.0%	0.1
Time constant normal	MPTTR	80...4000 s	1
Time constant start	MPTTR	80...4000 s	1
Env temperature mode	MPTTR	1 = FLC Only 2 = Use input 3 = Set Amb Temp	-
Env temperature Set	MPTTR	-20.0...70.0°C	0.1
Operation	MPTTR	1 = on 5 = off	-

19.24.27 Circuit breaker failure protection (CCBRBRF)**Table 57: Circuit breaker failure protection (CCBRBRF)**

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

⁴¹ Overload current > $1.2 \times$ Operate level temperature

19.24.28 Circuit breaker failure protection (CCBRBRF) main settings

Table 58: Circuit breaker failure protection (CCBRBRF) main settings

Parameter	Function	Value (Range)	Step
Current value	CCBRBRF	$0.05 \dots 2.00 \times I_n$	0.05
Current value Res	CCBRBRF	$0.05 \dots 2.00 \times I_n$	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

19.24.29 Arc protection (ARCSARC)

Table 59: Arc protection (ARCSARC)

Characteristic	Value			
Operation accuracy	±3% of the set value or ±0.01 × I _n			
Operate time		Minimum	Typical	Maximum
	<i>Operation mode</i> = "Light+current" ^{42, 43}	9 ms	12 ms ⁴⁴	15 ms ⁴⁴
		⁴⁴	6 ms ⁴⁵	9 ms ⁴⁵
		4 ms		
	⁴⁵			
	<i>Operation mode</i> = "Light only" ⁴³	9 ms ⁴⁴	10 ms ⁴⁴	12 ms ⁴⁴
4 ms ⁴⁵		6 ms ⁴⁵	7 ms ⁴⁵	
Reset time	Typically 40 ms			
Reset ratio	Typically 0.96			

⁴² *Phase start value* = $1.0 \times I_n$, current before fault = $2.0 \times$ set *Phase start value*, $f_n = 50$ Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements

⁴³ Includes the delay of the heavy-duty output contact

⁴⁴ Normal power output

⁴⁵ High-speed output

19.24.30 Arc protection (ARCSARC) main settings

Table 60: Arc protection (ARCSARC) main settings

Parameter	Function	Value (Range)	Step
Phase start value	ARCSARC	$0.50 \dots 40.00 \times I_n$	0.01
Ground start value	ARCSARC	$0.05 \dots 8.00 \times I_n$	0.01
Operation mode	ARCSARC	1 = Light+current 2 = Light only 3 = BI controlled	-

19.24.31 Multipurpose protection (MAPGAPC)

Table 61: Multipurpose protection (MAPGAPC)

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

19.24.32 Multipurpose protection (MAPGAPC) main settings

Table 62: Multipurpose protection (MAPGAPC) main settings

Parameter	Function	Value (Range)	Step
Start value	MAPGAPC	$-10000.0 \dots 10000.0$	0.1
Operate delay time	MAPGAPC	$0 \dots 200000$ ms	100
Operation mode	MAPGAPC	1 = Over 2 = Under	-

19.25 Control functions

19.25.1 Emergency start-up (ESMGAPC)

Table 63: Emergency start-up (ESMGAPC)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$ $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$

19.25.2 Emergency start-up (ESMGAPC) main settings

Table 64: Emergency start-up (ESMGAPC) main settings

Parameter	Function	Value (Range)	Step
Motor stand still A	ESMGAPC	$0.05...0.20 \times I_n$	0.01
Operation	ESMGAPC	1 = on 5 = off	-

19.26 Condition and supervision functions

19.26.1 Circuit-breaker condition monitoring (SSCBR)

Table 65: Circuit-breaker condition monitoring (SSCBR)

Characteristic	Value
Current measuring accuracy	$\pm 1.5\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.1...10 \times I_n$) $\pm 5.0\%$ (at currents in the range of $10...40 \times I_n$)
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 20 ms
Travelling time measurement	+10 ms / -0 ms

