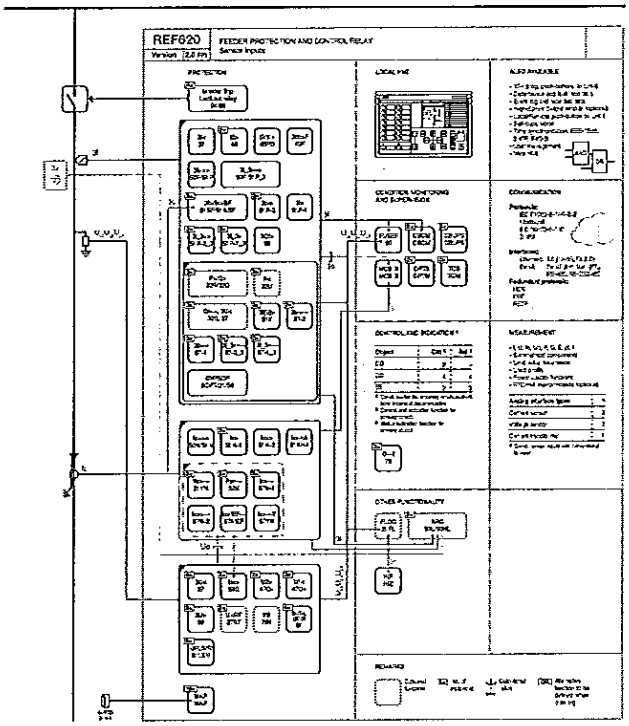

Figure 2. Functionality overview of default configuration with sensor inputs

Table 1. Supported functions

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1
Three-phase directional overcurrent protection, low stage	DPHLPDOC	2	2
Three-phase directional overcurrent protection, high stage	DPHHPDOC	2	2
Three-phase voltage-dependent overcurrent protection	PHPVOC	2	2
Non-directional earth-fault protection, low stage	EFLPTOC	2	2
Non-directional earth-fault protection, high stage	EFHPTOC	1	1
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	1	1
Directional earth-fault protection, low stage	DEFLPDEF	3	3[1]
Directional earth-fault protection, high stage	DEFHPDEF	1	1[1]
Admittance-based earth-fault protection	EFPADM	3	3[1]
Wattmetric-based earth-fault protection	WPWDE	3	3[1]
Multifrequency admittance-based earth-fault protection	MFADPSDE	1	1[1]
Transient/intermittent earth-fault protection	INTRPTEF	1	1[1]
Harmonics-based earth-fault protection	HAEFPTOC	1	1
Negative-sequence overcurrent protection	NSPTOC	2	2
Phase discontinuity protection	PDNSPTOC	1	1
Residual overvoltage protection	ROVPTOV	3	3[1]
Three-phase undervoltage protection	PHPTUV	4	4
Single-phase undervoltage protection, secondary side	PHAPTUV	1	
Three-phase overvoltage protection	PHPTOV	3	3
Single-phase overvoltage protection, secondary side	PHAPTOV	1	
Positive-sequence undervoltage protection	PSPTUV	2	2
Negative-sequence overvoltage protection	NSPTOV	2	2
Frequency protection	FRPFRQ	6	6
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	1	1
Loss of phase (undercurrent)	PHPTUC	1	1
Circuit breaker failure protection	CCBRBRF	3	3
Three-phase inrush detector	INRPHAR	1	1
Master trip	TRPPTRC	4	4
Arc protection	ARCSARC	(3)	(3)
High-impedance fault detection	PHIZ	1	1
Load-shedding and restoration	LSHDPFRQ	6	6
Multipurpose protection	MAPGAPC	18	18

Table 1. Supported functions, continued

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Automatic switch-onto-fault logic (SOF)	CVPSOF	1	1
Voltage vector shift protection	VVSPPAM	(1)	(1)
Directional reactive power undervoltage protection	DQPTUV	(2)	(2)
Underpower protection	DUPPDPR	(2)	(2)
Reverse power/directional overpower protection	DOPPDPR	(2)	(2)
Low-voltage ride-through protection	LVRTPTUV	(3)	(3)
High-impedance differential protection for phase A	HIAPDIF	1	
High-impedance differential protection for phase B	HIBPDIF	1	
High-impedance differential protection for phase C	HICPDIF	1	
Circuit breaker uncorresponding position start-up	UPCALH	3	3
Three-independent-phase non-directional overcurrent protection, low stage	PHSLPTOC	2	2
Three-independent-phase non-directional overcurrent protection, high stage	PHSHPTOC	2	2
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PHSIPTOC	1	1
Directional three-independent-phase directional overcurrent protection, low stage	DPHSLPDOC	2	2
Directional three-independent-phase directional overcurrent protection, high stage	DPHSHPDOC	2	2
Three-phase overload protection for shunt capacitor banks	COLPTOC	(1)	
Current unbalance protection for shunt capacitor banks	CUBPTOC	(1)	
Shunt capacitor bank switching resonance protection, current based	SRCPTOC	(1)	
Control			
Circuit-breaker control	CBXCBR	3	3
Disconnector control	DCXSWI	4	4
Earthing switch control	ESXSWI	3	3
Disconnector position indication	DCSXSWI	4	4
Earthing switch indication	ESSXSWI	3	3
Autoreclosing	DARREC	2	2
Synchronism and energizing check	SECRSYN	1	(1)[2]
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR	3	3
Trip circuit supervision	TCSSCBR	2	2
Current circuit supervision	CCSPVC	1	
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC	1	
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC	1	

Table 1. Supported functions, continued

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC	1	
Fuse failure supervision	SEQSPVC	1	1
Runtime counter for machines and devices	MDSOPT	2	2
Measurement			
Three-phase current measurement	CMMXU	1	1
Sequence current measurement	CSMSQI	1	1
Residual current measurement	RESCMMXU	1	1
Three-phase voltage measurement	VMMXU	1	1
Single-phase voltage measurement	VAMMXU	1	(1)[3]
Residual voltage measurement	RESVMMXU	1	
Sequence voltage measurement	VSMSQI	1	1
Three-phase power and energy measurement	PEMMXU	1	1
Load profile record	LDPRLRC	1	1
Frequency measurement	FMMXU	1	1
Fault location			
Fault locator	SCEFRFLO	(1)	(1)
Power quality			
Current total demand distortion	CMHAI	1	1
Voltage total harmonic distortion	VMHAI	1	1
Voltage variation	PHQVVR	1	1
Voltage unbalance	VSQVUB	1	1
Other			
Minimum pulse timer (2 pcs)	TPGAPC	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	2	2
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	2	2
Pulse timer (8 pcs)	PTGAPC	2	2
Time delay off (8 pcs)	TOFGAPC	4	4
Time delay on (8 pcs)	TONGAPC	4	4
Set-reset (8 pcs)	SRGAPC	4	4
Move (8 pcs)	MVGAPC	4	4
Integer value move	MVI4GAPC	4	4
Analog value scaling	SCAMGAPC	4	4
Generic control point (16 pcs)	SPCGAPC	3	3
Remote generic control points	SPCRGAPC	1	1
Local generic control points	SPCLGAPC	1	1
Generic up-down counters	UDFCNT	12	12

000614
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Table 1. Supported functions, continued

Function	IEC 61850	A (STA*/YT4)	B (Sensors)
Programmable buttons (16 buttons)	FKEYGGIO	1	1
Logging functions			
Disturbance recorder	RDRE	1	1
Fault recorder	FLTRFRC	1	1
Sequence event recorder	SER	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.
0 = optional

1) Uo is calculated from the measured phase voltages
2) Available only with IEC 61850-9-2 LE

3. Protection functions

The basic configurations available in REF620 consist of a wide range of protection functions making the protection relay suitable for various basic feeder applications. The relay offers directional and non-directional overcurrent and thermal overload protection as well as directional and non-directional earth-fault protection. Admittance-based, harmonics-based or wattmetric-based earth-fault protection can be used in addition to directional earth-fault protection. Furthermore, the relay features sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection, overvoltage and undervoltage protection, residual overvoltage protection, positive-sequence undervoltage protection and negative-sequence overvoltage protection. In addition, the relay offers frequency protection including overfrequency, underfrequency and frequency rate-of-change protection. The relay also incorporates three-pole multi-shot autoreclosing functions for overhead line feeders.

The standard content additionally includes multifrequency admittance-based earth-fault protection providing selective directional earth-fault protection for high-impedance earthed networks. The operation is based on multifrequency neutral admittance measurement utilizing fundamental frequency and harmonic components in Uo and Io.

ABB's continuous investments in research and a close cooperation with customers have resulted in the best earth-fault protection portfolio on the market. These functions are vital with different physical neutral groundings. In REF620, a special filtering algorithm enables dependable and secure fault direction also during intermittent/restriking earth faults. It provides a good combination of reliability and sensitivity of protection with a single function for low ohmic and higher ohmic earth faults and for transient and intermittent or restriking earth faults.

REF620 is also capable of protecting other applications than basic incoming or outgoing feeders. The relay includes high-impedance based busbar protection and measurement circuit supervision functions which enable the feeder relay to be used also for busbar protection. The relay includes an optional function package offering directional active and reactive power protection that enable the protected feeder to include also motors. Additionally, the optional package for capacitor bank protection includes functions for capacitor bank overload, unbalance and resonance protection enabling the protection of single star (wye) connected capacitor banks or double star (wye) connected capacitor banks with isolated or compensated neutral. Furthermore, the relay offers an optional protection package for interconnection protection providing function for low-voltage-ride-through, directional reactive power undervoltage protection (QU) and the voltage vector shift protection. This optional application package together with the relay's basic functionality can be used with distributed power generation like wind power or solar power generation to determine when to stay connected and when to disconnect distributed generation from the utility grid following different utility Grid Codes.

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

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

4. Application

REF620 provides feeder overcurrent and earth-fault protection for utility and industry distribution networks. The relay fits both isolated neutral networks and networks with resistance- or impedance-earthed neutrals. Furthermore, based on its advanced interstation communication facilities, the relay can also be applied for protecting ring type and meshed distribution networks as well as radial networks.

REF620 can be used with either single- or double-busbar configurations with one or two breakers, and with numerous switching device configurations. It supports a substantial number of both manually and motor-operated disconnectors and earthing switches, and it is capable of running large configurations. The number of controllable devices depends on the number of inputs and outputs left free from other application needs. The number of available I/Os can be increased with the RIO600 Remote I/O device.

The relay offers extensive possibilities to tailor the configurations to application requirements. The tool suite for all Relion relays is Protection and Control IED Manager PCM600, which contains all the necessary tools for configuring the device, including functionality, parameterization, the HMI and communication.

REF620 is an ideal protection and control relay for more advanced feeder schemes. To further improve the arc protection and to minimize the effects of an arc fault, the 620 series relays ordered with the arc protection option can be equipped with an I/O card featuring high-speed outputs operating in one millisecond.

The following figures demonstrate different application examples using relay's basic configuration. The configurations are modified by engineering functionality according to different application needs.

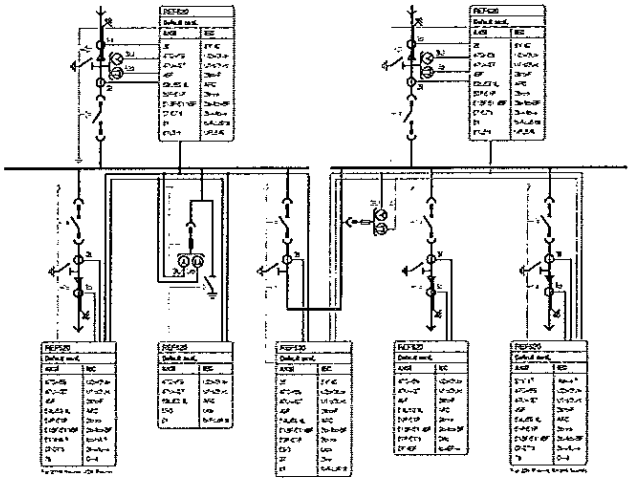

Figure 3. Single busbar AIS 2 section switchgear with conventional instrument transformers

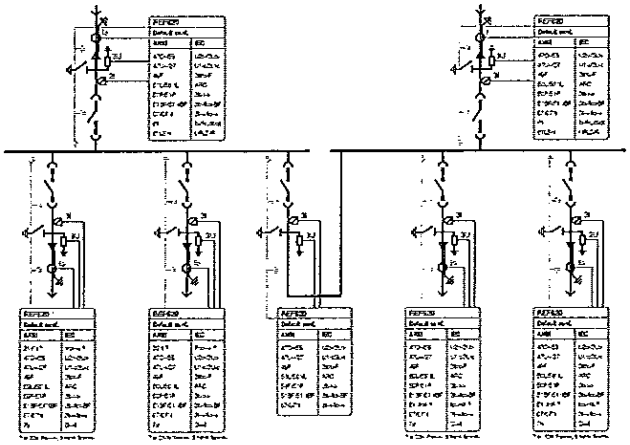

Figure 4. Single busbar AIS switchgear 2 section with sensors

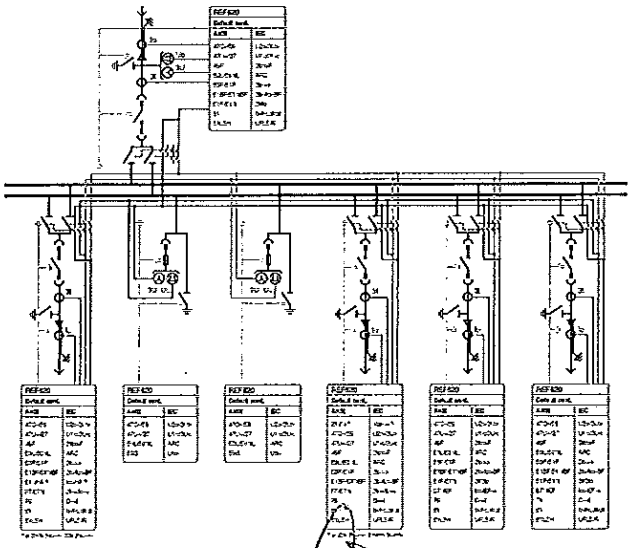

Figure 5. DBB AIS system with one incomer only (with some arrangements shown)

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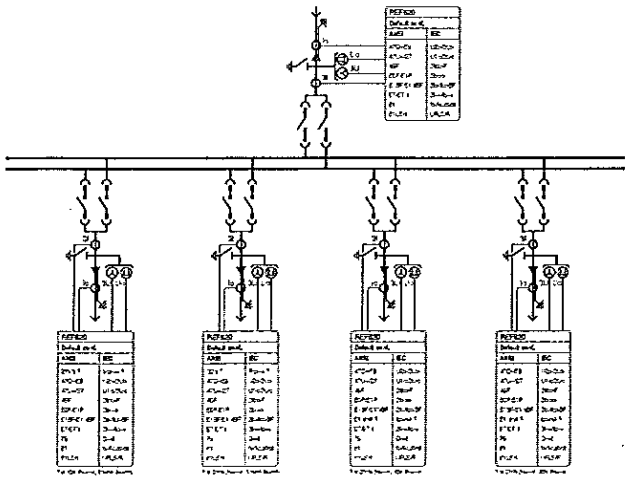

Figure 6. Back-to-back arrangement of AIS switchgear (two single-busbar panels with back walls facing each other), with two circuit breakers and a higher number of disconnectors available; A type of DBB system

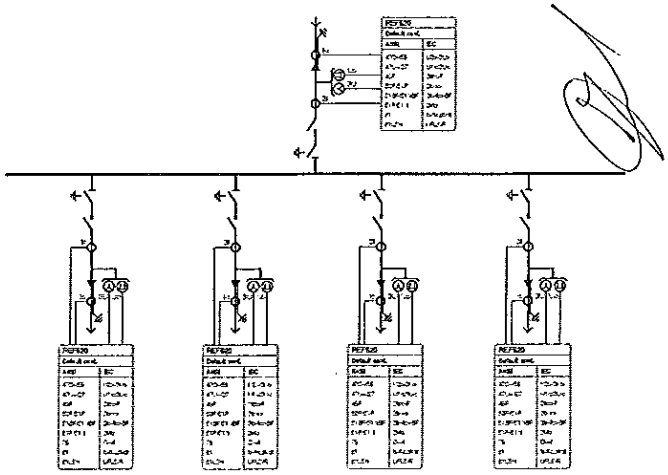

Figure 7. SSB GIS switchgear with the possibility to control the three-position disconnector switch

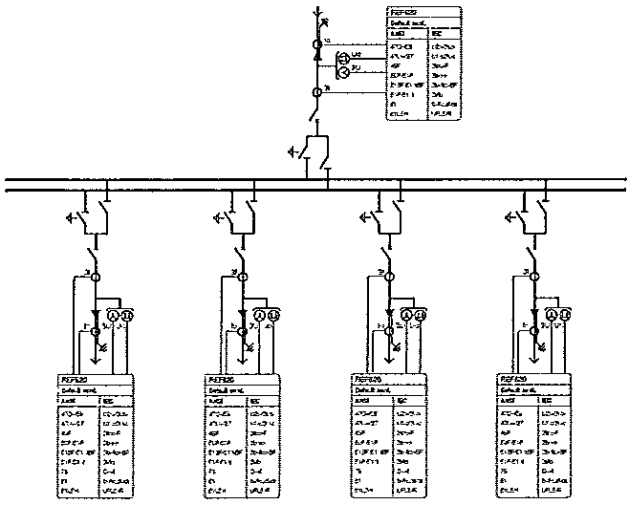

Figure 8. DBB GIS switchgear with the possibility to control the three-position disconnector switch

The following figures demonstrate the application function packages included in the relay. These packages offer new possibilities for several additional applications. The relay's basic functionality includes high-impedance based busbar differential protection functions. Thus, the relay can be engineered for busbar differential protection and by utilizing several relays, multizone differential protection schemes can also be created. The relay includes an optional protection package for capacitor bank protection and an optional protection package for interconnection protection for distributed power generation, for example, wind power. Furthermore, the relay includes an option for power protection. This package enhances the feeder relay capabilities to protect feeders including motors and includes also basic functionality to protect solar power generation connection to utility grid.

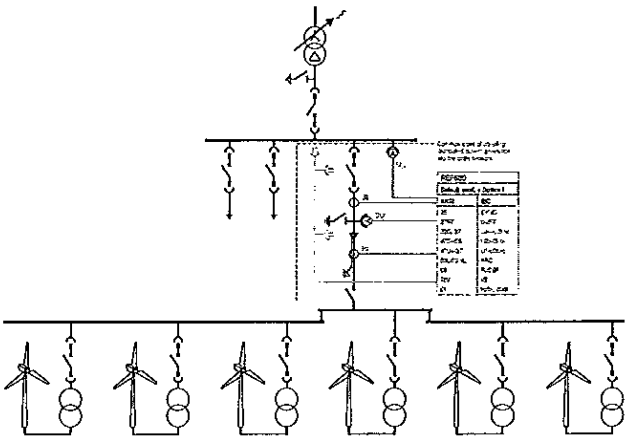

Figure 9. Application example of wind power plant as distributed power generation coupled into the utility network

000616
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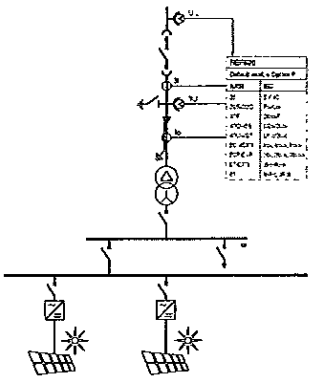

Figure 10. Application example of solar power plant as distributed power generation coupled into the utility network

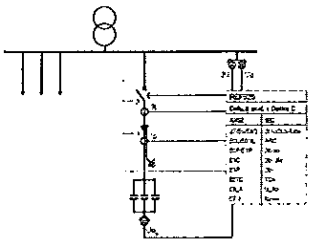

Figure 11. Protection of a single star connected capacitor bank

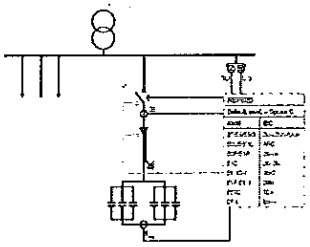

Figure 12. Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral

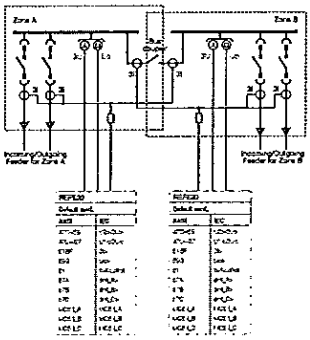

Figure 13. Application example of busbar differential protection covering two zones

5. Supported ABB solutions

ABB's 620 series protection and control relays together with the Substation Management Unit COM600 constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate and streamline the system engineering, ABB's 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 also includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with the Substation Management Unit COM600 or the network control and management system MicroSCADA Pro.

The 620 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 integrity of the protection and communication system, 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, COM600 uses the data content of the bay-level devices to enhance substation level functionality. COM600 features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The Web HMI of COM600 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, COM600 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 COM600. The history data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and history values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

COM600 can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems, such as MicroSCADA Pro and System 800xA.

Table 2. Supported ABB solutions

Product	Version
Substation Management Unit COM600	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

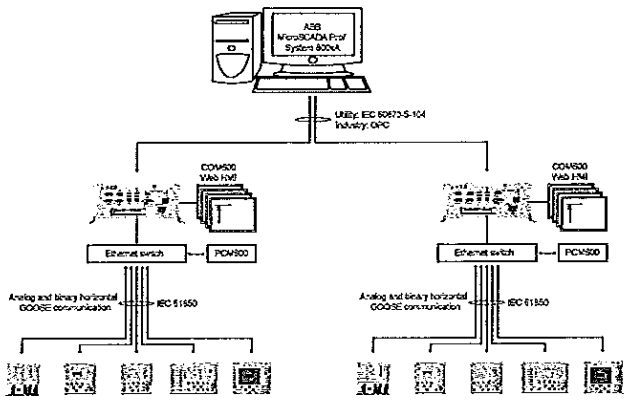

Figure 14. ABB power system example using Relion relays, Substation Management Unit COM600 and MicroSCADA Pro/System 800xA

6. Control

REF620 integrates functionality for the control of circuit breakers, disconnectors and earthing switches via the front panel HMI or by means of remote controls. The relay includes three circuit breaker control blocks. In addition to the circuit breaker control, the relay features four disconnector control blocks intended for the motor-operated control of disconnectors or circuit breaker truck. Furthermore, the relay offers three control blocks intended for the motor-operated control of earthing switch. On top of that, the relay includes additional four disconnector position indication blocks and three earthing switch position indication blocks usable with manually-only controlled disconnectors and earthing switches.

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 hardware configuration of the relay, the number of binary inputs and binary outputs varies. In case the amount of available binary inputs or outputs of the chosen hardware configuration is not sufficient, connecting an external input or output module, for example RIO600, to the relay can extend binary inputs and outputs utilizable in the relay configuration. 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.

The suitability of the binary outputs of the relay which have been selected for the 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 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 tools in PCM600.

Default configuration A incorporates a synchrocheck function to ensure that the voltage, phase angle and frequency on either side of an open circuit breaker satisfy the conditions for a safe interconnection of two networks. Synchrocheck function can also be used with default configuration B when 9-2 process bus

ВЕРНО С ОРИГИНАЛА
"КРАСИН" СМОЛЯН ООД
00617

is used. Compared to default configuration A, there are less physical voltage measurements available and thus the voltage measurements from the other side of the breaker have to be read through the 9-2 process bus. An autoreclosing function attempts to restore the power by reclosing the breaker with one to five programmable autoreclosing shots of desired type and duration. The function can be used with every circuit breaker that has the ability for a reclosing sequence. A load-shedding function is capable of performing load shedding based on underfrequency and the rate of change of the frequency.

7. Measurement

The relay continuously measures the phase currents and the neutral current. Furthermore, the relay measures the phase voltages and the residual voltage. In addition, the relay calculates the symmetrical components of the currents and voltages, the system frequency, the active and reactive power, the power factor, the active and reactive energy values as well as the demand value of current and power over a user-selectable preset time frame. Calculated values are also obtained from the protections and condition monitoring functions of the relay.

The values measured can be accessed locally via the user interface on the relay's front panel or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the Web browser-based user interface.

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

8. Power quality

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

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

The protection relay has the following power quality monitoring functions.

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

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

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

9. Fault location

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

10. Disturbance recorder

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

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

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

11. Event log

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

The sequence-of-events information can be accessed either locally via the user interface on the relay's front panel, or remotely via the communication interface of the relay. The information can also be accessed using the Web browser-based user interface, either locally or remotely.

12. Recorded data

The relay has the capacity to store the records of the 128 latest fault events. The records enable the user to analyze the power system events. Each record includes current, voltage and angle values, time stamp and so on. The fault recording can be triggered by the start signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. 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.

13. Condition monitoring

The condition monitoring functions of the relay constantly monitor the performance and the condition of the circuit breaker. The monitoring comprises the spring charging time, SF6 gas pressure, the travel time and the inactivity time of the circuit breaker.

The monitoring functions provide operational circuit breaker history data, which can be used for scheduling preventive circuit breaker maintenance.

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

14. Trip-circuit supervision

The trip-circuit supervision continuously monitors the availability and operability of the trip circuit. It provides open-circuit monitoring both when the circuit breaker is in its closed and in its open position. It also detects loss of circuit-breaker control voltage.

15. 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.

16. Fuse failure supervision

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

17. 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.

18. Access control

To protect the relay from unauthorized access and to maintain information integrity, the relay is provided with a four-level, role-based authentication system with administrator-programmable individual passwords for the Viewer, operator, engineer and administrator level. The access control applies to the front-panel user interface, the Web browser-based user interface and PCM600.

19. Inputs and outputs

REF620 can be selected to measure currents and voltages either with conventional current transducers and voltage transducers or with current sensors and voltage sensors. The relay variant with conventional transducers is equipped with three phase current inputs, one residual-current input, three phase voltage inputs, one residual-voltage input and one phase-to-phase voltage for synccheck input. In addition to current and voltage measurements, the relay's basic configuration includes 24 binary inputs and 14 binary outputs. The phase current inputs and the residual-current inputs are rated 1/5 A, that is, the inputs allow the connection of either 1 A or 5 A secondary current transformers. The optional sensitive 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 relay variant equipped with current and voltage sensors has three sensor inputs for the direct connection of three combisensors with RJ-45 connectors. As an alternative to the combisensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors. Additionally, the relay includes one conventional residual-current input 0.2/1 A normally used in applications requiring sensitive earth-fault protection and featuring core balance current transformers. In addition to current and voltage measurements, the relay's basic configuration includes 16 binary inputs and 14 binary outputs.

As an optional addition, the relay's basic configuration includes one empty slot which can be equipped with one of the following optional modules. The first option, additional binary inputs and outputs module, adds eight binary inputs and four binary outputs to the relay. This option is especially needed when connecting the relay to several controllable objects, still leaving room for additional inputs and outputs for other signals needed in configuration. The second option, an additional RTD/mA input module, increases the relay with six RTD inputs and two mA inputs when additional sensor measurements for example for temperatures, pressures, levels and so on are of interest. The third option is a high-speed output board including eight binary inputs and three high-speed outputs. The high-speed outputs have a shorter activation time compared to the conventional mechanical output relays, shortening the overall relay operation time by 4...6 ms with very time-critical applications like arc protection. The high-speed outputs are freely configurable in the relay application and not limited to arc protection only.

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 18... 176 V DC by adjusting the relay's parameter settings.

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

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

If the number of the relay's own inputs and outputs does not cover all the intended purposes, connecting to an external input or output module, for example RIO600, increases the number of binary inputs and outputs utilizable in the relay configuration. In this case, the external inputs and outputs are connected to the relay via IEC 61850 GOOSE to reach fast reaction times between the relay and RIO600 information. The needed binary input and output connections between the relay and RIO600 units can be configured in a PCM600 tool and then utilized in the relay configuration.

Table 3. Input/output overview

Default conf.	Order code digit		Analog channels			Binary channels			
	5-6	7-8	CT	VT	Combi sensor	BI	BO	RTD	mA
A	AA/AB	AA	4	5	-	32	4 PO + 14 SO	-	-
		AB				24	4 PO + 10 SO	6	2
		AC				32	4 PO + 10 SO + 3 HSO	-	-
		NN				24	4 PO + 10 SO	-	-
B	AC	AA	1	-	3	24	4 PO + 14 SO	-	-
		AB				16	4 PO + 10 SO	6	2
		AC				24	4 PO + 10 SO + 3 HSO	-	-
		NN				16	4 PO + 10 SO	-	-

20. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 1 and 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 modeling. The relay supports Edition 2 and Edition 1 versions of the standard. With Edition 2 support, the relay has the latest functionality modeling 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 620 series relays, having voltage based functions and 9-2 support. 620 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 protocols are able to overcome a failure of a link or switch with a zero switch-over time. In both 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 link 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.

000618
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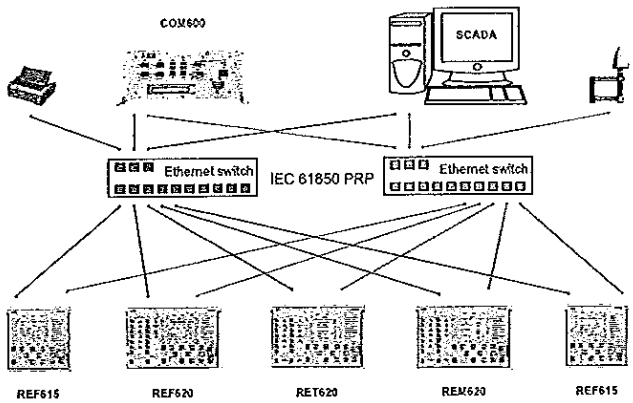

Figure 15. Parallel redundancy protocol (PRP) solution

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 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 620 series relays supports the connection of up to 30 relays. If more than 30 relays are connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

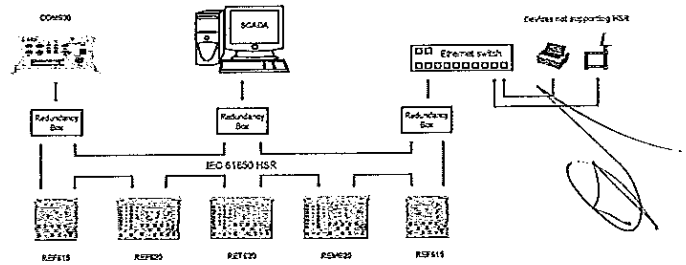

Figure 16. High availability seamless redundancy (HSR) solution

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 thirty 620 series relays. If more than 30 relays are 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.

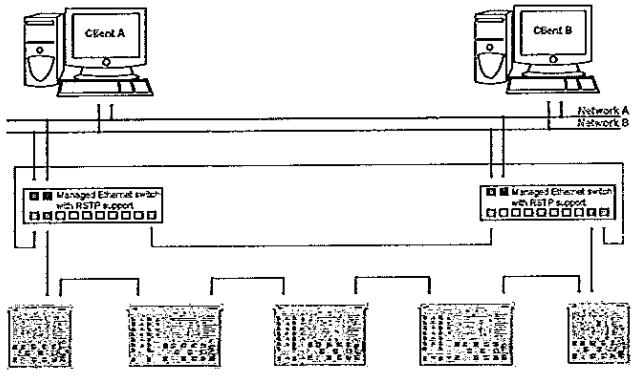

Figure 17. Self-healing Ethernet ring solution

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 a connection to the 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.

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

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

In addition, the relay supports time synchronization via Modbus, DNP3 and IEC 60870-5-103 serial communication protocols.

Table 4. Supported station communication interfaces and protocols

Interfaces/Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/485	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

000619
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21. Technical data

Table 5. Dimensions

Description	Value	
Width	Frame	252.2 mm
	Case	249 mm
Height	Frame	177 mm, 4U
	Case	160 mm
Depth		251 mm
Weight	Complete protection relay	max. 5.0 kg
	Plug-in unit only	max. 2.9 kg

Table 6. Power supply

Description	Type 1	Type 2
U_{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U_n rated	
U_{aux} variation	38...110% of U_n (38...264 V AC)	50...120% of U_n (12...72 V DC)
	80...120% of U_n (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	DC <18.0 W (nominal[1])/<22.5 W (max[2]) AC <19.0 W (nominal[1])/<23.0 W (max[2])	DC <18.5 W (nominal[1])/<22.5 W (max[2]) -
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

1) During the power consumption measurement, the relay is powered at rated auxiliary energizing voltage and the energizing quantities are energized without any binary inputs and outputs activated.
2) During the power consumption measurement, the relay is powered at rated auxiliary energizing voltage and the energizing quantities are energized to activate at least half of the binary inputs and outputs.

Table 7. 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

Table 8. Energizing inputs (sensors)

Description		Value
Current sensor input	Rated current voltage (in secondary side)	75...9000 mV[1]
	Continuous voltage withstand	125 V
	Input impedance at 50/60 Hz	2...3 MΩ[2]
Voltage sensor input	Rated voltage	6...33 kV[3]
	Continuous voltage withstand	50 V
	Input impedance at 50/60 Hz	3 MΩ

1) Equals the current range of 40...4000 A with a 50 A, 2 mV/A Rogowski.
2) Depending on the used nominal current (hardware gain)
3) The input is connected to 2 x rated with default division ratio of 10 000:1

Table 9. Binary inputs

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

Table 10. RTD/mA measurement

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

Table 11. Signal output with high make and carry

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

1) X100: SO1
X105: SO1, SO2, when any of the protection relay is equipped with BIO0005.
X110: SO1, SO2 when REF620 or REF630 is equipped with BIO0006
X115: SO1, SO2 when REF620 or REF630 is equipped with BIO0006

Table 12. Signal outputs and IRF output

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

1) X100: PO3, SO2
X105: SO1, SO2, when any of the protection relay is equipped with BIO0005
X110: SO1, SO2, when REF620 or REF630 is equipped with BIO0006
X115: SO1, SO2, when REF620 or REF630 is equipped with BIO0006

Table 13. Double-pole power outputs with TCS function X100: PO3 and PO4

Description	Value [1]
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R <40 ms, at 48/110/220 V DC (two contacts connected in a series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip circuit monitoring (TCS)	
• Control voltage range	20...250 V AC/DC
• Current drain through the monitoring circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V AC/DC (19...21 V)

1) P3x0003: PO3, P3x0004: PO3, P3x0003: PO4 and P3x0004: PO4.

Table 14. Single-pole power output relays X100: PO1 and PO2

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

000620
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Table 15. High-speed output HSO

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

1) HSO1, HSO2, HSO3, when any of the protection relays is equipped with BIO0007

Table 16. Front port Ethernet interfaces

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

Table 17. Station communication link, 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

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

Table 18. IRIG-B

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

1) According to the 200-04 IRIG standard

Table 19. 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

Table 20. Degree of protection of flush-mounted protection relay

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

Table 21. Environmental conditions

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

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

Table 22. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III IEEE C37.90.1-2002
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test		
	10 V (rms) 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
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 • 1...3 s	300 A/m 1000 A/m	
Pulse magnetic field immunity test	1000 A/m 6.4/16 μs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
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	300 V rms	

Table 22. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
• Differential mode	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	

Table 23. Insulation tests

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

Table 24. Mechanical tests

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

000621

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Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55°C • 16 h at +85°C [1]	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 • 96 h at +85°C	IEC 60068-2-1 IEC 60068-2-2

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

Table 26. Product safety

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

Table 27. EMC compliance

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

Table 28. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

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

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

1) Set Operate delay time = 0.02 s, Operate curve type = IEC definite time, Measurement mode = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

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

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

1) For further reference, see Operation characteristics table

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

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

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

Table 32. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 × I_n	0.01
	DPHHPDOC	0.10...40.00 × I_n	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	40...200000 ms	10
Operating curve type [1]	DPHLPDOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	-
Characteristic angle	DPHxPDOC	-179...180°	1

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

Table 33. Three-phase voltage-dependent overcurrent protection (PHPVOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	Current: ±1.5% of the set value or ± 0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time [1,2]	Typically 26 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in inverse time mode	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = default, current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

000622
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Table 34. Three-phase voltage-dependent overcurrent protection (PHPVOC) main settings

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

1) For further reference, see Operation characteristics table

Table 35. Non-directional earth-fault protection (EFxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	EFLPTOC	±1.5% of the set value or ±0.002 × I_n		
	EFHPTOC and EFIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time [1,2]		Minimum	Typical	Maximum
	EFIPTOC: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	16 ms 11 ms	19 ms 12 ms	23 ms 14 ms
	EFHPTOC and EFLPTOC: I_{Fault} = 2 × set *Start value*	23 ms	26 ms	29 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.95		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, ...$ Peak-to-Peak: No suppression		

1) Measurement mode = default (depends on stage), current before fault = 0.0 × I_n, I_n = 50 A, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.8 × I_n, *Start value* multiples in range of 1.5...20

Table 36. Non-directional earth-fault protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 × I_n	0.005
	EFHPTOC	0.10...40.00 × I_n	0.01
	EFIPTOC	1.00...40.00 × I_n	0.01
Time multiplier	EFLPTOC	0.05...15.00	0.01
	EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC	40...200000 ms	10
	EFHPTOC	40...200000 ms	10
	EFIPTOC	20...200000 ms	10
Operating curve type [1]	EFLPTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further reference, see Operation characteristics table

Table 37. Directional earth-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	DEFLPDEF	Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time [1,2]		Minimum	Typical	Maximum
	DEFHPDEF I_{Fault} = 2 × set *Start value*	42 ms	45 ms	49 ms
	DEFLPDEF I_{Fault} = 2 × set *Start value*	58 ms	62 ms	66 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, ...$ Peak-to-Peak: No suppression		

1) Set *Operate delay time* = 0.06 s, *Operate curve type* = IEC definite time, measurement mode = default (depends on stage), current before fault = 0.0 × I_n, I_n = 50 A, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.8 × I_n, *Start value* multiples in range of 1.5...20

Table 38. Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start value	DEFLPDEF	0.010...5.000 × I_n	0.005
	DEFHPDEF	0.10...40.00 × I_n	0.01
Directional mode	DEFxPDEF	1 = Non-directional 2 = Forward 3 = Reverse	-
Time multiplier	DEFLPDEF	0.05...15.00	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFLPDEF	60...200000 ms	10
	DEFHPDEF	40...200000 ms	10
Operating curve type [1]	DEFLPDEF	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or Inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFxPDEF	1 = Phase angle 2 = IoSin 3 = IoCos 4 = Phase angle 80 5 = Phase angle 88	-

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

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

Characteristic	Value		
Operation accuracy [1]	At the frequency $f = f_n$ ±1.5% or ±0.01 mS (in range of 0.5...100 mS)		
Start time [2]	Minimum	Typical	Maximum
	56 ms	60 ms	64 ms
Reset time	40 ms		
Operate time accuracy	±1.0% of the set value or ±20 ms		
Suppression of harmonics	-50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, ...$		

1) U_n = 1.0 × U_n
2) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

000623
ВЗЯТО С ОРИГИНАЛА
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Table 40. Admittance-based earth-fault protection (EFPADM) main settings

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

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

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

1) [illegible] voltage during earth fault in compensated or un-earthed network, the residual power value before fault [illegible], f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 42. Wattmetric-based earth-fault protection (WPWDE) main settings

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

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

Table 43. Multifrequency admittance-based earth-fault protection (MFADPSDE)

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

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

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

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

Table 45. Transient/intermittent earth-fault protection (INTRPTEF)

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

Table 46. Transient/intermittent earth-fault protection (INTRPTEF) main settings

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

Table 47. Harmonics-based earth-fault protection (HAEFPTOC)

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

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

Table 48. Harmonics-based earth-fault protection (HAEFPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 49. Negative-sequence overcurrent protection (NSPTOC)

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 [1,2]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	23 ms 15 ms	26 ms 18 ms	28 ms 20 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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

Table 50. Negative-sequence overcurrent protection (NSPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 51. Phase discontinuity protection (PDNSPTOC)

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

Table 52. Phase discontinuity protection (PDNSPTOC) main settings

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

000624
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Table 53. Residual overvoltage protection (ROVPTOV)

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

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

Table 54. Residual overvoltage protection (ROVPTOV) main settings

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

Table 55. Three-phase undervoltage protection (PHPTUV)

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

1) *Start value* = 1.0 × U_n, voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.50...0.99

Table 56. Three-phase undervoltage protection (PHPTUV) main settings

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

1) For further reference, see Operation characteristics table

Table 57. Single-phase undervoltage protection (PHAPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]	U_{Fault} = 0.9 × set *Start value*	Minimum 64 ms	Typical 68 ms	Maximum 74 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) *Start value* = 1.0 × U_n, voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50 × U_n, *Start value* multiples in range of 0.50...0.99

Table 58. Single-phase undervoltage protection (PHAPTUV) main settings

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

1) For further reference, see Operation characteristics table

Table 59. Three-phase overvoltage protection (PHPTOV)

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

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

Table 60. Three-phase overvoltage protection (PHPTOV) main settings

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

1) For further reference, see Operation characteristics table

Table 61. Single-phase overvoltage protection (PHAPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]	U_{Fault} = 1.1 × set *Start value*	Minimum 26 ms	Typical 28 ms	Maximum 32 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) *Start value* = 1.0 × U_n, voltage before fault = 2.0 × U_n, f_n = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 1.20 × U_n, *Start value* multiples in range of 1.10...2.00

Table 62. Single-phase overvoltage protection (PHAPTOV) main settings

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

1) For further reference, see Operation characteristics table

Table 63. Positive-sequence undervoltage protection (PSPTUV)

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

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

Table 64. Positive-sequence undervoltage protection (PSPTUV) main settings

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

000625

ВЯРНО С ОРИГИНАЛА
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Table 65. Negative-sequence overvoltage protection (NSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time [1][2]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value* U_{Fault} = 2.0 × set *Start value*	33 ms 24 ms	35 ms 26 ms	37 ms 28 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.99		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) Negative-sequence voltage before fault = 0.0 × U_n, f_n = 50 Hz, negative-sequence overvoltage = 0% in nominal frequency, injected sine-wave phase angle fault, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 66. Negative-sequence overvoltage protection (NSPTOV) main settings

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

Table 67. Frequency protection (FRPFRQ)

Characteristic		Value
Operation accuracy	f>/f<	±5 mHz
	df/dt	±50 mHz/s (in range |df/dt| <5 Hz/s) ±2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f>/f<	<80 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±33 ms

Table 68. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1 = Freq< 2 = Freq> 3 = df/dt 4 = Freq< + df/dt 5 = Freq> + df/dt 6 = Freq< OR df/dt 7 = Freq> OR df/dt	-
Start value Freq>	FRPFRQ	0.9000...1.2000 × f_n	0.0001
Start value Freq<	FRPFRQ	0.8000...1.1000 × f_n	0.0001
Start value df/dt	FRPFRQ	-0.2000...0.2000 × f_n/s	0.0025
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 69. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)

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

1) Overload current > 1.2 × Operate level temperature

Table 70. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings

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

Table 71. Loss of phase, undercurrent (PHPTUC)

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

Table 72. Phase undercurrent protection (PHPTUC) main settings

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

Table 73. Circuit breaker failure protection (CCBRBRF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Reset time [1]	Typically 40 ms
Retardation time	<20 ms

1) The pulse time defines the minimum pulse length

Table 74. Circuit breaker failure protection (CCBRBRF) main settings

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

Table 75. Three-phase inrush detector (INRPHAR)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$ Current measurement: ±1.5% of the set value or ±0.002 × I_n Ratio I2/I1f measurement: ±5.0% of the set value
Reset time	+35 ms / -0 ms
Reset ratio	Typically 0.96
Operate time accuracy	+35 ms / -0 ms

Table 76. Three-phase inrush detector (INRPHAR) main settings

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

Table 77. Arc protection (ARCSARC)

Characteristic		Value		
Operation accuracy		±3% of the set value or ±0.01 × I_n		
Operate time		Minimum	Typical	Maximum
	Operation mode = "Light current" [1][2]	9 ms [3] 4 ms [4]	12 ms [3] 6 ms [4]	15 ms [3] 9 ms [4]
	Operation mode = "Light only" [2]	9 ms [3] 4 ms [4]	10 ms [3] 6 ms [4]	12 ms [3] 7 ms [4]
Reset time		Typically 40 ms [3] <55 ms [4]		
Reset ratio		Typically 0.96		

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

Table 78. Arc protection (ARCSARC) main settings

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

Table 79. High-impedance fault detection (PHIZ) main settings

Parameter	Function	Value (Range)	Step
Security Level	PHIZ	1...10	1
System type	PHIZ	1 = Grounded 2 = Ungrounded	-

000626
ВЯРНО С ОРИГИНАЛА
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Table 80. Load-shedding and restoration (LSHDPFRQ)

Characteristic		Value
Operation accuracy	f<	±10 mHz
	df/dt	±100 mHz/s (in range |df/dt| < 5 Hz/s) ±2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f<	<83 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±33 ms

Table 81. Load-shedding and restoration (LSHDPFRQ) main settings

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

Table 82. Multipurpose protection (MAPGAPC)

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

Table 83. Multipurpose protection (MAPGAPC) main settings

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

Table 84. Automatic switch-onto-fault (CVPSOF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2Hz Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

Table 85. Automatic switch-onto-fault logic (CVPSOF) main settings

Parameter	Function	Value (Range)	Step
SOTF reset time	CVPSOF	0...60000 ms	10

Table 86. Voltage vector shift protection (VVSPPAM)

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

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

Table 87. Voltage vector shift protection (VVSPPAM) main settings

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

Table 88. Directional reactive power undervoltage protection (DQPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Reactive power range |PF| <0.71 Power: ±3.0% or ±0.002 × Q_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1][2]	Typically 45 ms
Reset time	<50 ms
Reset ratio	Typically 0.99
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Start value = 0.05 × S_n, reactive power before fault = 0.2 × Start value, reactive power overshoot 2 times, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 89. Directional reactive power undervoltage protection (DQPTUV) main settings

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

Table 90. Underpower protection (DUPPDPR)

Characteristic	Value
Operation accuracy [1]	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 33 ms
Reset ratio	Typically 1.04
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = "Pos Seq" default
2) U = U_n, f_n = 60 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 91. Underpower protection (DUPPDPR) main settings

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

Table 92. Reverse power/directional overpower protection (DOPPDPR)

Characteristic	Value
Operation accuracy [1]	Depending on the frequency of the measured current and voltage: f = f_n ±2 Hz Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 33 ms
Reset ratio	Typically 0.94
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = "Pos Seq" default
2) U = U_n, f_n = 60 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 93. Reverse power/directional overpower protection (DOPPDPR) main settings

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

Table 94. Low-voltage ride-through protection (LVRTPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n
Start time[1][2]	Typically 40 ms
Reset time	Based on maximum value of *Recovery time* setting
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

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

000627

ВЯРНО С ОРИГИНАЛА

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Table 95. Low-voltage ride-through protection (LVRTPTUV) main settings

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

Table 96. High-impedance differential protection (HiZPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
Start time[1][2]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start value*	12 ms	15 ms	24 ms
	I_{Fault} = 10 × set *Start value*	10 ms	12 ms	14 ms
Reset time		<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		

1) Measurement mode = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current with nominal frequency, injection from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 97. High-impedance differential protection (HiZPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HiZPDIF	1.0...200.0 % I_n	1
Minimum operate time	HiZPDIF	20...300000 ms	10

Table 98. Circuit breaker uncorresponding position start-up (UPCALH)

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

Table 99. Three-independent-phase non-directional overcurrent protection (PHxPTOC)

Characteristic		Value		
Operation accuracy	PHLPTOC	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
	PHHPTOC and PHIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time[1][2]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 × set *Start value*	15 ms	16 ms	17 ms
	I_{Fault} = 10 × set *Start value*	11 ms	14 ms	17 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 × set *Start value*	23 ms	25 ms	28 ms
Reset time		<40 ms		
Reset ratio		Typically 0.95		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression		

1) Measurement mode = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum Start value = 0.8 × I_n, Start value multiples in range of 1.5...20

Table 100. Three-independent-phase non-directional overcurrent protection (PHxPTOC) main settings

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

1) For further information, see Operation characteristics table

Table 101. Directional three-independent-phase directional overcurrent protection (DPHxPDOC)

Characteristic		Value		
Operation accuracy	DPHLPDOC	Depending on the frequency of the current measured: f_n ±2 Hz Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DPHHPDOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time[1][2]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value*	38 ms	40 ms	43 ms
Reset time		<40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression		

1) Measurement mode and Pol quantity = default, current before fault = 0.0 × I_n, voltage before fault = 1.0 × U_n, f_n = 50 Hz, fault current in one phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum Start value = 0.8 × I_n, Start value multiples in range of 1.5...20

Table 102. Directional three-independent-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 × I_n	0.01
	DPHHPDOC	0.10...40.00 × I_n	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	40...200000 ms	10
Operating curve type[1]	DPHLPDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHxPDOC	-179...180°	1

1) For further information, refer to the Operation characteristics table

000628

ВЯРНО С ОРИГИНАЛА

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Table 103. Three-phase overload protection for shunt capacitor banks (COLPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_f ±2 Hz, and no harmonics
	5% of the set value or 0.002 × I_n
Start time for overload stage[1,2]	Typically 75 ms
Start time for under current stage[2,3]	Typically 25 ms
Reset time for overload and alarm stage	Typically 80 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the set value or ±20 ms
Operate time accuracy in inverse time mode	15% of the theoretical value or ±20 ms
Suppression of harmonics for under current stage	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,...

1) Harmonic current before fault = 2.0 × I_n, harmonic fault current 1.3 × start value, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Harmonic current before fault = 1.2 × I_n, harmonic fault current 0.9 × start value, results based on statistical distribution of 1000 measurements

Table 104. Three-phase overload protection for shunt capacitor banks (COLPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value overload	COLPTOC	0.30...1.50 × I_n	0.01
Alarm start value	COLPTOC	50...125%	1
Start value Us Cur	COLPTOC	0.10...0.70 × I_n	0.01
Time multiplier	COLPTOC	0.05...2.00	0.01
Alarm delay time	COLPTOC	500...600000	100
Us Cur delay time	COLPTOC	100...120000	100

Table 105. Current unbalance protection for shunt capacitor banks (CUBPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_f ±2 Hz
	1.5% of the set value or 0.002 × I_n
Start time[1,2]	Typically 25 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the set value or ±20 ms
Operate time accuracy in inverse definite minimum time mode	5% of the theoretical value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,...

1) Fundamental frequency current = 1.0 × I_n, current before fault = 0.9 × I_n, fault current = 2.0 × start value, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 106. Current unbalance protection for shunt capacitor banks (CUBPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm mode	CUBPTOC	1 = Normal 2 = Element counter	-
Start value	CUBPTOC	0.01...1.00 × I_n	0.01
Alarm start value	CUBPTOC	0.01...1.00 × I_n	0.01
Time multiplier	CUBPTOC	0.05...15.00	0.01
Operating curve type[1]	CUBPTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	CUBPTOC	50...200000 ms	10
Alarm delay time	CUBPTOC	50...200000 ms	10

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

Table 107. Shunt capacitor bank switching resonance protection, current based (SRCPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: fn ±2 Hz
	Operate value accuracy: ±3% of the set value or ±0.002 × I_n (for 2nd order Harmonics) ±1.5% of the set value or ±0.002 × I_n (for 3rd order < Harmonics < 10th order) ±5% of the set value or ±0.004 × I_n (for Harmonics >= 10th order)
Reset time	Typically 45 ms or maximum 50 ms
Retardation time	Typically 0.95
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = f_n

Table 108. Shunt capacitor bank switching resonance protection, current based (SRCPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm start value	SRCPTOC	0.03...0.50 × I_n	0.01
Start value	SRCPTOC	0.03...0.50 × I_n	0.01
Tuning harmonic Num	SRCPTOC	1...11	1
Operate delay time	SRCPTOC	120...360000 ms	1
Alarm delay time	SRCPTOC	120...360000 ms	1

Table 109. Operation characteristics

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

Control functions

Table 110. Autoreclosing (DARREC)

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

Table 111. Synchronism and energizing check (SECRSYN)

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

Table 112. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	-1 = Off 1 = Both Dead 2 = Live L, Dead B 3 = Dead L, Live B 4 = Dead Bus, L Any 5 = Dead L, Bus Any 6 = One Live, Dead 7 = Not Both Live	-
Difference voltage	SECRSYN	0.01...0.50 × U_n	0.01
Difference frequency	SECRSYN	0.001...0.100 × f_n	0.001
Difference angle	SECRSYN	5...90°	1
Synchrocheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	-
Dead line value	SECRSYN	0.1...0.8 × U_n	0.1
Live line value	SECRSYN	0.2...1.0 × U_n	0.1
Close pulse	SECRSYN	200...60000 ms	10
Max energizing V	SECRSYN	0.50...1.15 × U_n	0.01
Control mode	SECRSYN	1 = Continuous 2 = Command	-
Phase shift	SECRSYN	-180...180°	1
Minimum Syn time	SECRSYN	0...60000 ms	10
Maximum Syn time	SECRSYN	100...6000000 ms	10
Energizing time	SECRSYN	100...60000 ms	10
Closing time of CB	SECRSYN	40...250 ms	10

000629
ВЯРНО С ОРИГИНАЛА
ЕВРАСИН ООД СМОЛЯН

Condition monitoring and supervision functions

Table 113. Circuit-breaker condition monitoring (SSCBR)

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

Table 114. Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time [1]	<30 ms

1) Including the delay of the output contact

Table 115. Current circuit supervision (CCSPVC) main settings

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

Table 116. Current transformer supervision for high-impedance protection scheme (HZCCxSPVC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: I_n ±2 Hz
	±1.5% of the set value or ±0.002 × I_n
Reset time	<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

Table 117. Fuse failure supervision (SEQSPVC)

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

1) Includes the delay of the signal output contact, f_n ± 2 Hz, fault voltage with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements

Table 118. Runtime counter for machines and devices (MDSOPT)

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

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

Measurement functions

Table 119. Three-phase current measurement (CMMXU)

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

Table 120. Sequence current measurement (CSMSQI)

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

Table 121. Residual current measurement (RESCMMXU)

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

Table 122. Three-phase voltage measurement (VMMXU)

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

Table 123. Single-phase voltage measurement (VAMMXU)

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

Table 124. Residual voltage measurement (RESVMMXU)

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

Table 125. Sequence voltage measurement (VSMSQI)

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

Table 126. Three-phase power and energy measurement (PEMMXU)

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

1) [illegible]
2) [illegible]

Table 127. Frequency measurement (FMMXU)

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

000630
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Fault location functions

Table 128. Fault locator (SCEFRFLO)

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

Table 129. Fault locator (SCEFRFLO) main settings

Parameter	Function	Value (Range)	Step
Z Max phase load	SCEFRFLO	1.0...10000.00 Ω	0.1
Ph leakage Ris	SCEFRFLO	20...100000 Ω	1
Ph capacitive React	SCEFRFLO	10...100000 Ω	1
R1 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
X1 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
R0 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
X0 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
Line Len section A	SCEFRFLO	0.000...1000.000 pu	0.001

Power quality functions

Table 130. Voltage variation (PHQVVR)

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

Table 131. Voltage variation (PHQVVR) main settings

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

Table 132. Voltage unbalance (VSQVUB)

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

Table 133. Voltage unbalance (VSQVUB) main settings

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

Other functions

Table 134. Pulse timer (PTGAPC)

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

Table 135. Time delay off (8 pcs) (TOFPAGC)

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

Table 136. Time delay on (8 pcs) (TONGAPC)

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

22. Local HMI

The relay supports process information and status monitoring from the relay's local HMI via its display and indication/alarm LEDs. The local LHMI also enables control operations for the equipment connected and controlled by the relay, either via display or via manual push buttons available on the local HMI.

LCD display offers front-panel user interface functionality with menu navigation and menu views. In addition, the display includes a user-configurable two-page single-line diagram (SLD) with a position indication for the associated primary equipment and primary measurements from the process. The SLD can be modified according to user requirements by using Graphical Display Editor in PCM600.

The local HMI also includes 11 programmable LEDs. These LEDs can be configured to show alarms and indications as needed by PCM600 graphical configuration tool. The LEDs include two separately controllable colors, red and green, making one LED able to indicate better the different states of the monitored object.

The relay also includes 16 configurable manual push buttons, which can freely be configured by the PCM600 graphical configuration tool. These buttons can be configured to control the relay's internal features for example changing setting group, trigger disturbance recordings and changing operation modes for functions or to control relay's external equipment, for example opening or closing the equipment, via relay's binary outputs. These buttons also include a small indication LED for each button. This LED is freely configurable, making it possible to use push button LEDs to indicate button activities or as additional indication/alarm LEDs in addition to the 11 programmable LEDs.

The local HMI includes a push button (L/R) for the local/remote operation of the relay. When the relay is in the local mode, the relay can be operated only by using the local front-panel user interface. When the relay is in the remote mode, the relay can execute commands sent remotely. 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 the relays are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.

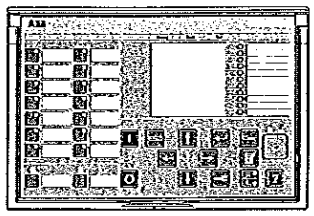

Figure 18. Example of the LHMI

23. Mounting methods

By means of appropriate mounting accessories the standard relay case can be flush mounted, semi-flush mounted or wall mounted.

Further, the relays can be mounted in any standard 19" instrument cabinet by means of 19" mounting panels available with cut-outs for one relay. Alternatively, the relay can be mounted in 19" instrument cabinets by means of 4U Combiflex equipment frames.

For the routine testing purposes, the relay cases can be equipped with test switches, type RTXP 24, which can be mounted side by side with the relay cases.

Mounting methods

- Flush mounting
- Semi-flush mounting
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame
- Mounting with a RTXP 24 test switch to a 19" rack

Panel cut-out for flush mounting

- Height: 162 ±1 mm
- Width: 244 ±1 mm

000631
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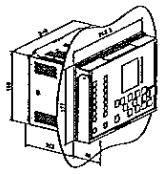

Figure 19. Flush mounting

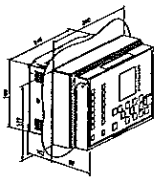

Figure 20. Semi-flush mounting

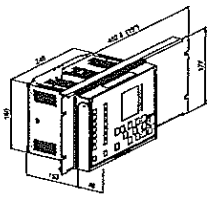

Figure 21. Rack mounting

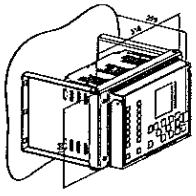

Figure 22. Wall mounting

24. Relay case and plug-in unit

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

25. Selection and ordering data

The relay type and serial number label identifies the protection and control relay. The label is placed above the HMI on the upper part of the plug-in unit. An order code label is placed on the side of the plug-in unit as well as inside the case. The order code consists of a string of letters and digits generated from the relay's hardware and software modules.

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.

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#	Description	
1	IED	
	620 series IED (including case)	N
	Complete Relay with conformal coating	S
2	Standard	
	IEC	B
	ON	O
3	Main application	
	Feeder protection and control	F
4	Functional application	
	Example configuration	N
5-6	Analog inputs and outputs	
	4(1A, 1/5 A) + 5U + 2(5I + 1)SO	AA
	4(1A,0.2/1 A) + 5U + 2(5I + 1)SO	AB
	Sensors (4I + 3I) + 1(1 + 1)SI + 1)SO	AU
7-8	Optional board	
	Optional I/Os 8RTD+4RO	AA
	Optional RTDs 6RTD In + 2mA in	AB
	Optional Fast I/Os 8SI + 3SO	AC
	No optional board	NN

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9	Communication (Serial/Ethernet)	
10	Serial RS 485, incl. an input for IRIG-B + Ethernet 100Base FX (1xLC)	AA
	Serial RS 485, incl. an input for IRIG-B + Ethernet 100Base TX (1xRJ45)	AB
	Serial RS 485, incl. an input for IRIG-B	AN
	Serial glass fibre (ST) + Ethernet 100Base TX (1xRJ45) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + Input for IRIG-B (cannot be combined with arc protection)	BA
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP	BC
	Serial glass fibre (ST) + Ethernet 100Base TX (2xRJ45) with HSR/PRP	BD
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP	BE
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP and IEC61850-9-2LE	BF
	Serial glass fibre (ST) + Ethernet 100Base TX (2xRJ45) with HSR/PRP and IEC61850-9-2LE	BG
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP and IEC61850-9-2LE	BH
	Serial glass fibre (ST) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + Input for IRIG-B (cannot be combined with arc protection)	BN
	RS 232/485 (including IRIG-B) + Ethernet 100Base TX (1xRJ45) (cannot be combined with arc protection)	CG
	RS 232/485 + RS 485of (plastic/fiber ST) (including IRIG-B) (cannot be combined with arc protection)	CN
	Ethernet 100Base FX (1xLC)	NA
	Ethernet 100Base TX (1xRJ45)	NB
	Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP	NC
	Ethernet 100Base TX (2xRJ45) with HSR/PRP	ND
	Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP	NE
	Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP and IEC61850-9-2LE	NF
	Ethernet 100Base TX (2xRJ45) with HSR/PRP and IEC61850-9-2LE	NG
	Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP and IEC61850-9-2LE	NH
	No communication module	NN

If serial communication is chosen, please choose a serial communication module including Ethernet (for example "BC") if a service bus for PCM600 or the WebHMI is required.

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#	Description	
11	Communication protocols	
	IEC 61850 (for Ethernet communication modules and IEDs without a communication module)	A
	Modbus (for Ethernet/serial or Ethernet + serial communication modules)	B
	IEC 61850 + Modbus (for Ethernet or serial + Ethernet communication modules)	C
	IEC 61850-5-103 (for serial or Ethernet + serial communication modules)	D
	DNP3 (for Ethernet/serial or Ethernet + serial communication modules)	F
	IEC 61850 + IEC 60870-5-103 (for serial + Ethernet communication modules)	G
	IEC 61850 + DNP3 (for Ethernet or serial + Ethernet communication modules)	H
12	Language	
	English	1
	English and Chinese	2
13	Front panel	
	Large LCD with Single Line Diagram - IEC	B
	Large LCD with Single Line Diagram - ON	U
14	Option 1	
	Arc protection (requires a communication module, cannot be combined with some module options ON, BG, CG and CN)	B
	None	N
15	Option 2	
	Fault locator	F
	Capacitor bank protection package	C
	Interlink/Interconnection/Distributed generation protection package	D
	Power protection package	P
	All options:Fault locator + Capacitor bank protection + Interlink/ Interconnection/Distributed generation protection + Power protection	L
	None	N
16	Power supply	
	Power supply 48-250 VDC, 100-240 VAC	1
	Power supply 24-60 VDC	2
17	Reserved	
18	Product version 2.0 FP1	A

000632
ВЯРНО С ОРИГИНАЛА
"КРАСИН" СМОЛЯН ООД

Example code: NBFNAANNABC1BNN11G

Your ordering code:

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

Figure 23. Ordering key for complete protection relays

26. Accessories and ordering data

Table 137. Cables

Item	Order number
Cable for optical sensors for arc protection 1.5 m	1MRS120534-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS120534-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS120534-5.0

Table 138. Mounting accessories

Item	Order number
Semi-flush mounting kit	2RCA030573A0001
Wall mounting kit	2RCA030834A0001
19" rack mounting kit with cut-out for one relay	2RCA031113SA0001
19" rack mounting kit for one relay and one RTXP24 test switch (the test switch and wire harness are not included in the delivery)	2RCA032818A0001
Mounting bracket for one relay with test switch RTXP in 4U Combiflex (RHGT 19" variant C) (the test switch, wire harness and Combiflex RSHT 19" variant C are not included in the delivery)	2RCA032828A0001
Functional earthing flange for RTD modules	2RCA036978A0001[1]

1) Cannot be used when the IED is mounted with the Combiflex 19" equipment frame 2RCA032828A0001.

27. Tools

The protection relay is delivered as a pre-configured unit including the example configuration. The default parameter setting values can be changed from the front-panel user interface, the Web browser-based user interface (Web HMI) or the PCM600 tool in combination with the relay-specific connectivity package.

The Protection and Control IED Manager PCM600 offers extensive relay configuration functions such as relay signal configuration, application configuration, graphical display configuration including single line diagram configuration, and IEC 61850 communication configuration including horizontal GOOSE communication.

When the Web browser-based user interface is used, the protection relay can be accessed either locally or remotely using a Web browser (Internet Explorer). For security reasons, the Web browser-based user interface is disabled by default but it can be enabled via the front-panel user interface. 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 139. Tools

Configuration and setting tools	Version
PCM600	2.6 (Rollup 20150626) or later
Web browser-based user interface	IE 8.0, IE 9.0, IE 10.0 or IE 11.0
REF620 Connectivity Package	2.1 or later

Table 140. Supported functions

Function	Web HMI	PCM600
Relay parameter setting	•	•
Saving of relay parameter settings in the relay	•	•
Signal monitoring	•	•
Disturbance recorder handling	•	•
Alarm LED viewing	•	•
Access control management	•	•
Relay signal configuration (Signal Matrix)	-	•
Modbus® communication configuration (communication management)	-	•
DNP3 communication configuration (communication management)	-	•
IEC 60870-5-103 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

28. Cyber security

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

29. Connection diagrams

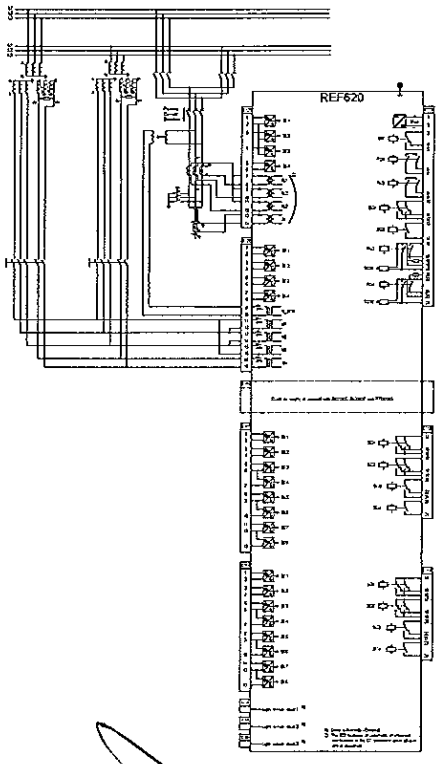

Figure 24. Connection diagram for the configuration with CTs and VTs

000633

ВЕРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

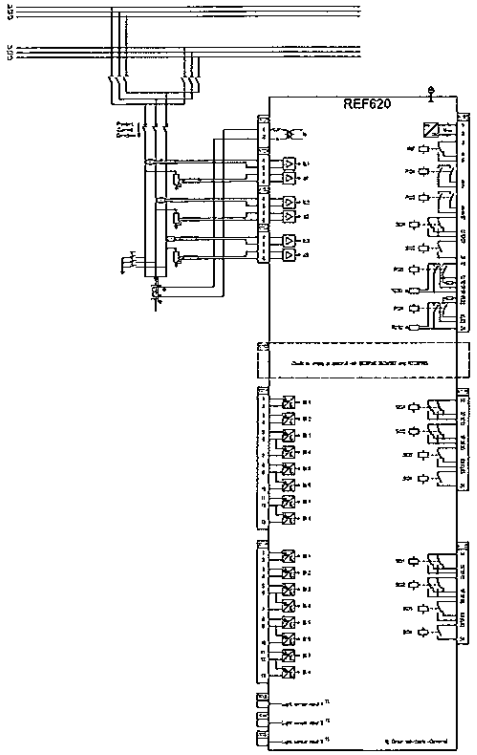

Figure 25. Connection diagram for the configuration with sensors

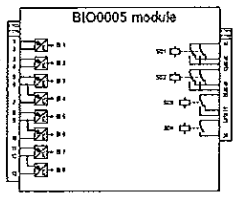

Figure 26. Optional BIO0005 module (slot X105)

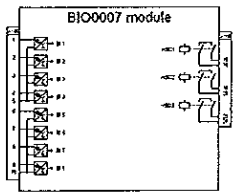

Figure 27. Optional BIO0007 module for fast outputs (slot X105)

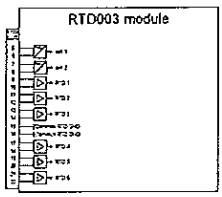

Figure 28. Optional RTD0003 module (slot X105)

30. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Relion® 620 series. Certificate number: 74108008-OPEANC 15-2319.

DNV GL has issued an IEC 61850 Edition 1 Certificate Level A1 for Relion® 620 series. Certificate number: 74108008-OPEANC 15-2323.

Additional certificates can be found on the product page.

31. 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 REF620 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

32. Functions, codes and symbols

Table 141. Functions included in the relay

Function	IEC 61850	IEC 60617	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)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3I> -> (1)	67-1 (1)
	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> -> (1)	67-2 (1)
	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Three-phase voltage-dependent overcurrent protection	PHPVOC1	3I(U)> (1)	51V (1)
	PHPVOC2	3I(U)> (2)	51V (2)
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance-based earth-fault protection	EFPADM1	Yo> -> (1)	21YN (1)
	EFPADM2	Yo> -> (2)	21YN (2)
	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric-based earth-fault protection	WPWDE1	Po> -> (1)	32N (1)
	WPWDE2	Po> -> (2)	32N (2)
	WPWDE3	Po> -> (3)	32N (3)
Multifrequency admittance-based earth-fault protection	MFADPSDE1	Io> -> Y (1)	67YN (1)
Transient/intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonics-based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)

ВЯРНО С ОРИГИНАЛА
"КРАСКИН" СМОЛЯН ООД
000634

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
	PHPTUV4	3U< (4)	27 (4)
Single-phase undervoltage protection, secondary side	PHAPTUV1	U_A< (1)	27_A (1)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Single-phase overvoltage protection, secondary side	PHAPTOV1	U_A> (1)	59_A (1)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
	NSPTOV2	U2> (2)	47O- (2)
Frequency protection	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F (1)	49F (1)
Loss of phase (undercurrent)	PHPTUC1	3I< (1)	37 (1)
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
	CCBRBRF3	3I>/Io>BF (3)	51BF/51NBF (3)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (1)
Master trip	TRPTTRC1	Master Trip (1)	94/86 (1)
	TRPTTRC2	Master Trip (2)	94/86 (2)
	TRPTTRC3	Master Trip (3)	94/86 (3)
	TRPTTRC4	Master Trip (4)	94/86 (4)
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)
High-impedance fault detection	PHIZ1	HIF (1)	HIZ (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Load-shedding and restoration	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
	LSHDPFRQ3	UFLS/R (3)	81LSH (3)
	LSHDPFRQ4	UFLS/R (4)	81LSH (4)
	LSHDPFRQ5	UFLS/R (5)	81LSH (5)
	LSHDPFRQ6	UFLS/R (6)	81LSH (6)
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)
	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)
Automatic switch-onto-fault logic (SOF)	CVPSOF1	CVPSOF (1)	SOFT/21/50 (1)
Voltage vector shift protection	VVSPPAM1	V3 (1)	78V (1)
Directional reactive power undervoltage protection	DQPTUV1	Q> -> 3U< (1)	32Q,27 (1)
	DQPTUV2	Q> -> 3U< (2)	32Q,27 (2)
Underpower protection	DUPPDPR1	P< (1)	32U (1)
	DUPPDPR2	P< (2)	32U (2)
Reverse power/directional overpower protection	DOPPDPR1	P>/Q> (1)	32R/32O (1)
	DOPPDPR2	P>/Q> (2)	32R/32O (2)
Low-voltage ride-through protection	LVRTPTUV1	U<RT (1)	27RT (1)
	LVRTPTUV2	U<RT (2)	27RT (2)
	LVRTPTUV3	U<RT (3)	27RT (3)
High-impedance differential protection for phase A	HIAPDIF1	dHi_A> (1)	87A (1)
High-impedance differential protection for phase B	HIBPDIF1	dHi_B> (1)	87B (1)
High-impedance differential protection for phase C	HICPDIF1	dHi_C> (1)	87C (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Circuit breaker uncorresponding position start-up	UPCALH1	CBUPS (1)	CBUPS (1)
	UPCALH2	CBUPS (2)	CBUPS (2)
	UPCALH3	CBUPS (3)	CBUPS (3)
Three-independent-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I_3> (1)	51P-1_3 (1)
	PHLPTOC2	3I_3> (2)	51P-1_3 (2)
Three-independent-phase non-directional overcurrent protection, High stage	PHHPTOC1	3I_3>> (1)	51P-2_3 (1)
	PHHPTOC2	3I_3>> (2)	51P-2_3 (2)
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I_3>>> (1)	50P/51P_3 (1)
Directional three-independent-phase directional overcurrent protection, low stage	DPHLPDOC1	3I_3> -> (1)	67-1_3 (1)
	DPHLPDOC2	3I_3> -> (2)	67-1_3 (2)
Directional three-independent-phase directional overcurrent protection, High stage	DPHHPDOC1	3I_3>> -> (1)	67-2_3 (1)
	DPHHPDOC2	3I_3>> -> (2)	67-2_3 (2)
Three-phase overload protection for shunt capacitor banks	COLPTOC1	3I> 3I< (1)	51C/37 (1)
Current unbalance protection for shunt capacitor banks	CUBPTOC1	dI>C (1)	51NC-1 (1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC1	TD> (1)	55TD (1)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
	CBXCBR3	I <-> O CB (3)	I <-> O CB (3)
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DC (2)
	DCXSWI3	I <-> O DCC (3)	I <-> O DC (3)
	DCXSWI4	I <-> O DCC (4)	I <-> O DC (4)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
	ESXSWI3	I <-> O ESC (3)	I <-> O ESC (3)
Disconnector 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)
	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
	ESSXSWI3	I <-> O ES (3)	I <-> O ES (3)
Autoreclosing	DARREC1	O -> I (1)	79 (1)
	DARREC2	O -> I (2)	79 (2)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
	SSCBR2	CBCM (2)	CBCM (2)
	SSCBR3	CBCM (3)	CBCM (3)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC1	MCS I_A (1)	MCS I_A (1)
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC1	MCS I_B (1)	MCS I_B (1)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC1	MCS I_C (1)	MCS I_C (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTS (1)	OPTM (1)
	MDSOPT2	OPTS (2)	OPTM (2)
Measurement			
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Single-phase voltage measurement	VAMMXU2	U_A (2)	V_A (2)
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)
Load profile record	LDPRLRC1	LOADPROF (1)	LOADPROF (1)
Frequency measurement	FMMXU1	f (1)	f (1)
Fault location			
Fault locator	SCEFRFLO1	FLOC (1)	21FL (1)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (1)
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)

000635
ВЗЯТО С ОРИГИНАЛА
"КРАСИН" ABB СМОЛЯН

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
	TPSGAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
	TPMGAPC2	TPM (2)	TPM (2)
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)
	MVGAPC3	MV (3)	MV (3)
	MVGAPC4	MV (4)	MV (4)
Integer value move	MVI4GAPC1	MVI4 (1)	MVI4 (1)
	MVI4GAPC2	MVI4 (2)	MVI4 (2)
	MVI4GAPC3	MVI4 (3)	MVI4 (3)
	MVI4GAPC4	MVI4 (4)	MVI4 (4)
Analog value scaling	SCA4GAPC1	SCA4 (1)	SCA4 (1)
	SCA4GAPC2	SCA4 (2)	SCA4 (2)
	SCA4GAPC3	SCA4 (3)	SCA4 (3)
	SCA4GAPC4	SCA4 (4)	SCA4 (4)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
	SPCGAPC3	SPC (3)	SPC (3)
Remote generic control points	SPCRGAPC1	SPCR (1)	SPCR (1)
Local generic control points	SPCLGAPC1	SPCL (1)	SPCL (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Generic up-down counters	UDFCNT1	UDCNT (1)	UDCNT (1)
	UDFCNT2	UDCNT (2)	UDCNT (2)
	UDFCNT3	UDCNT (3)	UDCNT (3)
	UDFCNT4	UDCNT (4)	UDCNT (4)
	UDFCNT5	UDCNT (5)	UDCNT (5)
	UDFCNT6	UDCNT (6)	UDCNT (6)
	UDFCNT7	UDCNT (7)	UDCNT (7)
	UDFCNT8	UDCNT (8)	UDCNT (8)
	UDFCNT9	UDCNT (9)	UDCNT (9)
	UDFCNT10	UDCNT (10)	UDCNT (10)
	UDFCNT11	UDCNT (11)	UDCNT (11)
	UDFCNT12	UDCNT (12)	UDCNT (12)
Programmable buttons (16 buttons)	FKEYGGIO1	FKEY (1)	FKEY (1)
Logging functions			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Fault recorder	FLTRFRC1	FAULTREC (1)	FAULTREC (1)
Sequence event recorder	SER1	SER (1)	SER (1)

33. Document revision history

Document revision/date	Product version	History
A/2013-05-07	2.0	First release
B/2013-07-01	2.0	Content updated
C/2014-07-01	2.0	Content updated
D/2014-09-11	2.0	Content updated
E/2015-12-11	2.0 FP1	Content updated to correspond to the product version

000636

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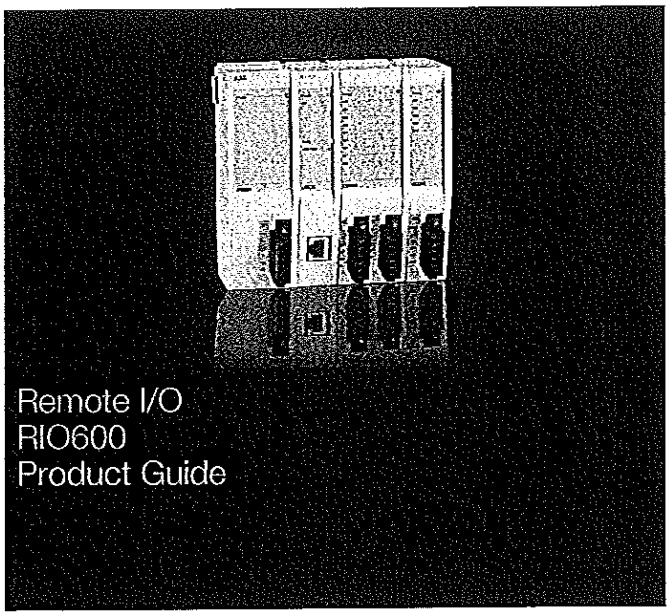

Remote I/O
RIO600
Product Guide

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Contents

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Remote I/O	1MRS757487 F
RIO600	
Product version: 1.7	Issued: 2016-06-09
	Revision: F

1. Description

RIO600 is designed to expand the digital and analog I/O of ABB's Relion® protection and control relays and to provide I/O for COM600 substation automation unit using the IEC 61850 and Modbus TCP communication. Both galvanic RJ-45 and optical LC type of connectors are supported for Ethernet station bus communication. RIO600 can also be used in secondary substations for fault passage indication and power measurements reporting values directly to a peer protection relay or to an upper level system. RIO600 accepts three-phase sensor signals (voltage and current) and provides fault detection and metering functions.

RIO600 allows flexible I/O assignment and provides seamless IEC 61850 connectivity between the substation input and output signals and protection relay or COM600 substation gateway ensuring improved functionality and performance. RIO600 supports both Edition 1 and Edition 2 versions of the IEC 61850 standard. RIO600 can also be used as a standalone device in grid automation applications.

RIO600 helps in simplifying and decreasing the wiring inside the substation by digitizing the hardwired signals. The fully hardwired traditional medium-voltage switchgear/substation control and protection system results in extensive I/O wiring, connecting devices in switchgear signaling to the external systems, for example, to the RTU or other higher-level automation systems.

RIO600 provides additional I/O within the switchgear using Ethernet communication. The I/O signals can be efficiently transmitted between the protection relay or COM600 with fast, high performance IEC 61850 GOOSE communication. Alternatively, RIO600 can communicate with an upper level automation system using the widely accepted Modbus TCP automation protocol.

RIO600 binary input module can be used for sending binary input values from primary equipment or secondary systems to peer protection relays or upper level system. The binary output modules can be used to control equipment based on the control signal received from communication.

RIO600 smart control module (SCM) can be used for different switchgear applications to drive primary switches. The module enables the control of a combined three-position switch (disconnector and earthing switch) used in gas insulated switchgears or standard two-position switches like disconnector or earthing switches. Alternatively, the heavy-duty output contacts of the smart control module can be used as power outputs for circuit breaker trip circuits to make, carry and break the belonging trip coil current. Furthermore, the smart control module can be used as a generic four binary input and four fast power output module.

With the RTD/mA module, RIO600 can be used in different monitoring applications. RIO600 can receive temperatures (°C) via RTDs or analog input signals (mA) from various transducers or devices. Input current (mA) can be linearly scaled for various applications, for example, transformer tap changer position indication. The input value is forwarded to a peer protection relay or to an upper level system. With the analog output module, RIO600 can control an external device having an mA input.

In addition, RIO600 includes a measurement module with fault passage indication (FPI) functionality. This module is intended for grid automation applications where RIO600 enables accurate current and voltage measurements from a medium voltage network utilizing ABB's accurate and light weight sensor technology. RIO600 with the measurement module can be used as a standalone fault passage indicator unit. Based on the measured MV values, it can give voltage presence and directional fault passage indication and report them to an upper level system. This also enables power flow and power quality monitoring. The typical accuracy of line voltages, currents and active power is better than 0.5% and for other power measurements better than 1%.

The FPI module incorporates the latest fault detection algorithms used in the Relion family. With easy-to-use multifrequency admittance-based (MFA) earth-fault detection algorithm, it accurately detects solid, resistive and intermittent type of earth faults. Practical sensitivity of up to 10 kΩ of the fault resistance can be achieved in symmetrical networks. This novel functionality is suitable for high-impedance earthed networks, and especially for compensated and unearthed networks where accurate and selective earth-fault detection is more challenging due to low fault currents.

2. Modular design

RIO600 is built on an industrial hardware platform which provides the same reliability, performance and real-time functionality as ABB protection relays withstanding extreme temperatures, electromagnetic interference and stringent industry standards.

Remote I/O	1MRS757487 F
RIO600	
Product version: 1.7	

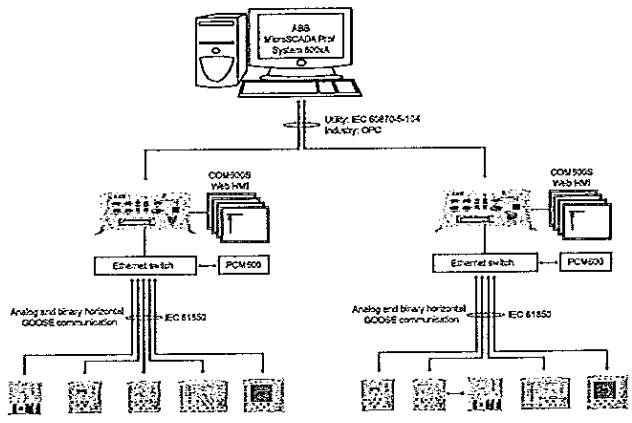

Figure 1. Connection overview of RIO600

RIO600 is designed using a modular architecture where the I/O control functionality is built on modules. The RIO600 modules can be stacked on a standard DIN rail to achieve the required configuration. The minimum configuration required for RIO600 contains a power supply module, a communication module and an I/O module.

000638

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Table 1. RIO600 module types

Module type			Description
Power supply modules		PSMH	High-voltage range power supply module
		PSML	Low-voltage range power supply module
Communication modules		LECM	Communication module with Ethernet port
		LECM	Communication module with Optical Ethernet port
I/O modules	Digital input module	DIMSH	High-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
		DIMSL	Low-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
	Digital output module	DOM4	Four output contacts in each digital output module with two pairs of potential free contacts with common return
	RTD module	RTD4	Four optically isolated channels supporting RTD sensors (Pt100, Pt250, Ni100, Ni120 and Ni250) and mA input (0...20 mA configurable). Individual channels are non-isolated from each other
	Analog output module	AOM4	Four individually isolated channels of configurable mA outputs driving 0...20 mA signal
	Sensor input module	SIM3F	Sensor input module with combined three-phase current and voltage signals
	Smart control module	SCMSH	High-voltage range, smart control module with five application types • 4I4O – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch
		SCMSL	Low-voltage range, smart control module with five application types • 4I4O – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch

The availability and combination of RIO600 modules and channels depends on the number of power supplies connected.

Table 2. Maximum number of modules and channels available when one power supply module is connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIMSH/DIMSL)	5	40	5	40
Digital output modules	5	20	4	16
RTD4 modules	5	20	4	16
Analog output modules	2	8	1	4
SIM3F modules	5	-	4	-
Smart control modules (SCMSH/SCMSL)	3	24	2	16

Table 3. Maximum number of modules and channels available when two power supply modules are connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIMSH/DIMSL)	5	40	5	40
Digital output modules	10	40	9	36
RTD4 modules	10	40	9	36
Analog output modules	4	16	3	12
SIM3F modules	5	-	5	-
Smart control module (SCMSH/SCMSL)	5	40	5	40

A combination of all the modules can be used in a single RIO600 stack. The total number of modules that can be supported by a number of power supply modules is automatically checked by PCM600. If the selected combination of modules exceeds the number of supported modules related to power consumption, the configuration tool gives an indication and does not proceed in configuring the stack.

Indication LEDs
RIO600 is equipped with different indication LEDs available on different modules.
- Ready LED on all modules
- Status indication LED for each binary input and output
- Status indication of detected power flows and disturbances in network
- IRF LED which indicates a fault condition if it is steadily ON
- Communication diagnostic LED on the communication module

Configuration examples
The user-specific configuration can be adapted according to application requirements by combining different modules.

RIO600 can be configured with a combination of low-voltage and high-voltage modules, for example, PSMH-LECM-DIMSL, PSML-LECM-DIMSH or PSML-PSMH-LECM-DIMSH-DIMSL-DOM4.

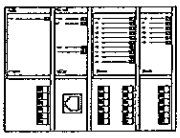

Figure 2. RIO600 configuration with 12 channels with 8 DI and 4 DO (1 × DIMSH + 1 × DOM4)

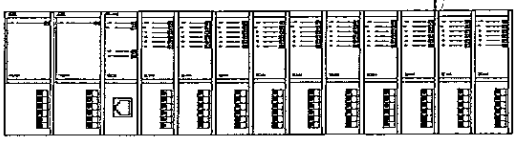

Figure 3. RIO600 configuration: 40 channels with 40 DO (10 × DOM4)

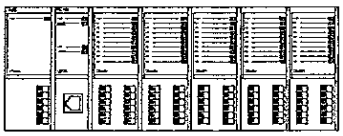

Figure 4. RIO600 configuration: 40 channels with 40 DI (5 × DIMSH)

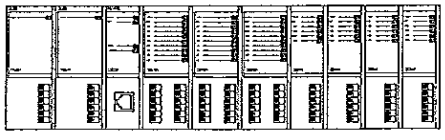

Figure 5. RIO600 configuration: 40 channels with 24 DI and 16 DO (3 × DIMSH + 4 × DOM4)

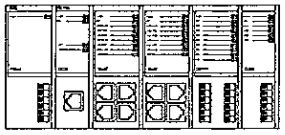

Figure 6. RIO600 configuration: 2 × SIM3F + 1 × DIMSH + 1 × DOM4

3. Applications

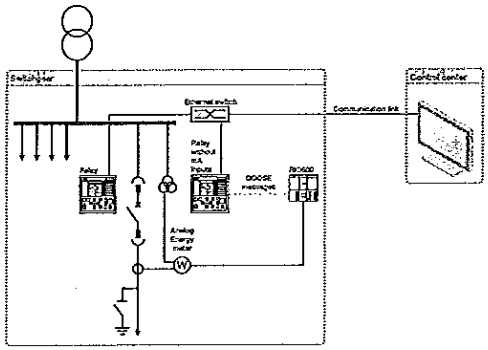

Figure 7. RIO600 as an external metering input for the protection relay

Figure 7 illustrates an application example in which RIO600 acts as an external metering input for the protection relay.

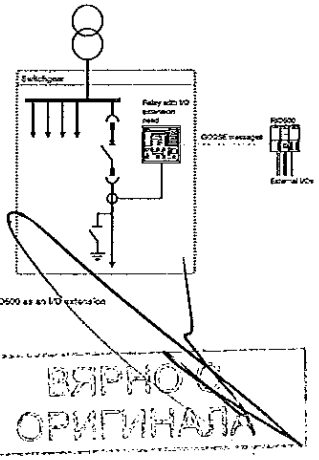

Figure 8. RIO600 as an I/O extension

000639

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In Figure 8 RIO600 is used as an input/output extension to a protection relay or a COM600 substation automation unit.

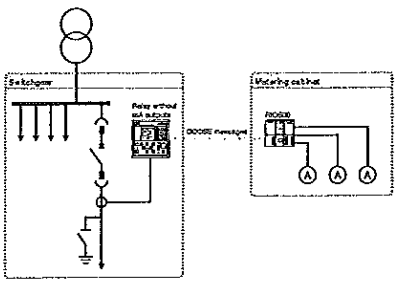

Figure 9. RIO600 communicating analog signals for the external meters

In the application example in Figure 9, RIO600 communicates analog signals for the external meters.

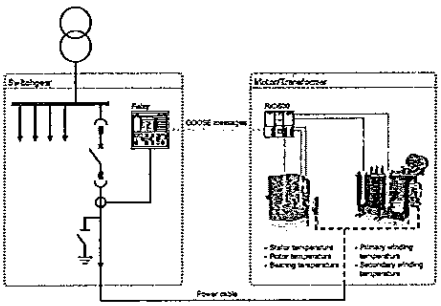

Figure 10. Temperature measurement using RIO600

Figure 10 illustrates the use of RIO600 to measure temperature from motor or transformer devices. The fiber-optic Ethernet can be used to achieve communication over longer distances.

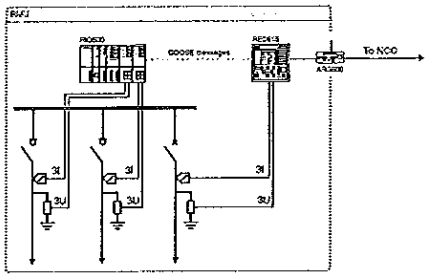

Figure 11. RMU fault passage indication using RIO600

Figure 11 shows RIO600 as a fault passage indicator in the RMU.