19.26.2 Current circuit supervision (CCSPVC)

Table 66: Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time ⁴⁶	<30 ms

19.26.3 Current circuit supervision (CCSPVC) main settings

Table 67: Current circuit supervision (CCSPVC) main settings

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

⁴⁶ Including the delay of the output contact

19.26.4 Fuse failure supervision (SEQSPVC)

Table 68: Fuse failure supervision (SEQSPVC)

Characteristic		Value
Operate time ⁴⁷	NPS function	$U_{\text{Fault}} = 1.1 \times \text{set } \textit{Neg Seq volt- age Lev}$ <33 ms
		$U_{\text{Fault}} = 5.0 \times \text{set } \textit{Neg Seq volt- age Lev}$ <18 ms
	Delta function	$\Delta U = 1.1 \times \text{set } \textit{Voltage change rate}$ <30 ms
		$\Delta U = 2.0 \times \text{set } \textit{Voltage change rate}$ <24 ms

19.26.5 Runtime counter for machines and devices (MDSOPT)

Table 69: Runtime counter for machines and devices (MDSOPT)

Description	Value
Motor runtime measurement accuracy ⁴⁸	$\pm 0.5\%$

19.27 Measurement functions

19.27.1 Three-phase current measurement (CMMXU)

Table 70: Three-phase current measurement (CMMXU)

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

⁴⁷ 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

⁴⁸ Of the reading, for a stand-alone relay, without time synchronization

19.27.2 Sequence current measurement (CSMSQI)**Table 71: Sequence current measurement (CSMSQI)**

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

19.27.3 Residual current measurement (RESCMMXU)**Table 72: Residual current measurement (RESCMMXU)**

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

19.27.4 Three-phase voltage measurement (VMMXU)**Table 73: Three-phase voltage measurement (VMMXU)**

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

19.27.5 Residual voltage measurement (RESVMMXU)**Table 74: Residual voltage measurement (RESVMMXU)**

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

19.27.6 Sequence voltage measurement (VSMSQI)

Table 75: Sequence voltage measurement (VSMSQI)

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

19.27.7 Three-phase power and energy measurement (PEMMXU)

Table 76: Three-phase power and energy measurement (PEMMXU)

Characteristic	Value
Operation accuracy	At all three currents in range $0.10...1.20 \times I_n$ At all three voltages in range $0.50...1.15 \times U_n$ At the frequency $f_n \pm 1$ Hz $\pm 1.5\%$ for apparent power S $\pm 1.5\%$ for active power P and active energy ⁴⁹ $\pm 1.5\%$ for reactive power Q and reactive energy ⁵⁰ ± 0.015 for power factor
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

19.27.8 RTD/mA measurement (XRGGIO130)

Table 77: RTD/mA measurement (XRGGIO130)

Description	Value
RTD inputs	Supported RTD sensors
	100 Ω platinum
	250 Ω platinum
	100 Ω nickel
	120 Ω nickel
	250 Ω nickel
	10 Ω copper
	Supported resistance range
	Maximum lead resistance (three-wire measurement)
	Isolation
	Response time

Table continues on the next page

⁴⁹ $|PF| > 0.5$ which equals $|\cos\phi| > 0.5$

⁵⁰ $|PF| < 0.86$ which equals $|\sin\phi| > 0.5$

Description		Value	
	RTD/resistance sensing current	Maximum 0.33 mA rms	
	Operation accuracy	Resistance	Temperature
		$\pm 2.0\%$ or $\pm 1\ \Omega$	$\pm 1^\circ\text{C}$
			10 Ω copper: $\pm 2^\circ\text{C}$
mA inputs	Supported current range	0...20 mA	
	Current input impedance	44 $\Omega \pm 0.1\%$	
	Operation accuracy	$\pm 0.5\%$ or $\pm 0.01\text{ mA}$	