4. Self-supervision

RIO600 has a built-in self-supervision feature which continuously monitors the state of the RIO600 hardware and the operation of the software. Any fault or malfunction detected is used for alerting the operator. A dedicated LED is provided to indicate the failure. The self-supervision status of RIO600 is also distributed to the IEC 61850 station bus as one data entry in the published GOOSE frame. One of the output contacts of the digital output module can be configured to indicate the status (life-contact) of RIO600.

Supervision information is available over Modbus TCP or via Web HMI.

All module version information, RIO600 configuration version and firmware checksums are also available for fleet management purposes.

5. Communication

RIO600 supports horizontal GOOSE (Generic Object Oriented Substation Event) communication according to the IEC 61850 substation automation standard versions Edition 1 and Edition 2. It meets the horizontal communication performance criteria for protection and fault detection purposes defined by IEC 61850-5, that is, peer-to-peer communication <10 ms. Currently, the IEC 61850 MMS profile for vertical TCP/IP communication is not supported.

RIO600 also supports Modbus TCP communication to one Modbus TCP client. IEC 61850 GOOSE and Modbus TCP can be used in parallel in the same Ethernet based station bus.

RIO600 is designed to send and receive binary and analog signals to or from the ABB Relion® series protection relays and the COM600 station automation unit/RTU using the IEC 61850-8-1 GOOSE profile or Modbus TCP. Also any RTU supporting the mentioned protocols can be used. RIO600 subscribes to a GOOSE message from a maximum of five peer protection relays and publishes to multiple protection relays as configured. RIO600 supports publishing of a maximum of seven GOOSE data sets. It is possible to send time stamped events using the GOOSE service with a T0 class accuracy.

RIO600 also supports Modbus TCP communication used in Ethernet networks. The communication type is client-server where RIO600 acts as a Modbus TCP server. RIO600 Modbus TCP server supports connection to one Modbus TCP client.

RIO600 communication module includes a galvanic RJ-45 port with 10/100 Mbit/s or fiber-optic LC Ethernet for IEC 61850 GOOSE and Modbus TCP communication. The used cable type must be shielded twisted pair cable CAT5e at the minimum or a multimode fiber-optic cable with an LC connector.

Using the same Ethernet port, RIO600 can be connected in parallel to PCM600 and a Web browser over the same communication bus.

6. Technical data

Table 4. Module weights

Description	Value
PSM-PSML	235 g
LECM	123 g
DIM-H/DIML	206 g
DOM4	163 g
RTD4	206 g
AOM4	206 g
SIM8F	180 g
SOM84/SOML	215 g

Table 5. Dimensions of the end clamp (EW 55, Weidmüller)

Description	Value
Width	8.5 mm (To be fitted at the ends of assembled modules)

Table 6. Power supply

Description	PSMH	PSML
U_{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz 110, 125, 220, 250 V DC	24, 30, 48, 60 V DC
U_{aux} variation	85...110% of U_{aux} nominal (85...264 V AC) 80...120% of U_{aux} nominal (88...300 V DC)	50...120% of U_{aux} nominal (12...72 V DC)
Start-up threshold		19.2 V DC (24 V DC × 80%)
Maximum interruption time in the auxiliary DC without resetting the PSO modules	100 ms at U_{aux} nominal	50 ms at U_{aux} nominal
Ripple in the DC auxiliary voltage	Max. 15% of the DC value (at frequency of 100 Hz)	
Reversal of DC power supply polarity	1 minute for each polarity	
Burden of auxiliary voltage supply		
• Quiescent (Pq) condition (none of the 20 I/O channels are activated)	<4.0 W nominal	
• Operating condition (20 binary output channels in DOM4 modules are activated)	<12.0 W (maximum)	

Module configuration	Condition	Max. consumption for PSMH and PSML
PSM + LECM + DIM/SH	All DIs activated	2 W
PSM + LECM + DIM/SL		
PSM + LECM + DOM4	All DOs activated	4 W
PSM + LECM + DOM4 (5)	All DOs activated	12 W
PSM (2) + LECM + DIM/SH (5)	All DIs activated	11 W
PSM (2) + LECM + DIM/SL (5)		
PSM (2) + LECM + DOM4 (10)	All DOs activated	22 W

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Table 7. Binary inputs

Description	DIM8H	DIM8L
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3...3.7 mA	2 mA
Power consumption/input channel	330...925 mW	30...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 8. Signal outputs (Digital output module DOM4)

Description	Value
Operating time	<5 ms
Nominal coil power	<500 mW
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry for 0.5 s	15 A
Breaking capacity when the control circuit time constant L/R <40 ms, at 48/115/220 V DC	1 A/0.25 A/0.15 A

Table 9. mA/RTD input (RTD4 module)

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
	Maximum lead resistance (three-wire measurement)	100 Ω platinum	200 Ω per lead
		250 Ω platinum	200 Ω per lead
		100 Ω nickel	200 Ω per lead
		120 Ω nickel	200 Ω per lead
		250 Ω nickel	200 Ω per lead
	Isolation	4 kV	Inputs to all other channel outputs and protective earth
	RTD/resistance sensing maximum	0.275 mA rms current	
	Operation accuracy	±1°C	
	Response time	<Filter time + 350 ms	
mA inputs	Supported current range	0...20 mA	
	Current input impedance	44 Ω ± 0.1%	
	Operation accuracy	±0.5% or ±0.1 mA	
	Isolation	4 kV	Inputs to all outputs and protective earth

Table 10. Analog output module (ROM4)

Description		Value
mA output	Supported current range	0.0...20.0 mA
	Operation accuracy	±0.1% or ±0.2 mA
	Isolation	4 kV between each output and protective earth

Table 11. Sensor input module (SIM8F)

Description		Value
Preferred AS3 sensors		• Combined sensor KEVCY 24 RE1, KEVCY35 RE1, KEVCY 43.5 RE1, KEVCD A • Combination of current sensor KECA 80 C85 or KECA 045 and voltage sensor KEVA 24 C10, 24 C21, 24 C22, 24 C23, 17.5 B22, 17.5 B21, 24 B20, or 24 B21
Current measurement	Range	4...6500 A
	Accuracy	±5% or ±1 A in the range of 4...80 A ±1% in the range of 80...4500 A ±10% in the range of 4500...6000 A
Line voltage measurement	Range	480 V...48 kV
	Accuracy	±5% in the range of 480...9600 V ±0.5% in the range of 9.6...48 kV
Power measurements: P, Q, S and PF	Range	9.6...28.8 kW 80...800 A
	Accuracy	±1.0% for active power P (±0.5% at +25°C) ±3.0% for reactive Q and apparent power S (±1% at +25°C) ±0.03 for power factor ±3.0% for energy
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz, ±50 mHz For 60 Hz, ±60 mHz
Average operating current, voltage and power		Average operating current, voltage, power as per selection: 5 min/10 min/15 min/1 hour/2 hours/24 hours
Peak current, voltage and power values		Peak values for 1 day, 1 week, 1 month, 1 year
General detection of the harmonics disturbances		• Current TDD (Total demand distortion) up to the 5th harmonics • Voltage THD (Total harmonic distortion) up to the 5th harmonics
Load flow direction		Forward/reverse
Non-directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: I_n ±1.5% of the set value Operate time: ±1.0% of the set value or ±20 ms
Directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: I_n Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2° Operate time: ±1.0% of the set value or ±20 ms

Table 11. Sensor input module (SIM8F), continued

Description		Value
Non-directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: I_n ±10% of the set value in range of 4...25 A ±1.5% of the set value in range of >25...1000 A Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)
Directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: I_n Current: • ±10% of the set value in range of 4...25 A • ±1.5% of the set value in range of >25...1000 A Voltage: ±1.5% of the set value Phase angle: ±3° Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)

Table 12. Binary inputs (Smart control module)

Description	SCM8H	SCM8L
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3...3.7 mA	2 mA
Power consumption/input channel	330...925 mW	30...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 13. High-speed outputs (Smart control module)

Description	SCM8H	SCM8L
Operating time	<1 ms	<1 ms
Rated voltage	110...250 V DC	24, 30, 48 and 60 V DC
Continuous current carry	20 A	20 A
Short time current carry	100 A for 10 ms	200 A for 10 ms

Table 14. Communication interface (Communication module LECM)

Connector	Cable	Data transfer	Maximum distance	Wave length	Permitted path attenuation[1]
RJ-45	S/N-elded twisted pair cable, at minimum CAT5e	10/100 Mbit/s	30 m	-	-
LC	Multimode 62.5/125 µm or 50/125 µm glass fibre core	100 Mbit/s	2 km	1310 nm	<8 dB

1) Maximum allowed attenuation caused by connectors and cable together

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Table 15. Degree of protection by enclosure

Description	Value
Degree of protection	IP20[1]

1) A higher IP class is required, the cabinet where the device is installed should provide proper protection.

Table 16. Environmental conditions

Description	Value
Operating temperature range	-25...+70°C
Relative humidity	<93%
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85°C

Table 17. Inspection of mechanical structure

Description	Reference	Result
Markings and mechanical structure	IEC 60255-1 and IEC 60255-27	OK
Enclosure class of the flush-mounted device	IEC 60529	IP 20
Clearances and creepage distances	IEC 60255-27	OK

Table 18. Overload test

Description	Reference	Result
Thermal withstand capability test	IEC 60255-1 and IEC 60255-27	OK

Table 19. Power supply module tests

Test	Type test value	Result
Operating range of auxiliary supply voltage test	85% and 120% of rated value for DC 85% and 110% of rated value for AC, frequency is between 50 Hz for -5% and 60 Hz for +5%	IEC 60255-1 and IEEE C37.90-2005
Power consumption of auxiliary supply • Quiescent load • Maximum load	<4 W <12 W	IEC 60255-1 and IEEE C37.90-2005
Reversal of DC power supply polarity	1 minute for each polarity	IEC60255-27
Start-up time test	<30 s	

Table 20. Contact tests

Description	Type test value	Reference
Make and carry	Signaling contacts • 5 A, continuous • 10 A for 3 s • 15 A for 0.5 s	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Breaking capacity for DC, L/R ≤40 ms	Signaling contacts • 48 V, 1.00 A • 110 V, 0.25 A • 220 V, 0.15 A	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Mechanical durability	10000 operations	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005

Table 21. Insulation tests

Description[1]	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min for communication 2.8 kV DC, 1 min 700 V DC, 1 min for communication	IEC 60255-27 and IEEE C37.90-2005
Impulse voltage tests	5 kV, 1.2/50 µs, 0.5 J	IEC 60255-27 and IEEE C37.90-2005
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27

1) Insulation tests are not applicable to SFP slot

Table 22. Electromagnetic compatibility and Immunity tests

Description	Type test value	Reference
Electrostatic discharge • Air discharge	 8 kV	IEC 60255-26 and IEC 61000-4-2, Level 3
Radio frequency electromagnetic field (amplitude modulated)	10 V/m (RMS) f = 80...1000 MHz and 1.4...2.7 GHz	IEC 60255-26 and IEC 61000-4-3, Level 3
Radio frequency electromagnetic field from digital radio telephones (pulse modulated)	10 V/m (RMS) f = 900 MHz, 1890 MHz	IEC 61000-4-3, Level 3
Power frequency (50 Hz) magnetic field • Continuous • 3 s	 100 A (RMS)/m 300 A (RMS)/m	IEC 60255-26 and IEC 61000-4-8
Pulsed magnetic field	1000 A/m; 6.4/16 µs TrTd; 5 pulses positive/negative; 10 s (fixed interval)	IEC 61000-4-9, Level 5
Conducted disturbance induced by radio frequency fields, Amplitude modulated	0.15...80 MHz - 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance 27 and 68 MHz (spot frequencies); 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance	IEC 60255-26 and IEC 61000-4-6, Level 3
Fast low-energy transient (EFT) (including functional earth port)	5/50 ns TrTd; 5 kHz repetition frequency 4 kV (peak) for power supply input/output ports and 2 kV (peak) for communication port	IEC 60255-26 and IEC 61000-4-4
Damped oscillatory waves (HFD) 100 kHz and 1 MHz burst • Power supply and input/output ports • Communication port	100 kHz and 1 MHz frequency; 75 ns Tr; 43 Hz and 400 Hz repetition frequency; 200 Ω source impedance Differential mode: 1 kV (peak) Common mode: 2.5 kV (peak) Differential mode: not applicable Common mode: 1 kV (peak)	IEC 60255-26 and IEC 61000-4-18
Slow high-energy transient (surge) 1.2/50 µs voltage pulse) • Auxiliary power supply and input/output ports[1] • Communication port	1.2/50 µs TrTh (open circuit) 8/20 µs TrTa (short circuit) ±4 kVp (L-Gnd) ±2 kVp (L-L) ±2 kVp (L-Gnd) while no L-L test is applicable	IEC 60255-26 and IEC 61000-4-5
Voltage dips, short interruptions and voltage variation immunity tests (AC 50 Hz and 60 Hz)	30% reduction for 25/30 cycles 60% reduction for 10/12 cycles 100% reduction for 0.5, 1.0, 2.5 and 5.0 cycles 100% reduction for 250/300 cycles	IEC 60255-26 and IEC 61000-4-11
Voltage dips, supply interruption and voltage variations on DC input power port (immunity tests)	30% reduction for 500 ms 60% reduction for 200 ms 100% reduction for 10, 20, 30 and 50 ms 100% reduction for 5 s	IEC 60255-26 and IEC 61000-4-29
Ripple voltage	15% U_n frequencies of ripple 100/120 Hz (for 50/60 Hz)	IEC 60255-26, IEC 61000-4-17 and IEEE C37.90-2005
Gradual shut-down/start-up test (for DC power supply) • Ramp towards shut-down • Wait at power off condition • Ramp towards start-up	 60 s 5 minutes 60 s	IEC 60255-26

Table 22. Electromagnetic compatibility and Immunity tests, continued

Description	Type test value	Reference
Power frequency voltage 50 Hz and 60 Hz input/output port • Differential mode • Common mode	 150 V (RMS) 150 Ω coupling resistor 0.1 µF coupling capacitor 300 V (RMS) 220 Ω coupling resistor 0.47 µF coupling capacitor	IEC 60255-26 and IEC 61000-4-16
Emission tests • Radiated 30...230 MHz 230...1000 MHz • Conducted 0.15...0.50 MHz 0.5...30 MHz	 <40 dB (µV/m) quasi-peak, measured at 10 m distance <47 dB (µV/m) quasi-peak, measured at 10 m distance <79 dB (µV) quasi-peak <66 dB (µV) average <73 dB (µV) quasi-peak <60 dB (µV) average	IEC 60255-26

1) When SFP is configured as a general I/O, the level associated is ±2 kVp (L-Gnd) and ±1 kVp (L-L)

Table 23. Electromagnetic compatibility and Immunity tests as per ANSI standards

Description	Type test value	Reference
1 MHz oscillatory SWC test	All ports: ±2.5 kV common mode/differential mode	IEEE C37.90.1-2002
Fast transient SWC test	All ports: ±4 kV common mode/differential mode	IEEE C37.90.1-2002
Radio frequency interference tests	20 V/m (prior to modulation) f = 80...1000 MHz (AM) f = 900 MHz (PM)	IEEE C37.90.2-2004
Electrostatic discharge test	±15 kV air discharge	IEEE C37.90.3-2001

000642
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Table 24. Mechanical tests

Description	Type test value	Reference
Vibration tests (sinusoidal)	Class 1	IEC 60255-21-1
• Vibration response test	f = 10...150 Hz Peak acceleration: 0.5 g 1 sweep cycle in each axis	
• Vibration endurance test	f = 10...150 Hz Peak acceleration: 1.0 g 20 sweep cycles in each axis	
Shock and Bump test	Class 1	IEC 60255-21-2
• Shock response test	Peak acceleration: 5 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Shock withstanding test	Peak acceleration: 15 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Bump test	Peak acceleration: 10 g Duration of the pulse: 16 ms Number of pulses in each direction: 1000	
Seismic test	Class 2	IEC 60255-21-3
• Nominal frequency range	1...35 Hz	
• Zero period acceleration	Horizontal direction: 2.0 gn Vertical direction: 1.0 gn	
• Number of time-histories in each axis	Single axis sine sweep	

Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +70°C	IEC 60068-2-2 and IEEE C37.90-2005
Dry cold test	• 96 h at -25°C • 16 h at -45°C	IEC 60068-2-1 and IEEE C37.90-2005
Damp heat cyclic test	• 6 cycles (12 h + 12 h) at +25...+55°C, humidity >93%	IEC 60068-2-30
Damp heat steady state test	• Temperature 40°C • Humidity 93% • Duration 56 h	IEC 60068-2-78 and IEEE C37.90-2005
Change of temperature test	• 5 cycles (3 h + 3 h) at -25...+55°C	IEC60068-2-14
Storage test	• 96 h at -40°C • 96 h at +85°C	IEC 60068-2-1, IEC 60068-2-2 and IEEE C37.90-2005

Table 26. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Table 27. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Functions available in SMSF

Table 28. Functions available in SMSF

Function	IEC 61850 Edition 1	IEC 61850 Edition 2	IEC 60617	IEC-ANSI
Measurement functions				
Three-phase current measurement	CMMXU	CMMXU	3I	3I
Three-phase voltage measurement	VMMXU	VMMXU	3U	3U
Residual current measurement	RESCMMXU	RESCMMXU	Io	Io
Residual voltage measurement	RESVMMXU	RESVMMXU	Uo	Uo
Three-phase power and energy measurement	PEMMXU	PEMMXU	P	P
Three-phase power direction	PWRRDIR	PWRRDIR	-	-
Energy monitoring	EMMTR	EMMTR	E	E
Current, voltage and power average and peak measurement	CMSTA	CAVMMXU CMAMMXU RCAVMMXU	-	-
	VMSTA	VAVMMXU VMAMMXU		
	PEMSTA	PEAVMMXU PEMAMMXU		
Power quality measurement functions (harmonics)				
Current total demand distortion monitoring	CMHAI	CMHAI	PQMSI	PQMSI
Voltage total demand distortion monitoring	VMHAI	VMHAI	PQMSU	PQMSV
Detection and indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3I>	51P
Three-phase directional overcurrent fault detection	DPHPTOC	DPHPTOC	3I>->	67P
Non-directional earth-fault fault detection	EFPTOC	EFPTOC	Io>	51N
Directional earth-fault fault detection	DEFPTOC	DEFPTOC	Io>->	67N
Multifrequency admittance-based earth-fault indication	MFAPSDE	MFAPSDE	Io->Y	67YN
Voltage presence indication	PHSVPR	PHSVPR	PHSVPR	PHSVPR

Table 29. CMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5% or ±1 A in the range of 4...50 A ±1% in the range of 50...4 000 A ±10% in the range of 4 000...8 000 A
Suppression of harmonics	RMS: No suppression

000643

Table 30. VMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5% in the range of 450 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV ±1% in the range of 28.8...48 kV
Suppression of harmonics	RMS: No suppression

Table 31. RESCMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5.0% (when all three phase currents in the range of 50...630 A)
Suppression of harmonics	RMS: No suppression

Table 32. RESVMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5.0% (when all three voltages are in the range of 9.6...14.4 kV or 19.2...28.8 kV)
Suppression of harmonics	RMS: No suppression

Table 33. PEMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 50...630 A Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71
	±1.0% for Active power P (±0.5% at +25°C) ±3.0% for Reactive Q and Apparent Power S (±1% at +25°C) ±0.03 for power factor
Suppression of harmonics	RMS: No suppression

Table 34. EMMTR Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 50...630 A Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71
	±3.0% for energy
Suppression of harmonics	RMS: No suppression

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Table 35. PHPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f = f_n ±1.5% of the set value
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 36. DPHPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the nominal frequency of the current measured: f = f_n Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2°
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 37. EFPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f = f_n ±10% of the set value in range of 4...25 A ±1.5% of the set value in range of 26...1500 A (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 38. DEFPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f = f_n Current: ±10% of the set value in range of 4...25 A ±1.5% of the set value in range of 26...1500 A Voltage: ±1.5% of the set value Phase angle: ±1° (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 39. MFAPSDE Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5% in the range of 450 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV
Operate time accuracy	±1.0% of the set value or ±50 mS

Table 40. PHSVPR Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5% in the range of 450 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV

7. Module dimensions

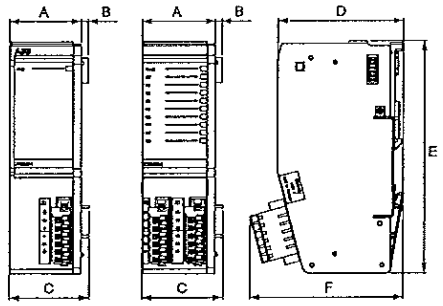

Figure 12. Dimension and mounting details of the PSUI/PSUL/DOM/BI/DOM/SL/RTD4/AOM4/SCM8/SCM/SL modules

A 48 mm
B 4.5 mm
C 51 mm
D 81 mm
E 148 mm
F 99 mm

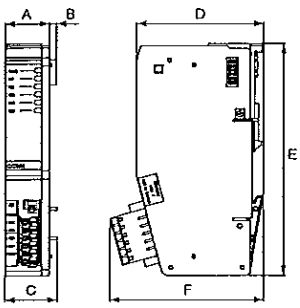

Figure 13. Dimension and mounting details of the digital output module DOM4

A 27.5 mm
B 4.5 mm
C 33 mm
D 81 mm
E 148 mm
F 99 mm

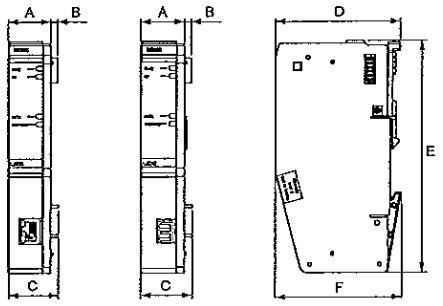

Figure 14. Dimension and mounting details of the communication module LEC4

A 27.5 mm
B 4.5 mm
C 33 mm
D 81 mm
E 148 mm
F 81 mm

000644

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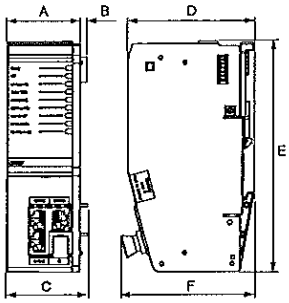

Figure 15. Dimension and mounting details of the SIM3F module

A 45 mm
B 4.25 mm
C 51 mm
D 81 mm
E 149.5 mm
F 85 mm

8. Assembly diagram

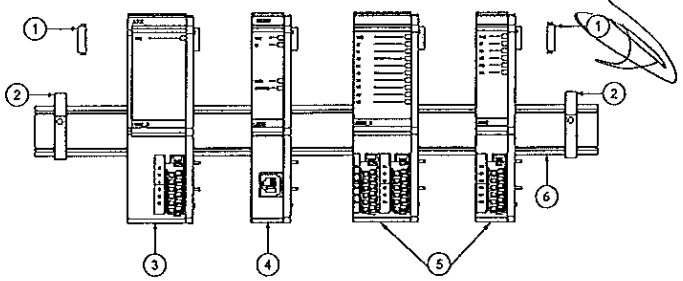

Figure 16. Assembly drawings of RIO600 modules

1 Rubber cap
2 End clamp
3 PSM module
4 LECM module
5 Modules (DIM/DOAM/RTD4/AOM4/SIM3F/SOM3H-SCM3L)
6 DIN Rail

The total width of the assembly can be calculated by adding together the length of all modules.

The width of the end clamp depends on the selected part. This mounting uses the Weidmuller part EW 35, which is 8.5 mm wide.

9. Ordering data

Table 41. Ordering details for RIO600 modules

Item	Order number
Digital input module with 8 inputs, high-voltage power supply	MOD600ADIM3H
Digital input module with 8 inputs, low-voltage power supply	MOD600ADIM3L
Digital output module with 4 outputs	MOD600ADOM4R
RTD/mA input module with 4 inputs	MOD600ARTD4
Analog output module with 4 outputs	MOD600AADM4
Sensor input module	MOD600ASIM3F
Smart control module with 4 inputs and 4 high-speed outputs, high-voltage power supply	MOD600ASCM3H
Smart control module with 4 inputs and 4 high-speed outputs, low-voltage power supply	MOD600ASCM3L
High-power supply module	MOD600APSM-H07
Low-power supply module	MOD600APSM-L07
Communication module with RJ-45 port	MOD600FLECM3R
Communication module with multimode fiber-optic LC port	MOD600BLECM3FO

10. Tools

The present status information of RIO600 can be viewed from the Web browser-based user interface (Web HMI) and the parameter setting values can be viewed or changed from the PCM600 tool in combination with the RIO600-specific connectivity package.

The Protection and Control IED Manager PCM600 with the RIO600 connectivity package is used for configuring RIO600 in the offline or online mode to connect to the other protection relays or substation gateways in the IEC 61850 station bus. When the Web browser-based user interface is used, RIO600 can be accessed remotely with a Web browser.

The RIO600 connectivity package is a collection of software tools with specific device information which enables system products and tools to connect and interact with RIO600. The connectivity packages supports system integration and engineering and its minimizing device configuration and setup time.

RIO600 parameters can be configures with Parameter Setting in PCM600. Internal and station communication based logics are engineered in graphical Application Configuration and in Signal Matrix. IEC 61850 peer-to-peer communication can be configured in PCM600 as well.

Table 42. Tools

Description	Version
PCM600	2.7 Hotfix 1 or later
Web browser	IE 9.0 or later
RIO600 Connectivity Package	1.7 or later

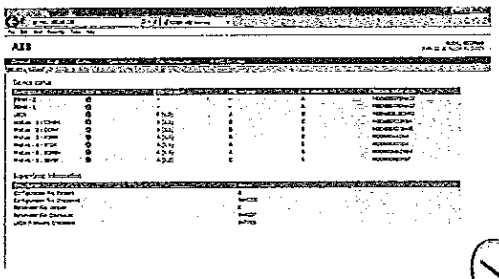

Figure 17. General view of RIO600 Web HMI

000645

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11. Connection and terminal diagrams

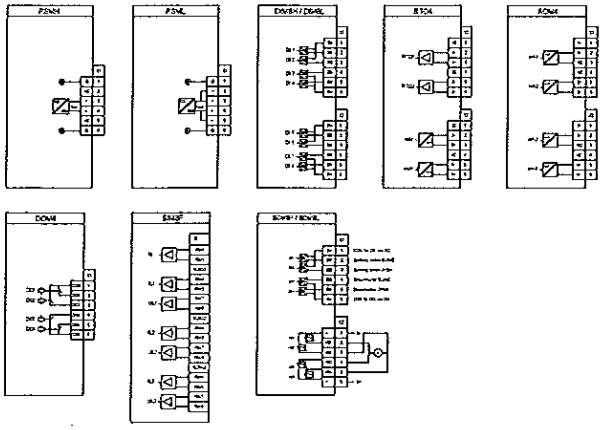

Figure 18. Connection and terminal diagram of RIO500 modules

12. Document revision history

Document revision/date	Product version	History
A/2011-12-23	1.0	First release
B/2012-12-18	1.1	Content updated
C/2013-09-30	1.2	Content updated
D/2014-09-29	1.5	Content updated
E/2015-08-31	1.6	Content updated
F/2016-06-09	1.7	Content updated

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за участие в открита процедура за възлагане на обществена поръчка с предмет:

„Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Зенит" от линеен ножов разединител 110 kV на ПС „Хаджи Димитър" до линеен ножов разединител 110 kV в ПС „Подуяне", реф. № РРС 17 – 169

Техническо предложение

Техническа документация

Приложение № 5 към Предложение за изпълнение на поръчката по т.15.5. от Техническото предложение – Заверени копия на документи за Цифров локален контролер за въводно поле 110 kV:

- Приложение № 5.2. към т.15.5.2. от Техническото предложение – Други по преценка на участника (декларации за съответствие, протоколи от типови изпитания и др.)

000647

1MRS757890

EU Declaration of Conformity

Issued	26.04.2013
Version	B/20.04.2016
Technical ref.	Mika Kortesniemi
Checked by	Asko Koiranen

Application of this document

This document is intended for use as an approval for CE-marking of below mentioned products:

Family of	620 series

Declaration

We ABB Oy, Medium Voltage Products, Distribution Automation
P.O. Box 699 FI-65101 Vaasa, FINLAND,
declare under our sole responsibility that the family:

Feeder Protection and Control	REF620
Motor Protection and Control	REM620
Transformer Protection and Control	RET620

to which this declaration relates is in conformity with the following directives:

Directives	EMC Directive 2014/30/EU Low Voltage Directive 2014/35/EU RoHS Directive 2011/65/EU
CE - marked	2013

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	EN 60255-26:	2013
	EN 61000-6-2:	2005
	EN 61000-6-4:	2007
	EN 60255-1:	2010
	EN 60255-27:	2013

Vaasa 20.04.2016

на основание чл. 2 от ЗЗЛД

Signed by: Antti Hakala-Ranta, SVP Medium Voltage Products

ABB Oy, Medium Voltage Products
Distribution Automation
P.O Box 699, FI-65101 Vaasa, FINLAND
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www.abb.com/substationautomation

000648

ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

1MRS758050

EU Declaration of Conformity

Issued	26.11.2013
Version	B/20.04.2016
Technical ref.	Jatin Parmar
Checked by	Janne Starck

Application of this document

This document is intended for use as an approval for CE-marking of below mentioned products:

Family of	RIO600

Declaration

We ABB Oy, Medium Voltage Products, Distribution Automation
P.O. Box 699 FI-65101 Vaasa, FINLAND,
declare under our sole responsibility that the family:

Remote I/O	RIO600

to which this declaration relates is in conformity with the following directives:

Directives	EMC Directive 2014/30/EU Low Voltage Directive 2014/35/EU
CE - marked	2013

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	EN 60255-26:	2013
	EN 61000-6-2:	2005
	EN 61000-6-4:	2007
	EN 60255-1:	2010
	EN 60255-27:	2013

Vaasa 20.04.2016

на основание чл. 2 от ЗЗЛД

Signed by:

Antti Hakala-Ranta, SVP Medium Voltage Products

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000649

ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

за участие в открита процедура за възлагане на обществена поръчка с предмет:

„Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Зенит" от линеен ножов разединител 110 kV на ПС „Хаджи Димитър" до линеен ножов разединител 110 kV в ПС „Подуяне", реф. № РРС 17 – 169

Техническо предложение

Техническа документация

Приложение № 6 към Предложение за изпълнение на поръчката по т.15.6. от Техническото предложение – Заверени копия на документи за Цифров локален контролер за трансформаторно присъединение 110 kV:

- Приложение № 6.1. към т.15.6.1. от Техническото предложение – Последно издание на каталога на производителя

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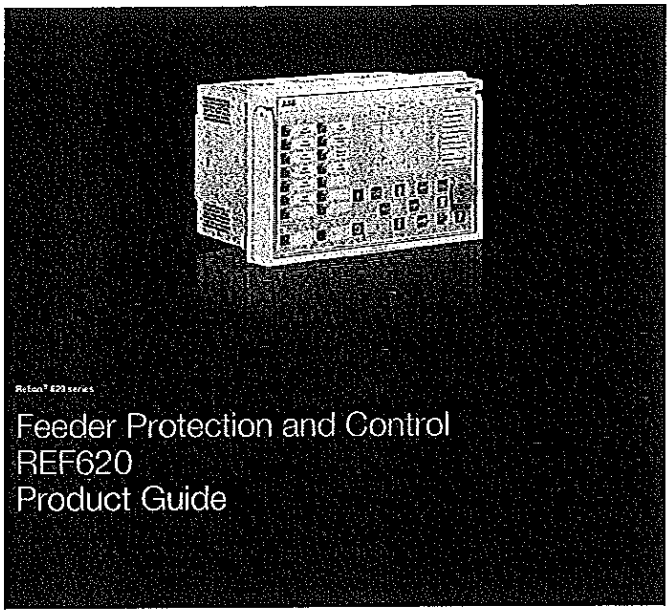

Relion® 620 series

Feeder Protection and Control REF620 Product Guide

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Contents

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Feeder Protection and Control	1MRS757844 E
REF620	
Product version: 2.0 FP1	Issued: 2015-12-11
	Revision: E

1. Description

REF620 is a dedicated feeder management relay perfectly aligned for the protection, control, measurement and supervision of utility and industrial power distribution systems, including radial, looped and meshed networks, with or without distributed power generation. REF620 can also be used to protect feeders including motors or capacitor banks. Additionally REF620 offers functionality for interconnection protection used with distributed generation like wind or solar power connection to utility grid. Furthermore REF620 includes functionality for high-impedance based busbar protection. REF620 is a member of ABB's Relion® protection and control product family and its 620 series. The 620 series relays are characterized by their functional scalability and withdrawable-unit design. The 620 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability of substation automation devices.

The 620 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.

series engineering with different function blocks. The default configurations are not aimed to be used as real end-user applications. The end-users always need to create their own application configuration with the configuration tool. However, the default configuration can be used as a starting point by modifying it according to the requirements.

REF620 is available in two alternative default configurations: configuration A with traditional current and voltage measurement transducers and configuration B with current and voltage sensors. Default configuration A with measurement transducers has more voltage measurements and I/Os than default configuration B. This gives more possibilities in applications supported by default configuration A. The default configuration can be altered by means of the graphical signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Furthermore, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions using various logical elements, including timers and flip-flops. By combining protection functions with logic function blocks, the relay configuration can be adapted to user-specific application requirements.

2. Default configurations

The 620 series relays are configured with default configurations, which can be used as examples of the 620

Feeder Protection and Control	1MRS757844 E
REF620	
Product version: 2.0 FP1	

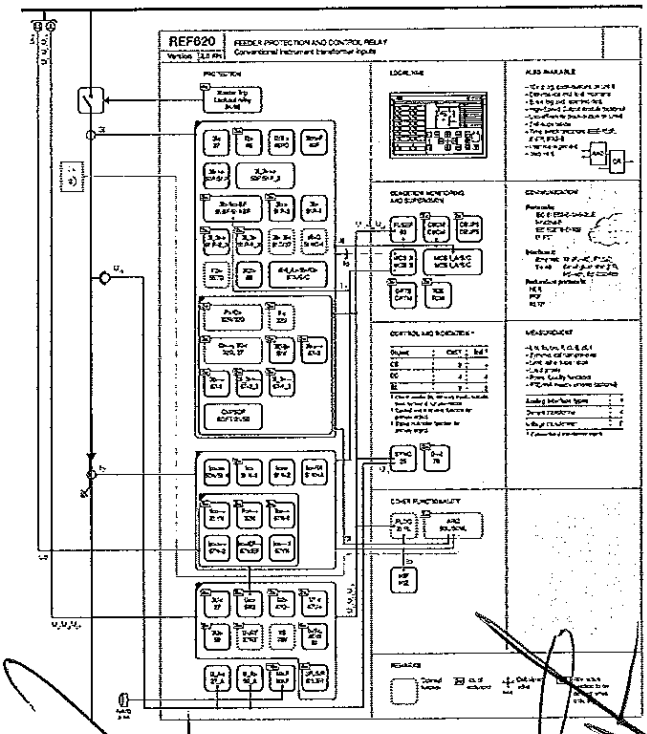

Figure 1. Functionality overview of default configuration with conventional instrument transformer inputs

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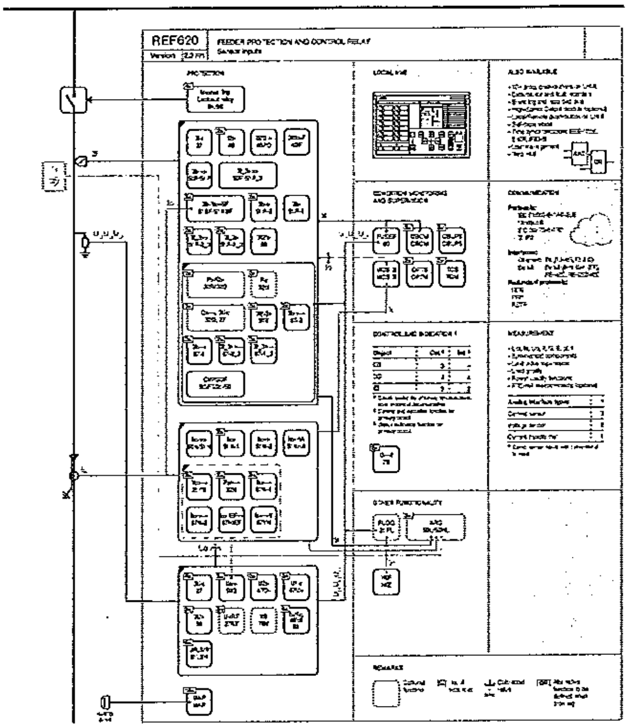

Figure 2. Functionality overview of default configuration with sensor inputs

Table 1. Supported functions

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1
Three-phase directional overcurrent protection, low stage	DPHLPDOC	2	2
Three-phase directional overcurrent protection, high stage	DPHHPDOC	2	2
Three-phase voltage-dependant overcurrent protection	PHPVOC	2	2
Non-directional earth-fault protection, low stage	EFLPTOC	2	2
Non-directional earth-fault protection, high stage	EFHPTOC	1	1
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	1	1
Directional earth-fault protection, low stage	DEFLPDEF	3	3[1]
Directional earth-fault protection, high stage	DEFHPDEF	1	1[1]
Admittance-based earth-fault protection	EFPADM	3	3[1]
Wattmetric-based earth-fault protection	WPWDE	3	3[1]
Multifrequency admittance-based earth-fault protection	MFADPSDE	1	1[1]
Transient/intermittent earth-fault protection	INTRPTEF	1	1[1]
Harmonics-based earth-fault protection	HAEFPTOC	1	1
Negative-sequence overcurrent protection	NSPTOC	2	2
Phase discontinuity protection	PDNSPTOC	1	1
Residual overvoltage protection	ROVPTOV	3	3[1]
Three-phase undervoltage protection	PHPTUV	4	4
Single-phase undervoltage protection, secondary side	PHAPTUV	1	
Three-phase overvoltage protection	PHPTOV	3	3
Single-phase overvoltage protection, secondary side	PHAPTOV	1	
Positive-sequence undervoltage protection	PSPTUV	2	2
Negative-sequence overvoltage protection	NSPTOV	2	2
Frequency protection	FRPFRQ	6	6
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	1	1
Loss of phase (undercurrent)	PHPTUC	1	1
Circuit breaker failure protection	CCBRBRF	3	3
Three-phase inrush detector	INRPHAR	1	1
Master trip	TRPPTRC	4	4
Arc protection	ARCSARC	(3)	(3)
High-impedance fault detection	PHIZ	1	1
Load-shedding and restoration	LSHDPFRQ	6	6
Multipurpose protection	MAPGAPC	18	18

Table 1. Supported functions, continued

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Automatic switch-onto-fault logic (SOF)	CVPSOF	1	1
Voltage vector shift protection	VVSPPAM	(1)	(1)
Directional reactive power undervoltage protection	DQPTUV	(2)	(2)
Underpower protection	DUPPDPR	(2)	(2)
Reverse power/directional overpower protection	DOPPDPR	(2)	(2)
Low-voltage ride-through protection	LVRTPTUV	(3)	(3)
High-impedance differential protection for phase A	HIAPDIF	1	
High-impedance differential protection for phase B	HIBPDIF	1	
High-impedance differential protection for phase C	HICPDIF	1	
Circuit breaker uncorresponding position start-up	UPCALH	3	3
Three-independent-phase non-directional overcurrent protection, low stage	PH3LPTOC	2	2
Three-independent-phase non-directional overcurrent protection, high stage	PH3HPTOC	2	2
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PH3IPTOC	1	1
Directional three-independent-phase directional overcurrent protection, low stage	DPH3LPDOC	2	2
Directional three-independent-phase directional overcurrent protection, high stage	DPH3HPDOC	2	2
Three-phase overload protection for shunt capacitor banks	COLPTOC	(1)	
Current unbalance protection for shunt capacitor banks	CUBPTOC	(1)	
Shunt capacitor bank switching resonance protection, current based	SRCPTOC	(1)	
Control			
Circuit-breaker control	CBXCBR	3	3
Disconnector control	DCXSWI	4	4
Earthing switch control	ESXSWI	3	3
Disconnector position indication	DCSXSWI	4	4
Earthing switch indication	ESSXSWI	3	3
Autoreclosing	DARREC	2	2
Synchronism and energizing check	SECRSYN	1	(1)[2]
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR	3	3
Trip circuit supervision	TCSSCBR	2	2
Current circuit supervision	CCSPVC	1	1
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC	1	
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC	1	

Table 1. Supported functions, continued

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC	1	
Fuse failure supervision	SEQSPVC	1	1
Runtime counter for machines and devices	MDSOPT	2	2
Measurement			
Three-phase current measurement	CMMXU	1	1
Sequence current measurement	CSMSQI	1	1
Residual current measurement	RESCMMXU	1	1
Three-phase voltage measurement	VMMXU	1	1
Single-phase voltage measurement	VAMMXU	1	(1)[2]
Residual voltage measurement	RESVMMXU	1	
Sequence voltage measurement	VSMSQI	1	1
Three-phase power and energy measurement	PEMMXU	1	1
Load profile record	LDPRLRC	1	1
Frequency measurement	FMMXU	1	1
Fault location			
Fault locator	SCEFRFLO	(1)	(1)
Power quality			
Current total demand distortion	CMHAI	1	1
Voltage total harmonic distortion	VMHAI	1	1
Voltage variation	PHQVVR	1	1
Voltage unbalance	VSQVUB	1	1
Other			
Minimum pulse timer (2 pcs)	TPGAPC	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	2	2
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	2	2
Pulse timer (8 pcs)	PTGAPC	2	2
Time delay off (8 pcs)	TOFGAPC	4	4
Time delay on (8 pcs)	TONGAPC	4	4
Set-reset (8 pcs)	SRGAPC	4	4
Move (8 pcs)	MVGAPC	4	4
Integer value move	MVI4GAPC	4	4
Analog value scaling	SCA4GAPC	4	4
Generic control point (16 pcs)	SPCGAPC	3	3
Remote generic control points	SPCRGAPC	1	1
Local generic control points	SPCLGAPC	1	1
Generic up-down counters	UDFCNT	12	12

000652

ВЯРНО С ОРИГИНАЛА

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Table 1. Supported functions, continued

Function	IEC 61850	A (CT/VT)	B (Sensors)
Programmable buttons (16 buttons)	FKEYGGIO	1	1
Logging functions			
Disturbance recorder	RDRE	1	1
Fault recorder	FLTRFRC	1	1
Sequence event recorder	SER	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.
O = optional

1) Uo is calculated from the measured phase voltages
2) Available only with IEC 61850-9-2 LE

3. Protection functions

The basic configurations available in REF620 consist of a wide range of protection functions making the protection relay suitable for various basic feeder applications. The relay offers directional and non-directional overcurrent and thermal overload protection as well as directional and non-directional earth-fault protection. Admittance-based, harmonics-based or wattmetric-based earth-fault protection can be used in addition to directional earth-fault protection. Furthermore, the relay features sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection, overvoltage and undervoltage protection, residual overvoltage protection, positive-sequence undervoltage protection and negative-sequence overvoltage protection. In addition, the relay offers frequency protection including overfrequency, underfrequency and frequency rate-of-change protection. The relay also incorporates three-pole multi-shot autoreclosing functions for overhead line feeders.

The standard content additionally includes multifrequency admittance-based earth-fault protection providing selective directional earth-fault protection for high-impedance earthed networks. The operation is based on multifrequency neutral admittance measurement utilizing fundamental frequency and harmonic components in Uo and Io.

ABB's continuous investments in research and a close cooperation with customers have resulted in the best earth-fault protection portfolio on the market. These functions are vital with different physical neutral groundings. In REF620, a special filtering algorithm enables dependable and secure fault direction also during intermittent/restriking earth faults. It provides a good combination of reliability and sensitivity of protection with a single function for low ohmic and higher ohmic earth faults and for transient and intermittent or restriking earth faults.

REF620 is also capable of protecting other applications than basic incoming or outgoing feeders. The relay includes high-impedance based busbar protection and measurement circuit supervision functions which enable the feeder relay to be used also for busbar protection. The relay includes an optional function package offering directional active and reactive power protection that enable the protected feeder to include also motors. Additionally, the optional package for capacitor bank protection includes functions for capacitor bank overload, unbalance and resonance protection enabling the protection of single star (wye) connected capacitor banks or double star (wye) connected capacitor banks with isolated or compensated neutral. Furthermore, the relay offers an optional protection package for interconnection protection providing function for low-voltage-ride-through, directional reactive power undervoltage protection (QU) and the voltage vector shift protection. This optional application package together with the relay's basic functionality can be used with distributed power generation like wind power or solar power generation to determine when to stay connected and when to disconnect distributed generation from the utility grid following different utility Grid Codes.

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

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

4. Application

REF620 provides feeder overcurrent and earth-fault protection for utility and industry distribution networks. The relay fits both isolated neutral networks and networks with resistance- or impedance-earthed neutrals. Furthermore, based on its advanced interstation communication facilities, the relay can also be applied for protecting ring type and meshed distribution networks as well as radial networks.