19.27.9 Frequency measurement (FMMXU)

Table 78: Frequency measurement (FMMXU)

Characteristic	Value
Operation accuracy	$\pm 5\text{ mHz}$ (in measurement range 35...75 Hz)

19.28 Other functions

19.28.1 Pulse timer (PTGAPC)

Table 79: Pulse timer (PTGAPC)

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

19.28.2 Time delay off (8 pcs) (TOFPAGC)

Table 80: Time delay off (8 pcs) (TOFPAGC)

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

19.28.3 Time delay on (8 pcs) (TONGAPC)

Table 81: Time delay on (8 pcs) (TONGAPC)

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

20. Local HMI

The relay is available with two optional displays, a large one and a small one. 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 small display is suited for remotely controlled substations where the relay is only occasionally

accessed locally via the front panel user interface.

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

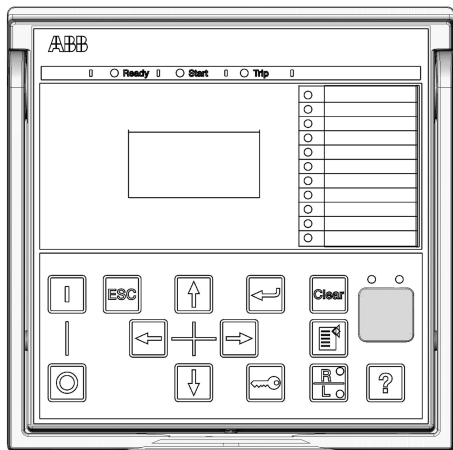


Figure 12: Small display

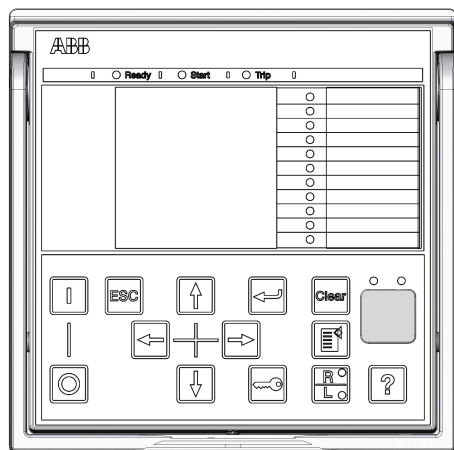


Figure 13: Large display

Table 82: Small display

Character size ⁸⁰	Rows in the view	Characters per row
Small, mono-spaced (6 × 12 pixels)	5	20
Large, variable width (13 × 14 pixels)	3	8 or more

Table 83: Large display

Character size ⁸⁰	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

⁸⁰ 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. Alternatively, the relays can be mounted in 19" instrument cabinets by means of 4U Combiflex equipment frames.

For routine testing purposes, the relay cases can be equipped with test switches, type RTXP

18, which can be mounted side by side with the relay cases.