REF620 can be used with either single- or double-busbar configurations with one or two breakers, and with numerous switching device configurations. It supports a substantial number of both manually and motor-operated disconnectors and earthing switches, and it is capable of running large configurations. The number of controllable devices depends on the number of inputs and outputs left free from other application needs. The number of available I/Os can be increased with the RIO600 Remote I/O device.

The relay offers extensive possibilities to tailor the configurations to application requirements. The tool suite for all Relion relays is Protection and Control IED Manager PCM600, which contains all the necessary tools for configuring the device, including functionality, parameterization, the HMI and communication.

REF620 is an ideal protection and control relay for more advanced feeder schemes. To further improve the arc protection and to minimize the effects of an arc fault, the 620 series relays ordered with the arc protection option can be equipped with an I/O card featuring high-speed outputs operating in one millisecond.

The following figures demonstrate different application examples using relay's basic configuration. The configurations are modified by engineering functionality according to different application needs.

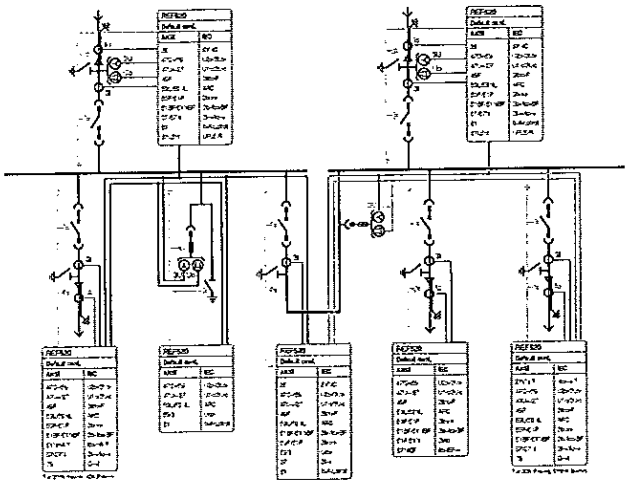

Figure 3. Single busbar AIS 2 section switchgear with conventional instrument transformers

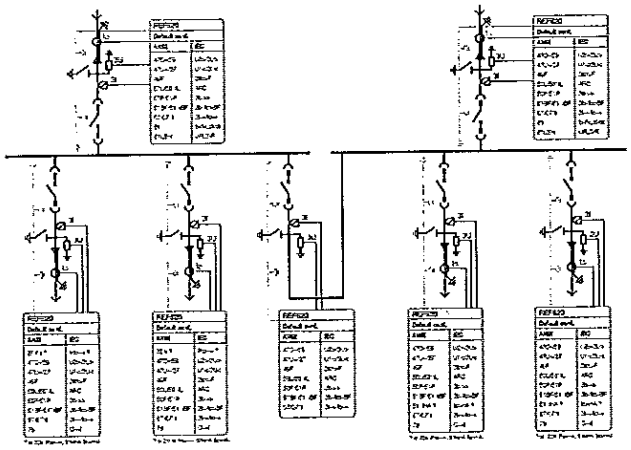

Figure 4. Single busbar AIS switchgear 2 section with sensors

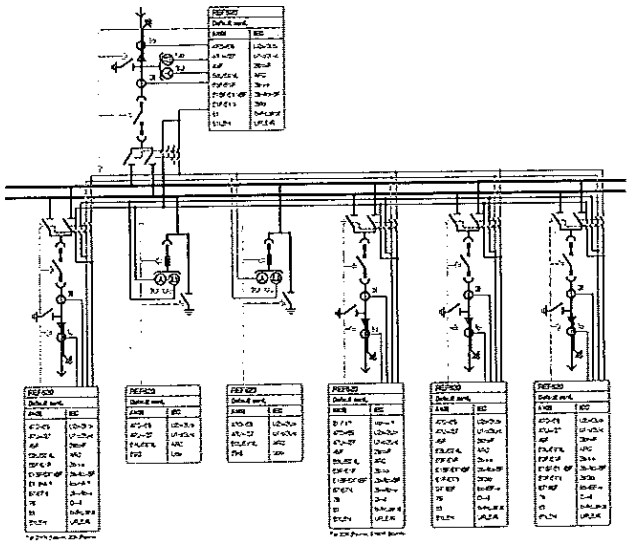

Figure 5. DSB AIS system with one incomer only (with some arrangements simplified)

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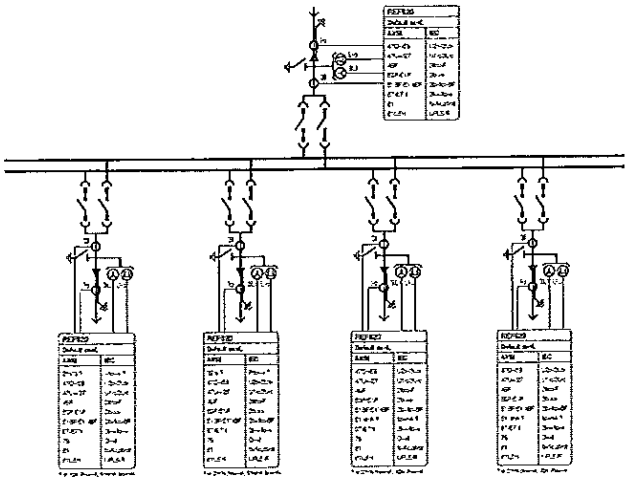

Figure 6. Back-to-back arrangement of AIS switchgear (two single-busbar panels with back walls facing each other), with two circuit breakers and a higher number of disconnectors available. A type of DBB system.

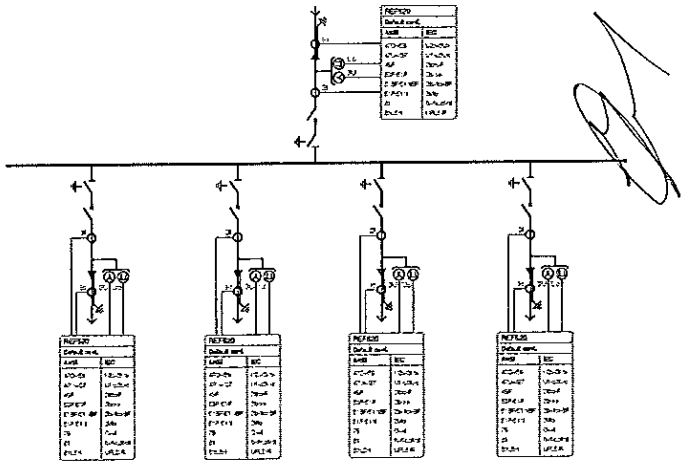

Figure 7. SBB GIS switchgear with the possibility to control the three-position disconnector switch

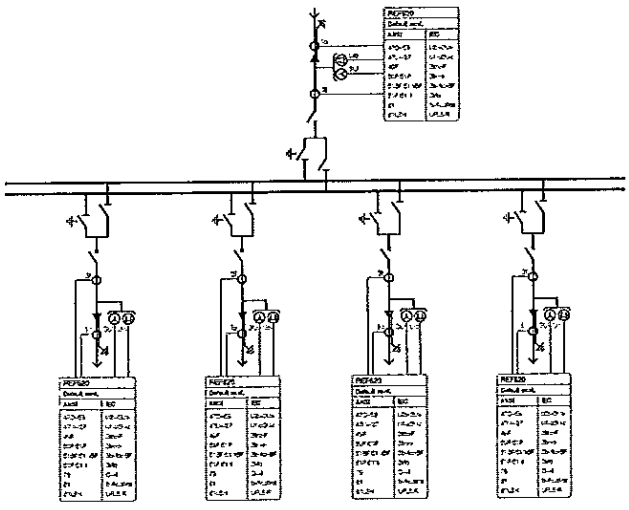

Figure 8. DBB GIS switchgear with the possibility to control the three-position disconnector switch

The following figures demonstrate the application function packages included in the relay. These packages offer new possibilities for several additional applications. The relay's basic functionality includes high-impedance based busbar differential protection functions. Thus, the relay can be engineered for busbar differential protection and by utilizing several relays, multizone differential protection schemes can also be created. The relay includes an optional protection package for capacitor bank protection and an optional protection package for interconnection protection for distributed power generation, for example, wind power. Furthermore, the relay includes an option for power protection. This package enhances the feeder relay capabilities to protect feeders including motors and includes also basic functionality to protect solar power generation connection to utility grid.

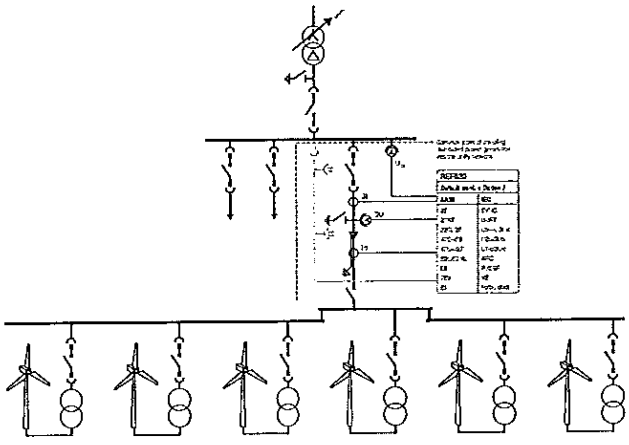

Figure 9. Application example of wind power plant as distributed power generation coupled into the utility network

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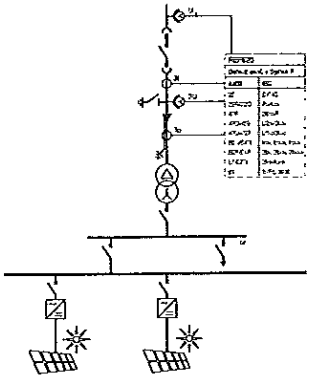

Figure 10. Application example of solar power plant as distributed power generation coupled into the utility network

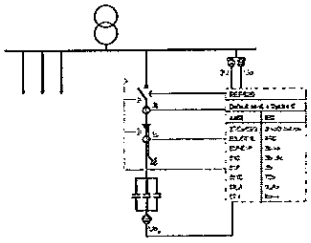

Figure 11. Protection of a single star connected capacitor bank

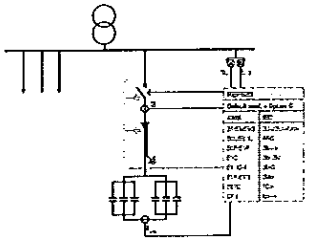

Figure 12. Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral

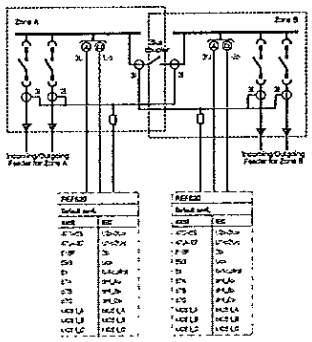

Figure 13. Application example of busbar differential protection covering two zones

5. Supported ABB solutions

ABB's 620 series protection and control relays together with the Substation Management Unit COM600 constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate and streamline the system engineering, ABB's 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 also includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with the Substation Management Unit COM600 or the network control and management system MicroSCADA Pro.

The 620 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 integrity of the protection and communication system, 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, COM600 uses the data content of the bay-level devices to enhance substation level functionality. COM600 features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The Web HMI of COM600 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, COM600 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 COM600. The history data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and history values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

COM600 can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems, such as MicroSCADA Pro and System 800xA.

Table 2. Supported ABB solutions

Product	Version
Substation Management Unit COM600	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

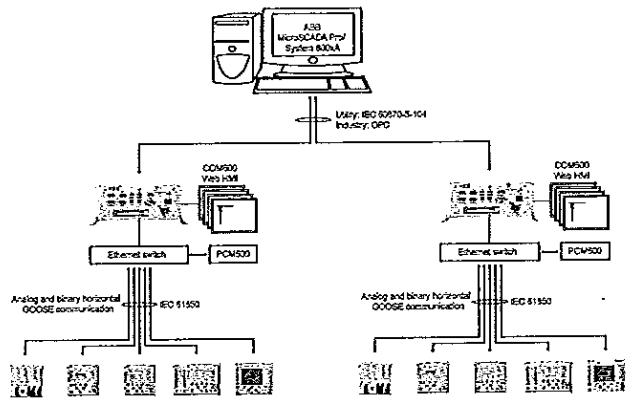

Figure 14. ABB power system example using Relion relays, Substation Management Unit COM600 and MicroSCADA Pro/System 800xA

6. Control

REF620 integrates functionality for the control of circuit breakers, disconnectors and earthing switches via the front panel HMI or by means of remote controls. The relay includes three circuit breaker control blocks. In addition to the circuit breaker control, the relay features four disconnector control blocks intended for the motor-operated control of disconnectors or circuit breaker truck. Furthermore, the relay offers three control blocks intended for the motor-operated control of earthing switch. On top of that, the relay includes additional four disconnector position indication blocks and three earthing switch position indication blocks usable with manually-only controlled disconnectors and earthing switches.

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 hardware configuration of the relay, the number of binary inputs and binary outputs varies. In case the amount of available binary inputs or outputs of the chosen hardware configuration is not sufficient, connecting an external input or output module, for example RIO600, to the relay can extend binary inputs and outputs utilizable in the relay configuration. 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.

The suitability of the binary outputs of the relay which have been selected for the 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 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 tools in PCM600.

Default configuration A incorporates a synchrocheck function to ensure that the voltage, phase angle and frequency on either side of an open circuit breaker satisfy the conditions for a safe interconnection of two networks. Synchrocheck function can also be used with default configuration B when IEC 61850-9-2 process bus

ОРИГИНАЛА
«КРАСИН» СМОЛЯН ООД
000655

is used. Compared to default configuration A, there are less physical voltage measurements available and thus the voltage measurements from the other side of the breaker have to be read through the 9-2 process bus. An autoreclosing function attempts to restore the power by reclosing the breaker with one to five programmable autoreclosing shots of desired type and duration. The function can be used with every circuit breaker that has the ability for a reclosing sequence. A load-shedding function is capable of performing load shedding based on underfrequency and the rate of change of the frequency.

7. Measurement

The relay continuously measures the phase currents and the neutral current. Furthermore, the relay measures the phase voltages and the residual voltage. In addition, the relay calculates the symmetrical components of the currents and voltages, the system frequency, the active and reactive power, the power factor, the active and reactive energy values as well as the demand value of current and power over a user-selectable preset time frame. Calculated values are also obtained from the protections and condition monitoring functions of the relay.

The values measured can be accessed locally via the user interface on the relay's front panel or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the Web browser-based user interface.

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

8. Power quality

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

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

The protection relay has the following power quality monitoring functions.

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

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

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

9. Fault location

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

10. Disturbance recorder

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

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

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

11. Event log

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

The sequence-of-events information can be accessed either locally via the user interface on the relay's front panel, or remotely via the communication interface of the relay. The information can also be accessed using the Web browser-based user interface, either locally or remotely.

12. Recorded data

The relay has the capacity to store the records of the 128 latest fault events. The records enable the user to analyze the power system events. Each record includes current, voltage and angle values, time stamp and so on. The fault recording can be triggered by the start signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. 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.

13. Condition monitoring

The condition monitoring functions of the relay constantly monitor the performance and the condition of the circuit breaker. The monitoring comprises the spring charging time, SF6 gas pressure, the travel time and the inactivity time of the circuit breaker.

The monitoring functions provide operational circuit breaker history data, which can be used for scheduling preventive circuit breaker maintenance.

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

14. Trip-circuit supervision

The trip-circuit supervision continuously monitors the availability and operability of the trip circuit. It provides open-circuit monitoring both when the circuit breaker is in its closed and in its open position. It also detects loss of circuit-breaker control voltage.

15. 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.

16. Fuse failure supervision

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

17. 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.

18. Access control

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

19. Inputs and outputs

REF620 can be selected to measure currents and voltages either with conventional current transducers and voltage transducers or with current sensors and voltage sensors. The relay variant with conventional transducers is equipped with three phase current inputs, one residual-current input, three phase voltage inputs, one residual-voltage input and one phase-to-phase voltage for synccheck input. In addition to current and voltage measurements, the relay's basic configuration includes 24 binary inputs and 14 binary outputs. The phase current inputs and the residual-current inputs are rated 1/5 A, that is, the inputs allow the connection of either 1 A or 5 A secondary current transformers. The optional sensitive 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 relay variant equipped with current and voltage sensors has three sensor inputs for the direct connection of three combisensors with RJ-45 connectors. As an alternative to the combisensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors. Additionally, the relay includes one conventional residual-current input 0.2/1 A normally used in applications requiring sensitive earth-fault protection and featuring core balance current transformers. In addition to current and voltage measurements, the relay's basic configuration includes 16 binary inputs and 14 binary outputs.

As an optional addition, the relay's basic configuration includes one empty slot which can be equipped with one of the following optional modules. The first option, additional binary inputs and outputs module, adds eight binary inputs and four binary outputs to the relay. This option is especially needed when connecting the relay to several controllable objects, still leaving room for additional inputs and outputs for other signals needed in configuration. The second option, an additional RTD/mA input module, increases the relay with six RTD inputs and two mA inputs when additional sensor measurements for example for temperatures, pressures, levels and so on are of interest. The third option is a high-speed output board including eight binary inputs and three high-speed outputs. The high-speed outputs have a shorter activation time compared to the conventional mechanical output relays, shortening the overall relay operation time by 4...8 ms with very time-critical applications like arc protection. The high-speed outputs are freely configurable in the relay application and not limited to arc protection only.

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 inputs and outputs contacts are freely configurable with the signal matrix or application configuration functionality of PCM600.

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

If the number of the relay's own inputs and outputs does not cover all the intended purposes, connecting to an external input or output module, for example RIO600, increases the number of binary inputs and outputs utilizable in the relay configuration. In this case, the external inputs and outputs are connected to the relay via IEC 61850 GOOSE to reach fast reaction times between the relay and RIO600 information. The needed binary input and output connections between the relay and RIO600 units can be configured in a PCM600 tool and then utilized in the relay configuration.

Table 3. Input/output overview

Default configuration	Order code digit		Analog channels			Binary channels			
	5-6	7-8	CT	VT	Combi sensor	BI	BO	RTD	mA
A	AA/AB	AA	4	5	-	32	4 PO + 14 SO	-	-
		AB				24	4 PO + 10 SO	6	2
		AC				32	4 PO + 10 SO + 3 HSO	-	-
		NN				24	4 PO + 10 SO	-	-
B	AC	AA	1	-	3	24	4 PO + 14 SO	-	-
		AB				16	4 PO + 10 SO	6	2
		AC				24	4 PO + 10 SO + 3 HSO	-	-
		NN				16	4 PO + 10 SO	-	-

20. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 1 and 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 620 series relays, having voltage based functions and 9-2 support. 620 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 protocols are able to overcome a failure of a link or switch with a zero switch-over time. In both 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.

000656

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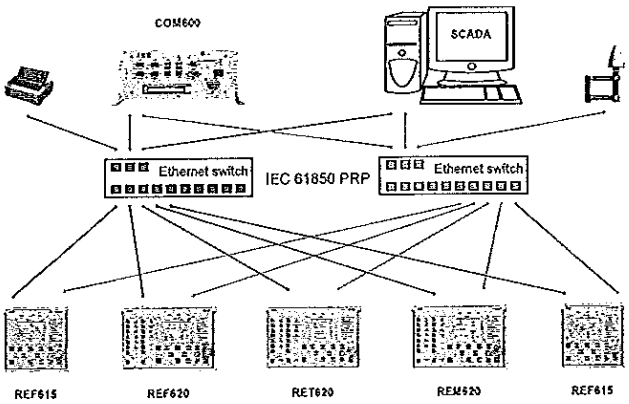

Figure 15. Parallel redundancy protocol (PRP) solution

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 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 620 series relays supports the connection of up to 30 relays. If more than 30 relays are connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

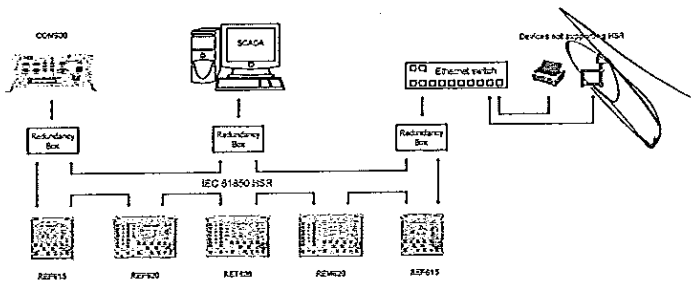

Figure 16. High availability seamless redundancy (HSR) solution

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 thirty 620 series relays. If more than 30 relays are 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.

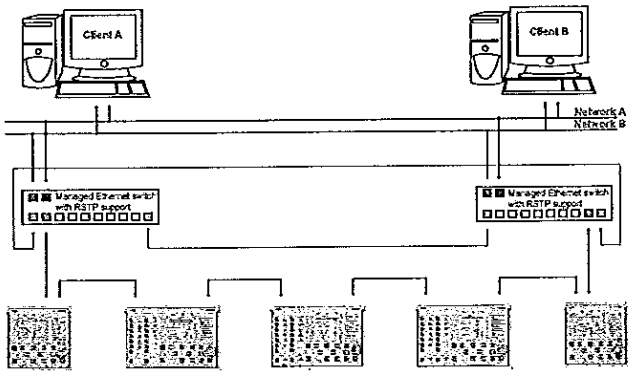

Figure 17. Self-healing Ethernet ring solution

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 a connection to the 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.

620 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)

000657

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

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

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

In addition, the relay supports time synchronization via Modbus, DNP3 and IEC 60870-5-103 serial communication protocols.

Table 4. 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

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21. Technical data

Table 5. Dimensions

Description	Value	
Width	Frame	252.2 mm
	Case	245 mm
Height	Frame	177 mm, 4U
	Case	160 mm
Depth		201 mm
Weight	Complete protection relay	max. 5.0 kg
	Plug-in unit only	max. 2.9 kg

Table 6. Power supply

Description	Type 1	Type 2
U_{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U_n rated	
U_{aux} variation	38...110% of U_n (38...264 V AC)	50...120% of U_n (12...72 V DC)
	80...120% of U_n (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	DC <15.0 W (nominal[1])/<22.5 W (max[2]) AC <19.0 W (nominal[1])/<23.0 W (max[2])	DC <15.5 W (nominal[1])/<22.5 W (max[2])
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

1) During the power consumption measurement, the relay is energized at rated auxiliary energizing voltage and the energizing quantities are energized without any binary output being active
2) During the power consumption measurement, the relay is energized at rated auxiliary energizing voltage and the energizing quantities are energized to activate at least half of the binary outputs

Table 7. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Current inputs	Rated current, I_n	0.2/1 A[1]	1/5 A[1]
	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...240 V AC	
	Voltage withstand:		
	• Continuous	240 V AC	
	• For 10 s	360 V AC	
	Burden at rated voltage	<0.05 VA	

1) Depending on the residual current input
2) Residual current from phase current

Table 8. Energizing inputs (sensors)

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

1) Equals the current range of 40...4000 A with a 80 A, 2 mV/A Rogowski
2) Depending on the used nominal current (hardware type)
3) The range is defined to be 2 times the sensor's rated voltage of 10...20 kV

Table 9. Binary inputs

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...570.0 mW
Threshold voltage	18...176 V DC
Reaction time	<3 ms

Table 10. RTD/mA measurement

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

Table 11. Signal output with high make and carry

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

1) X100: SO1
X105: SO1, SO2, when any of the protection relay is equipped with BIO0005
X110: SO1, SO2 when REF620 or REF630 is equipped with BIO0006
X110: SO1, SO2 when REF620 or REM620 is equipped with BIO0006

Table 12. Signal outputs and IRF output

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

1) X100: IRF, SO1
X105: SO1, SO2, when any of the protection relay is equipped with BIO0005
X110: SO1, SO2, when REF620 or REF630 is equipped with BIO0006
X110: SO1, SO2, when REF620 or REM620 is equipped with BIO0006

Table 13. Double-pole power outputs with TCS function X100: PO3 and PO4

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

1) PS1/X100: PO3, PS1/X100: PO3, PS1/X100: PO4 and PS1/X100: PO4

Table 14. Single-pole power output relays X100: PO1 and PO2

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

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Table 15. High-speed output HSO

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

1) HSO1, HSO2, HSO3, when two of the contacts are connected in parallel

Table 16. Front port Ethernet interfaces

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

Table 17. Station communication link, fiber optic

Connector	Fiber type [1]	Wave length	Typical max. length [2]	Permitted path attenuation [3]
LC	MM 62.5/125 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

1) Use multimode fiber with graded-index core
2) Maximum length is limited by the cable attenuation and quality, the amount of splices and connectors in the path
3) Maximum allowed attenuation caused by connectors and cable together

Table 18. IRIG-B

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

1) According to the 200-04 IRIG standard

Table 19. 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

Table 20. Degree of protection of flush-mounted protection relay

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

Table 21. Environmental conditions

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

1) Degradation in MTBF and HW parameters within the temperature range -40...-25°C and +55...+85°C
2) For relays with an LCD, the maximum operating temperature is +70°C

Table 22. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III IEEE C37.90.1-2002
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
• Contact discharge	6 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
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	
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	300 V rms	

Table 22. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
• Differential mode	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 60255-25 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	

Table 23. Insulation tests

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

Table 24. Mechanical tests

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

000659

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Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55°C • 16 h at +85°C[1]	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 • 96 h at +85°C	IEC 60068-2-1 IEC 60068-2-2

1) For relay with an LC communication interface the maximum operating temperature is +70°C

Table 26. Product safety

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

Table 27. EMC compliance

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

Table 28. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

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

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	PHLPTOC	±1.5% of the set value or ±0.002 × I_n		
	PHHPTOC and PHIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time[1][2]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	16 ms 11 ms	19 ms 12 ms	23 ms 14 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 × set *Start value*	23 ms	28 ms	33 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression P-to-P+backup: No suppression		

1) Fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

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

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

1) For further reference, see Operation characteristics table

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

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

1) Measurement mode and *Pol quantity* = default, current before fault = 0.5 × I_n, I_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value multiples* in range of 1.5...20

Table 32. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 × I_n	0.01
	DPHHPDOC	0.10...40.00 × I_n	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	40...200000 ms	10
Operating curve type[1]	DPHLPDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	1
Characteristic angle	DPHxPDOC	-179...180°	1

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

Table 33. Three-phase voltage-dependent overcurrent protection (PHPVOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Current: ±1.5% of the set value or ± 0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1][2]	Typically 26 ms
Reset time	Typically 43 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in inverse time mode	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = default, current before fault = 0.9 × I_n, I_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

000660

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Table 34. Three-phase voltage-dependent overcurrent protection (PHPVOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPVOC	0.05...5.00 × I_n	0.01
Start value low	PHPVOC	0.05...1.00 × I_n	0.01
Voltage high limit	PHPVOC	0.01...1.00 × U_n	0.01
Voltage low limit	PHPVOC	0.01...1.00 × U_n	0.01
Start value Mult	PHPVOC	0.8...15.0	0.1
Time multiplier	PHPVOC	0.05...15.00	0.01
Operating curve type[1]	PHPVOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	PHPVOC	40...200000 ms	10

1) For further information, see Operation characteristics table

Table 35. Non-directional earth-fault protection (EFLPTOC)

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

1) Measurement mode = default, operation in single-phase current before fault = 0.0 × I_n, I_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = 2.5 × I_n, Start value multiples in range of 1.5...20

Table 36. Non-directional earth-fault protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 × I_n	0.005
	EFHPTOC	0.10...40.00 × I_n	0.01
	EFIPTOC	1.00...40.00 × I_n	0.01
Time multiplier	EFLPTOC	0.05...15.00	0.01
	EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC	40...200000 ms	10
	EFHPTOC	40...200000 ms	10
	EFIPTOC	20...200000 ms	10
Operating curve type[1]	EFLPTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further information, see Operation characteristics table

Table 37. Directional earth-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	DEFLPDEF	Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time[1,2]		Minimum	Typical	Maximum
	DEFHPDEF I_{Fault} = 2 × set *Start value*	42 ms	45 ms	49 ms
	DEFLPDEF I_{Fault} = 2 × set *Start value*	58 ms	62 ms	66 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression		

1) Set Operate delay time = 0.06 s, Operate curve type = IEC definite time, measurement mode = default (depends on stage), current before fault = 0.0 × I_n, I_n = 50 Hz, fault current = 4.0 × set start value, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = 2.5 × I_n, Start value multiples in range of 1.5...20

Table 38. Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start value	DEFLPDEF	0.010...5.000 × I_n	0.005
	DEFHPDEF	0.10...40.00 × I_n	0.01
Directional mode	DEFxPDEF	1 = Non-directional 2 = Forward 3 = Reverse	-
Time multiplier	DEFLPDEF	0.05...15.00	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFLPDEF	60...200000 ms	10
	DEFHPDEF	40...200000 ms	10
Operating curve type[1]	DEFLPDEF	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or Inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFxPDEF	1 = Phase angle 2 = IoSin 3 = IoCos 4 = Phase angle 80 5 = Phase angle 88	-

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

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

Characteristic		Value		
Operation accuracy[1]		At the frequency $f = f_n$ ±1.0% or ±0.01 mS (in range of 0.5...100 mS)		
Start time[2]		Minimum	Typical	Maximum
		56 ms	60 ms	64 ms
Reset time		40 ms		
Operate time accuracy		±1.0% of the set value of ±20 ms		
Suppression of harmonics		-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) U_0 > 1.0 × U_{0n}
2) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

000661
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Table 40. Admittance-based earth-fault protection (EFPADM) main settings

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

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

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

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

Table 42. Wattmetric-based earth-fault protection (WPWDE) main settings

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

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

Table 43. Multifrequency admittance-based earth-fault protection (MFADPSDE)

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

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

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

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

Table 45. Transient/intermittent earth-fault protection (INTRPTEF)

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

Table 46. Transient/intermittent earth-fault protection (INTRPTEF) main settings

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

Table 47. Harmonics-based earth-fault protection (HAEFPTOC)

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

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

Table 48. Harmonics-based earth-fault protection (HAEFPTOC) main settings

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

1) For further reference, see Operating characteristics table

000662

Table 49. Negative-sequence overcurrent protection (NSPTOC)

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 [1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	23 ms 15 ms	26 ms 18 ms	28 ms 20 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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

Table 50. Negative-sequence overcurrent protection (NSPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 51. Phase discontinuity protection (PDNSPTOC)

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

Table 52. Phase discontinuity protection (PDNSPTOC) main settings

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

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Table 53. Residual overvoltage protection (ROVPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: $f_n \pm 2$ Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1,2]		Minimum	Typical	Maximum
	U_{Fault} = 2 × set *Start value*	49 ms	51 ms	54 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.99		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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

Table 54. Residual overvoltage protection (ROVPTOV) main settings

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

Table 55. Three-phase undervoltage protection (PHPTUV)

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

1) Start value = 1.0 × U_n, voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.99

Table 56. Three-phase undervoltage protection (PHPTUV) main settings

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

1) For further reference, see Operation characteristics table

Table 57. Single-phase undervoltage protection (PHAPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: $f_n \pm 2$ Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1,2]		Minimum	Typical	Maximum
	U_{Fault} = 0.9 × set *Start value*	64 ms	68 ms	71 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) Start value = 1.0 × U_n, voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.99 × U_n, *Start value* multiples in range of 0.90...0.99

Table 58. Single-phase undervoltage protection (PHAPTUV) main settings

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

1) For further reference, see Operation characteristics table

Table 59. Three-phase overvoltage protection (PHPTOV)

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

1) Start value = 1.0 × U_n, voltage before fault = 0.9 × U_n, f_n = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 1.01 × U_n, *Start value* multiples in range of 1.10...2.00

Table 60. Three-phase overvoltage protection (PHPTOV) main settings

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

1) For further reference, see Operation characteristics table

Table 61. Single-phase overvoltage protection (PHAPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: $f_n \pm 2$ Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1,2]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value*	25 ms	28 ms	32 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) Start value = 1.0 × U_n, voltage before fault = 0.9 × U_n, f_n = 50 Hz, overvoltage in one phase-to-phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 1.01 × U_n, *Start value* multiples in range of 1.10...2.00

Table 62. Single-phase overvoltage protection (PHAPTOV) main settings

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

1) For further reference, see Operation characteristics table

Table 63. Positive-sequence undervoltage protection (PSPTUV)

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

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

Table 64. Positive-sequence undervoltage protection (PSPTUV) main settings

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

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Table 65. Negative-sequence overvoltage protection (NSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value*	33 ms	35 ms	37 ms
	U_{Fault} = 2.0 × set *Start value*	24 ms	25 ms	23 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,...		

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

Table 66. Negative-sequence overvoltage protection (NSPTOV) main settings

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

Table 67. Frequency protection (FRPFRQ)

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

Table 68. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1 = Freq< 2 = Freq>>>br>3 = df/dt 4 = Freq< + df/dt 5 = Freq> + df/dt 6 = Freq< OR df/dt 7 = Freq> OR df/dt	-
Start value Freq>	FRPFRQ	0.9000...1.2000 × f_n	0.0001
Start value Freq<	FRPFRQ	0.8000...1.1000 × f_n	0.0001
Start value df/dt	FRPFRQ	-0.2000...0.2000 × f_n/s	0.0025
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 69. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)

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

1) Overload current > 1.2 × Operate level temperature

Table 70. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings

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

Table 71. Loss of phase, undercurrent (PHPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Start time	Typically <55 ms
Reset time	<40 ms
Reset ratio	Typically 1.04
Retardation time	<35 ms
Operate time accuracy in definite time mode	±0.0% of the set value or ±20 ms

Table 72. Phase undercurrent protection (PHPTUC) main settings

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

Table 73. Circuit breaker failure protection (CCBRBRF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Reset time[1]	Typically 40 ms
Retardation time	<20 ms

1) The pulse time depends on the minimum pulse length

Table 74. Circuit breaker failure protection (CCBRBRF) main settings

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

Table 75. Three-phase inrush detector (INRPHAR)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$ Current measurement: ±1.5% of the set value or ±0.002 × I_n Ratio I2/I1 measurement: ±5.0% of the set value
Reset time	+35 ms / -0 ms
Reset ratio	Typically 0.96
Operate time accuracy	+35 ms / -0 ms

Table 76. Three-phase inrush detector (INRPHAR) main settings

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

Table 77. Arc protection (ARCSARC)

Characteristic		Value		
Operation accuracy		±3% of the set value or ±0.01 × I_n		
Operate time		Minimum	Typical	Maximum
	Operation mode = "Light + current"[1][2]	9 ms[3] 4 ms[4]	12 ms[3] 6 ms[4]	15 ms[3] 9 ms[4]
	Operation mode = "Light only"[3]	9 ms[3] 4 ms[4]	10 ms[3] 6 ms[4]	12 ms[3] 7 ms[4]
Reset time		Typically 40 ms[3] <55 ms[4]		
Reset ratio		Typically 0.96		

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

Table 78. Arc protection (ARCSARC) main settings

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

Table 79. High-impedance fault protection (PHIZ) main settings

Parameter	Function	Value (Range)	Step
Security Level	PHIZ	1...10	1
System type	PHIZ	1 = Grounded 2 = Ungrounded	-

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Table 80. Load-shedding and restoration (LSHDPFRQ)

Characteristic		Value
Operation accuracy	f<	±10 mHz
	df/dt	±100 mHz/s (in range |df/dt| < 5 Hz/s) ± 2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f<	<80 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 81. Load-shedding and restoration (LSHDPFRQ) main settings

Parameter	Function	Value (Range)	Step
Load shed mode	LSHDPFRQ	1 = Freq< 5 = Freq< OR df/dt 6 = Freq< AND df/dt	-
Restore mode	LSHDPFRQ	1 = Disabled 2 = Auto 3 = Manual	-
Start value Freq	LSHDPFRQ	0.800...1.200 × f_n	0.001
Start value df/dt	LSHDPFRQ	-0.200...-0.005 × f_n	0.005
Operate Tm Freq	LSHDPFRQ	80...200000 ms	10
Operate Tm df/dt	LSHDPFRQ	120...200000 ms	10
Restore start Val	LSHDPFRQ	0.800...1.200 × f_n	0.001
Restore delay time	LSHDPFRQ	80...200000 ms	10

Table 82. Multipurpose protection (MAPGAPC)

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

Table 83. Multipurpose protection (MAPGAPC) main settings

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

Table 84. Automatic switch-onto-fault (CVPSOF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2Hz Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

Table 85. Automatic switch-onto-fault logic (CVPSOF) main settings

Parameter	Function	Value (Range)	Step
SOTF reset time	CVPSOF	0...60000 ms	10

Table 86. Voltage vector shift protection (VVSPPAM)

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

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

Table 87. Voltage vector shift protection (VVSPPAM) main settings

Parameter	Function	Value (Range)	Step
Start value	VVSPPAM	2.0...30.0°	0.1
Over Volt Blk value	VVSPPAM	0.43...1.50 × Un	0.01
Under Volt Blk value	VVSPPAM	0.15...1.00 × Un	0.01
Phase supervision	VVSPPAM	7 = Ph A + B + C 8 = Pos sequence	-

Table 88. Directional reactive power undervoltage protection (DQPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Reactive power range |PF| <0.71 Power: ±3.0% or ±0.002 × Q_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1][2]	Typically 46 ms
Reset time	<50 ms
Reset ratio	Typically 0.96
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Start value = 0.05 × S_n, reactive power before fault = 0.2 × Start value, reactive power overload 2 times, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 89. Directional reactive power undervoltage protection (DQPTUV) main settings

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

Table 90. Underpower protection (DUPPDPR)

Characteristic	Value
Operation accuracy[1]	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 1.04
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = "Pos Seq" (default)
2) U = U_n, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 91. Underpower protection (DUPPDPR) main settings

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

Table 92. Reverse power/directional overpower protection (DOPPDPR)

Characteristic	Value
Operation accuracy[1]	Depending on the frequency of the measured current and voltage: $f = f_n$ ±2 Hz Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 33 ms
Reset ratio	Typically 0.94
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = "Pos Seq" (default)
2) U = U_n, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 93. Reverse power/directional overpower protection (DOPPDPR) main settings

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

Table 94. Low-voltage ride-through protection (LVRTPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n
Start time[1][2]	Typically 40 ms
Reset time	Based on maximum value of *Recovery time* setting
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

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

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Table 95. Low-voltage ride-through protection (LVRTPTUV) main settings

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

Table 96. High-impedance differential protection (HIxPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
Start time[1][2]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start value*	12 ms	16 ms	24 ms
	I_{Fault} = 10 × set *Start value*	10 ms	12 ms	14 ms
Reset time		<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		

1) Measurement mode = default (depends on stage), current before fault = 0.0 × I_n, I_n = 50 Hz, fault current in one phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 97. High-impedance differential protection (HIxPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HIxPDIF	1.0...200.0 %I_n	1
Minimum operate time	HIxPDIF	20...300000 ms	10

Table 98. Circuit breaker uncorresponding position start-up (UPCALH)

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

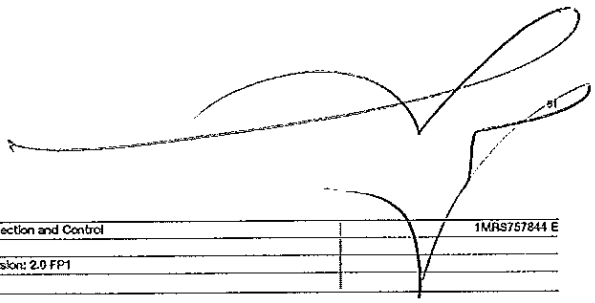

Table 99. Three-independent-phase non-directional overcurrent protection (PHIxPTOC)

Characteristic		Value		
Operation accuracy	PHIPTOC	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
	PHHPTOC and PHIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time[1][2]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 × set *Start value*	15 ms	18 ms	17 ms
	I_{Fault} = 10 × set *Start value*	11 ms	14 ms	17 ms
	PHHPTOC and PHIPTOC: I_{Fault} = 2 × set *Start value*	23 ms	25 ms	28 ms
Reset time		<40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression		

1) Measurement mode = default (depends on stage), current before fault = 0.0 × I_n, I_n = 50 Hz, fault current in one phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum start value = 2.5 × I_n, start value multiples in range of 1.5...20

Table 100. Three-independent-phase non-directional overcurrent protection (PHIxPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 101. Directional three-independent-phase directional overcurrent protection (DPHIxPDOC)

Characteristic		Value		
Operation accuracy	DPHILPDOC	Depending on the frequency of the current measured: f_n ±2 Hz Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DPHIHPDOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time[1][2]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value*	33 ms	40 ms	43 ms
Reset time		<40 ms		
Reset ratio		Typically 0.95		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression		

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

Table 102. Directional three-independent-phase directional overcurrent protection (DPHIxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHILPDOC	0.05...5.00 × I_n	0.01
	DPHIHPDOC	0.10...40.00 × I_n	0.01
Time multiplier	DPHIxPDOC	0.05...15.00	0.01
Operate delay time	DPHIxPDOC	40...200000 ms	10
Operating curve type[1]	DPHILPDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHIHPDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPHIxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHIxPDOC	-179...180°	1

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

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Table 103. Three-phase overload protection for shunt capacitor banks (COLPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_f ±2 Hz, and no harmonics
	5% of the set value or 0.002 × I_n
Start time for overload stage[1][2]	Typically 75 ms
Start time for under current stage[2][3]	Typically 25 ms
Reset time for overload and alarm stage	Typically 60 ms
Reset ratio	Typically 0.95
Operate time accuracy in definite time mode	1% of the set value or ±20 ms
Operate time accuracy in inverse time mode	10% of the theoretical value or ±20 ms
Suppression of harmonics for under current stage	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,...

1) Harmonic current before fault = 2.5 × I_n, harmonic fault current 3.5 × start value, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Harmonic current before fault = 1.2 × I_n, harmonic fault current 3.5 × start value, results based on statistical distribution of 1000 measurements

Table 104. Three-phase overload protection for shunt capacitor banks (COLPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value overload	COLPTOC	0.30...1.50 × I_b	0.01
Alarm start value	COLPTOC	50...125%	1
Start value Un Cur	COLPTOC	0.10...0.70 × I_b	0.01
Time multiplier	COLPTOC	0.05...2.00	0.01
Alarm delay time	COLPTOC	500...6000000	100
Un Cur delay time	COLPTOC	100...120000	100

Table 105. Current unbalance protection for shunt capacitor banks (CUBPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_f ±2 Hz
	1.5% of the set value or 0.002 × I_n
Start time[1][2]	Typically 25 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
Operate time accuracy in definite time mode	1% of the theoretical value or ±20 ms
Operate time accuracy in inverse definite minimum time mode	5% of the theoretical value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,...