Mounting methods

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

Panel cut-out for flush mounting

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

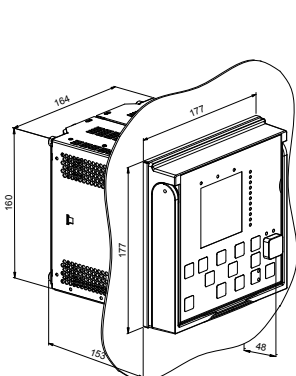


Figure 14: Flush mounting

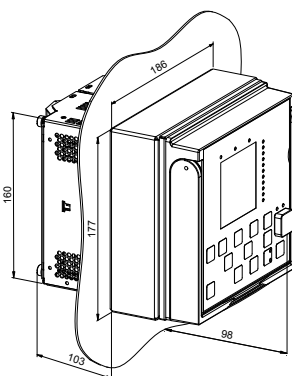


Figure 15: Semi-flush mounting

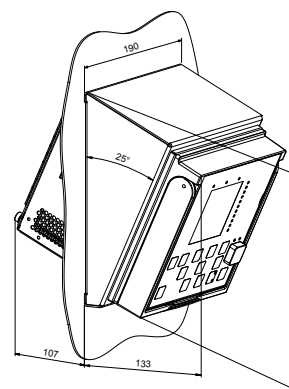


Figure 16: Semi-flush mounting in a 25° tilt

22. Relay case and plug-in unit

The relay cases are assigned to a certain type of plug-in unit. For safety reasons, the relay cases for current measuring relays are provided with automatically operating contacts for shortcircuiting 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 IEC 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 84: 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 85: 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
Mounting bracket for one relay with test switch RTXP in 4U Combiflex (RHGT 19" variant C)	2RCA022642P0001
Mounting bracket for one relay in 4U Combiflex (RHGT 19" variant C)	2RCA022643P0001
19" rack mounting kit for one relay and one RTXP18 test switch (the test switch is not included in the delivery)	2RCA021952A0003
19" rack mounting kit for one relay and one RTXP24 test switch (the test switch is not included in the delivery)	2RCA022561A0003
Functional earthing flange for RTD modules ⁵¹	2RCA036978A0001
Replacement kit for a Strömberg SP_J40 series relay (cut-out in the center of the installation plate)	2RCA027871A0001
Replacement kit for a Strömberg SP_J40 series relay (cut-out on the left or the right of the installation plate)	2RCA027874A0001
Replacement kit for two Strömberg SP_J3 series relays	2RCA027880A0001
19" rack replacement kit for Strömberg SP_J3/J6 series relays (one cut-out)	2RCA027894A0001
19" rack replacement kit for Strömberg SP_J3/J6 series relays (two cut-outs)	2RCA027897A0001

Table continues on the next page

⁵¹ Cannot be used when the protection relay is mounted with the Combiflex 19" equipment frame (2RCA032826A0001)

Item	Order number
Replacement kit for a Strömberg SP_J6 series relay	2RCA027881A0001
Replacement kit for three BBC S_ series relays	2RCA027882A0001
Replacement kit for a SPA 300 series relay	2RCA027885A0001

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 IED Manager PCM600 in combination with the relay-specific connectivity package.

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

When the Web HMI is used, the protection relay can be accessed either locally or remotely using

a Web browser (Internet Explorer). For security reasons, the Web HMI is disabled by default but it can be enabled via the local HMI. The Web HMI functionality can be limited to read-only access.

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

Table 86: Tools

Description	Version
PCM600	2.6 (Rollup 20150626) or later
Web browser	IE 8.0, IE 9.0, IE 10.0 or IE 11.0
REM615 Connectivity Package	5.1 or later

Table 87: 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)	–	•

Table continues on the next page

Function	Web HMI	PCM600
Modbus® communication configuration (communication management)	–	•
DNP3 communication configuration (communication management)	–	•
IEC 60870-5-103 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 nonvolatile 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

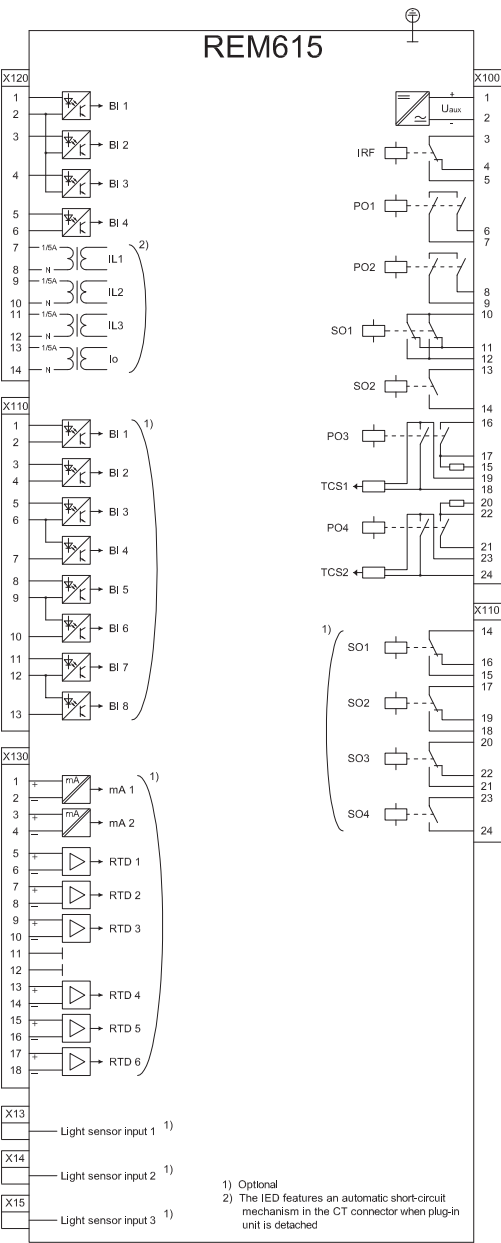


Figure 17: Terminal diagram of standard configuration A

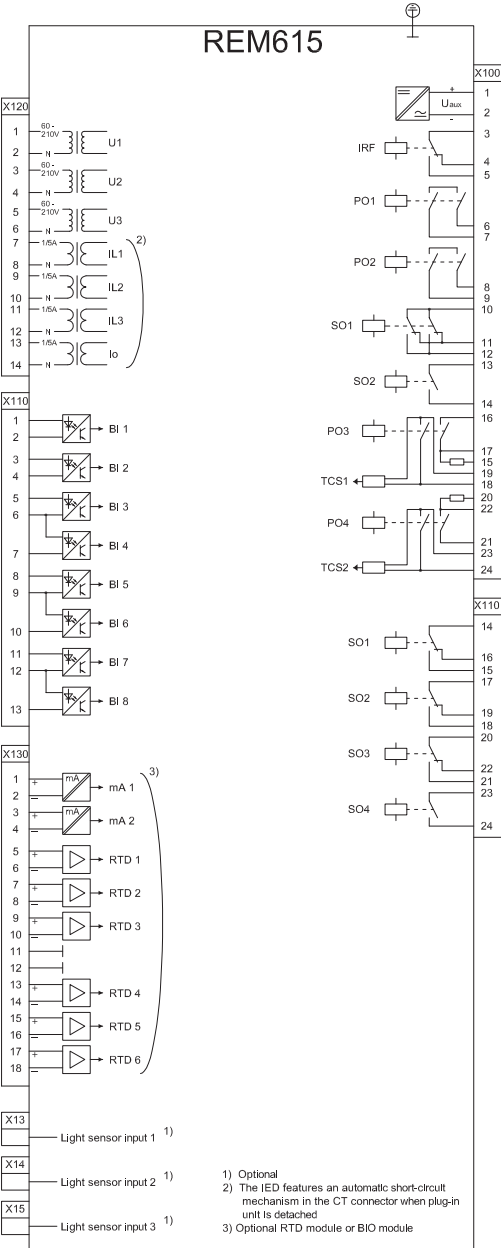


Figure 18: Terminal diagram of standard configuration B

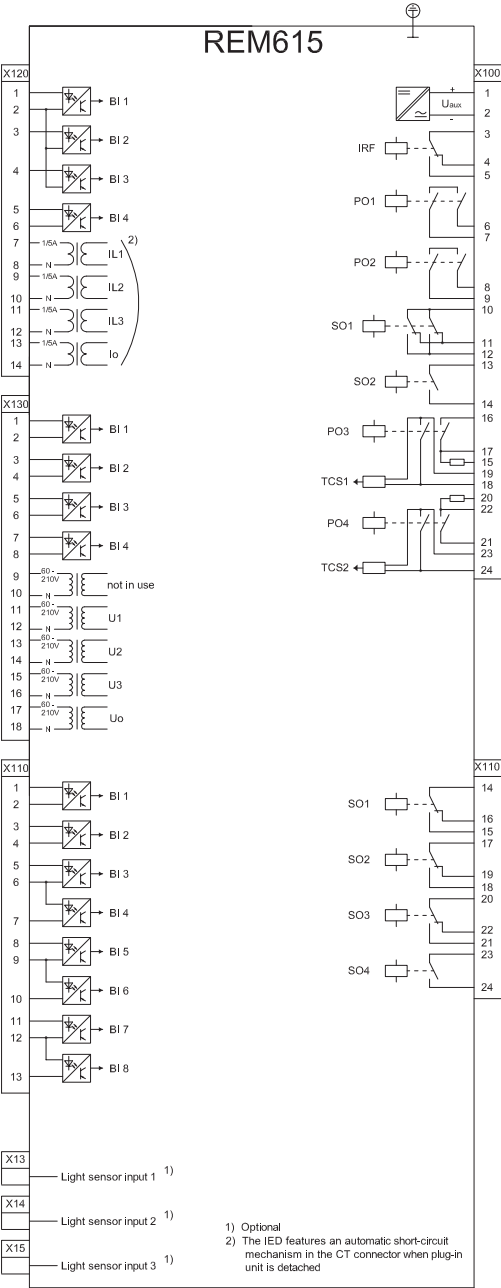


Figure 19: Terminal diagram of standard configuration C