1) Fundamental frequency current = 1.0 × I_n, current before fault = 0.0 × I_n, fault current = 2.0 × start value, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 106. Current unbalance protection for shunt capacitor banks (CUBPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm mode	CUBPTOC	1 = Normal 2 = Element counter	-
Start value	CUBPTOC	0.01...1.00 × I_b	0.01
Alarm start value	CUBPTOC	0.01...1.00 × I_n	0.01
Time multiplier	CUBPTOC	0.05...15.00	0.01
Operating curve type[1]	CUBPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	CUBPTOC	50...200000 ms	10
Alarm delay time	CUBPTOC	50...200000 ms	10

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

Table 107. Shunt capacitor bank switching resonance protection, current based (SRCPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_f ±2 Hz Operate value accuracy: ±3% of the set value or ±0.002 × I_n (for 2nd order Harmonics) ±1.5% of the set value or ±0.002 × I_n (for 3rd order < Harmonics < 10th order) ±5% of the set value or ±0.004 × I_n (for Harmonics >= 10th order)
Reset time	Typically 45 ms or maximum 60 ms
Retardation time	Typically 0.95
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = f_n

Table 108. Shunt capacitor bank switching resonance protection, current based (SRCPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm start value	SRCPTOC	0.03...0.50 × I_b	0.01
Start value	SRCPTOC	0.03...0.50 × I_b	0.01
Tuning harmonic Num	SRCPTOC	1...11	1
Operate delay time	SRCPTOC	120...360000 ms	1
Alarm delay time	SRCPTOC	120...360000 ms	1

Table 109. Operation characteristics

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

Control functions

Table 110. Autoreclosing (DARREC)

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

Table 111. Synchronism and energizing check (SECRSYN)

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

Table 112. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	-1 = Off 1 = Both Dead 2 = Live L, Dead B 3 = Dead L, Live B 4 = Dead B.a, L Any 5 = Dead L, B.a Any 6 = One Live, Dead 7 = Not Both Live	-
Difference voltage	SECRSYN	0.01...0.50 × U_n	0.01
Difference frequency	SECRSYN	0.001...0.100 × f_n	0.001
Difference angle	SECRSYN	5...90°	1
Synchrocheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	-
Dead line value	SECRSYN	0.1...0.8 × U_n	0.1
Live line value	SECRSYN	0.2...1.0 × U_n	0.1
Close pulse	SECRSYN	200...60000 ms	10
Max energizing V	SECRSYN	0.50...1.15 × U_n	0.01
Control mode	SECRSYN	1 = Continuous 2 = Command	-
Phase shift	SECRSYN	-180...180°	1
Minimum Syn time	SECRSYN	0...60000 ms	10
Maximum Syn time	SECRSYN	100...6000000 ms	10
Energizing time	SECRSYN	100...60000 ms	10
Closing time of CB	SECRSYN	40...250 ms	10

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000667

Condition monitoring and supervision functions

Table 113. Circuit-breaker condition monitoring (SSCBR)

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

Table 114. Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time [1]	<30 ms

1) Including the delay of the output contact

Table 115. Current circuit supervision (CCSPVC) main settings

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

Table 116. Current transformer supervision for high-impedance protection scheme (HZCCASPVC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Reset time	<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

Table 117. Fuse failure supervision (SEQSPVC)

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

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

Table 118. Runtime counter for machines and devices (MDSOPT)

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

1) Of the reading, for a constant load, without time synchronization

Measurement functions

Table 119. Three-phase current measurement (CMMXU)

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

Table 120. Sequence current measurement (CSMSQI)

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

Table 121. Residual current measurement (RESCMMXU)

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

Table 122. Three-phase voltage measurement (VMMXU)

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

Table 123. Single-phase voltage measurement (VAMMXU)

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

Table 124. Residual voltage measurement (RESVMMXU)

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

Table 125. Sequence voltage measurement (VSMSQI)

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

Table 126. Three-phase power and energy measurement (PEMMXU)

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

1) |PF| >0.5 when |I| >0.5
2) |PF| <0.86 when |I| >0.5

Table 127. Frequency measurement (FMMXU)

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

000668
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Fault location functions

Table 128. Fault locator (SCEFRFLO)

Characteristic	Value
Measurement accuracy	At the frequency f = f$_n$ Impedance: ±2.5% or ±0.25 Ω Distance: ±2.5% or ±0.16 km/0.1 mile XCOF_CALC: ±2.5% or ±50 Ω IFLT_PER_ILO: ±5% or ±0.05

Table 129. Fault locator (SCEFRFLO) main settings

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

Power quality functions

Table 130. Voltage variation (PHQVVR)

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

Table 131. Voltage variation (PHQVVR) main settings

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

Table 132. Voltage unbalance (VSQVUB)

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

Table 133. Voltage unbalance (VSQVUB) main settings

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

Other functions

Table 134. Pulse timer (PTGAPC)

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

Table 135. Time delay off (8 pcs) (TOFPAOC)

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

Table 136. Time delay on (8 pcs) (TONGAPC)

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

22. Local HMI

The relay supports process information and status monitoring from the relay's local HMI via its display and indication/alarm LEDs. The local LHMI also enables control operations for the equipment connected and controlled by the relay, either via display or via manual push buttons available on the local HMI.

LCD display offers front-panel user interface functionality with menu navigation and menu views. In addition, the display includes a user-configurable two-page single-line diagram (SLD) with a position indication for the associated primary equipment and primary measurements from the process. The SLD can be modified according to user requirements by using Graphical Display Editor in PCM600.

The local HMI also includes 11 programmable LEDs. These LEDs can be configured to show alarms and indications as needed by PCM600 graphical configuration tool. The LEDs include two separately controllable colors, red and green, making one LED able to indicate better the different states of the monitored object.

The relay also includes 18 configurable manual push buttons, which can freely be configured by the PCM600 graphical configuration tool. These buttons can be configured to control the relay's internal features for example changing setting group, trigger disturbance recordings and changing operation modes for functions or to control relay's external equipment, for example opening or closing the equipment, via relay's binary outputs. These buttons also include a small indication LED for each button. This LED is freely configurable, making it possible to use push button LEDs to indicate button activities or as additional indication/alarm LEDs in addition to the 11 programmable LEDs.

The local HMI includes a push button (L/R) for the local/remote operation of the relay. When the relay is in the local mode, the relay can be operated only by using the local front-panel user interface. When the relay is in the remote mode, the relay can execute commands sent remotely. 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 the relays are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.

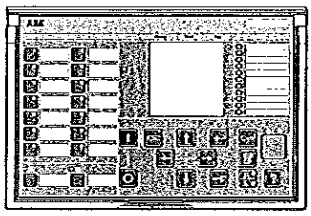

Figure 18. Example of the LHMI

23. Mounting methods

By means of appropriate mounting accessories the standard relay case can be flush mounted, semi-flush mounted or wall mounted.

Further, the relays can be mounted in any standard 19" instrument cabinet by means of 19" mounting panels available with cut-outs for one relay. Alternatively, the relay can be mounted in 19" instrument cabinets by means of 4U Combiflex equipment frames.

For the routine testing purposes, the relay cases can be equipped with test switches, type RTXP 24, which can be mounted side by side with the relay cases.

Mounting methods

- Flush mounting
- Semi-flush mounting
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame
- Mounting with a RTXP 24 test switch to a 19" rack

Panel cut-out for flush mounting

- Height: 162 ±1 mm
- Width: 243 ±1 mm

000669
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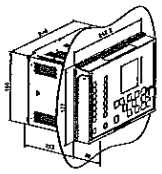

Figure 19. Flush mounting

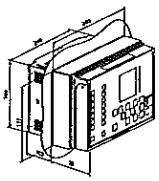

Figure 20. Semi-flush mounting

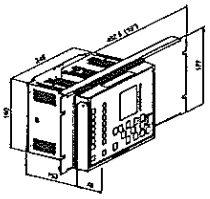

Figure 21. Rack mounting

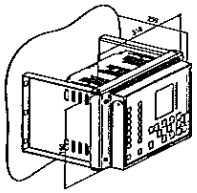

Figure 22. Wall mounting

24. Relay case and plug-in unit

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

25. Selection and ordering data

The relay type and serial number label identifies the protection and control relay. The label is placed above the HMI on the upper part of the plug-in unit. An order code label is placed on the side of the plug-in unit as well as inside the case. The order code consists of a string of letters and digits generated from the relay's hardware and software modules.

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.

#	Description	
1	IED	
	620 series IED (including case)	N
	Complete Relay with conformal coating	S
2	Standard	
	IEC	B
	ANSI	C
3	Main application	
	Feeder protection and control	F
4	Functional application	
	Complete configuration	N
5-6	Analog inputs and outputs	
	4 (I, 1/5 A) + 5 (U, 100/200 V) + 1 (Io, 1/5 A) + 4 (U, 100/200 V)	AA
	4 (I, 0.2/1 A) + 5 (U, 100/200 V) + 1 (Io, 0.2/1 A) + 4 (U, 100/200 V)	AB
	Sensors (3 (I, 0.1/0.2 A) + 1 (U, 100/200 V) + 1 (Io, 0.1/0.2 A) + 4 (U, 100/200 V)	AC
7-8	Optional board	
	Optional I/Os (8 RTDs + 4 mA)	AA
	Optional RTDs (6 RTD in + 2 mA in)	AB
	Optional Fast I/Os (8 + 3 + 5 O)	AC
	No optional board	NN

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#	Communication (Serial/Ethernet)	
10	Serial RS 485, incl. an input for IRIG-B + Ethernet 100Base FX (1xLC)	AA
	Serial RS 485, incl. an input for IRIG-B + Ethernet 100Base TX (1xRJ45)	AB
	Serial RS 485, incl. an input for IRIG-B	AN
	Serial glass fibre (ST) + Ethernet 100Base TX (1xRJ45) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for IRIG-B (cannot be combined with arc protection)	BR
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP	BC
	Serial glass fibre (ST) + Ethernet 100Base TX (2xRJ45) with HSR/PRP	BD
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP	BE
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP and IEC61850-9-2LE	BF
	Serial glass fibre (ST) + Ethernet 100Base TX (3xRJ45) with HSR/PRP and IEC61850-9-2LE	BG
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP and IEC61850-9-2LE	BH
	Serial glass fibre (ST) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for IRIG-B (cannot be combined with arc protection)	BN
	RS 232/485 (including IRIG-B) + Ethernet 100Base TX (1xRJ45) (cannot be combined with arc protection)	CB
	RS 232/485 + RS 485/Fiber ST (including IRIG-B) (cannot be combined with arc protection)	CN
	Ethernet 100Base FX (1xLC)	NA
	Ethernet 100Base TX (1xRJ45)	ND
	Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP	NF
	Ethernet 100Base TX (2xRJ45) with HSR/PRP	NG
	Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP	NE
	Ethernet 100Base TX and FX (1xLC, 2xRJ45) with HSR/PRP and IEC61850-9-2LE	NF
	Ethernet 100Base TX (3xRJ45) with IEC61850-8-1 and IEC61850-9-2LE	NG
	Ethernet 100Base TX and FX (2xLC, 1xRJ45) with HSR/PRP and IEC61850-9-2LE	NH
	No communication module	NN

If serial communication is chosen, please choose a serial communication module including Ethernet (for example "BC") if a service bus for PCM600 or the WebHMI is required.

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#	Description	
11	Communication protocols	
	IEC 61850 (for Ethernet communication modules and IEDs without a communication module)	A
	Modbus (for Ethernet/serial or Ethernet + serial communication modules)	B
	IEC 61850 + Modbus (for Ethernet or serial + Ethernet communication modules)	C
	IEC 60870-5-103 (for serial or Ethernet + serial communication modules)	D
	DNP3 (for Ethernet/serial or Ethernet + serial communication modules)	F
	IEC 61850 + IEC 60870-5-103 (for serial + Ethernet communication modules)	G
	IEC 61850 + DNP3 (for Ethernet or serial + Ethernet communication modules)	H
12	Language	
	English	1
	English and Chinese	2
13	Front panel	
	Large LCD with Single Line Diagram - IEC	B
	Large LCD with Single Line Diagram - ANSI	D
14	Option 1	
	Arc protection (requires a communication module, cannot be combined with com. module options DN, DD, CD and CN)	B
	None	N
15	Option 2	
	Fault locator	F
	Capacitor bank protection package	C
	Interconnection/Distributed generation protection package	D
	Power protection package	P
	All options (Fault locator + Capacitor bank protection + Interconnection/Distributed generation protection + Power protection)	L
	None	N
16	Power supply	
	Power supply 48-250 VDC, 100-240 VAC	1
	Power supply 24-60 VDC	2
17	Reserved	
18	Product version 2.0 FP1	1

NBFNAANNABC1BNN11G

000679
ВЗЯТО С ОРИГИНАЛА
"КРАСИН" СМОЛЯН ООД

Example code: NBFNAANNABC1BNN11G

Your ordering code:

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

Figure 23. Ordering key for complete protection relays

28. Accessories and ordering data

Table 137. Cables

Item	Order number
Cable for optical sensors for arc protection 1.5 m	1MRS120534-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS120534-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS120534-5.0

Table 138. Mounting accessories

Item	Order number
Semi-flush mounting kit	2RCA035673A0001
Wall mounting kit	2RCA035694A0001
19" rack mounting kit with cut-out for one relay	2RCA031155A0001
19" rack mounting kit for one relay and one RTXP24 test switch (the test switch and wire harness are not included in the delivery)	2RCA032318A0001
Mounting bracket for one relay with test switch RTXP in 4U Combiflex (RHGT 19" variant C) (the test switch, wire harness and Combiflex RGHT 19" variant C are not included in the delivery)	2RCA032320A0001
Functional earthing flange for RTD modules	2RCA036978A0001 1)

1) Cannot be used when the IED is mounted with the Combiflex 19" equipment frame (2RCA025854A0001).

27. Tools

The protection relay is delivered as a pre-configured unit including the example configuration. The default parameter setting values can be changed from the front-panel user interface, the Web browser-based user interface (Web HMI) or the PCM600 tool in combination with the relay-specific connectivity package.

The Protection and Control IED Manager PCM600 offers extensive relay configuration functions such as relay signal configuration, application configuration, graphical display configuration including single line diagram configuration, and IEC 61850 communication configuration including horizontal GOOSE communication.

When the Web browser-based user interface is used, the protection relay can be accessed either locally or remotely using a Web browser (Internet Explorer). For security reasons, the Web browser-based user interface is disabled by default but it can be enabled via the front-panel user interface. 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 139. Tools

Configuration and setting tools	Version
PCM600	2.6 (RollUp 20150626) or later
Web browser-based user interface	IE 8.0, IE 9.0, IE 10.0 or IE 11.0
REF620 Connectivity Package	2.1 or later

Table 140. Supported functions

Function	Web HMI	PCM600
Relay parameter setting	•	•
Saving of relay parameter settings in the relay	•	•
Signal monitoring	•	•
Disturbance recorder handling	•	•
Alarm LED viewing	•	•
Access control management	•	•
Relay signal configuration (Signal Matrix)	-	•
Modbus® communication configuration (communication management)	-	•
DNP3 communication configuration (communication management)	-	•
IEC 60870-5-103 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

28. Cyber security

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

29. Connection diagrams

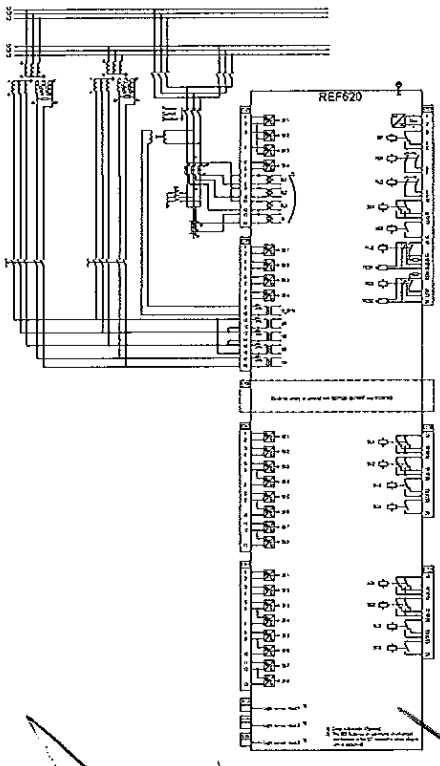

Figure 24. Connection diagram for the configuration with CTs and VTs

000671

ВЕРНО С ОРИГИНАЛА

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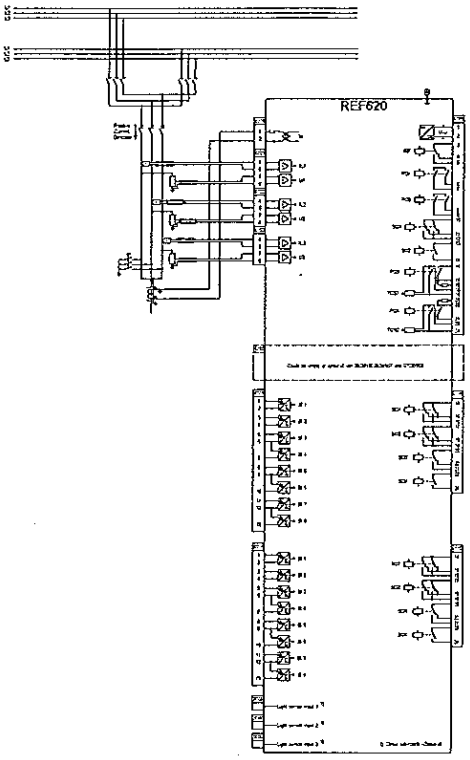

Figure 25. Connection diagram for the configuration with sensors

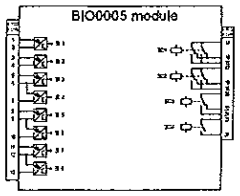

Figure 26. Optional BIO0005 module (slot X105)

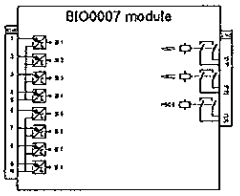

Figure 27. Optional BIO0007 module for fast outputs (slot X105)

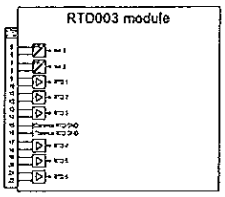

Figure 28. Optional RTD0003 module (slot X105)

30. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Relion® 620 series. Certificate number: 74108008-OPEANC 15-2319.

DNV GL has issued an IEC 61850 Edition 1 Certificate Level A1 for Relion® 620 series. Certificate number: 74108008-OPEANC 15-2323.

Additional certificates can be found on the product page.

31. 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 REF620 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

32. Functions, codes and symbols

Table 141. Functions included in the relay

Function	IEC 61850	IEC 60617	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)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3I> -> (1)	67-1 (1)
	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> -> (1)	67-2 (1)
	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Three-phase voltage-dependent overcurrent protection	PHPVOC1	3I(U)> (1)	51V (1)
	PHPVOC2	3I(U)> (2)	51V (2)
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance-based earth-fault protection	EFPADM1	Yo> -> (1)	21YN (1)
	EFPADM2	Yo> -> (2)	21YN (2)
	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric-based earth-fault protection	WPWDE1	Po> -> (1)	32N (1)
	WPWDE2	Po> -> (2)	32N (2)
	WPWDE3	Po> -> (3)	32N (3)
Multifrequency admittance-based earth-fault protection	MFADPSDE1	Io> -> Y (1)	67YN (1)
Transient/intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonics-based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)

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000672

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
	PHPTUV4	3U< (4)	27 (4)
Single-phase undervoltage protection, secondary side	PHAPTUV1	U_A< (1)	27_A (1)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Single-phase overvoltage protection, secondary side	PHAPTOV1	U_A> (1)	59_A (1)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
	NSPTOV2	U2> (2)	47O- (2)
Frequency protection	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	TPTTR1	3Ith>F (1)	49F (1)
Loss of phase (undercurrent)	PHPTUC1	3I< (1)	37 (1)
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
	CCBRBRF3	3I>/Io>BF (3)	51BF/51NBF (3)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (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)
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)
High-impedance fault detection	PHIZ1	HIF (1)	HIZ (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Load-shedding and restoration	LSHDFFRQ1	UFLS/R (1)	81LSH (1)
	LSHDFFRQ2	UFLS/R (2)	81LSH (2)
	LSHDFFRQ3	UFLS/R (3)	81LSH (3)
	LSHDFFRQ4	UFLS/R (4)	81LSH (4)
	LSHDFFRQ5	UFLS/R (5)	81LSH (5)
	LSHDFFRQ6	UFLS/R (6)	81LSH (6)
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)
	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)
Automatic switch-onto-fault logic (SOF)	CVPSOF1	CVPSOF (1)	SOFT/21/50 (1)
Voltage vector shift protection	VVSPPAM1	VS (1)	78V (1)
Directional reactive power undervoltage protection	DQPTUV1	Q> -> ,3U< (1)	32Q,27 (1)
	DQPTUV2	Q> -> ,3U< (2)	32Q,27 (2)
Underpower protection	DUPPDPR1	P< (1)	32U (1)
	DUPPDPR2	P< (2)	32U (2)
Reverse power/directional overpower protection	DOPPDPR1	P>/Q> (1)	32R/32O (1)
	DOPPDPR2	P>/Q> (2)	32R/32O (2)
Low voltage ride-through protection	LVRTPTUV1	U<RT (1)	27RT (1)
	LVRTPTUV2	U<RT (2)	27RT (2)
	LVRTPTUV3	U<RT (3)	27RT (3)
High-impedance differential protection for phase A	HIAPDIF1	dHi_A> (1)	87A (1)
High-impedance differential protection for phase B	HIBPDIF1	dHi_B> (1)	87B (1)
High-impedance differential protection for phase C	HICPDIF1	dHi_C> (1)	87C (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Circuit breaker uncommanded position start-up	UPCALH1	CBUPS (1)	CBUPS (1)
	UPCALH2	CBUPS (2)	CBUPS (2)
	UPCALH3	CBUPS (3)	CBUPS (3)
Three-independent-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I_3> (1)	51P-1_3 (1)
	PHLPTOC2	3I_3> (2)	51P-1_3 (2)
Three-independent-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I_3>> (1)	51P-2_3 (1)
	PHHPTOC2	3I_3>> (2)	51P-2_3 (2)
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I_3>>> (1)	50P/51P_3 (1)
Directional three-independent-phase directional overcurrent protection, low stage	DPHLPDOC1	3I_3> -> (1)	67-1_3 (1)
	DPHLPDOC2	3I_3> -> (2)	67-1_3 (2)
Directional three-independent-phase directional overcurrent protection, high stage	DPHHPDOC1	3I_3>> -> (1)	67-2_3 (1)
	DPHHPDOC2	3I_3>> -> (2)	67-2_3 (2)
Three-phase overload protection for shunt capacitor banks	COLPTOC1	3I> 3K< (1)	51C/37 (1)
Current unbalance protection for shunt capacitor banks	CUBPTOC1	dI>C (1)	51NC-1 (1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC1	TD> (1)	55TD (1)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
	CBXCBR3	I <-> O CB (3)	I <-> O CB (3)
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
	ESXSWI3	I <-> O ESC (3)	I <-> O ESC (3)
Disconnector 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)
	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
	ESSXSWI3	I <-> O ES (3)	I <-> O ES (3)
Autoreclosing	DARREC1	O -> I (1)	79 (1)
	DARREC2	O -> I (2)	79 (2)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
	SSCBR2	CBCM (2)	CBCM (2)
	SSCBR3	CBCM (3)	CBCM (3)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC1	MCS I_A (1)	MCS I_A (1)
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC1	MCS I_B (1)	MCS I_B (1)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC1	MCS I_C (1)	MCS I_C (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTS (1)	OPTM (1)
	MDSOPT2	OPTS (2)	OPTM (2)
Measurement			
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	Io (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Single-phase voltage measurement	VAMMXU2	U_A (2)	V_A (2)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vo (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)
Load profile record	LDPRLRC1	LOADPROF (1)	LOADPROF (1)
Frequency measurement	FMMXU1	f (1)	f (1)
Fault location			
Fault locator	SCEFRFLO1	FLOC (1)	21FL (1)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (1)
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)

000673
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Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
	TPSGAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
	TPMGAPC2	TPM (2)	TPM (2)
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)
	MVGAPC3	MV (3)	MV (3)
	MVGAPC4	MV (4)	MV (4)
Integer value move	MVI4GAPC1	MVI4 (1)	MVI4 (1)
	MVI4GAPC2	MVI4 (2)	MVI4 (2)
	MVI4GAPC3	MVI4 (3)	MVI4 (3)
	MVI4GAPC4	MVI4 (4)	MVI4 (4)
Analog value scaling	SCA4GAPC1	SCA4 (1)	SCA4 (1)
	SCA4GAPC2	SCA4 (2)	SCA4 (2)
	SCA4GAPC3	SCA4 (3)	SCA4 (3)
	SCA4GAPC4	SCA4 (4)	SCA4 (4)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
	SPCGAPC3	SPC (3)	SPC (3)
Remote generic control points	SPCRGAPC1	SPCR (1)	SPCR (1)
Local generic control points	SPCLGAPC1	SPCL (1)	SPCL (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Generic up-down counters	UDFCNT1	UDCNT (1)	UDCNT (1)
	UDFCNT2	UDCNT (2)	UDCNT (2)
	UDFCNT3	UDCNT (3)	UDCNT (3)
	UDFCNT4	UDCNT (4)	UDCNT (4)
	UDFCNT5	UDCNT (5)	UDCNT (5)
	UDFCNT6	UDCNT (6)	UDCNT (6)
	UDFCNT7	UDCNT (7)	UDCNT (7)
	UDFCNT8	UDCNT (8)	UDCNT (8)
	UDFCNT9	UDCNT (9)	UDCNT (9)
	UDFCNT10	UDCNT (10)	UDCNT (10)
	UDFCNT11	UDCNT (11)	UDCNT (11)
	UDFCNT12	UDCNT (12)	UDCNT (12)
Programmable buttons (16 buttons)	FKEYGGIO1	FKEY (1)	FKEY (1)
Logging functions			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Fault recorder	FLTFRC1	FAULTREC (1)	FAULTREC (1)
Sequence event recorder	SER1	SER (1)	SER (1)

33. Document revision history

Document revision/date	Product version	History
A/2013-05-07	2.0	First release
B/2013-07-01	2.0	Content updated
C/2014-07-01	2.0	Content updated
D/2014-09-11	2.0	Content updated
E/2015-12-11	2.0 FP1	Content updated to correspond to the product version

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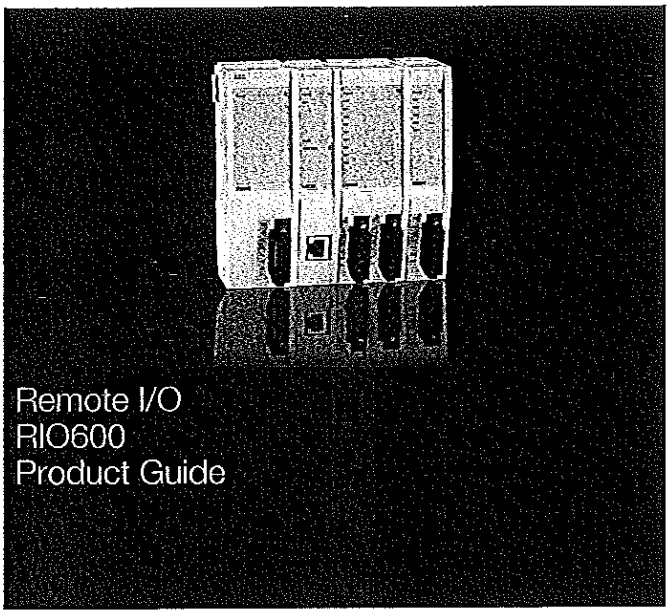

Remote I/O
RIO600
Product Guide

Contents

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Remote I/O	1MRS757487 F
RIO600	
Product version: 1.7	

	Issued: 2016-06-09
	Revision: F

1. Description

RIO600 is designed to expand the digital and analog I/O of ABB's Relion® protection and control relays and to provide I/O for COM600 substation automation unit using the IEC 61850 and Modbus TCP communication. Both galvanic RJ-45 and optical LC type of connectors are supported for Ethernet station bus communication. RIO600 can also be used in secondary substations for fault passage indication and power measurements reporting values directly to a peer protection relay or to an upper level system. RIO600 accepts three-phase sensor signals (voltage and current) and provides fault detection and metering functions.

RIO600 allows flexible I/O assignment and provides seamless IEC 61850 connectivity between the substation input and output signals and protection relay or COM600 substation gateway ensuring improved functionality and performance. RIO600 supports both Edition 1 and Edition 2 versions of the IEC 61850 standard. RIO600 can also be used as a standalone device in grid automation applications.

RIO600 helps in simplifying and decreasing the wiring inside the substation by digitizing the hardwired signals. The fully hardwired traditional medium-voltage switchgear/substation control and protection system results in extensive I/O wiring, connecting devices in switchgear signaling to the external systems, for example, to the RTU or other higher-level automation systems.

RIO600 provides additional I/O within the switchgear using Ethernet communication. The I/O signals can be efficiently transmitted between the protection relay or COM600 with fast, high performance IEC 61850 GOOSE communication. Alternatively, RIO600 can communicate with an upper level automation system using the widely accepted Modbus TCP automation protocol.

RIO600 binary input module can be used for sending binary input values from primary equipment or secondary systems to peer protection relays or upper level system. The binary output modules can be used to control equipment based on the control signal received from communication.

RIO600 smart control module (SCM) can be used for different switchgear applications to drive primary switches. The module enables the control of a combined three-position switch (disconnector and earthing switch) used in gas insulated switchgears or standard two-position switches like disconnector or earthing switches. Alternatively, the heavy-duty output contacts of the smart control module can be used as power outputs for circuit breaker trip circuits to make, carry and break the belonging trip coil current. Furthermore, the smart control module can be used as a generic four binary input and four fast power output module.

With the RTD/mA module, RIO600 can be used in different monitoring applications. RIO600 can receive temperatures (°C) via RTDs or analog input signals (mA) from various transducers or devices. Input current (mA) can be linearly scaled for various applications, for example, transformer tap changer position indication. The input value is forwarded to a peer protection relay or to an upper level system. With the analog output module, RIO600 can control an external device having an mA input.

In addition, RIO600 includes a measurement module with fault passage indication (FPI) functionality. This module is intended for grid automation applications where RIO600 enables accurate current and voltage measurements from a medium voltage network utilizing ABB's accurate and light weight sensor technology. RIO600 with the measurement module can be used as a standalone fault passage indicator unit. Based on the measured MV values, it can give voltage presence and directional fault passage indication and report them to an upper level system. This also enables power flow and power quality monitoring. The typical accuracy of line voltages, currents and active power is better than 0.5% and for other power measurements better than 1%.

The FPI module incorporates the latest fault detection algorithms used in the Relion family. With easy-to-use multifrequency admittance-based (MFA) earth-fault detection algorithm, it accurately detects solid, resistive and intermittent type of earth faults. Practical sensitivity of up to 10 kΩ of the fault resistance can be achieved in symmetrical networks. This novel functionality is suitable for high-impedance earthed networks, and especially for compensated and unearthed networks where accurate and selective earth-fault detection is more challenging due to low fault currents.

2. Modular design

RIO600 is built on an industrial hardware platform which provides the same reliability, performance and real-time functionality as ABB protection relays withstanding extreme temperatures, electromagnetic interference and stringent industry standards.

Remote I/O	1MRS757487 F
RIO600	
Product version: 1.7	

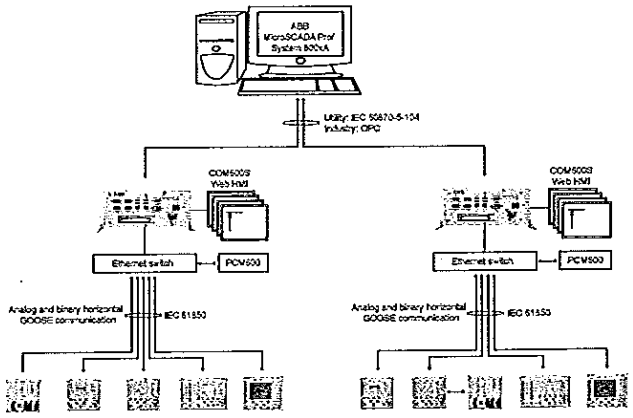

Figure 1. Connection overview of RIO600

RIO600 is designed using a modular architecture where the I/O control functionality is built on modules. The RIO600 modules can be stacked on a standard DIN rail to achieve the required configuration. The minimum configuration required for RIO600 contains a power supply module, a communication module and an I/O module.

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Table 1. RIO600 module types

Module type			Description
Power supply modules		PSVH	High-voltage range power supply module
		PSVL	Low-voltage range power supply module
Communication modules		LECM	Communication module with Ethernet port
		LECM	Communication module with Optical Ethernet port
I/O modules	Digital input module	DIVSH	High-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
		DIVSL	Low-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
	Digital output module	DOM4	Four output contacts in each digital output module with two pairs of potential free contacts with common return
	RTD module	RTD4	Four optically isolated channels supporting RTD sensors (Pt100, Pt250, Ni100, Ni120 and Ni250) and mA input (0...20 mA configurable). Individual channels are non-isolated from each other
	Analog output module	AOM4	Four individually isolated channels of configurable mA outputs driving 0...20 mA signal
	Sensor input module	SIM3F	Sensor input module with combined three-phase current and voltage signals
	Smart control module	SCMSH	High-voltage range, smart control module with five application types • 4IO – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch
		SCMSL	Low-voltage range, smart control module with five application types • 4IO – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch

The availability and combination of RIO600 modules and channels depends on the number of power supplies connected.

Table 2. Maximum number of modules and channels available when one power supply module is connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIVSH/DIVSL)	5	40	5	40
Digital output modules	5	20	4	16
RTD4 modules	5	20	4	16
Analog output modules	2	8	1	4
SIM3F modules	5	-	4	-
Smart control module (SCMSH/SCMSL)	3	24	2	16

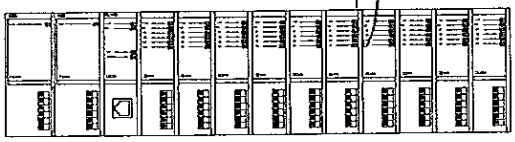

Figure 3. RIO600 configuration: 40 channels with 40 DO (10 x DOM4)

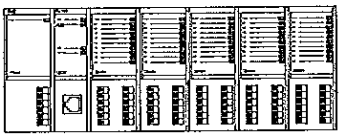

Figure 4. RIO600 configuration: 40 channels with 40 DI (5 x DIVSH)

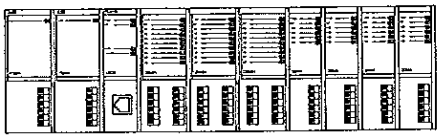

Figure 5. RIO600 configuration: 40 channels with 24 DI and 16 DO (3 x DIVSH + 4 x DOM4)

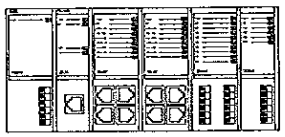

Figure 6. RIO600 configuration: 2 x SIM3F + 1 x DIVSH + 1 x DOM4

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Table 3. Maximum number of modules and channels available when two power supply modules are connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIVSH/DIVSL)	5	40	5	40
Digital output modules	10	40	9	36
RTD4 modules	10	40	9	36
Analog output modules	4	16	3	12
SIM3F modules	5	-	5	-
Smart control module (SCMSH/SCMSL)	5	40	5	40

A combination of all the modules can be used in a single RIO600 stack. The total number of modules that can be supported by a number of power supply modules is automatically checked by PCM600, if the selected combination of modules exceeds the number of supported modules related to power consumption, the configuration tool gives an indication and does not proceed in configuring the stack.

Indication LEDs

RIO600 is equipped with different indication LEDs available on different modules.

- Ready LED on all modules
- Status indication LED for each binary input and output
- Status indication of detected power flows and disturbances in network
- IRF LED which indicates a fault condition if it is steadily ON
- Communication diagnostic LED on the communication module

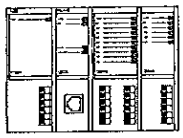

Figure 2. RIO600 configuration with 12 channels with 8 DI and 4 DO (1 x DIVSH + 1 x DOM4)

Configuration examples

The user-specific configuration can be adapted according to application requirements by combining different modules.

RIO600 can be configured with a combination of low-voltage and high-voltage modules, for example, PSVH-LECM-DIVSL-PSVL-LECM-DIVSH or PSVL-PSVH-LECM-DIVSH-DIVSL-DOM4.

3. Applications

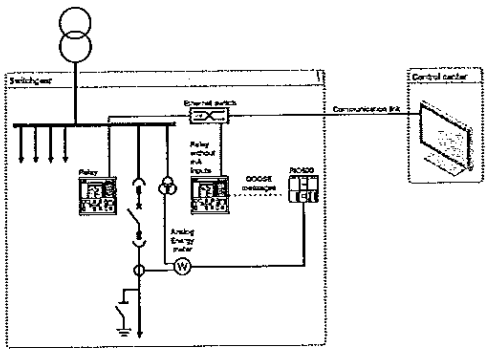

Figure 7. RIO600 as an external metering input for the protection relay

Figure 7 illustrates an application example in which RIO600 acts as an external metering input for the protection relay.

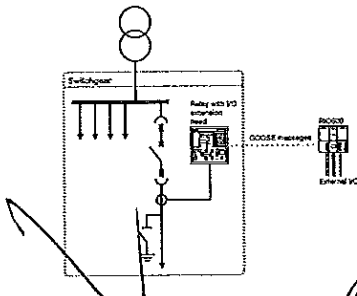

Figure 8. RIO600 as an I/O extension

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In Figure 8 RIO600 is used as an input/output extension to a protection relay or a COM600 substation automation unit.

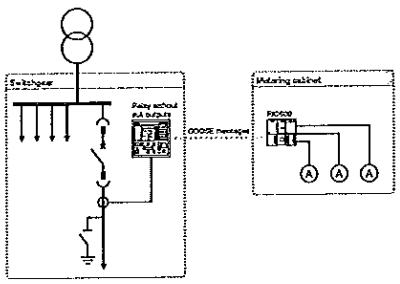

Figure 9. RIO600 communicating analog signals for the external meters

In the application example in Figure 9, RIO600 communicates analog signals for the external meters.

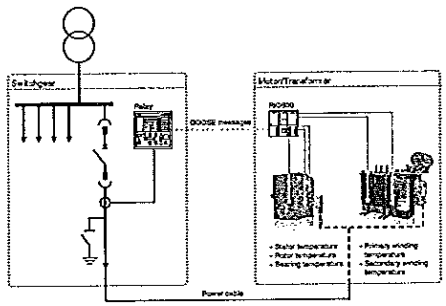

Figure 10. Temperature measurement using RIO600

Figure 10 illustrates the use of RIO600 to measure temperature from motor or transformer devices. The fiber-optic Ethernet can be used to achieve communication over longer distances.

5. Communication

RIO600 supports horizontal GOOSE (Generic Object Oriented Substation Event) communication according to the IEC 61850 substation automation standard versions Edition 1 and Edition 2. It meets the horizontal communication performance criteria for protection and fault detection purposes defined by IEC 61850-5, that is, peer-to-peer communication <10 ms. Currently, the IEC 61850 MMS profile for vertical TCP/IP communication is not supported.

RIO600 also supports Modbus TCP communication to one Modbus TCP client. IEC 61850 GOOSE and Modbus TCP can be used in parallel in the same Ethernet based station bus.

RIO600 is designed to send and receive binary and analog signals to or from the ABB Relion® series protection relays and the COM600 station automation unit/RTU using the IEC 61850-8-1 GOOSE profile or Modbus TCP. Also any RTU supporting the mentioned protocols can be used. RIO600 subscribes to a GOOSE message from a maximum of five peer protection relays and publishes to multiple protection relays as configured. RIO600 supports publishing of a maximum of seven GOOSE data sets. It is possible to send time stamped events using the GOOSE service with a T0 class accuracy.

RIO600 also supports Modbus TCP communication used in Ethernet networks. The communication type is client-server where RIO600 acts as a Modbus TCP server. RIO600 Modbus TCP server supports connection to one Modbus TCP client.

RIO600 communication module includes a galvanic RJ-45 port with 10/100 Mbits/s or fiber-optic LC Ethernet for IEC 61850 GOOSE and Modbus TCP communication. The used cable type must be shielded twisted pair cable CAT5e at the minimum or a multimode fiber-optic cable with an LC connector.

Using the same Ethernet port, RIO600 can be connected in parallel to PCM600 and a Web browser over the same communication bus.

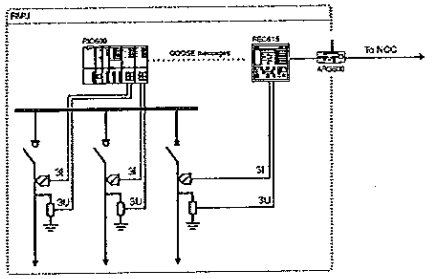

Figure 11. RMU fault passage indication using RIO600

Figure 11 shows RIO600 as a fault passage indicator in the RMU.

4. Self-supervision

RIO600 has a built-in self-supervision feature which continuously monitors the state of the RIO600 hardware and the operation of the software. Any fault or malfunction detected is used for alerting the operator. A dedicated LED is provided to indicate the failure. The self-supervision status of RIO600 is also distributed to the IEC 61850 station bus as one data entry in the published GOOSE frame. One of the output contacts of the digital output module can be configured to indicate the status (life-contact) of RIO600.

Supervision information is available over Modbus TCP or via Web HMI.

All module version information, RIO600 configuration version and firmware checksums are also available for fleet management purposes.

6. Technical data

Table 4. Module weights

Description	Value
PSM/HPSML	235 g
LECM	123 g
DIM8H/DIM8L	206 g
DOM4	163 g
RTD4	206 g
AOM4	206 g
SIM1F	183 g
SCM8H/SCM8L	215 g

Table 5. Dimensions of the end clamp (EW 35, Weidmuller)

Description	Value
Width	6.5 mm (To be fixed at the ends of assembled modules)

Table 6. Power supply

Description	PSMH	PSML
U_{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	110, 125, 220, 250 V DC	
U_{aux} variation	85...110% of U_{aux} nominal (85...264 V AC)	50...120% of U_{aux} nominal (12...72 V DC)
	80...120% of U_{aux} nominal (88...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Maximum interruption time in the auxiliary DC without resetting the RIO modules	150 ms at U_{aux} nominal	50 ms at U_{aux} nominal
Ripple in the DC auxiliary voltage	Max. 15% of the DC value (at frequency of 100 Hz)	
Reversal of DC power supply polarity	1 minute for each polarity	
Burden of auxiliary voltage supply		
• Quiescent (Pq) condition (none of the 20 I/O channels are activated)	<4.0 W nominal	
• Operating condition (20 binary output channels in DOM4 modules are activated)	<12.0 W (maximum)	

Module configuration	Condition	Max. consumption for PSMH and PSML
PSM + LECM + DIM8H	All DIs activated	2 W
PSM + LECM + DIM8L		
PSM + LECM + DOM4	All DOs activated	4 W
PSM + LECM + DOM4 (5)	All DOs activated	12 W
PSM (2) + LECM + DIM8H (5)	All DIs activated	11 W
PSM (2) + LECM + DIM8L (5)		
PSM (2) + LECM + DOM4 (10)	All DOs activated	22 W

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Table 7. Binary inputs

Description	DI4SH	DI4SL
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3...3.7 mA	2 mA
Power consumption/input channel	330...925 mW	90...180 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 8. Signal outputs (Digital output module DO4H)

Description	Value
Operating time	<5 ms
Nominal coil power	<500 mW
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry for 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

Table 9. mA/RTD input (RTD4 module)

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
	Maximum lead resistance (three-wire measurement)	100 Ω platinum	20 Ω per lead
		250 Ω platinum	20 Ω per lead
		100 Ω nickel	20 Ω per lead
		120 Ω nickel	20 Ω per lead
		250 Ω nickel	20 Ω per lead
	Isolation	4 kV	Inputs to all other channel outputs and protective earth
	RTD/resistance sensing maximum	0.275 mA rms current	
	Operation accuracy	±1°C	
	Response time	< Filter time + 350 ms	
mA inputs	Supported current range	0...23 mA	
	Current input impedance	44 Ω ± 0.1%	
	Operation accuracy	±0.5% or ±0.1 mA	
	Isolation	4 kV	Inputs to all outputs and protective earth

Table 10. Analog output module (AO4H)

Description		Value
mA output	Supported current range	0.0...21.0 mA
	Operation accuracy	±0.1% or ±0.2 mA
	Isolation	4 kV between each output and protective earth

Table 11. Sensor input module (SIM3F)

Description		Value
Preferred ABB sensors		• Combined sensors KEVCY 24 F81, KEVCY36 F81, KEVCY 40.5 F81, KEVCD A • Combination of current sensor KECA 80 C85 or KECA D85 and voltage sensor KEVA 24 C10, 24 C21, 24 C22, 24 C23, 17.5 B20, 17.5 B21, 24 B23, or 24 B21
Current measurement	Range	4...6000 A
	Accuracy	±5% or ±1 A in the range of 4...80 A ±1% in the range of 80...4800 A ±10% in the range of 4800...6000 A
Line voltage measurement	Range	480 V...48 kV
	Accuracy	±5% in the range of 480...9600 V ±0.5% in the range of 9.6...48 kV
Power measurements: P, Q, S and PF	Range	9.6...28.8 kV 80...830 A
	Accuracy	±1.0% for active power P (±0.5% at +25°C) ±3.5% for reactive Q and apparent power S (±1% at +25°C) ±0.03 for power factor ±3.5% for energy
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz, ±50 m-Hz For 60 Hz, ±60 m-Hz
Average operating current, voltage and power		Average operating current, voltage, power as per selection: 3 min/15 min/ 15 min/1 hour/2 hours/24 hours
Peak current, voltage and power values		Peak values for 1 day, 1 week, 1 month, 1 year
General detection of the harmonics disturbances		• Current TDD (Total demand distortion) up to the 8th harmonics • Voltage THD (Total harmonic distortion) up to the 8th harmonics
Load flow direction		Forward/reverse
Non-directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: f_n ±1.5% of the set value Operate time: ±1.0% of the set value or ±20 ms
Directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: f_n Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2° Operate time: ±1.0% of the set value or ±20 ms

Table 11. Sensor input module (SIM3F), continued

Description		Value
Non-directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: f_n ±10% of the set value in range of 4...25 A ±1.5% of the set value in range of >25...1000 A Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)
Directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: f_n Current: • ±10% of the set value in range of 4...25 A • ±1.5% of the set value in range of >25...1000 A Voltage: ±1.5% of the set value Phase angle: ±3° Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)

Table 12. Binary inputs (Smart control module)

Description	SCM8H	SCM8L
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3...3.7 mA	2 mA
Power consumption/input channel	330...925 mW	90...180 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 13. High-speed outputs (Smart control module)

Description	SCM8H	SCM8L
Operating time	<1 ms	<1 ms
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Continuous current carry	20 A	20 A
Short time current carry	100 A for 10 ms	200 A for 10 ms

Table 14. Communication interface (Communication module LECM)

Connector	Cable	Data transfer	Maximum distance	Wave length	Permitted path attenuation[1]
RJ-45	Shielded twisted pair cable, at minimum CAT5e	10/100 MBits/s	30 m	-	-
LC	Multimode 62.5/125 µm or 50/125 µm glass fibre core	100 MBit/s	2 km	1310 nm	8 dB

1) Maximum allowed attenuation caused by connectors and cable together

000679
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Table 15. Degree of protection by enclosure

Description	Value
Degree of protection	IP20[1]

1) If a higher IP class is required, the stand where the device is installed should provide proper protection.