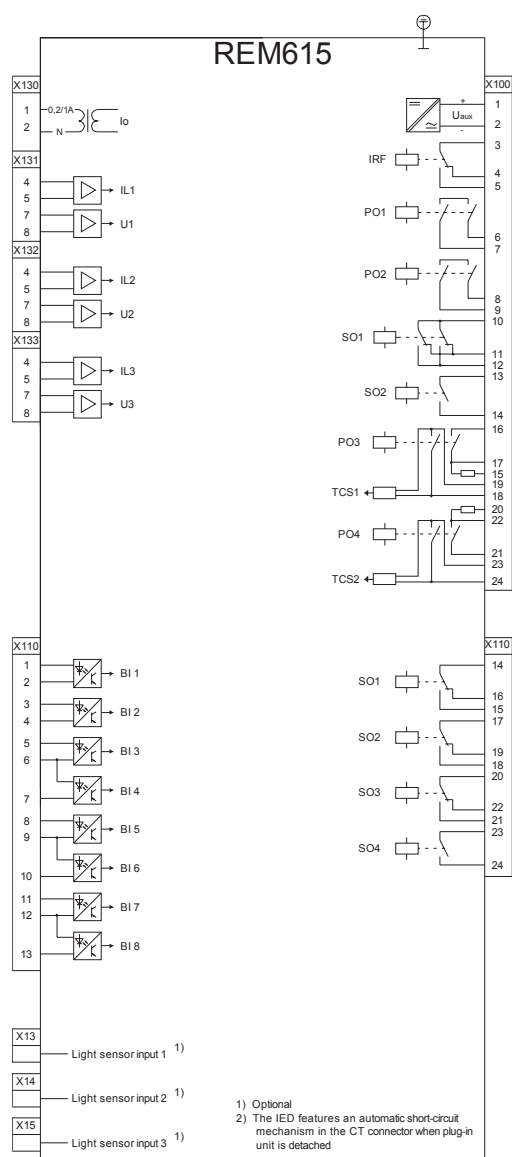


Figure 20: Terminal diagram of standard configuration D

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: 7410570I-OPE/INC 15-1145.

UL 508 and CAN/CSA C22.2 No. 14-13, Industrial Control Equipment.