Table 16. Environmental conditions

Description	Value
Operating temperature range	-25...+70°C
Relative humidity	<93%
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-43...+85°C

Table 17. Inspection of mechanical structure

Description	Reference	Result
Markings and mechanical structure	IEC 60255-1 and IEC 60255-27	OK
Enclosure class of the flush-mounted device	IEC 60529	IP 20
Clearances and creepage distances	IEC 60255-27	OK

Table 18. Overload test

Description	Reference	Result
Thermal withstand capability test	IEC 60255-1 and IEC 60255-27	OK

Table 19. Power supply module tests

Test	Type test value	Result
Operating range of auxiliary supply voltage test	80% and 120% of rated value for DC 85% and 110% of rated value for AC, frequency is between 50 Hz for -5% and 60 Hz for +5%	IEC 60255-1 and IEEE C37.90-2005
Power consumption of auxiliary supply		IEC 60255-1 and IEEE C37.90-2005
• Quiescent load	<4 W	
• Maximum load	<12 W	
Reversal of DC power supply polarity	1 minute for each polarity	IEC60255-27
Start-up time test	<30 s	

Table 20. Contact tests

Description	Type test value	Reference
Make and carry	Signaling contacts • 5 A, continuous • 10 A for 3 s • 15 A for 0.5 s	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Breaking capacity for DC, L/R ≤40 ms	Signaling contacts • 48 V, 1.00 A • 110 V, 0.25 A • 220 V, 0.15 A	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Mechanical durability	10000 operations	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005

Table 21. Insulation tests

Description[1]	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min for communication 2.8 kV DC, 1 min 700 V DC, 1 min for communication	IEC 60255-27 and IEEE C37.90-2005
Impulse voltage tests	5 kV, 1.2/50 µs, 0.5 J	IEC 60255-27 and IEEE C37.90-2005
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27

1) Insulation tests are not applicable to SPA-ZP.

Table 22. Electromagnetic compatibility and Immunity tests

Description	Type test value	Reference
Electrostatic discharge		IEC 60255-26 and IEC 61000-4-2, Level 3
• Air discharge	8 kV	
Radio frequency electromagnetic field (amplitude modulated)	10 V/m (RMS) f = 80...1000 MHz and 1.4...2.7 GHz	IEC 60255-26 and IEC 61000-4-3, Level 3
Radio frequency electromagnetic field from digital radio telephones (pulse modulated)	10 V/m (RMS) f = 900 MHz, 1890 MHz	IEC 61000-4-3, Level 3
Power frequency (50 Hz) magnetic field		IEC 60255-26 and IEC 61000-4-8
• Continuous	100 A (RMS)/m	
• 3 s	300 A (RMS)/m	
Pulsed magnetic field	1000 A/m; 6.4/16 µs Tr/Td; 5 pulses positive/negative; 10 s time interval	IEC 61000-4-9, Level 5
Conducted disturbance induced by radio frequency fields, Amplitude modulated	0.15...80 MHz - 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance 27 and 68 MHz (spot frequencies); 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance	IEC 60255-26 and IEC 61000-4-6, Level 3
Fast low-energy transient (EFT) (including functional earth port)	5/50 ns Tr/Td, 5 kHz repetition frequency 4 kV (peak) for power supply input/output ports and 2 kV (peak) for communication port	IEC 60255-26 and IEC 61000-4-4
Damped oscillatory waves (HFD) 100 kHz and 1 MHz burst	100 kHz and 1 MHz frequency; 75 ns Tr; 40 Hz and 400 Hz repetition frequency; 200 Ω source impedance	IEC 60255-26 and IEC 61000-4-18
• Power supply and input/output ports	Differential mode: 1 kV (peak) Common mode: 2.5 kV (peak)	
• Communication port	Differential mode: not applicable Common mode: 1 kV (peak)	
Slow high-energy transient (surge 1.2/50 µs voltage pulse)	1.2/50 µs Tr/Th (open circuit) 8/20 µs Tr/Th (short circuit)	IEC 60255-26 and IEC 61000-4-5
• Auxiliary power supply and input/output ports[1]	±4 kVp (L-Gnd) ±2 kVp (L-L)	
• Communication port	±2 kVp (L-Gnd) while no L-L test is applicable	
Voltage dips, short interruptions and voltage variation immunity tests (AC 50 Hz and 60 Hz)	30% reduction for 25/30 cycles 60% reduction for 10/12 cycles 100% reduction for 0.5, 1.0, 2.5 and 5.0 cycles 100% reduction for 250/300 cycles	IEC 60255-26 and IEC 61000-4-11
Voltage dips, supply interruption and voltage variations on DC input power port (immunity tests)	30% reduction for 500 ms 60% reduction for 200 ms 100% reduction for 10, 20, 30 and 50 ms 100% reduction for 5 s	IEC 60255-26 and IEC 61000-4-29
Ripple voltage	15% U_n, frequencies of ripple 100/120 Hz (for 50/60 Hz)	IEC 60255-26, IEC 61000-4-17 and IEEE C37.90-2005
Gradual shut-down/start-up test (for DC power supply)		IEC 60255-26
• Ramp towards shut-down	60 s	
• Wait at power of condition	5 minutes	
• Ramp towards start-up	60 s	

Table 22. Electromagnetic compatibility and Immunity tests, continued

Description	Type test value	Reference
Power frequency voltage 50 Hz and 60 Hz input/output port		IEC 60255-26 and IEC 61000-4-16
• Differential mode	150 V (RMS) 150 Ω coupling resistor 0.1 µF coupling capacitor	
• Common mode	300 V (RMS) 200 Ω coupling resistor 0.47 µF coupling capacitor	
Emission tests		IEC 60255-25
• 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	
• 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	

1) When SPA-ZC 400 is configured as a generic I/O, the limit is reduced to ±2 kVp (L-Gnd) and ±1 kVp (L-L).

Table 23. Electromagnetic compatibility and Immunity tests as per ANSI standards

Description	Type test value	Reference
1 MHz oscillatory SWC test	All ports: 2.5 kV common mode/differential mode	IEEE C37.90.1-2002
Fast transient SWC test	All ports: 4 kV common mode/differential mode	IEEE C37.90.1-2002
Radio frequency interference tests	20 V/m (prior to modulation) f = 80...1000 MHz (AM) f = 900 MHz (FM)	IEEE C37.90.2-2004
Electrostatic discharge test	±15 kV air discharge	IEEE C37.90.3-2001

000680
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Table 24. Mechanical tests

Description	Type test value	Reference
Vibration tests (sinusoidal)	Class 1	IEC 60255-21-1
• Vibration response test	f = 10...150 Hz Peak acceleration: 0.5 g 1 sweep cycle in each axis	
• Vibration endurance test	f = 10...150 Hz Peak acceleration: 1.0 g 20 sweep cycles in each axis	
Shock and Bump test	Class 1	IEC 60255-21-2
• Shock response test	Peak acceleration: 5 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Shock withstanding test	Peak acceleration: 15 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Bump test	Peak acceleration: 10 g Duration of the pulse: 16 ms Number of pulses in each direction: 1000	
Seismic test	Class 2	IEC 60255-21-3
• Nominal frequency range	1...35 Hz	
• Zero period acceleration	Horizontal direction: 2.0 gn Vertical direction: 1.0 gn	
• Number of time-histories in each axis	Single axis sine sweep	

Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +70°C	IEC 60068-2-2 and IEEE C37.90-2005
Dry cold test	• 96 h at -25°C • 16 h at -40°C	IEC 60068-2-1 and IEEE C37.90-2005
Damp heat cyclic test	• 6 cycles (12 h + 12 h) at +25...+55°C, humidity >93%	IEC 60068-2-30
Damp heat steady state test	• Temperature 40°C • Humidity 93% • Duration 56 h	IEC 60068-2-78 and IEEE C37.90-2005
Change of temperature test	• 5 cycles (3 h + 3 h) at -25...+55°C	IEC60068-2-14
Storage test	• 96 h at -40°C • 96 h at +85°C	IEC 60068-2-1, IEC 60068-2-2 and IEEE C37.90-2005

Table 26. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Table 27. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Functions available in SIM2F

Table 28. Functions available in SIM5F

Function	IEC 61850 Edition 1	IEC 61850 Edition 2	IEC 60617	IEC-ANSI
Measurement functions				
Three-phase current measurement	CMMXU	CMMXU	3I	3I
Three-phase voltage measurement	VMMXU	VMMXU	3U	3U
Residual current measurement	RESCMMXU	RESCMMXU	Io	Io
Residual voltage measurement	RESVMMXU	RESVMMXU	Uo	Uo
Three-phase power and energy measurement	PEMMXU	PEMMXU	P	P
Three-phase power direction	PWRDIR	PWRDIR	-	-
Energy monitoring	EMMTR	EMMTR	E	E
Current, voltage and power average and peak measurement	CMSTA	CAVMMXU CMAMMXU RCAVMMXU	-	
	VMSTA	VAVMMXU VMAMMXU		
	PEMSTA	PEAVMMXU PEMAMMXU		
Power quality measurement functions (harmonics)				
Current total demand distortion monitoring	CMHAI	CMHAI	PQM3I	PQM3I
Voltage total demand distortion monitoring	VMHAI	VMHAI	PQM3U	PQM3V
Detection and indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3I>	51P
Three-phase directional overcurrent fault detection	DPHPTOC	DPHPTOC	3I>->	67P
Non-directional earth-fault fault detection	EFPTOC	EFPTOC	Io>	51N
Directional earth-fault fault detection	DEFPTOC	DEFPTOC	Io>->	67N
Multifrequency admittance-based earth-fault indication	MFAPSDE	MFAPSDE	Io>->Y	67YN
Voltage presence indication	PHSVPR	PHSVPR	PHSVPR	PHSVPR

Table 29. CMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = fn ±5% or ±1 A in the range of 4...80 A ±1% in the range of 80...4000 A ±10% in the range of 4000...8000 A
Suppression of harmonics	RMS: No suppression

Table 30. VMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = fn ±5% in the range of 450 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV ±1% in the range of 28.8...48 kV
Suppression of harmonics	RMS: No suppression

Table 31. RESCMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = fn ±5.0% (when all three phase currents in the range of 80...630 A)
Suppression of harmonics	RMS: No suppression

Table 32. RESVMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = fn ±5.0% (when all three voltages are in the range of 9.6...14.4 kV or 19.2...28.8 kV)
Suppression of harmonics	RMS: No suppression

Table 33. PEMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = fn All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 80...630 A Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71 ±1.0% for Active power P (±0.5% at +25°C) ±3.0% for Reactive Q and Apparent Power S (±1% at +25°C) ±0.03 for power factor
Suppression of harmonics	RMS: No suppression

Table 34. EMMTR Technical data

Characteristic	Value
Operation accuracy	At frequency f = fn All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 80...630 A Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71 ±3.0% for energy
Suppression of harmonics	RMS: No suppression

000681
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Table 35. PHPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ ±1.5% of the set value
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 36. DPHPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the nominal frequency of the current measured: $f = f_n$ Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2°
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 37. EFPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ ±1.0% of the set value in range of 4...25 A ±1.5% of the set value in range of 26...1000 A (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 38. DEFPTOC Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ Current: ±1.0% of the set value in range of 4...25 A ±1.5% of the set value in range of 26...1000 A Voltage: ±1.5% of the set value Phase angle: ±3° (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 39. MFAPSDE Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5% in the range of 480 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV
Operate time accuracy	±1.0% of the set value or ±50 ms

Table 40. PHSYPR Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5% in the range of 480 V...9.6 kV ±3.5% in the range of 9.6...28.8 kV

7. Module dimensions

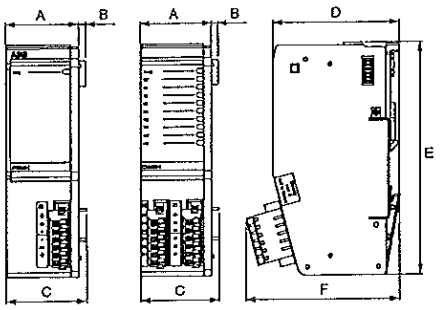

Figure 12. Dimension and mounting details of the PSM/PSU/DI/DO/RTD/AOM/SCM/SCMSL modules

A 45 mm
B 4.5 mm
C 51 mm
D 81 mm
E 146 mm
F 99 mm

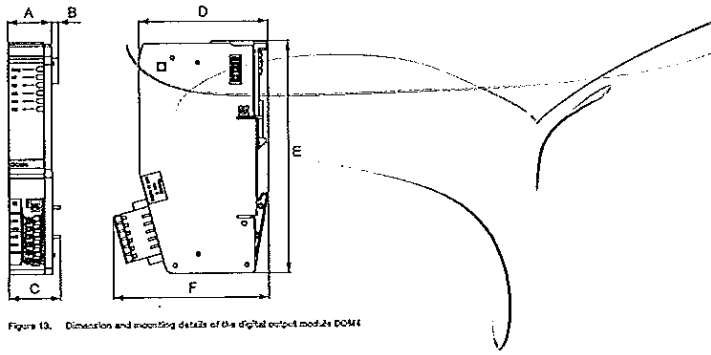

Figure 13. Dimension and mounting details of the digital output module DOM4

A 27.5 mm
B 4.5 mm
C 33 mm
D 81 mm
E 146 mm
F 59 mm

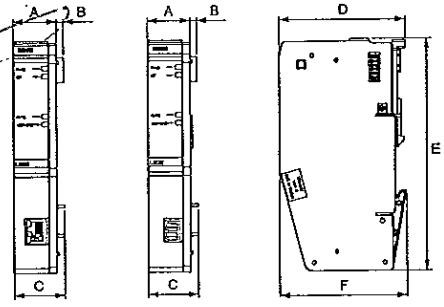

Figure 14. Dimension and mounting details of the communication module LECM

A 27.5 mm
B 4.5 mm
C 33 mm
D 81 mm
E 146 mm
F 81 mm

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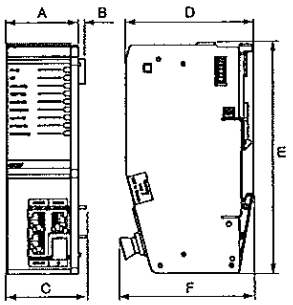

Figure 15. Dimension and mounting details of the SIM8F module

A 45 mm
B 4.25 mm
C 51 mm
D 81 mm
E 145.5 mm
F 85 mm

8. Assembly diagram

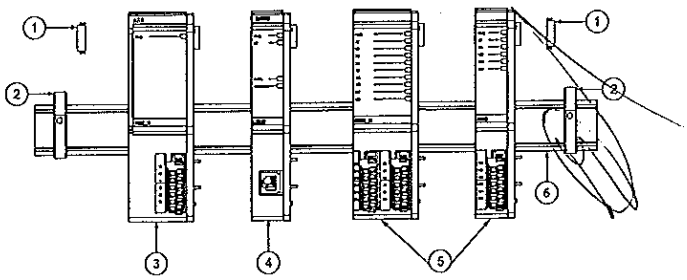

Figure 16. Assembly drawings of RIO600 modules

1 Rubber cap
2 End clamp
3 PSM module
4 LECM module
5 Modules (DM/DOM4/RTD4/AOM4/SIM8F/SCM8H/SCM8L)
6 DIN Rail

The total width of the assembly can be calculated by adding together the length of all modules.

The width of the end clamp depends on the selected part. This mounting uses the Weidmuller part EW 35, which is 8.5 mm wide.

9. Ordering data

Table 41. Ordering details for RIO600 modules

Item	Order number
Digital input module with 8 inputs, high-voltage power supply	MOD600ADM8H
Digital input module with 8 inputs, low-voltage power supply	MOD600ADM8L
Digital output module with 4 outputs	MOD600ADOM4R
RTD/mA input module with 4 inputs	MOD600ARTD4
Analog output module with 4 outputs	MOD600AAOM4
Sensor input module	MOD600ASIM8F
Smart control module with 4 inputs and 4 high-speed outputs, high-voltage power supply	MOD600ASCM8H
Smart control module with 4 inputs and 4 high-speed outputs, low-voltage power supply	MOD600ASCM8L
High-power supply module	MOD600APSMH07
Low-power supply module	MOD600APSML07
Communication module with RJ-45 port	MOD600LECMCR
Communication module with multimode fiber-optic LC port	MOD600LECMFO

10. Tools

The present status information of RIO600 can be viewed from the Web browser-based user interface (Web HMI) and the parameter setting values can be viewed or changed from the PCM600 tool in combination with the RIO600-specific connectivity package.

The Protection and Control IED Manager PCM600 with the RIO600 connectivity package is used for configuring RIO600 in the offline or online mode to connect to the other protection relays or substation gateways in the IEC 61850 station bus. When the Web browser-based user interface is used, RIO600 can be accessed remotely with a Web browser.

The RIO600 connectivity package is a collection of software tools with specific device information which enables system products and tools to connect and interact with RIO600. The connectivity packages supports system integration and engineering and its minimizing device configuration and setup time.

RIO600 parameters can be configures with Parameter Setting in PCM600, internal and station communication based logics are engineered in graphical Application Configuration and in Signal Matrix. IEC 61850 peer-to-peer communication can be configured in PCM600 as well.

Table 42. Tools

Description	Version
PCM600	2.7 Hotfix 1 or later
Web browser	IE 9.0 or later
RIO600 Connectivity Package	1.7 or later

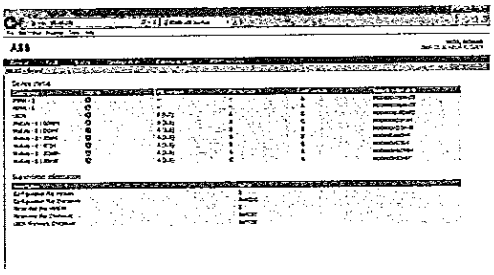

Figure 17. General view of RIO600 Web HMI

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11. Connection and terminal diagrams

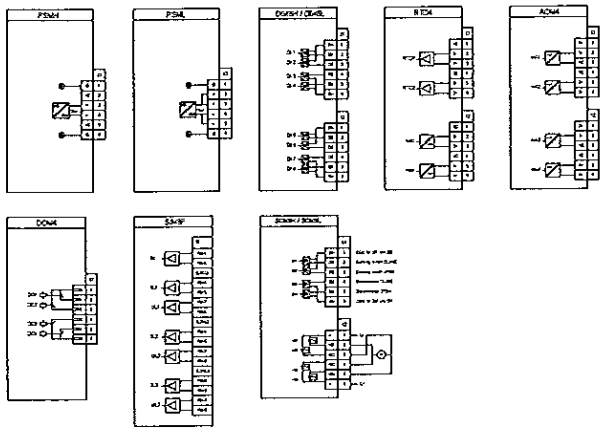

Figure 18. Connection and terminal diagram of RIO600 modules

12. Document revision history

Document revision/date	Product version	History
A/2011-12-23	1.0	First release
B/2012-12-18	1.1	Content updated
C/2013-09-30	1.2	Content updated
D/2014-09-29	1.5	Content updated
E/2015-08-31	1.6	Content updated
F/2016-05-09	1.7	Content updated

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за участие в открита процедура за възлагане на обществена поръчка с предмет:

„Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Зенит" от линеен ножов разединител 110 kV на ПС „Хаджи Димитър" до линеен ножов разединител 110 kV в ПС „Подуяне", реф. № РРС 17 – 169

Техническо предложение

Техническа документация

Приложение № 6 към Предложение за изпълнение на поръчката по т.15.6. от Техническото предложение – Заверени копия на документи за Цифров локален контролер за трансформаторно присъединение 110 kV:

- Приложение № 6.2. към т.15.6.2. от Техническото предложение – Други по преценка на участника (декларации за съответствие, протоколи от типови изпитания и др.).

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1MRS757890

EU Declaration of Conformity

Issued	26.04.2013
Version	B/20.04.2016
Technical ref.	Mika Kortesniemi
Checked by	Asko Koiranen

49

Application of this document

This document is intended for use as an approval for CE-marking of below mentioned products:

Family of	620 series

Declaration

We ABB Oy, Medium Voltage Products, Distribution Automation
P.O. Box 699 FI-65101 Vaasa, FINLAND,
declare under our sole responsibility that the family:

Feeder Protection and Control	REF620
Motor Protection and Control	REM620
Transformer Protection and Control	RET620

to which this declaration relates is in conformity with the following directives:

Directives	EMC Directive 2014/30/EU Low Voltage Directive 2014/35/EU RoHS Directive 2011/65/EU
CE - marked	2013

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	EN 60255-26:	2013
	EN 61000-6-2:	2005
	EN 61000-6-4:	2007
	EN 60255-1:	2010
	EN 60255-27:	2013

Vaasa 20.04.2016

Signed by: на основание чл. 2 от ЗЗЛД

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1MRS758050

EU Declaration of Conformity

Issued	26.11.2013
Version	B/20.04.2016
Technical ref.	Jatin Parmar
Checked by	Janne Starck

Application of this document

This document is intended for use as an approval for CE-marking of below mentioned products:

Family of	RIO600

Declaration

We ABB Oy, Medium Voltage Products, Distribution Automation
P.O. Box 699 FI-65101 Vaasa, FINLAND,
declare under our sole responsibility that the family:

Remote I/O	RIO600

to which this declaration relates is in conformity with the following directives:

Directives	EMC Directive 2014/30/EU Low Voltage Directive 2014/35/EU
CE - marked	2013

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	EN 60255-26:	2013
	EN 61000-6-2:	2005
	EN 61000-6-4:	2007
	EN 60255-1:	2010
	EN 60255-27:	2013

Vaasa 20.04.2016

на основание чл. 2 от ЗЗЛД

Signed by:

Antti Hakala-Ranta, SVP Medium Voltage Products

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за участие в открита процедура за възлагане на обществена поръчка с предмет:

„Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Зенит" от линеен ножов разединител 110 kV на ПС „Хаджи Димитър" до линеен ножов разединител 110 kV в ПС „Подуяне", реф. № РРС 17 – 169

Техническо предложение

Техническа документация

Приложение № 7 към Предложение за изпълнение на поръчката по т.15.7. от Техническото предложение – Заверени копия на документи за цифров локален контролер за поле „Секциониране" 110 kV:

- Приложение № 7.1. към т.15.7.1. от Техническото предложение – Последно издание на каталога на производителя.

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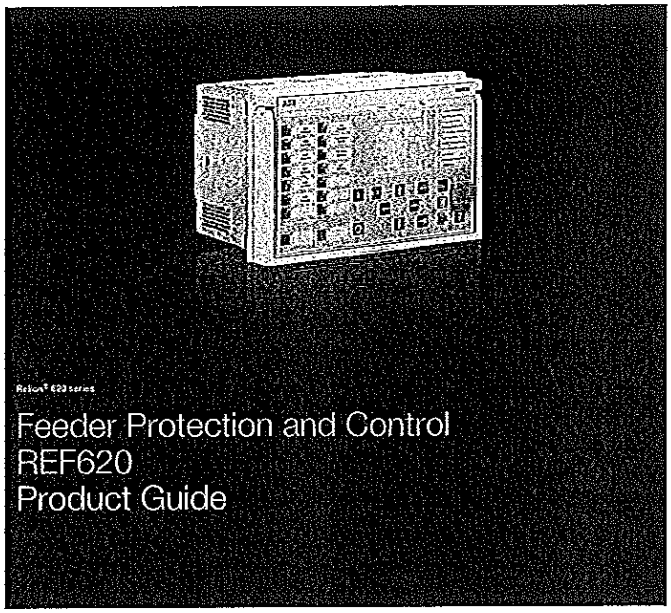

Relion® 620 series

Feeder Protection and Control
REF620
Product Guide

Power and productivity for a better world™

ABB

Contents

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1. Description

REF620 is a dedicated feeder management relay perfectly aligned for the protection, control, measurement and supervision of utility and industrial power distribution systems, including radial, looped and meshed networks, with or without distributed power generation. REF620 can also be used to protect feeders including motors or capacitor banks. Additionally REF620 offers functionality for interconnection protection used with distributed generation like wind or solar power connection to utility grid. Furthermore REF620 includes functionality for high-impedance based busbar protection. REF620 is a member of ABB's Relion® protection and control product family and its 620 series. The 620 series relays are characterized by their functional scalability and withdrawable-unit design. The 620 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability of substation automation devices.

The 620 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.

series engineering with different function blocks. The default configurations are not aimed to be used as real end-user applications. The end-users always need to create their own application configuration with the configuration tool. However, the default configuration can be used as a starting point by modifying it according to the requirements.

REF620 is available in two alternative default configurations: configuration A with traditional current and voltage measurement transducers and configuration B with current and voltage sensors. Default configuration A with measurement transducers has more voltage measurements and I/Os than default configuration B. This gives more possibilities in applications supported by default configuration A. The default configuration can be altered by means of the graphical signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Furthermore, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions using various logical elements, including timers and flip-flops. By combining protection functions with logic function blocks, the relay configuration can be adapted to user-specific application requirements.

2. Default configurations

The 620 series relays are configured with default configurations, which can be used as examples of the 620

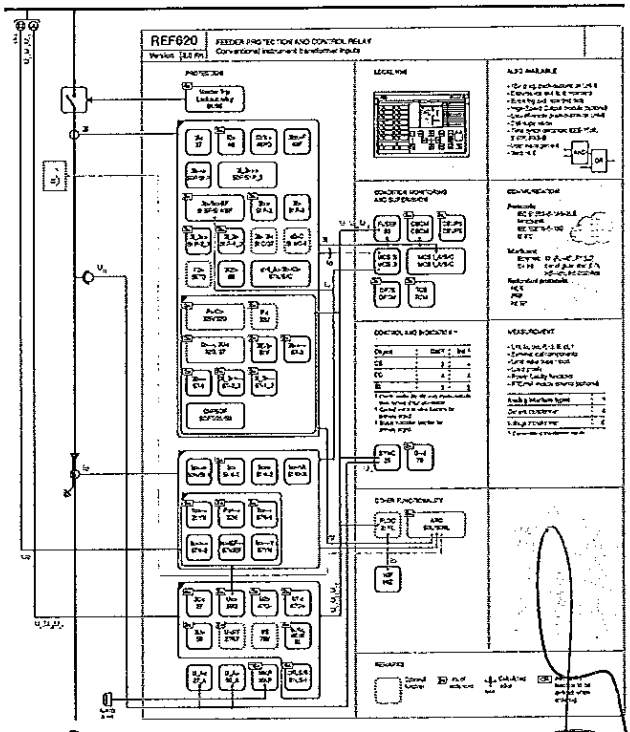

Figure 1. Functionality overview of default configuration with conventional instrument transformer inputs

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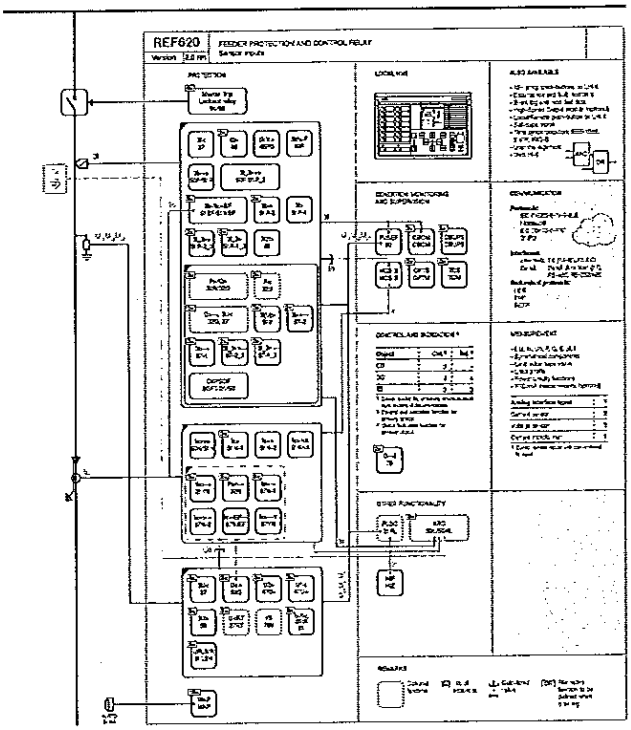

Figure 2. Functionality overview of default configuration with sensor inputs

Table 1. Supported functions

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1
Three-phase directional overcurrent protection, low stage	DPHLPDOC	2	2
Three-phase directional overcurrent protection, high stage	DPHHPDOC	2	2
Three-phase voltage-dependent overcurrent protection	PHPVOC	2	2
Non-directional earth-fault protection, low stage	EFLPTOC	2	2
Non-directional earth-fault protection, high stage	EFHPTOC	1	1
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	1	1
Directional earth-fault protection, low stage	DEFLPDEF	3	3[1]
Directional earth-fault protection, high stage	DEFHPDEF	1	1[1]
Admittance-based earth-fault protection	EFPADM	3	3[1]
Wattmetric-based earth-fault protection	WPWDE	3	3[1]
Multifrequency admittance-based earth-fault protection	MFADPSDE	1	1[1]
Transient/intermittent earth-fault protection	INTRPTEF	1	1[1]
Harmonics-based earth-fault protection	HAEFPTOC	1	1
Negative-sequence overcurrent protection	NSPTOC	2	2
Phase discontinuity protection	PDNSPTOC	1	1
Residual overvoltage protection	ROVPTOV	3	3[1]
Three-phase undervoltage protection	PHPTUV	4	4
Single-phase undervoltage protection, secondary side	PHAPTUV	1	
Three-phase overvoltage protection	PHPTOV	3	3
Single-phase overvoltage protection, secondary side	PHAPTOV	1	
Positive-sequence undervoltage protection	PSPTUV	2	2
Negative-sequence overvoltage protection	NSPTOV	2	2
Frequency protection	FRPFRQ	6	6
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	1	1
Loss of phase (undercurrent)	PHPTUC	1	1
Circuit breaker failure protection	CCBRBRF	3	3
Three-phase inrush detector	INRPHAR	1	1
Master trip	TRPPTRC	4	4
Arc protection	ARCSARC	(3)	(3)
High-impedance fault detection	PHIZ	1	1
Load-shedding and restoration	LSHDPFRQ	6	6
Multipurpose protection	MAPGAPC	18	18

Table 1. Supported functions, continued

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Autoreclosing	DARREC	2	2
Synchronism and energizing check	SECRSYN	1	(1)[2]
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR	3	3
Trip circuit supervision	TCSSCBR	2	2
Current circuit supervision	CCSPVC	1	1
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC	1	
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC	1	
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC	1	
Fuse failure supervision	SEQSPVC	1	1
Runtime counter for machines and devices	MDSOPT	2	2
Measurement			
Three-phase current measurement	CMMXU	1	1
Sequence current measurement	CSMSQI	1	1
Residual current measurement	RESCMMXU	1	1
Three-phase voltage measurement	VMMXU	1	1
Single-phase voltage measurement	VAMMXU	1	(1)[2]
Residual voltage measurement	RESVMMXU	1	
Sequence voltage measurement	VSMSQI	1	1
Three-phase power and energy measurement	PEMMXU	1	1
Load profile record	LDPRLRC	1	1
Frequency measurement	FMMXU	1	1
Fault location			
Fault locator	SCEFRFLO	(1)	(1)
Power quality			
Current total demand distortion	CMHAI	1	1
Voltage total harmonic distortion	VMHAI	1	1
Voltage variation	PHQVVR	1	1
Voltage unbalance	VSQVUB	1	1
Other			
Minimum pulse timer (2 pcs)	TPGAPC	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	2	2
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	2	
Pulse timer (8 pcs)	PTGAPC	2	2
Time delay off (8 pcs)	TOFGAPC	4	4
Time delay on (8 pcs)	TONGAPC	4	4
Set-reset (8 pcs)	SRGAPC	4	4
Move (8 pcs)	MVGAPC	4	4
Integer value move	MVIGAPC	4	4
Analog value scaling	SCAVGAPC	4	4
Generic control point (16 pcs)	SPCGAPC	3	3
Remote generic control points	SPCRGAPC	1	1
Local generic control points	SPCLGAPC	1	1
Generic up-down counters	UDFCNT	12	

000690

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Table 1. Supported functions, continued

Function	IEC 61850	A (CTs/VTs)	B (Sensors)
Programmable buttons (16 buttons)	FKEYGGIO	1	1
Logging functions			
Disturbance recorder	RDRE	1	1
Fault recorder	FLTRFRC	1	1
Sequence event recorder	SER	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.
O = optional

1) Uo is calculated from the measured phase voltages
2) Available only with IEC 61850-9-2 LE

3. Protection functions

The basic configurations available in REF620 consist of a wide range of protection functions making the protection relay suitable for various basic feeder applications. The relay offers directional and non-directional overcurrent and thermal overload protection as well as directional and non-directional earth-fault protection. Admittance-based, harmonics-based or wattmetric-based earth-fault protection can be used in addition to directional earth-fault protection. Furthermore, the relay features sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection, overvoltage and undervoltage protection, residual overvoltage protection, positive-sequence undervoltage protection and negative-sequence overvoltage protection. In addition, the relay offers frequency protection including overfrequency, underfrequency and frequency rate-of-change protection. The relay also incorporates three-pole multi-shot autoreclosing functions for overhead line feeders.

The standard content additionally includes multifrequency admittance-based earth-fault protection providing selective directional earth-fault protection for high-impedance earthed networks. The operation is based on multifrequency neutral admittance measurement utilizing fundamental frequency and harmonic components in Uo and Io.

ABB's continuous investments in research and a close cooperation with customers have resulted in the best earth-fault protection portfolio on the market. These functions are vital with different physical neutral groundings. In REF620, a special filtering algorithm enables dependable and secure fault direction also during intermittent/restriking earth faults. It provides a good combination of reliability and sensitivity of protection with a single function for low ohmic and higher ohmic earth faults and for transient and intermittent or restriking earth faults.

REF620 is also capable of protecting other applications than basic incoming or outgoing feeders. The relay includes high-impedance based busbar protection and measurement circuit supervision functions which enable the feeder relay to be used also for busbar protection. The relay includes an optional function package offering directional active and reactive power protection that enables the protected feeder to include also motors. Additionally, the optional package for capacitor bank protection includes functions for capacitor bank overload, unbalance and resonance protection enabling the protection of single star (wye) connected capacitor banks or double star (wye) connected capacitor banks with isolated or compensated neutral. Furthermore, the relay offers an optional protection package for interconnection protection providing function for low-voltage-ride-through, directional reactive power undervoltage protection (QU) and the voltage vector shift protection. This optional application package together with the relay's basic functionality can be used with distributed power generation like wind power or solar power generation to determine when to stay connected and when to disconnect distributed generation from the utility grid following different utility Grid Codes.

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

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

4. Application

REF620 provides feeder overcurrent and earth-fault protection for utility and industry distribution networks. The relay fits both isolated neutral networks and networks with resistance- or impedance-earthed neutrals. Furthermore, based on its advanced interstation communication facilities, the relay can also be applied for protecting ring type and meshed distribution networks as well as radial networks.

REF620 can be used with either single- or double-busbar configurations with one or two breakers, and with numerous switching device configurations. It supports a substantial number of both manually and motor-operated disconnectors and earthing switches, and it is capable of running large configurations. The number of controllable devices depends on the number of inputs and outputs left free from other application needs. The number of available I/Os can be increased with the RIO600 Remote I/O device.

The relay offers extensive possibilities to tailor the configurations to application requirements. The tool suite for all Relion relays is Protection and Control IED Manager PCM600, which contains all the necessary tools for configuring the device, including functionality, parameterization, the HMI and communication.

REF620 is an ideal protection and control relay for more advanced feeder schemes. To further improve the arc protection and to minimize the effects of an arc fault, the 620 series relays ordered with the arc protection option can be equipped with an I/O card featuring high-speed outputs operating in one millisecond.

The following figures demonstrate different application examples using relay's basic configuration. The configurations are modified by engineering functionality according to different application needs.

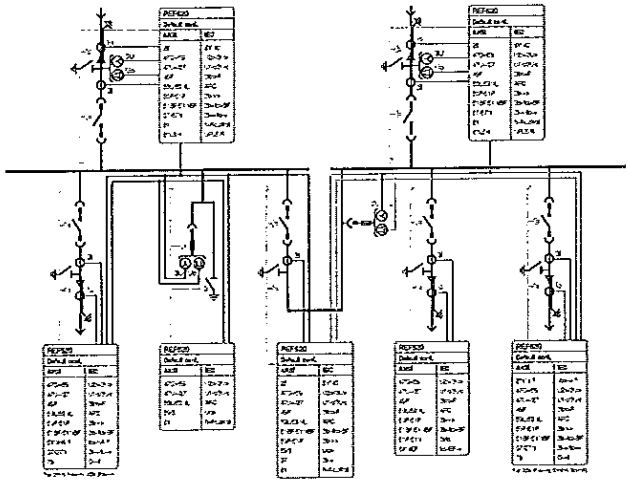

Figure 3. Single busbar AIS 2 section switchgear with conventional instrument transformers

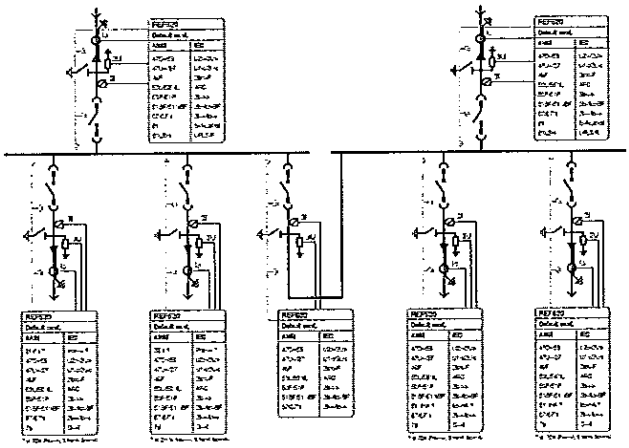

Figure 4. Single busbar AIS switchgear 2 section with sensors

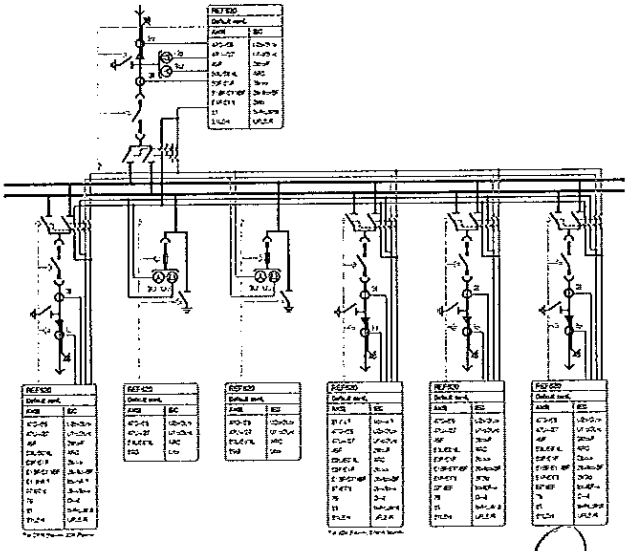

Figure 5. DBB AIS system with one incomer only (with some arrangements simplified)

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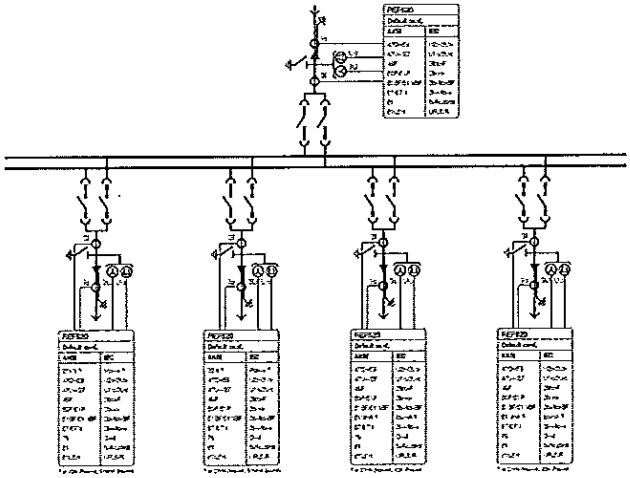

Figure 6. Back-to-back arrangement of AIS switchgear (two single-busbar panels with back walls facing each other), with two circuit breakers and a higher number of disconnectors available. A type of DBB system

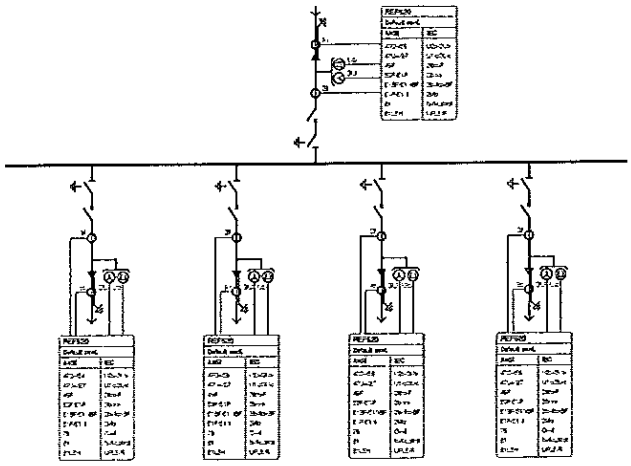

Figure 7. SBB GIS switchgear with the possibility to control the three-position disconnector switch

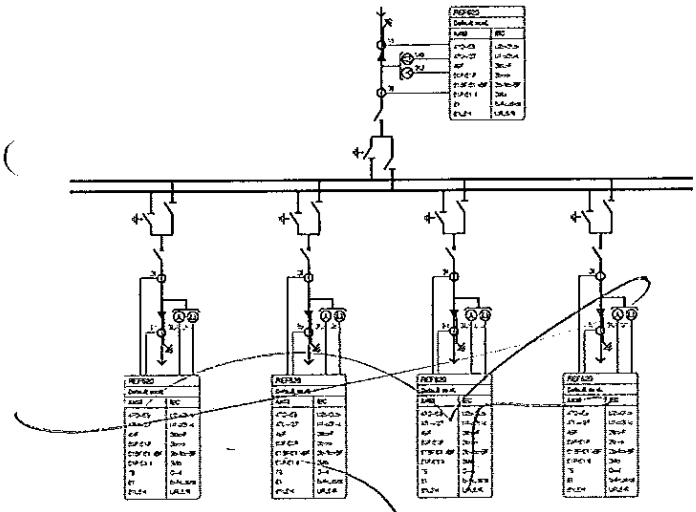

Figure 8. DBB GIS switchgear with the possibility to control the three-position disconnector switch

The following figures demonstrate the application function packages included in the relay. These packages offer new possibilities for several additional applications. The relay's basic functionality includes high-impedance based busbar differential protection functions. Thus, the relay can be engineered for busbar differential protection and by utilizing several relays, multizone differential protection schemes can also be created. The relay includes an optional protection package for capacitor bank protection and an optional protection package for interconnection protection for distributed power generation, for example, wind power. Furthermore, the relay includes an option for power protection. This package enhances the feeder relay capabilities to protect feeders including motors and includes also basic functionality to protect solar power generation connection to utility grid.

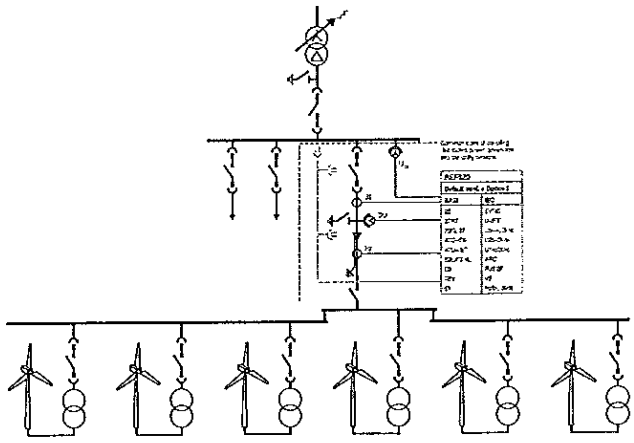

Figure 9. Application example of wind power plant as distributed power generation coupled into the utility network

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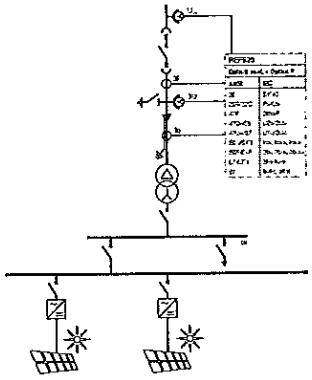

Figure 10. Application example of solar power plant as distributed power generation coupled into the utility network

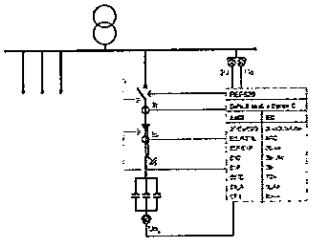

Figure 11. Protection of a single star connected capacitor bank

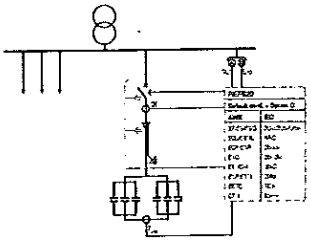

Figure 12. Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral

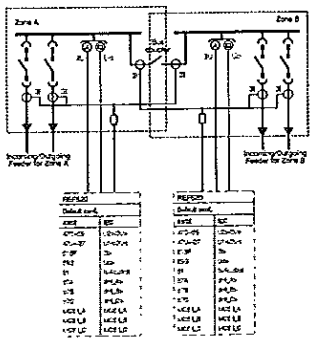

Figure 13. Application example of busbar differential protection covering two zones

5. Supported ABB solutions

ABB's 620 series protection and control relays together with the Substation Management Unit COM600 constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate and streamline the system engineering, ABB's 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 also includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with the Substation Management Unit COM600 or the network control and management system MicroSCADA Pro.

The 620 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 integrity of the protection and communication system, 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, COM600 uses the data content of the bay-level devices to enhance substation level functionality. COM600 features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The Web HMI of COM600 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, COM600 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 COM600. The history data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and history values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

COM600 can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems, such as MicroSCADA Pro and System 800xA.

Table 2. Supported ABB solutions

Product	Version
Substation Management Unit COM600	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

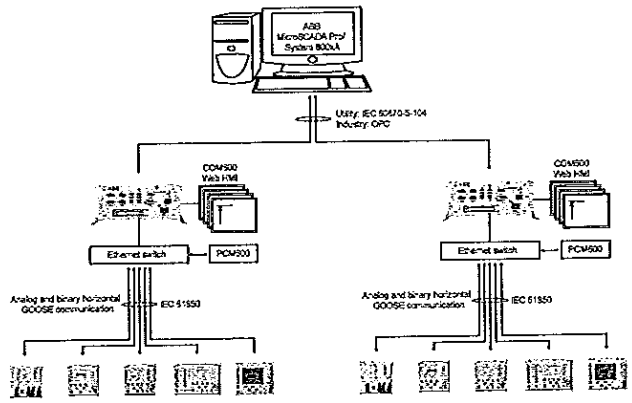

Figure 14. ABB power system example using Relion relays, Substation Management Unit COM600 and MicroSCADA Pro/System 800xA

6. Control

REF620 integrates functionality for the control of circuit breakers, disconnectors and earthing switches via the front panel HMI or by means of remote controls. The relay includes three circuit breaker control blocks. In addition to the circuit breaker control, the relay features four disconnector control blocks intended for the motor-operated control of disconnectors or circuit breaker truck. Furthermore, the relay offers three control blocks intended for the motor-operated control of earthing switch. On top of that, the relay includes additional four disconnector position indication blocks and three earthing switch position indication blocks usable with manually-only controlled disconnectors and earthing switches.

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 hardware configuration of the relay, the number of binary inputs and binary outputs varies. In case the amount of available binary inputs or outputs of the chosen hardware configuration is not sufficient, connecting an external input or output module, for example RIO600, to the relay can extend binary inputs and outputs utilizable in the relay configuration. 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.

The suitability of the binary outputs of the relay which have been selected for the 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 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 tools in PCM600.

Default configuration A incorporates a synchrocheck function to ensure that the voltage, phase angle and frequency on either side of an open circuit breaker satisfy the conditions for a safe interconnection of two networks. Synchrocheck function can also be used with default configuration B, half 9-2 process bus

ВЗЯТО С ОРИГИНАЛА
"КРАСАН" СМОЛЯН ООД
000693

is used. Compared to default configuration A, there are less physical voltage measurements available and thus the voltage measurements from the other side of the breaker have to be read through the 9-2 process bus. An autoreclosing function attempts to restore the power by reclosing the breaker with one to five programmable autoreclosing shots of desired type and duration. The function can be used with every circuit breaker that has the ability for a reclosing sequence. A load-shedding function is capable of performing load shedding based on underfrequency and the rate of change of the frequency.

7. Measurement

The relay continuously measures the phase currents and the neutral current. Furthermore, the relay measures the phase voltages and the residual voltage. In addition, the relay calculates the symmetrical components of the currents and voltages, the system frequency, the active and reactive power, the power factor, the active and reactive energy values as well as the demand value of current and power over a user-selectable preset time frame. Calculated values are also obtained from the protections and condition monitoring functions of the relay.

The values measured can be accessed locally via the user interface on the relay's front panel or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the Web browser-based user interface.

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

8. Power quality

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

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

The protection relay has the following power quality monitoring functions.

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

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

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

9. Fault location

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

10. Disturbance recorder

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

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

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

11. Event log

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

The sequence-of-events information can be accessed either locally via the user interface on the relay's front panel, or remotely via the communication interface of the relay. The information can also be accessed using the Web browser-based user interface, either locally or remotely.

12. Recorded data

The relay has the capacity to store the records of the 128 latest fault events. The records enable the user to analyze the power system events. Each record includes current, voltage and angle values, time stamp and so on. The fault recording can be triggered by the start signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. 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.

13. Condition monitoring

The condition monitoring functions of the relay constantly monitor the performance and the condition of the circuit breaker. The monitoring comprises the spring charging time, SF6 gas pressure, the travel time and the inactivity time of the circuit breaker.

The monitoring functions provide operational circuit breaker history data, which can be used for scheduling preventive circuit breaker maintenance.

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

14. Trip-circuit supervision

The trip-circuit supervision continuously monitors the availability and operability of the trip circuit. It provides open-circuit monitoring both when the circuit breaker is in its closed and in its open position. It also detects loss of circuit-breaker control voltage.

15. 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.

16. Fuse failure supervision

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

17. 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.

18. Access control

To protect the relay from unauthorized access and to maintain information integrity, the relay is provided with a four-level, role-based authentication system with administrator-programmable individual passwords for the Viewer, Operator, Engineer and Administrator level. The access control applies to the front-panel user interface, the Web browser-based user interface and PCM600.

19. Inputs and outputs

REF620 can be selected to measure currents and voltages either with conventional current transducers and voltage transducers or with current sensors and voltage sensors. The relay variant with conventional transducers is equipped with three phase current inputs, one residual-current input, three phase voltage inputs, one residual-voltage input and one phase-to-phase voltage for synccheck input. In addition to current and voltage measurements, the relay's basic configuration includes 24 binary inputs and 14 binary outputs. The phase current inputs and the residual-current inputs are rated 1/5 A, that is, the inputs allow the connection of either 1 A or 5 A secondary current transformers. The optional sensitive 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 relay variant equipped with current and voltage sensors has three sensor inputs for the direct connection of three combisensors with RJ-45 connectors. As an alternative to the combisensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors. Additionally, the relay includes one conventional residual-current input 0.2/1 A normally used in applications requiring sensitive earth-fault protection and featuring core balance current transformers. In addition to current and voltage measurements, the relay's basic configuration includes 16 binary inputs and 14 binary outputs.

As an optional addition, the relay's basic configuration includes one empty slot which can be equipped with one of the following optional modules. The first option, additional binary inputs and outputs module, adds eight binary inputs and four binary outputs to the relay. This option is especially needed when connecting the relay to several controllable objects, still leaving room for additional inputs and outputs for other signals needed in configuration. The second option, an additional RTD/mA input module, increases the relay with six RTD inputs and two mA inputs when additional sensor measurements for example for temperatures, pressures, levels and so on are of interest. The third option is a high-speed output board including eight binary inputs and three high-speed outputs. The high-speed outputs have a shorter activation time compared to the conventional mechanical output relays, shortening the overall relay operation time by 4...6 ms with very time-critical applications like arc protection. The high-speed outputs are freely configurable in the relay application and not limited to arc protection only.

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 inputs and outputs contacts are freely configurable with the signal matrix or application configuration functionality of PCM600.

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

If the number of the relay's own inputs and outputs does not cover all the intended purposes, connecting to an external input or output module, for example RIO600, increases the number of binary inputs and outputs utilizable in the relay configuration. In this case, the external inputs and outputs are connected to the relay via IEC 61850 GOOSE to reach fast reaction times between the relay and RIO600 information. The needed binary input and output connections between the relay and RIO600 units can be configured in a PCM600 tool and then utilized in the relay configuration.

Table 3. Input/output overview

Default conf.	Order code digit		Analog channels			Binary channels			
	6-8	7-8	CT	VT	Combi sensor	BI	BO	RTD	mA
A	AA/AB	AA	4	5	-	32	4 PO + 14 SO	-	-
		AB				24	4 PO + 10 SO	6	2
		AC				32	4 PO + 10 SO + 3 HSO	-	-
		NN				24	4 PO + 10 SO	-	-
B	AC	AA	1	-	3	24	4 PO + 14 SO	-	-
		AB				16	4 PO + 10 SO	6	2
		AC				24	4 PO + 10 SO + 3 HSO	-	-
		NN				16	4 PO + 10 SO	-	-

000694

20. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 1 and 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 modeling 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 61850-9-1 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 620 series relays, having voltage based functions and 9-2 support. 620 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 protocols are able to overcome a failure of a link or switch with a zero switch-over time. In both 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.

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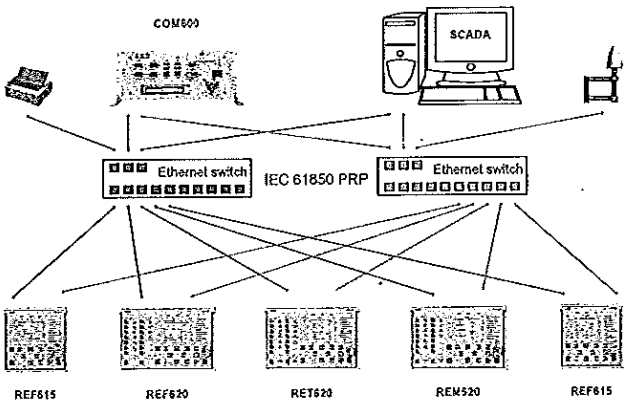

Figure 15. Parallel redundancy protocol (PRP) solution

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 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 620 series relays supports the connection of up to 30 relays. If more than 30 relays are connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

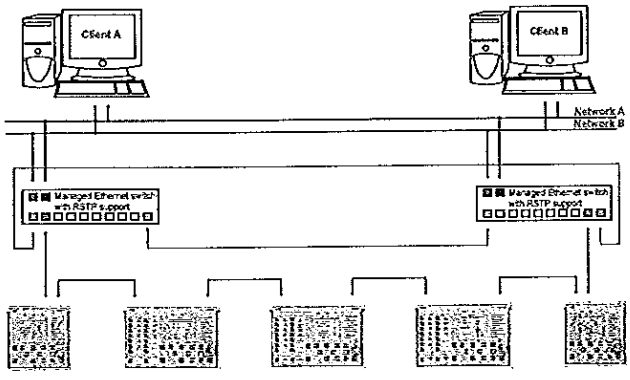

Figure 17. Self-healing Ethernet ring solution

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 a connection to the 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.

620 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)

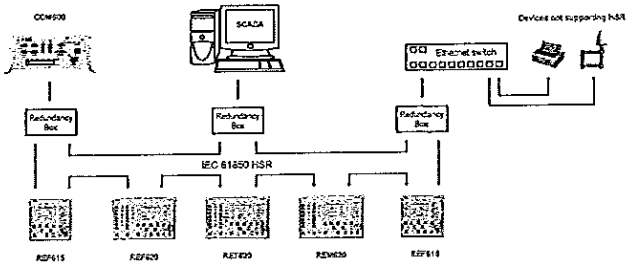

Figure 16. High availability seamless redundancy (HSR) solution

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 thirty 620 series relays. If more than 30 relays are 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.

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

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

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

In addition, the relay supports time synchronization via Modbus, DNP3 and IEC 60870-5-103 serial communication protocols.

Table 4. 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

000695

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21. Technical data

Table 5. Dimensions

Description	Value	
Width	Frame	262.2 mm
	Case	246 mm
Height	Frame	177 mm, 4U
	Case	160 mm
Depth		201 mm
Weight	Complete protection relay	max. 5.0 kg
	Plug-in unit only	max. 2.9 kg

Table 6. Power supply

Description	Type 1	Type 2
U_{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U_n rated	
U_{aux} variation	38...110% of U_n (38...264 V AC)	50...120% of U_n (12...72 V DC)
	80...120% of U_n (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC * 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	DC <18.0 W (nominal[1])/<22.5 W (max[2]) AC <19.0 W (nominal[1])/<23.0 W (max[2])	DC <18.5 W (nominal[1])/<22.5 W (max[2])
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

1) During the power consumption measurement, the relay is powered at rated auxiliary energizing voltage and the energizing quantities are energized without any binary output being active
2) During the power consumption measurement, the relay is powered at rated auxiliary energizing voltage and the energizing quantities are energized to activate at least half of the binary outputs

Table 7. 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

Table 8. Energizing inputs (sensors)

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

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

Table 9. Binary inputs

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...570.0 mW
Threshold voltage	15...175 V DC
Reaction time	<3 ms

Table 10. RTD/mA measurement

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

Table 11. Signal output with high make and carry

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

1) X100: SO1
X105: SO1, SO2, when any of the protection relays is equipped with BIO0005
X110: SO1, SO2 when REF620 or RET620 is equipped with BIO0005
X115: SO1, SO2 when REF620 or REM620 is equipped with BIO0005

Table 12. Signal outputs and IRF output

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

1) X100: IRF, SO2
X105: SO3, SO4, when any of the protection relays is equipped with BIO0005
X110: SO3, SO4, when REF620 or RET620 is equipped with BIO0006
X115: SO3, SO4, when REF620 or REM620 is equipped with BIO0006

Table 13. Double-pole power outputs with TCS function X100: PO3 and PO4

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

1) PSM0003: PO3, PSM0004: PO3, PSM0003: PO4 and PSM0004: PO4.

Table 14. Single-pole power output relays X100: PO1 and PO2

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

000696

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Table 15. High-speed output HSO

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

1) HSO1, HSO2, HSO3, when any of the protection relays is ordered with BIO0007

Table 16. Front port Ethernet interfaces

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

Table 17. 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

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

Table 18. IRIG-B

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

1) According to the 200-04 IRIG standard

Table 19. 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

Table 20. Degree of protection of flush-mounted protection relay

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

Table 21. Environmental conditions

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

1) Degradation in MTBF and HMI performance outside the temperature range of -25...+55°C
2) For the IEC variant, LCD temperature can reach the maximum operating temperature of +70°C

Table 22. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III IEEE C37.90.1-2002
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test		
	10 V (rms) 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
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 • 1...3 s	300 A/m 1000 A/m	
Pulse magnetic field immunity test	1000 A/m 6.4/16 µs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s • 1 MHz	100 A/m 400 transients/s	
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	300 V rms	

Table 22. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
• Differential mode	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 60255-25 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	

Table 23. Insulation tests

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

Table 24. Mechanical tests

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

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Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55°C • 16 h at +85°C [1]	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 • 96 h at +85°C	IEC 60068-2-1 IEC 60068-2-2

1) For devices with an I/O communication interface the maximum operating temperature is +70°C

Table 26. Product safety

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

Table 27. EMC compliance

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

Table 28. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

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

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

1) Set *Operate delay time* to 0.02 s, *Operating curve type* to IEC definite time, *Measurement mode* to default (peak-to-peak), current before fault = 0.0 × I_n, I_n = 50 A, fault current in one phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

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

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

1) For further reference, see "Operation characteristics" table

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

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

1) Measurement mode = default, current before fault = 2.0 × I_n, voltage before fault = 1.0 × U_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiple in range of 1.5...20

Table 32. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 × I_n	0.01
	DPHHPDOC	0.10...40.00 × I_n	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	40...200000 ms	10
Operating curve type [1]	DPHLPDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 13, 12, 15, 17	
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHxPDOC	-179...180°	1

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

Table 33. Three-phase voltage-dependent overcurrent protection (PHPVOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: $f_n \pm 2$ Hz Current: ±1.5% of the set value or ± 0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time [1][2]	Typically 26 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in inverse time mode	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = default, current before fault = 0.0 × I_n, I_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

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Table 34. Three-phase voltage-dependent overcurrent protection (PHPVOC) main settings

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

1) For further reference, see Operation characteristics table

Table 35. Non-directional earth-fault protection (EFxPTOC)

Characteristic		Value		
Operation accuracy	EFLPTOC	Depending on the frequency of the measured current: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
	EFHPTOC and EFIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time [1][2]		Minimum	Typical	Maximum
	EFIPTOC: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	16 ms 11 ms	19 ms 12 ms	23 ms 14 ms
	EFHPTOC and EFLPTOC: I_{Fault} = 2 × set *Start value*	23 ms	29 ms	29 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.95		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression		

1) Measurement mode = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = 2.5 × I_n, Start value multiples in range of 1.5...20

Table 36. Non-directional earth-fault protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 × I_n	0.005
	EFHPTOC	0.10...40.00 × I_n	0.01
	EFIPTOC	1.00...40.00 × I_n	0.01
Time multiplier	EFLPTOC	0.05...15.00	0.01
	EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC	40...200000 ms	10
	EFHPTOC	40...200000 ms	10
	EFIPTOC	20...200000 ms	10
Operating curve type[1]	EFLPTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further reference, see Operation characteristics table

Table 37. Directional earth-fault protection (DEFxPDEF)

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

1) Set Operate delay time = 0.06 s, Definite time characteristic, Measurement mode = default (depends on stage), current before fault = 0.9 × I_n, f_n = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = 2.5 × I_n, Start value multiples in range of 1.5...20

Table 38. Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start value	DEFLPDEF	0.010...5.000 × I_n	0.005
	DEFHPDEF	0.10...40.00 × I_n	0.01
Directional mode	DEFxPDEF	1 = Non-directional 2 = Forward 3 = Reverse	-
Time multiplier	DEFLPDEF	0.05...15.00	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFLPDEF	60...200000 ms	10
	DEFHPDEF	40...200000 ms	10
Operating curve type[1]	DEFLPDEF	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or Inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFxPDEF	1 = Phase angle 2 = IoSin 3 = IoCos 4 = Phase angle 80 5 = Phase angle 88	-

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

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

Characteristic	Value		
Operation accuracy[1]	At the frequency f = f_n ±1.0% or ±0.01 mS (in range of 0.5...100 mS)		
Start time[2]	Minimum	Typical	Maximum
	56 ms	60 ms	64 ms
Reset time	40 ms		
Operate time accuracy	±1.0% of the set value or ±20 ms		
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) U_n = 1.0 × U_n
2) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

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Table 40. Admittance-based earth-fault protection (EFPADM) main settings

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

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

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

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

Table 42. Wattmetric-based earth-fault protection (WPWDE) main settings

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

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

Table 43. Multifrequency admittance-based earth-fault protection (MFADPSDE)

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

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

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

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

Table 45. Transient/intermittent earth-fault protection (INTRPTEF)

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

Table 46. Transient/intermittent earth-fault protection (INTRPTEF) main settings

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

Table 47. Harmonics-based earth-fault protection (HAEFPTOC)

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

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

Table 48. Harmonics-based earth-fault protection (HAEFPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 49. Negative-sequence overcurrent protection (NSPTOC)

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 [1,2]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	23 ms 15 ms	26 ms 18 ms	28 ms 20 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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

Table 50. Negative-sequence overcurrent protection (NSPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 51. Phase discontinuity protection (PDNSPTOC)

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

Table 52. Phase discontinuity protection (PDNSPTOC) main settings

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

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Table 53. Residual overvoltage protection (ROVPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]	U_{Fault} = 2 × set *Start value*	Minimum 48 ms	Typical 51 ms	Maximum 54 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.98		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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

Table 54. Residual overvoltage protection (ROVPTOV) main settings

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

Table 55. Three-phase undervoltage protection (PHPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]	U_{Fault} = 0.9 × set *Start value*	Minimum 62 ms	Typical 65 ms	Maximum 70 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) *Start value* = 1.0 × U_n, voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value multiple* in range of 0.50...0.75

Table 56. Three-phase undervoltage protection (PHPTUV) main settings

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

1) For further reference, see Operation characteristics table

Table 57. Single-phase undervoltage protection (PHAPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]	U_{Fault} = 0.9 × set *Start value*	Minimum 64 ms	Typical 66 ms	Maximum 71 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) *Start value* = 1.0 × U_n, voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50 × U_n, *Start value multiple* in range of 0.50...0.75

Table 58. Single-phase undervoltage protection (PHAPTUV) main settings

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

1) For further reference, see Operation characteristics table

Table 59. Three-phase overvoltage protection (PHPTOV)

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

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

Table 60. Three-phase overvoltage protection (PHPTOV) main settings

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

1) For further reference, see Operation characteristics table

Table 61. Single-phase overvoltage protection (PHAPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]	U_{Fault} = 1.1 × set *Start value*	Minimum 25 ms	Typical 28 ms	Maximum 32 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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

Table 62. Single-phase overvoltage protection (PHAPTOV) main settings

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

1) For further reference, see Operation characteristics table

Table 63. Positive-sequence undervoltage protection (PSPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]	U_{Fault} = 0.99 × set *Start value* U_{Fault} = 0.9 × set *Start value*	Minimum 52 ms 44 ms	Typical 55 ms 47 ms	Maximum 58 ms 50 ms
Reset time		Typically 60 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

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

Table 64. Positive-sequence undervoltage protection (PSPTUV) main settings

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

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ВЯРНО С ОРИГИНАЛА

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Table 65. Negative-sequence overvoltage protection (NSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × U_n		
Start time[1][2]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value*	33 ms	35 ms	37 ms
	U_{Fault} = 2.0 × set *Start value*	24 ms	25 ms	28 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.99		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...		

1) Negative-sequence voltage before fault = 0.9 × U_n, f_n = 50 Hz, negative-sequence overvoltage with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 66. Negative-sequence overvoltage protection (NSPTOV) main settings

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

Table 67. Frequency protection (FRPFRQ)

Characteristic		Value
Operation accuracy	f> f<	±5 mHz
	df/dt	±53 mHz/s (in range |df/dt| <5 Hz/s) ±2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f> f<	<53 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 68. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1 = Freq< 2 = Freq> 3 = df/dt 4 = Freq< + df/dt 5 = Freq> + df/dt 6 = Freq< OR df/dt 7 = Freq> OR df/dt	-
Start value Freq>	FRPFRQ	0.9000...1.2000 × f_n	0.0001
Start value Freq<	FRPFRQ	0.8000...1.1000 × f_n	0.0001
Start value df/dt	FRPFRQ	-0.2000...0.2000 × f_n/s	0.0025
Operate Tm Freq	FRPFRQ	83...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 69. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)

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

1) Overload current > 1.2 × Operate level temperature

Table 70. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings

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

Table 71. Loss of phase, undercurrent (PHPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Start time	Typically <55 ms
Reset time	<60 ms
Reset ratio	Typically 1.04
Retardation time	<35 ms
Operate time accuracy in definite time mode	mode ±1.0% of the set value or ±20 ms

Table 72. Phase undercurrent protection (PHPTUC) main settings

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

Table 73. Circuit breaker failure protection (CCBRBRF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Reset time[1]	Typically 40 ms
Retardation time	<20 ms

1) Trip pulse time defines the minimum pulse length

Table 74. Circuit breaker failure protection (CCBRBRF) main settings

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

Table 75. Three-phase inrush detector (INRPHAR)

Characteristic	Value
Operation accuracy	At the frequency f = f_n Current measurement: ±1.5% of the set value or ±0.002 × I_n Ratio I2f(1) measurement: ±5.0% of the set value
Reset time	+35 ms / -0 ms
Reset ratio	Typically 0.96
Operate time accuracy	+35 ms / -0 ms

Table 76. Three-phase inrush detector (INRPHAR) main settings

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

Table 77. Arc protection (ARCSARC)

Characteristic		Value		
Operation accuracy		±3% of the set value or ±0.01 × I_n		
Operate time		Minimum	Typical	Maximum
	Operation mode = "Light +current"[1][2]	9 ms[3] 4 ms[4]	12 ms[3] 6 ms[4]	15 ms[3] 9 ms[4]
	Operation mode = "Light only"[3]	9 ms[3] 4 ms[4]	10 ms[3] 6 ms[4]	12 ms[3] 7 ms[4]
Reset time		Typically 40 ms[3] <55 ms[4]		
Reset ratio		Typically 0.96		

1) Phase start value = 1.0 × I_n, current before fault = 0.0 × set *Phase start value*, f_n = 50 Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements
2) Includes the delay of the heavy-duty output contact
3) Normal power output
4) High-speed output

Table 78. Arc protection (ARCSARC) main settings

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

Table 79. High-impedance fault detection (PHIZ) main settings

Parameter	Function	Value (Range)	Step
Security Level	PHIZ	1...10	1
System type	PHIZ	1 = Grounded 2 = Ungrounded	

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ВЯРНО С ОРИГИНАЛА
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Table 80. Load-shedding and restoration (LSHDFFRQ)

Characteristic		Value
Operation accuracy	f<	±10 mHz
	df/dt	±100 mHz/s (in range |df/dt| < 5 Hz/s) ± 2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f<	<80 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 81. Load-shedding and restoration (LSHDFFRQ) main settings

Parameter	Function	Value (Range)	Step
Load shed mode	LSHDFFRQ	1 = Freq< 6 = Freq< OR df/dt 8 = Freq< AND df/dt	-
Restore mode	LSHDFFRQ	1 = Disabled 2 = Auto 3 = Manual	-
Start value Freq	LSHDFFRQ	0.800...1.200 × f_n	0.001
Start value df/dt	LSHDFFRQ	-0.200...-0.005 × f_n	0.005
Operate Tm Freq	LSHDFFRQ	60...200000 ms	10
Operate Tm df/dt	LSHDFFRQ	120...200000 ms	10
Restore start Val	LSHDFFRQ	0.800...1.200 × f_n	0.001
Restore delay time	LSHDFFRQ	60...200000 ms	10

Table 82. Multipurpose protection (MAPGAPC)

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

Table 83. Multipurpose protection (MAPGAPC) main settings

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

Table 84. Automatic switch-onto-fault (CVPSOF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2Hz
	Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

Table 85. Automatic switch-onto-fault logic (CVPSOF) main settings

Parameter	Function	Value (Range)	Step
SOTF reset time	CVPSOF	0...60000 ms	10

Table 86. Voltage vector shift protection (VVSPPAM)

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

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

Table 87. Voltage vector shift protection (VVSPPAM) main settings

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

Table 88. Directional reactive power undervoltage protection (DQPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Reactive power range |PF| <0.71
	Power: ±3.0% or ±0.002 × Q_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1][2]	Typically 46 ms
Reset time	<50 ms
Reset ratio	Typically 0.96
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Start value = 0.50 × S_n, reactive power before fault = 0.0 × S_n, start value reactive power overshoot 2 times, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 89. Directional reactive power undervoltage protection (DQPTUV) main settings

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

Table 90. Underpower protection (DUPPDPR)

Characteristic	Value
Operation accuracy [1]	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 1.04
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = "Pos Seq" (default)
2) U_n = U_n, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 91. Underpower protection (DUPPDPR) main settings

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

Table 92. Reverse power/directional overpower protection (DOPPDPR)

Characteristic	Value
Operation accuracy [1]	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time[2][3]	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 0.94
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

1) Measurement mode = "Pos Seq" (default)
2) U_n = U_n, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 93. Reverse power/directional overpower protection (DOPPDPR) main settings

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

Table 94. Low-voltage ride-through protection (LVRTPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × U_n
Start time[1][2]	Typically 40 ms
Reset time	Based on maximum value of *Recovery time* setting
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,...

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

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Table 95. Low-voltage ride-through protection (LVRTPTUV) main settings

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

Table 96. High-impedance differential protection (HDxPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
Start time[1][2]		Minimum	Typical	Maximum
	I_{FAULT} = 2.0 × set *Start value*	12 ms	15 ms	24 ms
	I_{FAULT} = 10 × set *Start value*	10 ms	12 ms	14 ms
Reset time		<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		

1) Measurement mode = default (depending on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 97. High-impedance differential protection (HDxPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HDxPDIF	1.0...200.0 %I_n	1
Minimum operate time	HDxPDIF	20...300000 ms	10

Table 98. Circuit breaker uncorresponding position start-up (UPCALH)

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

Table 99. Three-independent-phase non-directional overcurrent protection (PHxPTOC)

Characteristic		Value		
Operation accuracy	PHLPTOC	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n		
	PHHPTOC and PHIPTOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n)		
Start time[1][2]		Minimum	Typical	Maximum
	PHLPTOC: I_{FAULT} = 2 × set *Start value*	15 ms	18 ms	17 ms
	I_{FAULT} = 10 × set *Start value*	11 ms	14 ms	17 ms
	PHHPTOC and PHIPTOC: I_{FAULT} = 2 × set *Start value*	23 ms	25 ms	28 ms
Reset time		<40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression		

1) Measurement mode = default (depending on stage), current before fault = 2.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = 2.5 × I_n, Start value multiples in range of 1.5...20

Table 100. Three-independent-phase non-directional overcurrent protection (PHxPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 101. Directional three-independent-phase directional overcurrent protection (DPHxPDOC)

Characteristic		Value		
Operation accuracy	DPHLPDOC	Depending on the frequency of the current measured: f_n ±2 Hz Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DPHHPDOC	±1.5% of set value or ±0.002 × I_n (at currents in the range of 0.1...10 × I_n) ±5.0% of the set value (at currents in the range of 10...40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time[1][2]		Minimum	Typical	Maximum
	I_{FAULT} = 2 × set *Start value*	38 ms	43 ms	43 ms
Reset time		<40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression		

1) Measurement mode and default current before fault = 0.9 × I_n, voltage before fault = 1.0 × U_n, f_n = 50 Hz, fault current in one phase with nominal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = 2.5 × I_n, Start value multiples in range of 1.5...20

Table 102. Directional three-independent-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 × I_n	0.01
	DPHHPDOC	0.10...40.00 × I_n	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	40...200000 ms	10
Operating curve type[1]	DPHLPDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHxPDOC	-179...180°	1

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

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Table 103. Three-phase overload protection for shunt capacitor banks (COLPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz, and no harmonics
	5% of the set value or 0.002 × I_n
Start time for overload stage[1)2)]	Typically 75 ms
Start time for under current stage[2)3)]	Typically 25 ms
Reset time for overload and alarm stage	Typically 60 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the set value or ±20 ms
Operate time accuracy in inverse time mode	10% of the theoretical value or ±20 ms
Suppression of harmonics for under current stage	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,...

1) Harmonics current before fault = 0.8 × I_n, harmonics fault current 1.2 × start value, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Harmonics current before fault = 1.2 × I_n, harmonics fault current 0.8 × start value, results based on statistical distribution of 1000 measurements

Table 104. Three-phase overload protection for shunt capacitor banks (COLPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value overload	COLPTOC	0.30...1.50 × I_n	0.01
Alarm start value	COLPTOC	50...120%	1
Start value Un Cur	COLPTOC	0.10...0.70 × I_n	0.01
Time multiplier	COLPTOC	0.05...2.00	0.01
Alarm delay time	COLPTOC	500...6000000	100
Un Cur delay time	COLPTOC	100...120000	100

Table 105. Current unbalance protection for shunt capacitor banks (CUBPTOC)

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[1)2)]	Typically 28 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the theoretical value or ±20 ms
Operate time accuracy in inverse definite minimum time mode	5% of the theoretical value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,...

1) Fundamental frequency current = 1.0 × I_n, current before fault = 0.0 × I_n, fault current = 2.0 × start value, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 106. Current unbalance protection for shunt capacitor banks (CUBPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm mode	CUBPTOC	1 = Normal 2 = Element counter	-
Start value	CUBPTOC	0.01...1.00 × I_n	0.01
Alarm start value	CUBPTOC	0.01...1.00 × I_n	0.01
Time multiplier	CUBPTOC	0.05...15.00	0.01
Operating curve type[1)]	CUBPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	CUBPTOC	50...200000 ms	10
Alarm delay time	CUBPTOC	50...200000 ms	10

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

Table 107. Shunt capacitor bank switching resonance protection, current based (SRCPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: fn ±2 Hz Operate value accuracy: ±3% of the set value or ±0.002 × I_n (for 2nd order Harmonics) ±1.5% of the set value or ±0.002 × I_n (for 3rd order < Harmonics < 10th order) ±6% of the set value or ±0.004 × I_n (for Harmonics >= 10th order)
Reset time	Typically 45 ms or maximum 50 ms
Retardation time	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = f_n

Table 108. Shunt capacitor bank switching resonance protection, current based (SRCPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm start value	SRCPTOC	0.03...0.50 × I_n	0.01
Start value	SRCPTOC	0.03...0.50 × I_n	0.01
Tuning harmonic Num	SRCPTOC	1...11	1
Operate delay time	SRCPTOC	120...360000 ms	1
Alarm delay time	SRCPTOC	120...360000 ms	1

Table 109. Operation characteristics

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

Control functions

Table 110. Autoreclosing (DARREC)

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

Table 111. Synchronism and energizing check (SECRSYN)

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

Table 112. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	-1 = Off 1 = Both Dead 2 = Live L, Dead B 3 = Dead L, Live B 4 = Dead Bus, L Any 5 = Dead L, Bus Any 6 = One Live, Dead 7 = Not Both Live	-
Difference voltage	SECRSYN	0.01...0.50 × U_n	0.01
Difference frequency	SECRSYN	0.001...0.100 × f_n	0.001
Difference angle	SECRSYN	5...90°	1
Synchrocheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	-
Dead line value	SECRSYN	0.1...0.8 × U_n	0.1
Live line value	SECRSYN	0.2...1.0 × U_n	0.1
Close pulse	SECRSYN	200...60000 ms	10
Max energizing V	SECRSYN	0.50...1.15 × U_n	0.01
Control mode	SECRSYN	1 = Continuous 2 = Command	-
Phase shift	SECRSYN	-180...180°	1
Minimum Syn time	SECRSYN	0...60000 ms	10
Maximum Syn time	SECRSYN	100...6000000 ms	10
Energizing time	SECRSYN	100...60000 ms	10
Closing time of CB	SECRSYN	40...250 ms	10

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Condition monitoring and supervision functions

Table 113. Circuit-breaker condition monitoring (SSCBR)

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

Table 114. Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time [1]	<30 ms

1) Including the delay of the output contact

Table 115. Current circuit supervision (CCSPVC) main settings

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

Table 116. Current transformer supervision for high-impedance protection scheme (HZCCxSPVC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz ±1.5% of the set value or ±0.002 × I_n
Reset time	<40 ms
Reset ratio	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.5% of the set value or ±20 ms

Table 117. Fuse failure supervision (SEQSPVC)

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

1) Includes the delay of the signal output contact, f_n ±2 Hz, fault voltage with sinusoidal frequency, injected from random phase angle, results based on statistical distribution of 1000 measurements

Table 118. Runtime counter for machines and devices (MDSOPT)

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

1) Of the reading, for a constant ambient temperature and stable network frequency

Measurement functions

Table 119. Three-phase current measurement (CMMXU)

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

Table 120. Sequence current measurement (CSMSQI)

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

Table 121. Residual current measurement (RESCMMXU)

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

Table 122. Three-phase voltage measurement (VMMXU)

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

Table 123. Single-phase voltage measurement (VAMMXU)

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

Table 124. Residual voltage measurement (RESVMMXU)

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

Table 125. Sequence voltage measurement (VSMSQI)

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

Table 126. Three-phase power and energy measurement (PEMMXU)

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

1) |PF| ≥ 0.5 when S is in range [0.2...1.2] × S_n
2) |PF| < 0.5 when S is in range [0.5...1.2] × S_n

Table 127. Frequency measurement (FMMXU)

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

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Fault location functions

Table 128. Fault locator (SCEFRFLO)

Characteristic	Value
Measurement accuracy	At the frequency $f = f_n$ Impedance: ±2.5% or ±0.25 Ω Distance: ±2.5% or ±0.15 km/0.1 mile XCGF_CALC: ±2.5% or ±50 Ω RFLT_PER_RLO: ±5% or ±0.05

Table 129. Fault locator (SCEFRFLO) main settings

Parameter	Function	Value (Range)	Step
Z Max phase load	SCEFRFLO	1.0...10000.00 Ω	0.1
Ph leakage Ris	SCEFRFLO	25...1000000 Ω	1
Ph capacitive Reactance	SCEFRFLO	15...1000000 Ω	1
R1 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
X1 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
R0 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
X0 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
Line Len section A	SCEFRFLO	0.000...1000.000 pu	0.001

Power quality functions

Table 130. Voltage variation (PHQVVR)

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

Table 131. Voltage variation (PHQVVR) main settings

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

Table 132. Voltage unbalance (VSQVUB)

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

Table 133. Voltage unbalance (VSQVUB) main settings

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

Other functions

Table 134. Pulse timer (PTGAPC)

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

Table 135. Time delay off (8 pcs) (TOFPAGC)

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

Table 136. Time delay on (8 pcs) (TONGAPC)

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

22. Local HMI

The relay supports process information and status monitoring from the relay's local HMI via its display and indication/alarm LEDs. The local LHMI also enables control operations for the equipment connected and controlled by the relay, either via display or via manual push buttons available on the local HMI.

LCD display offers front-panel user interface functionality with menu navigation and menu views. In addition, the display includes a user-configurable two-page single-line diagram (SLD) with a position indication for the associated primary equipment and primary measurements from the process. The SLD can be modified according to user requirements by using Graphical Display Editor in PCM600.

The local HMI also includes 11 programmable LEDs. These LEDs can be configured to show alarms and indications as needed by PCM600 graphical configuration tool. The LEDs include two separately controllable colors, red and green, making one LED able to indicate better the different states of the monitored object.

The relay also includes 18 configurable manual push buttons, which can freely be configured by the PCM600 graphical configuration tool. These buttons can be configured to control the relay's internal features for example changing setting group, trigger disturbance recordings and changing operation modes for functions or to control relay's external equipment, for example opening or closing the equipment, via relay's binary outputs. These buttons also include a small indication LED for each button. This LED is freely configurable, making it possible to use push button LEDs to indicate button activities or as additional indication/alarm LEDs in addition to the 11 programmable LEDs.

The local HMI includes a push button (L/R) for the local/remote operation of the relay. When the relay is in the local mode, the relay can be operated only by using the local front-panel user interface. When the relay is in the remote mode, the relay can execute commands sent remotely. 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 the relays are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.

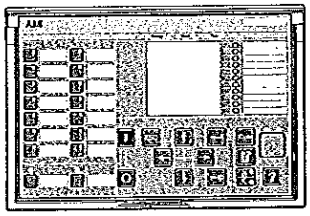

Figure 18. Example of the LHMI

23. Mounting methods

By means of appropriate mounting accessories the standard relay case can be flush mounted, semi-flush mounted or wall mounted.

Further, the relays can be mounted in any standard 19" instrument cabinet by means of 19" mounting panels available with cut-outs for one relay. Alternatively, the relay can be mounted in 19" instrument cabinets by means of 4U Combiflex equipment frames.

For the routine testing purposes, the relay cases can be equipped with test switches, type RTXP 24, which can be mounted side by side with the relay cases.

Mounting methods

- Flush mounting
- Semi-flush mounting
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame
- Mounting with a RTXP 24 test switch to a 19" rack

Panel cut-out for flush mounting

- Height: 152 ±1 mm
- Width: 248 ±1 mm

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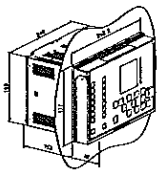

Figure 19. Flush mounting

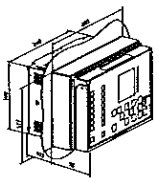

Figure 20. Semi-flush mounting

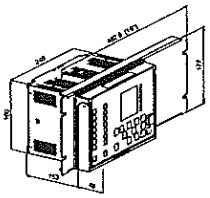

Figure 21. Rack mounting

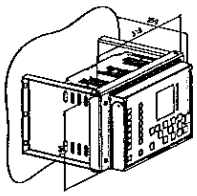

Figure 22. Wall mounting

24. Relay case and plug-in unit

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

25. Selection and ordering data

The relay type and serial number label identifies the protection and control relay. The label is placed above the HMI on the upper part of the plug-in unit. An order code label is placed on the side of the plug-in unit as well as inside the case. The order code consists of a string of letters and digits generated from the relay's hardware and software modules.

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 service 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.

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#	Description	
1	IED	
	620 series IED (including case)	N
	Complete Relay with conformal coating	S
2	Standard	
	IEC	B
	CN	C
3	Main application	
	Feeder protection and control	F
4	Functional application	
	Example configuration	N
5-6	Analog inputs and outputs	
	4I (1/5 A) + 5U + 2I5I + 14BO	AA
	4I (0.2/1 A) + 5U + 2I5I + 14BO	AB
	Sensors (4 + 3U) + 1I01 + 1I03 + 16BO	AC
7-8	Optional board	
	Optional I/Os 8RTD + 4mA	AA
	Optional RTDs 8RTD in + 2mA out	AB
	Optional Fast I/Os 9BI + 3HSO	AC
	No optional board	NN

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9	Communication (Serial/Ethernet)	
10	Serial RS 485, incl. an input for IRIG-B + Ethernet 100Base FX (1+LC)	AA
	Serial RS 485, incl. an input for IRIG-B + Ethernet 100Base TX (1+RJ45)	AB
	Serial RS 485, incl. an input for IRIG-B	AN
	Serial glass fibre (ST) + Ethernet 100Base TX (1+RJ45) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for IRIG-B (cannot be combined with arc protection)	BA
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (1+LC, 2+RJ45) with HSR/PRP	BC
	Serial glass fibre (ST) + Ethernet 100Base FX (2+RJ45) with HSR/PRP	BD
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (2+LC, 1+RJ45) with HSR/PRP	BE
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (1+LC, 2+RJ45) with HSR/PRP and IEC61850-9-2LE	BF
	Serial glass fibre (ST) + Ethernet 100Base TX (3+RJ45) with HSR/PRP and IEC61850-9-2LE	BG
	Serial glass fibre (ST) + Ethernet 100Base TX and FX (2+LC, 1+RJ45) with HSR/PRP and IEC61850-9-2LE	BH
	Serial glass fibre (ST) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for IRIG-B (cannot be combined with arc protection)	BN
	RS 232/485 (including IRIG-B) + Ethernet 100Base FX (1+RJ45) (cannot be combined with arc protection)	CB
	RS 232/485 + RS 485/ Glass/Plastic ST (including IRIG-B) (cannot be combined with arc protection)	CN
	Ethernet 100Base FX (1+LC)	NA
	Ethernet 100Base TX (1+RJ45)	NB
	Ethernet 100Base TX and FX (1+LC, 2+RJ45) with HSR/PRP	NC
	Ethernet 100Base TX (2+RJ45) with HSR/PRP	ND
	Ethernet 100Base TX and FX (2+LC, 1+RJ45) with HSR/PRP	NE
	Ethernet 100Base TX and FX (1+LC, 2+RJ45) with HSR/PRP and IEC61850-9-2LE	NF
	Ethernet 100Base TX (2+RJ45) with HSR/PRP and IEC61850-9-2LE	NG
	Ethernet 100Base TX and FX (2+LC, 1+RJ45) with HSR/PRP and IEC61850-9-2LE	NH
	No communication module	NN

If serial communication is chosen, please choose a serial communication module including Ethernet (for example "BC") if a service bus for PCM600 or the Web-HMI is required.

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8	Description	
11	Communication protocols	
	IEC 61850 (for Ethernet communication modules and IEDs without a communication module)	A
	Modbus (for Ethernet/serial or Ethernet + serial communication modules)	B
	IEC 61850 + Modbus (for Ethernet or serial + Ethernet communication modules)	C
	IEC 60870-5-103 (for serial or Ethernet + serial communication modules)	D
	DNP3 (for Ethernet/serial or Ethernet + serial communication modules)	F
	IEC 61850 + IEC 60870-5-103 (for serial + Ethernet communication modules)	G
	IEC 61850 + DNP3 (for Ethernet or serial + Ethernet communication modules)	H
12	Language	
	English	1
	English and Chinese	2
13	Front panel	
	Large LCD with Single Line Diagram - IEC	B
	Large LCD with Single Line Diagram - ON	D
14	Option 1	
	Arc protection (requires a communication module, cannot be combined with comm. module options DN, DD, DB and DH)	B
	None	N
15	Option 2	
	Fault locator	F
	Capacitor bank protection package	C
	Interconnection/Distributed generation protection package	D
	Power protection package	P
	All options (Fault locator + Capacitor bank protection + Interconnection/Distributed generation protection + Power protection)	L
	None	N
16	Power supply	
	Power supply 48-250 VDC, 100-240 VAC	1
	Power supply 24-60 VDC	2
17	Reserved	
18	Product version 2.0 FP1	H

000708

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Example code: NBFNAANNABC1BNN11G

Your ordering code:

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

Figure 23. Ordering key for complete protection relays

28. Accessories and ordering data

Table 137. Cables

Item	Order number
Cable for optical sensors for arc protection 1.5 m	1MRS120534-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS120534-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS120534-5.0

Table 138. Mounting accessories

Item	Order number
Semi-flush mounting kit	2RCA039673A0001
Wall mounting kit	2RCA039643A0001
19" rack mounting kit with cut-out for one relay	2RCA031135A0001
19" rack mounting kit for one relay and one RTXP24 test switch (the test switch and wire harness are not included in the delivery)	2RCA032818A0001
Mounting bracket for one relay with test switch RTXP in 4U Combiflex (RHGT 19" variant C) (the test switch, wire harness and Combiflex RGHT 19" variant C are not included in the delivery)	2RCA032828A0001
Functional earthing flange for RTD modules	2RCA035978A0001 1)

1) Cannot be used when the IED is mounted with the Combiflex 19" equipment frame (2RCA032828A0001).