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 REM615 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 88: Functions included in the relay

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
Frequency protection	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Negative-sequence overcurrent protection for machines	MNSPTOC1	I2>M (1)	46M (1)
	MNSPTOC2	I2>M (2)	46M (2)
Loss of load supervision	LOFLPTUC1	3I< (1)	37 (1)
Motor load jam protection	JAMPTOC1	Ist> (1)	51LR (1)
Motor start-up supervision	STTPMSU1	Is2t n< (1)	49,66,48,51LR (1)
Phase reversal protection	PREVPTOC1	I2>> (1)	46R (1)
Thermal overload protection for motors	MPTTR1	3Ith>M (1)	49M (1)
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)
	TRPPTRC2	Master Trip (2)	94/86 (2)
	TRPPTRC3	Master Trip (3)	94/86 (3)
	TRPPTRC4	Master Trip (4)	94/86 (4)
	TRPPTRC5	Master Trip (5)	94/86 (5)
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)
Multipurpose protection	MAPGAPC1	MAP (1)	MAP (1)
	MAPGAPC2	MAP (2)	MAP (2)
	MAPGAPC3	MAP (3)	MAP (3)
	MAPGAPC4	MAP (4)	MAP (4)
	MAPGAPC5	MAP (5)	MAP (5)
	MAPGAPC6	MAP (6)	MAP (6)
	MAPGAPC7	MAP (7)	MAP (7)
	MAPGAPC8	MAP (8)	MAP (8)
	MAPGAPC9	MAP (9)	MAP (9)
	MAPGAPC10	MAP (10)	MAP (10)

Table continues on the next page

Function	IEC 61850	IEC 60617	IEC-ANSI
	MAPGAPC11	MAP (11)	MAP (11)
	MAPGAPC12	MAP (12)	MAP (12)
	MAPGAPC13	MAP (13)	MAP (13)
	MAPGAPC14	MAP (14)	MAP (14)
	MAPGAPC15	MAP (15)	MAP (15)
	MAPGAPC16	MAP (16)	MAP (16)
	MAPGAPC17	MAP (17)	MAP (17)
	MAPGAPC18	MAP (18)	MAP (18)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Disconnecter control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnecter position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Emergency start-up	ESMGAPC1	ESTART (1)	ESTART (1)
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTS (1)	OPTM (1)
Measurement			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Load profile record	LDPRLRC1	LOADPROF (1)	LOADPROF (1)
Fault record	FLTRFRC1	FAULTREC (1)	FAULTREC (1)
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, IO (1)	I1, I2, IO (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
RTD/mA measurement	XRGGIO130	X130 (RTD) (1)	X130 (RTD) (1)
Frequency measurement	FMMXU1	f (1)	f (1)
IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER	SMVSENDER
IEC 61850-9-2 LE sampled value receiving (voltage sharing)	SMVRCV	SMVRCV	SMVRCV
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)

Table continues on the next page

Function	IEC 61850	IEC 60617	IEC-ANSI
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
Analog value scaling	SCA4GAPC1	SCA4 (1)	SCA4 (1)
	SCA4GAPC2	SCA4 (2)	SCA4 (2)
	SCA4GAPC3	SCA4 (3)	SCA4 (3)
	SCA4GAPC4	SCA4 (4)	SCA4 (4)
Integer value move	MVI4GAPC1	MVI4 (1)	MVI4 (1)

31. Document revision history

Document revision/date	Product version	History
A/2009-07-03	2.0	First release
B/2009-10-01	2.0	Content updated
C/2010-06-11	3.0	Content updated to correspond to the product version
D/2010-06-29	3.0	Terminology updated
E/2010-09-07	3.0	Content updated
F/2012-05-11	4.0	Content updated to correspond to the product version
G/2013-02-21	4.0 FP1	Content updated to correspond to the product version

Table continues on the next page

Document revision/date	Product version	History
H/2014-01-24	5.0	Content updated to correspond to the product version
K/2014-09-04	5.0	Content updated
L/2015-10-30	5.0 FP1	Content updated to correspond to the product version
M/2016-05-20	5.0 FP1	Content updated
N/2018-12-20	5.0 FP1	Content updated
P/2021-12-30	5.0 FP1	Content updated



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