27. Tools

The protection relay is delivered as a pre-configured unit including the example configuration. The default parameter setting values can be changed from the front-panel user interface, the Web browser-based user interface (Web HMI) or the PCM600 tool in combination with the relay-specific connectivity package.

The Protection and Control IED Manager PCM600 offers extensive relay configuration functions such as relay signal configuration, application configuration, graphical display configuration including single line diagram configuration, and IEC 61850 communication configuration including horizontal GOOSE communication.

When the Web browser-based user interface is used, the protection relay can be accessed either locally or remotely using a Web browser (Internet Explorer). For security reasons, the Web browser-based user interface is disabled by default but it can be enabled via the front-panel user interface. 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 139. Tools

Configuration and setting tools	Version
PCM600	2.8 (Rollup 20150626) or later
Web browser-based user interface	IE 8.0, IE 9.0, IE 10.0 or IE 11.0
REF620 Connectivity Package	2.1 or later

Table 140. Supported functions

Function	Web HMI	PCM600
Relay parameter setting	•	•
Saving of relay parameter settings in the relay	•	•
Signal monitoring	•	•
Disturbance recorder handling	•	•
Alarm LED viewing	•	•
Access control management	•	•
Relay signal configuration (Signal Matrix)	-	•
Modbus® communication configuration (communication management)	-	•
DNP3 communication configuration (communication management)	-	•
IEC 60870-5-103 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

28. Cyber security

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

29. Connection diagrams

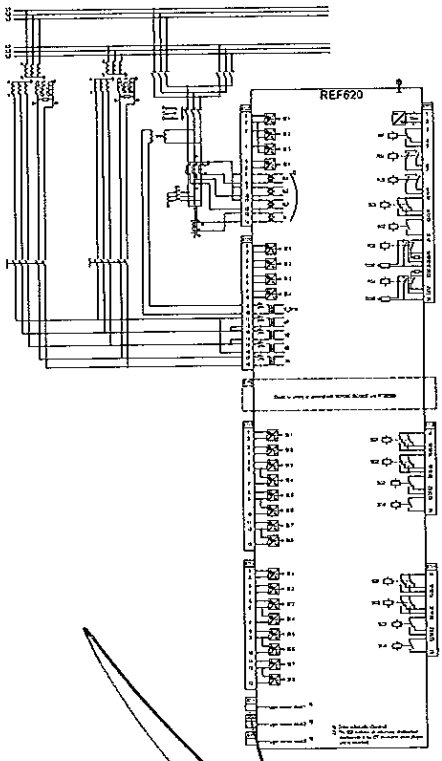

Figure 24. Connection diagram for this configuration with CTs and VTs

000709

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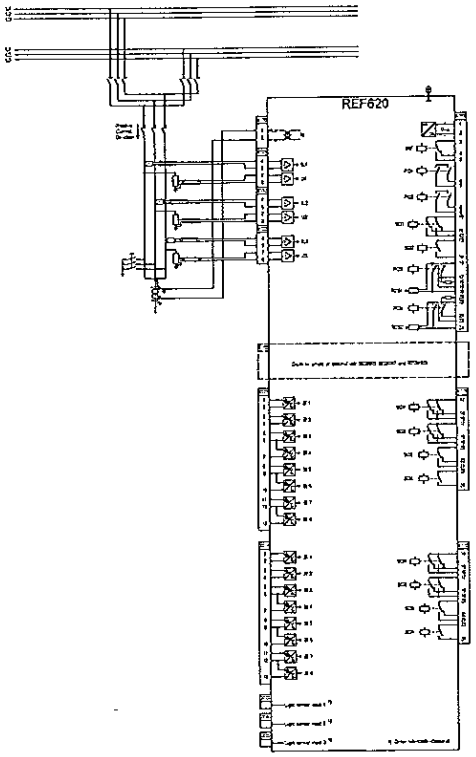

Figure 25. Connection diagram for the configuration with sensors

30. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Relion® 620 series, Certificate number: 74106008-OPE/INC 15-2319.

DNV GL has issued an IEC 61850 Edition 1 Certificate Level A1 for Relion® 620 series, Certificate number: 74106008-OPE/INC 15-2323.

Additional certificates can be found on the product page.

31. 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 REF620 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

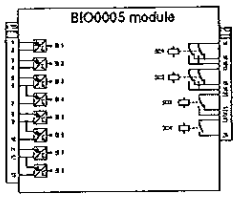

Figure 26. Optional BIO0005 module (slot X105)

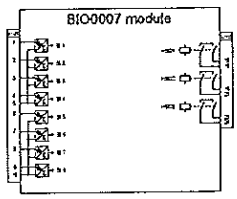

Figure 27. Optional BIO0007 module for fast outputs (slot X105)

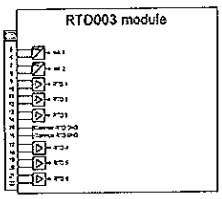

Figure 28. Optional RTD0003 module (slot X105)

32. Functions, codes and symbols

Table 141. Functions included in the relay

Function	IEC 61850	IEC 60617	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)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3I> -> (1)	67-1 (1)
	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> -> (1)	67-2 (1)
	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Three-phase voltage-dependent overcurrent protection	PHPVOC1	3I(U)> (1)	51V (1)
	PHPVOC2	3I(U)> (2)	51V (2)
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance-based earth-fault protection	EFPADM1	Yo> -> (1)	21YN (1)
	EFPADM2	Yo> -> (2)	21YN (2)
	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric-based earth-fault protection	WPWDE1	Po> -> (1)	32N (1)
	WPWDE2	Po> -> (2)	32N (2)
	WPWDE3	Po> -> (3)	32N (3)
Multifrequency admittance-based earth-fault protection	MFADPSDE1	Io> -> Y (1)	67YN (1)
Transient/intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonics-based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)

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Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
	PHPTUV4	3U< (4)	27 (4)
Single-phase undervoltage protection, secondary side	PHAPTUV1	U_A< (1)	27_A (1)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Single-phase overvoltage protection, secondary side	PHAPTOV1	U_A> (1)	59_A (1)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
	NSPTOV2	U2> (2)	47O- (2)
Frequency protection	FPFFRQ1	f>/f<,df/dt (1)	81 (1)
	FPFFRQ2	f>/f<,df/dt (2)	81 (2)
	FPFFRQ3	f>/f<,df/dt (3)	81 (3)
	FPFFRQ4	f>/f<,df/dt (4)	81 (4)
	FPFFRQ5	f>/f<,df/dt (5)	81 (5)
	FPFFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F (1)	49F (1)
Loss of phase (undercurrent)	PHPTUC1	3I< (1)	37 (1)
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
	CCBRBRF3	3I>/Io>BF (3)	51BF/51NBF (3)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (1)
Master trip	TRPTTRC1	Master Trip (1)	94/86 (1)
	TRPTTRC2	Master Trip (2)	94/86 (2)
	TRPTTRC3	Master Trip (3)	94/86 (3)
	TRPTTRC4	Master Trip (4)	94/86 (4)
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)
High-impedance fault detection	PHIZ1	HIF (1)	HIZ (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Load-shedding and restoration	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
	LSHDPFRQ3	UFLS/R (3)	81LSH (3)
	LSHDPFRQ4	UFLS/R (4)	81LSH (4)
	LSHDPFRQ5	UFLS/R (5)	81LSH (5)
	LSHDPFRQ6	UFLS/R (6)	81LSH (6)
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)
	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)
Automatic switch-onto-fault logic (SOF)	CVPSOF1	CVPSOF (1)	SOFT/21/50 (1)
Voltage vector shift protection	VVSPPAM1	VS (1)	78V (1)
Directional reactive power undervoltage protection	DQPTUV1	Q> -> ,3U< (1)	32Q,27 (1)
	DQPTUV2	Q> -> ,3U< (2)	32Q,27 (2)
Underpower protection	DUPPDPR1	P< (1)	32U (1)
	DUPPDPR2	P< (2)	32U (2)
Reverse power/directional overpower protection	DOPPDPR1	P>/Q> (1)	32R/32O (1)
	DOPPDPR2	P>/Q> (2)	32R/32O (2)
Low-voltage ride-through protection	LVRTPTUV1	U<RT (1)	27RT (1)
	LVRTPTUV2	U<RT (2)	27RT (2)
	LVRTPTUV3	U<RT (3)	27RT (3)
High-impedance differential protection for phase A	HIAPDIF1	dId_A> (1)	87A (1)
High-impedance differential protection for phase B	HIBPDIF1	dId_B> (1)	87B (1)
High-impedance differential protection for phase C	HICPDIF1	dId_C> (1)	87C (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Circuit breaker uncorresponding position start-up	UPCALH1	CBUPS (1)	CBUPS (1)
	UPCALH2	CBUPS (2)	CBUPS (2)
	UPCALH3	CBUPS (3)	CBUPS (3)
Three-independent-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I_3> (1)	51P-1_3 (1)
	PHLPTOC2	3I_3> (2)	51P-1_3 (2)
Three-independent-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I_3>> (1)	51P-2_3 (1)
	PHHPTOC2	3I_3>> (2)	51P-2_3 (2)
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I_3>>> (1)	50P/51P_3 (1)
Directional three-independent-phase directional overcurrent protection, low stage	DPHLPDOC1	3I_3> -> (1)	67-1_3 (1)
	DPHLPDOC2	3I_3> -> (2)	67-1_3 (2)
Directional three-independent-phase directional overcurrent protection, high stage	DPHHPDOC1	3I_3>> -> (1)	67-2_3 (1)
	DPHHPDOC2	3I_3>> -> (2)	67-2_3 (2)
Three-phase overload protection for shunt capacitor banks	COLPTOC1	3I> 3I< (1)	51CO37 (1)
Current unbalance protection for shunt capacitor banks	CUBPTOC1	dI>C (1)	51NC-1 (1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC1	TD> (1)	55TD (1)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
	CBXCBR3	I <-> O CB (3)	I <-> O CB (3)
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
	ESXSWI3	I <-> O ESC (3)	I <-> O ESC (3)
Disconnector 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)
	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
	ESSXSWI3	I <-> O ES (3)	I <-> O ES (3)
Autoreclosing	DARREC1	O -> I (1)	79 (1)
	DARREC2	O -> I (2)	79 (2)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
	SSCBR2	CBCM (2)	CBCM (2)
	SSCBR3	CBCM (3)	CBCM (3)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC1	MCS I_A (1)	MCS I_A (1)
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC1	MCS I_B (1)	MCS I_B (1)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC1	MCS I_C (1)	MCS I_C (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTS (1)	OPTM (1)
	MDSOPT2	OPTS (2)	OPTM (2)
Measurement			
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Single-phase voltage measurement	VAMMXU2	U_A (2)	V_A (2)
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)
Load profile record	LDPRLRC1	LOADPROF (1)	LOADPROF (1)
Frequency measurement	FMMXU1	f (1)	f (1)
Fault location			
Fault locator	SCEFRFLO1	FLOC (1)	21FL (1)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (1)
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)

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Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
	TPSGAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
	TPMGAPC2	TPM (2)	TPM (2)
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)
	MVGAPC3	MV (3)	MV (3)
	MVGAPC4	MV (4)	MV (4)
Integer value move	MVI4GAPC1	MVI4 (1)	MVI4 (1)
	MVI4GAPC2	MVI4 (2)	MVI4 (2)
	MVI4GAPC3	MVI4 (3)	MVI4 (3)
	MVI4GAPC4	MVI4 (4)	MVI4 (4)
Analog value scaling	SCA4GAPC1	SCA4 (1)	SCA4 (1)
	SCA4GAPC2	SCA4 (2)	SCA4 (2)
	SCA4GAPC3	SCA4 (3)	SCA4 (3)
	SCA4GAPC4	SCA4 (4)	SCA4 (4)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
	SPCGAPC3	SPC (3)	SPC (3)
Remote generic control points	SPCRGAPC1	SPCR (1)	SPCR (1)
Local generic control points	SPCLGAPC1	SPCL (1)	SPCL (1)

Table 141. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Generic up-down counters	UDFCNT1	UDCNT (1)	UDCNT (1)
	UDFCNT2	UDCNT (2)	UDCNT (2)
	UDFCNT3	UDCNT (3)	UDCNT (3)
	UDFCNT4	UDCNT (4)	UDCNT (4)
	UDFCNT5	UDCNT (5)	UDCNT (5)
	UDFCNT6	UDCNT (6)	UDCNT (6)
	UDFCNT7	UDCNT (7)	UDCNT (7)
	UDFCNT8	UDCNT (8)	UDCNT (8)
	UDFCNT9	UDCNT (9)	UDCNT (9)
	UDFCNT10	UDCNT (10)	UDCNT (10)
	UDFCNT11	UDCNT (11)	UDCNT (11)
	UDFCNT12	UDCNT (12)	UDCNT (12)
Programmable buttons (16 buttons)	FKEYGGIO1	FKEY (1)	FKEY (1)
Logging functions			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Fault recorder	FLTRFRC1	FAULTREC (1)	FAULTREC (1)
Sequence event recorder	SER1	SER (1)	SER (1)

33. Document revision history

Document revision/date	Product version	History
A/2013-05-07	2.0	First release
B/2013-07-01	2.0	Content updated
C/2014-07-01	2.0	Content updated
D/2014-09-11	2.0	Content updated
E/2015-12-11	2.0 FP1	Content updated to correspond to the product version

000712

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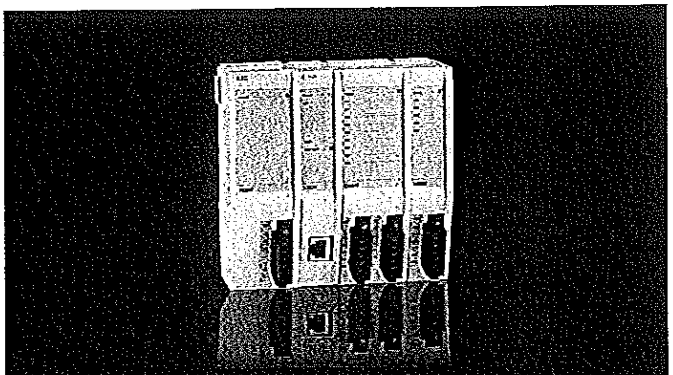

Remote I/O
RIO600
Product Guide

Contents

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Power and productivity for a better world™

Remote I/O
RIO600
Product version: 1.7
1MRS757487 F

Issued: 2016-06-09
Revision: F

1. Description

RIO600 is designed to expand the digital and analog I/O of ABB's Relion® protection and control relays and to provide I/O for COM600 substation automation unit using the IEC 61850 and Modbus TCP communication. Both galvanic RJ-45 and optical LC type of connectors are supported for Ethernet station bus communication. RIO600 can also be used in secondary substations for fault passage indication and power measurements reporting values directly to a peer protection relay or to an upper level system. RIO600 accepts three-phase sensor signals (voltage and current) and provides fault detection and metering functions.

RIO600 allows flexible I/O assignment and provides seamless IEC 61850 connectivity between the substation input and output signals and protection relay or COM600 substation gateway ensuring improved functionality and performance. RIO600 supports both Edition 1 and Edition 2 versions of the IEC 61850 standard. RIO600 can also be used as a standalone device in grid automation applications.

RIO600 helps in simplifying and decreasing the wiring inside the substation by digitizing the hardwired signals. The fully hardwired traditional medium-voltage switchgear/substation control and protection system results in extensive I/O wiring, connecting devices in switchgear signaling to the external systems, for example, to the RTU or other higher-level automation systems.

RIO600 provides additional I/O within the switchgear using Ethernet communication. The I/O signals can be efficiently transmitted between the protection relay or COM600 with fast, high performance IEC 61850 GOOSE communication. Alternatively, RIO600 can communicate with an upper level automation system using the widely accepted Modbus TCP automation protocol.

RIO600 binary input module can be used for sending binary input values from primary equipment or secondary systems to peer protection relays or upper level system. The binary output modules can be used to control equipment based on the control signal received from communication.

RIO600 smart control module (SCM) can be used for different switchgear applications to drive primary switches. The module enables the control of a combined three-position switch (disconnector and earthing switch) used in gas insulated switchgears or standard two-position switches like disconnector or earthing switches. Alternatively, the heavy-duty output contacts of the smart control module can be used as power outputs for circuit breaker trip circuits to make, carry and break the belonging trip coil current. Furthermore, the smart control module can be used as a generic four binary input and four fast power output module.

With the RTD/mA module, RIO600 can be used in different monitoring applications. RIO600 can receive temperatures (°C) via RTDs or analog input signals (mA) from various transducers or devices. Input current (mA) can be linearly scaled for various applications, for example, transformer tap changer position indication. The input value is forwarded to a peer protection relay or to an upper level system. With the analog output module, RIO600 can control an external device having an mA input.

In addition, RIO600 includes a measurement module with fault passage indication (FPI) functionality. This module is intended for grid automation applications where RIO600 enables accurate current and voltage measurements from a medium voltage network utilizing ABB's accurate and light weight sensor technology. RIO600 with the measurement module can be used as a standalone fault passage indicator unit. Based on the measured MV values, it can give voltage presence and directional fault passage indication and report them to an upper level system. This also enables power flow and power quality monitoring. The typical accuracy of line voltages, currents and active power is better than 0.5% and for other power measurements better than 1%.

The FPI module incorporates the latest fault detection algorithms used in the Relion family. With easy-to-use multifrequency admittance-based (MFA) earth-fault detection algorithm, it accurately detects solid, resistive and intermittent type of earth faults. Practical sensitivity of up to 10 kΩ of the fault resistance can be achieved in symmetrical networks. This novel functionality is suitable for high-impedance earthed networks, and especially for compensated and unearthed networks where accurate and selective earth-fault detection is more challenging due to low fault currents.

2. Modular design

RIO600 is built on an industrial hardware platform which provides the same reliability, performance and real-time functionality as ABB protection relays withstanding extreme temperatures, electromagnetic interference and stringent industry standards.

Remote I/O
RIO600
Product version: 1.7
1MRS757487 F

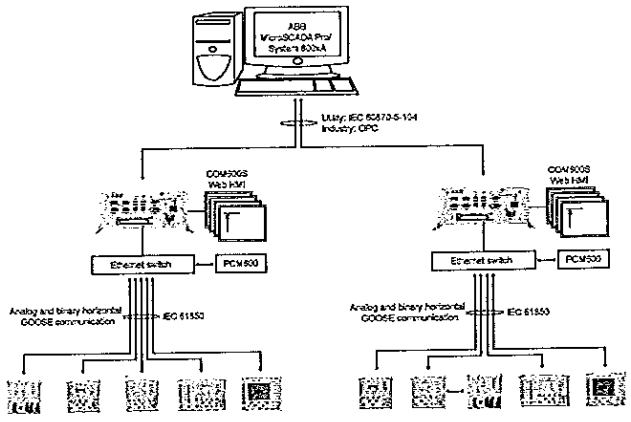

Figure 1. Connection overview of RIO600

RIO600 is designed using a modular architecture where the I/O control functionality is built on modules. The RIO600 modules can be stacked on a standard DIN rail to achieve the required configuration. The minimum configuration required for RIO600 contains a power supply module, a communication module and an I/O module.

000714

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Table 1. RIO600 module types

Module type			Description
Power supply modules		PSMH	High-voltage range power supply module
		PSML	Low-voltage range power supply module
Communication modules		LECM	Communication module with Ethernet port
		LECM	Communication module with Optical Ethernet port
I/O modules	Digital input module	DIMSH	High-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
		DIMSL	Low-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
	Digital output module	DOM4	Four output contacts in each digital output module with two pairs of potential free contacts with common return
	RTD module	RTD4	Four optically isolated channels supporting RTD sensors (Pt100, Pt250, Ni100, Ni120 and Ni250) and mA input (0...20 mA configurable). Individual channels are non-isolated from each other
	Analog output module	ADM4	Four individually isolated channels of configurable mA outputs driving 0...20 mA signal
	Sensor input module	SIM3F	Sensor input module with combined three-phase current and voltage signals
	Smart control module	SCM5H	High-voltage range, smart control module with five application types • 4IO4O – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch
		SCM5L	Low-voltage range, smart control module with five application types • 4IO4O – four input and four output channels • Three-position switch • Disconnector • Circuit breaker • Earthing switch

The availability and combination of RIO600 modules and channels depends on the number of power supplies connected.

Table 2. Maximum number of modules and channels available when one power supply module is connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIMSH/DIMSL)	5	40	5	40
Digital output modules	5	20	4	16
RTD4 modules	5	20	4	16
Analog output modules	2	8	1	4
SIM3F modules	5	-	4	-
Smart control module (SCM5H/SCM5L)	3	24	2	16

Table 3. Maximum number of modules and channels available when two power supply modules are connected

	LECM with copper interface		LECM with fiber interface	
Description	Modules	Channels	Modules	Channels
Digital input modules (DIMSH/DIMSL)	5	40	5	40
Digital output modules	10	40	9	36
RTD4 modules	10	40	9	36
Analog output modules	4	16	3	12
SIM3F modules	5	-	5	-
Smart control module (SCM5H/SCM5L)	5	40	5	40

A combination of all the modules can be used in a single RIO600 stack. The total number of modules that can be supported by a number of power supply modules is automatically checked by PCM600. If the selected combination of modules exceeds the number of supported modules related to power consumption, the configuration tool gives an indication and does not proceed in configuring the stack.

Indication LEDs
RIO600 is equipped with different indication LEDs available on different modules.
- Ready LED on all modules
- Status indication LED for each binary input and output
- Status indication of detected power flows and disturbances in network
- IRF LED which indicates a fault condition if it is steadily ON
- Communication diagnostic LED on the communication module

Configuration examples
The user-specific configuration can be adapted according to application requirements by combining different modules.

RIO600 can be configured with a combination of low-voltage and high-voltage modules, for example, PSMH-LECM-DIMSL, PSML-LECM-DIMSH or PSML-PSMH-LECM-DIMSH-DIMSL-DOM4.

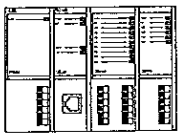

Figure 2. RIO600 configuration with 12 channels with 8 DI and 4 DO (1 × DIMSH + 1 × DOM4)

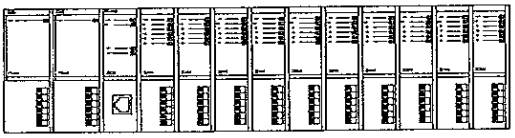

Figure 3. RIO600 configuration: 40 channels with 40 DO (10 × DOM4)

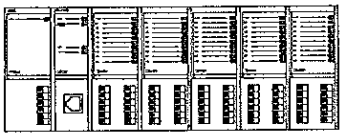

Figure 4. RIO600 configuration: 40 channels with 40 DI (5 × DIMSH)

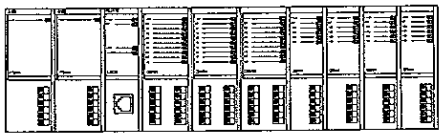

Figure 5. RIO600 configuration: 40 channels with 24 DI and 16 DO (3 × DIMSH + 4 × DOM4)

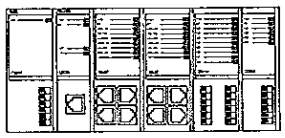

Figure 6. RIO600 configuration: 2 × SIM3F + 1 × DIMSH + 1 × DOM4

3. Applications

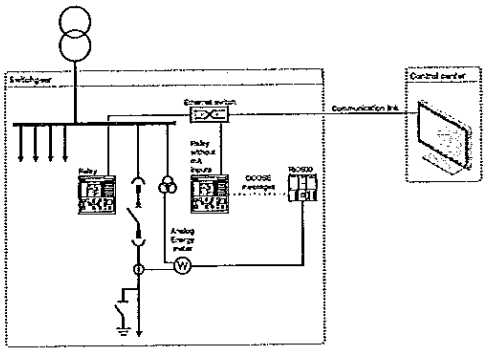

Figure 7. RIO600 as an external metering input for the protection relay

Figure 7 illustrates an application example in which RIO600 acts as an external metering input for the protection relay.

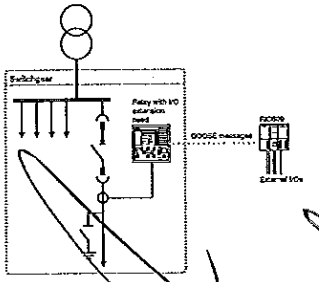

Figure 8. RIO600 as an I/O extension

000715
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In Figure 8 RIO600 is used as an input/output extension to a protection relay or a COM600 substation automation unit.

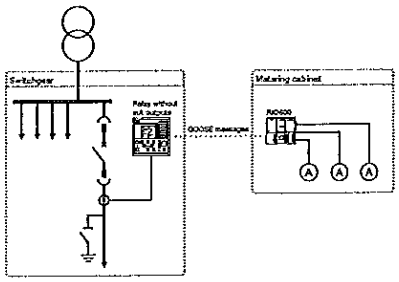

Figure 9. RIO600 communicating analog signals for the external meters

In the application example in Figure 9, RIO600 communicates analog signals for the external meters.

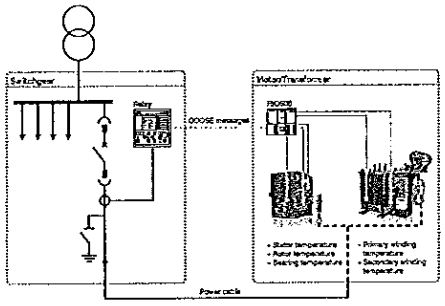

Figure 10. Temperature measurement using RIO600

Figure 10 illustrates the use of RIO600 to measure temperature from motor or transformer devices. The fiber-optic Ethernet can be used to achieve communication over longer distances.

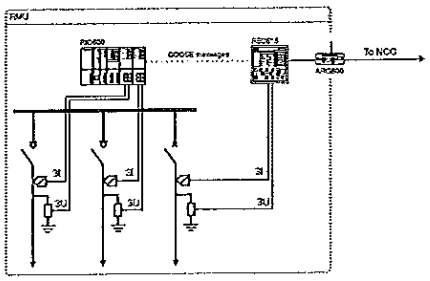

Figure 11. RMU fault passage indication using RIO600

Figure 11 shows RIO600 as a fault passage indicator in the RMU.

4. Self-supervision

RIO600 has a built-in self-supervision feature which continuously monitors the state of the RIO600 hardware and the operation of the software. Any fault or malfunction detected is used for alerting the operator. A dedicated LED is provided to indicate the failure. The self-supervision status of RIO600 is also distributed to the IEC 61850 station bus as one data entry in the published GOOSE frame. One of the output contacts of the digital output module can be configured to indicate the status (fix-contact) of RIO600.

Supervision information is available over Modbus TCP or via Web HMI.

All module version information, RIO600 configuration version and firmware checksums are also available for fleet management purposes.

5. Communication

RIO600 supports horizontal GOOSE (Generic Object Oriented Substation Event) communication according to the IEC 61850 substation automation standard versions Edition 1 and Edition 2. It meets the horizontal communication performance criteria for protection and fault detection purposes defined by IEC 61850-5, that is, peer-to-peer communication <10 ms. Currently, the IEC 61850 MMS profile for vertical TCP/IP communication is not supported.

RIO600 also supports Modbus TCP communication to one Modbus TCP client. IEC 61850 GOOSE and Modbus TCP can be used in parallel in the same Ethernet based station bus.

RIO600 is designed to send and receive binary and analog signals to or from the ABB Relion® series protection relays and the COM600 station automation unit/RTU using the IEC 61850-8-1 GOOSE profile or Modbus TCP. Also any RTU supporting the mentioned protocols can be used. RIO600 subscribes to a GOOSE message from a maximum of five peer protection relays and publishes to multiple protection relays as configured. RIO600 supports publishing of a maximum of seven GOOSE data sets. It is possible to send time stamped events using the GOOSE service with a T0 class accuracy.

RIO600 also supports Modbus TCP communication used in Ethernet networks. The communication type is client-server where RIO600 acts as a Modbus TCP server. RIO600 Modbus TCP server supports connection to one Modbus TCP client.

RIO600 communication module includes a galvanic RJ-45 port with 10/100 Mbits/s or fiber-optic LC Ethernet for IEC 61850 GOOSE and Modbus TCP communication. The used cable type must be shielded twisted pair cable CAT5e at the minimum or a multimode fiber-optic cable with an LC connector.

Using the same Ethernet port, RIO600 can be connected in parallel to PCM600 and a Web browser over the same communication bus.

6. Technical data

Table 4. Module weights

Description	Value
PSM/HPSM/L	235 g
LECM	123 g
DIM/HDIM/L	206 g
DOM4	193 g
RTD4	206 g
AOM4	208 g
SIM3F	180 g
SOM/HSOM/L	215 g

Table 5. Dimensions of the end clamp (EW 35, Weidmuller)

Description	Value
Width	8,5 mm (To be fixed at the ends of assembled modules)

Table 6. Power supply

Description	PSM/H	PSM/L
U_{AN} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	110, 125, 220, 250 V DC	
U_{AN} variation	85...110% of U_{AN} nominal (85...264 V AC)	80...120% of U_{AN} nominal (12...72 V DC)
	80...120% of U_{AN} nominal (88...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Maximum interruption time in the auxiliary DC without resetting the RIO modules	100 ms at U_{AN} nominal	50 ms at U_{AN} nominal
Ripple in the DC auxiliary voltage	Max. 15% of the DC value (at frequency of 100 Hz)	
Reversal of DC power supply polarity	1 minute for each polarity	
Burden of auxiliary voltage supply		
• Quiescent (P0) condition (none of the 20 I/O channels are activated)	<4.0 W nominal	
• Operating condition (20 binary output channels in DOM4 modules are activated)	<12.0 W (maximum)	

Module configuration	Condition	Max. consumption for PSM/H and PSM/L
PSM + LECM + DIM/H	All DIs activated	2 W
PSM + LECM + DIM/L		
PSM + LECM + DOM4	All DOs activated	4 W
PSM + LECM + DOM4 (5)	All DOs activated	12 W
PSM (2) + LECM + DIM/H (5)	All DIs activated	11 W
PSM (2) + LECM + DIM/L (5)		
PSM (2) + LECM + DOM4 (10)	All DOs activated	22 W

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000716

Table 7. Binary inputs

Description	DIM8H	DIM8L
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3...3.7 mA	2 mA
Power consumption/input channel	330...925 mW	30...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 8. Signal outputs (Digital output module DOM4)

Description	Value
Operating time	<5 ms
Nominal coil power	<500 mW
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry for 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

Table 9. mA/RTD input (RTD4 module)

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
	Maximum lead resistance (three-wire measurement)	100 Ω platinum	20 Ω per lead
		250 Ω platinum	20 Ω per lead
		100 Ω nickel	20 Ω per lead
		120 Ω nickel	20 Ω per lead
		250 Ω nickel	20 Ω per lead
	Isolation	4 kV	Inputs to all other channel outputs and protective earth
	RTD resistance sensing maximum	0.275 mA rms current	
	Operation accuracy	±1°C	
	Response time	< Filter time + 350 ms	
mA inputs	Supported current range	0...20 mA	
	Current input impedance	44 Ω ± 0.1%	
	Operation accuracy	±0.5% or ±0.1 mA	
	Isolation	4 kV	Inputs to all outputs and protective earth

Table 10. Analog output module (AOM4)

Description		Value
mA output	Supported current range	0.0...20.0 mA
	Operation accuracy	±0.1% or ±0.2 mA
	Isolation	4 kV between each output and protective earth

Table 11. Sensor input module (SIM8)

Description		Value
Preferred ABB sensors		• Combined sensors KEVCY 24 RE1, KEVCY36 RE1, KEVCY 43.5 RE1, KEVCD A • Combination of current sensor KECA 80 C85 or KECA 085 and voltage sensor KEVA 24 C13, 24 C21, 24 C22, 24 C23, 17.5 B20, 17.5 B21, 24 B20, or 24 B21
Current measurement	Range	4...6000 A
	Accuracy	±5% or ±1 A in the range of 4...80 A ±1% in the range of 80...4800 A ±16% in the range of 4800...6000 A
Line voltage measurement	Range	480 V...48 kV
	Accuracy	±5% in the range of 480...9600 V ±0.5% in the range of 9.6...48 kV
Power measurements: P, Q, S and PF	Range	9.6...28.8 kV 80...600 A
	Accuracy	±1.0% for active power P (±0.5% at +25°C) ±3.0% for reactive Q and apparent power S (±1% at +25°C) ±0.03 for power factor ±3.0% for energy
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz, ±50 mHz For 60 Hz, ±60 mHz
Average operating current, voltage and power		Average operating current, voltage, power as per selection: 3 min/10 min/15 min/1 hour/2 hours/24 hours
Peak current, voltage and power values		Peak values for 1 day, 1 week, 1 month, 1 year
General detection of the harmonics disturbances		• Current TDD (Total demand distortion) up to the 6th harmonics • Voltage THD (Total harmonic distortion) up to the 6th harmonics
Load flow direction		Forward/reverse
Non-directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: I_n ±1.5% of the set value Operate time: ±1.0% of the set value or ±20 ms
Directional overcurrent fault detection	Operating range	50...2000 A
	Accuracy	Depending on the nominal frequency of the current measured: I_n Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2° Operate time: ±1.0% of the set value or ±20 ms

Table 11. Sensor input module (SIM8), continued

Description		Value
Non-directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: I_n ±10% of the set value in range of 4...25 A ±1.5% of the set value in range of >25...1000 A Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)
Directional earth-fault detection	Operating range	4...200 A (isolated/compensated network) 200...1000 A (solidly grounded/low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: I_n Current: • ±10% of the set value in range of 4...25 A • ±1.5% of the set value in range of >25...1000 A Voltage: ±1.5% of the set value Phase angle: ±3° Operate time: ±1.0% of the set value or ±20 ms (Current measurement based on internal calculation)

Table 12. Binary inputs (Smart control module)

Description	SCM8H	SCM8L
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Operating voltage range	±20% of rated voltage	±20% of rated voltage
Current drain	3...3.7 mA	2 mA
Power consumption/input channel	330...925 mW	30...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s filtering time	5 ms...4.0 s filtering time

Table 13. High-speed outputs (Smart control module)

Description	SCM8H	SCM8L
Operating time	<1 ms	<1 ms
Rated voltage	110...250 V DC	24, 30, 48, 60 V DC
Continuous current carry	20 A	20 A
Short time current carry	100 A for 10 ms	200 A for 10 ms

Table 14. Communication interface (Communication module LECM)

Connector	Cable	Data transfer	Maximum distance	Wave length	Permitted path attenuation[1]
RJ-45	Shielded twisted pair cable, at minimum CAT5e	10/100 Mbit/s	30 m	-	-
LC	Multimode 62.5/125 µm or 50/125 µm glass fibre core	100 Mbit/s	2 km	1310 nm	<5 dB

1) Maximum allowed attenuation caused by connectors and cable together

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Table 15. Degree of protection by enclosure

Description	Value
Degree of protection	IP20[1]

1) If a higher IP class is required, the cabinet where the device is installed should provide proper protection.

Table 16. Environmental conditions

Description	Value
Operating temperature range	-25...+70°C
Relative humidity	<93%
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85°C

Table 17. Inspection of mechanical structure

Description	Reference	Result
Markings and mechanical structure	IEC 60255-1 and IEC 60255-27	OK
Enclosure class of the flush-mounted device	IEC 60529	IP 20
Clearances and creepage distances	IEC 60255-27	OK

Table 18. Overload test

Description	Reference	Result
Thermal withstand capability test	IEC 60255-1 and IEC 60255-27	OK

Table 19. Power supply module tests

Test	Type test value	Result
Operating range of auxiliary supply voltage test	85% and 120% of rated value for DC 85% and 110% of rated value for AC, frequency is between 50 Hz for -5% and 60 Hz for +5%	IEC 60255-1 and IEEE C37.90-2005
Power consumption of auxiliary supply		IEC 60255-1 and IEEE C37.90-2005
• Quiescent load	<4 W	
• Maximum load	<12 W	
Reversal of DC power supply polarity	1 minute for each polarity	IEC60255-27
Start-up time test	<30 s	

Table 20. Contact tests

Description	Type test value	Reference
Make and carry	Signaling contacts • 5 A, continuous • 10 A for 3 s • 15 A for 0.5 s	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Breaking capacity for DC, L/R ≤40 ms	Signaling contacts • 48 V, 1.00 A • 110 V, 0.25 A • 220 V, 0.15 A	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005
Mechanical durability	10000 operations	IEC 60255-1, IEC 61810-1 and IEEE C37.90-2005

Table 21. Insulation tests

Description[1]	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min for communication 2.8 kV DC, 1 min 700 V DC, 1 min for communication	IEC 60255-27 and IEEE C37.90-2005
Impulse voltage tests	5 kV, 1.2/50 µs, 0.5 J	IEC 60255-27 and IEEE C37.90-2005
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27

1) Insulation tests are not applicable to SPNF

Table 22. Electromagnetic compatibility and immunity tests

Description	Type test value	Reference
Electrostatic discharge		IEC 60255-26 and IEC 61000-4-2, Level 3
• Air discharge	8 kV	
Radio frequency electromagnetic field (amplitude modulated)	10 V/m (RMS) f = 80...1000 MHz and 1.4...2.7 GHz	IEC 60255-26 and IEC 61000-4-3, Level 3
Radio frequency electromagnetic field from digital radio telephones (pulse modulated)	10 V/m (RMS) f = 900 MHz, 1890 MHz	IEC 61000-4-3, Level 3
Power frequency (50 Hz) magnetic field		IEC 60255-26 and IEC 61000-4-8
• Continuous	100 A (RMS)/m	
• 3 s	300 A (RMS)/m	
Pulsed magnetic field	1000 A/m, 6.4/16 µs TrTd; 5 pulses positive/negative; 10 s (time interval)	IEC 61000-4-9, Level 5
Conducted disturbance induced by radio frequency fields, Amplitude modulated	0.15...80 MHz - 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance 27 and 68 MHz (spot frequencies); 10 V (unmod, RMS); 80% AM (1 kHz); 150 Ω source impedance	IEC 60255-26 and IEC 61000-4-6, Level 3
Fast low-energy transient (EFT) (including functional earth port)	5/50 ns TrTd; 5 kHz repetition frequency 4 kV (peak) for power supply input/output ports and 2 kV (peak) for communication port	IEC 60255-26 and IEC 61000-4-4
Damped oscillatory waves (IHD) 100 kHz and 1 MHz burst	100 kHz and 1 MHz frequency; 75 ns Tr; 40 Hz and 400 Hz repetition frequency; 200 Ω source impedance	IEC 60255-26 and IEC 61000-4-18
• Power supply and input/output ports	Differential mode: 1 kV (peak) Common mode: 2.5 kV (peak)	
• Communication port	Differential mode: not applicable Common mode: 1 kV (peak)	
Slow high-energy transient (surge) 250 µs voltage pulse)	• 1.2/50 µs TrTh (open circuit) 8/20 µs TrTh (short circuit)	IEC 60255-26 and IEC 61000-4-5
• Auxiliary power supply and input/output ports[1]	±4 kVp (L-Gnd) ±2 kVp (L-L)	
• Communication port	±2 kVp (L-Gnd) while no L-L test is applicable	
Voltage dips, short interruptions and voltage variation immunity tests (AC 50 Hz and 60 Hz)	30% reduction for 25/30 cycles 60% reduction for 10/12 cycles 100% reduction for 0.5, 1.0, 2.5 and 5.0 cycles 100% reduction for 250/300 cycles	IEC 60255-26 and IEC 61000-4-11
Voltage dips, supply interruption and voltage variations on DC input power port (immunity tests)	30% reduction for 500 ms 60% reduction for 200 ms 100% reduction for 10, 20, 30 and 50 ms 100% reduction for 5 s	IEC 60255-26 and IEC 61000-4-29
Ripple voltage	15% U_n, frequencies of ripple 100/120 Hz (for 50/60 Hz)	IEC 60255-26, IEC 61000-4-17 and IEEE C37.90-2005
Gradual shut-down/start-up test (for DC power supply)		IEC 60255-26
• Ramp towards shut-down	60 s	
• Wait at power of condition	5 minutes	
• Ramp towards start-up	60 s	

Table 22. Electromagnetic compatibility and immunity tests, continued

Description	Type test value	Reference
Power frequency voltage 50 Hz and 60 Hz input/output port		IEC 60255-26 and IEC 61000-4-16
• Differential mode	150 V (RMS) 100 Ω coupling resistor 0.1 µF coupling capacitor	
• Common mode	300 V (RMS) 220 Ω coupling resistor 0.47 µF coupling capacitor	
Emission tests		IEC 60255-25
• 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	
• 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	

1) When SGM is configured as a generic I/O, the level supported is ±2 kV (L-Gnd) and ±1 kV (L-L)

Table 23. Electromagnetic compatibility and immunity tests as per ANSI standards

Description	Type test value	Reference
1 MHz oscillatory SWC test	All ports: ±2.5 kV common mode/differential mode	IEEE C37.90.1-2002
Fast transient SWC test	All ports: ±4 kV common mode/differential mode	IEEE C37.90.1-2002
Radio frequency interference tests	20 V/m (prior to modulation) f = 80...1000 MHz (AM) f = 900 MHz (PM)	IEEE C37.90.2-2004
Electrostatic discharge test	±15 kV air discharge	IEEE C37.90.3-2001

000718

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Table 24. Mechanical tests

Description	Type test value	Reference
Vibration tests (sinusoidal)	Class 1	IEC 60255-21-1
• Vibration response test	f = 10...150 Hz Peak acceleration: 0.5 g 1 sweep cycle in each axis	
• Vibration endurance test	f = 10...150 Hz Peak acceleration: 1.0 g 20 sweep cycles in each axis	
Shock and Bump test	Class 1	IEC 60255-21-2
• Shock response test	Peak acceleration: 5 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Shock withstanding test	Peak acceleration: 15 g Duration of the pulse: 11 ms Number of pulses in each direction: 3	
• Bump test	Peak acceleration: 10 g Duration of the pulse: 16 ms Number of pulses in each direction: 1000	
Seismic test	• Class 2	IEC 60255-21-3
• Nominal frequency range	1...35 Hz	
• Zero period acceleration	Horizontal direction: 2.0 gn Vertical direction: 1.0 gn	
• Number of time-histories in each axis	Single axis sine sweep	

Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +70°C	IEC 60068-2-2 and IEEE C37.90-2005
Dry cold test	• 96 h at -25°C • 16 h at -40°C	IEC 60068-2-1 and IEEE C37.90-2005
Damp heat cyclic test	• 6 cycles (12 h + 12 h) at +25...+55°C, humidity >93%	IEC 60068-2-30
Damp heat steady state test	• Temperature 40°C • Humidity 93% • Duration 96 h	IEC 60068-2-78 and IEEE C37.90-2005
Change of temperature test	• 5 cycles (3 h + 3 h) at -25...+55°C	IEC60068-2-14
Storage test	• 96 h at -40°C • 96 h at +85°C	IEC 60068-2-1, IEC 60068-2-2 and IEEE C37.90-2005

Table 26. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Table 27. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Functions available in SIMAP

Table 28. Functions available in SIMAP

Function	IEC 61850 Edition 1	IEC 61850 Edition 2	IEC 60617	IEC-ANSI
Measurement functions				
Three-phase current measurement	CMMXU	CMMXU	3I	3I
Three-phase voltage measurement	VMMXU	VMMXU	3U	3U
Residual current measurement	RESCMMXU	RESCMMXU	Io	Io
Residual voltage measurement	RESVMMXU	RESVMMXU	Uo	Uo
Three-phase power and energy measurement	PEMMXU	PEMMXU	P	P
Three-phase power direction	PWRDIR	PWRDIR	-	-
Energy monitoring	EMMTR	EMMTR	E	E
Current, voltage and power average and peak measurement	CMSTA	CAVMMXU CMAMMXU RCAVMMXU	-	-
	VMSTA	VAVMMXU VMAMMXU		
	PEMSTA	PEAVMMXU PEMAMMXU		
Power quality measurement functions (harmonics)				
Current total demand distortion monitoring	CMHAI	CMHAI	PQM3I	PQM3I
Voltage total demand distortion monitoring	VMHAI	VMHAI	PQM3U	PQM3V
Detection and indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3I>	51P
Three-phase directional overcurrent fault detection	DPHPTOC	DPHPTOC	3I>->	67P
Non-directional earth-fault fault detection	EFPTOC	EFPTOC	Io>	51N
Directional earth-fault fault detection	DEFPTOC	DEFPTOC	Io>->	67N
Multifrequency admittance-based earth-fault indication	MFAPSDE	MFAPSDE	Io->Y	67YN
Voltage presence indication	PHSVPR	PHSVPR	PHSVPR	PHSVPR

Table 29. CUMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5% or ±1 A in the range of 4...50 A ±1% in the range of 50...4000 A ±10% in the range of 4000...6000 A
Suppression of harmonics	RMS: No suppression

Table 30. VMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5% in the range of 480 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV ±1% in the range of 28.8...40 kV
Suppression of harmonics	RMS: No suppression

Table 31. RESCMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5.0% (when all three phase currents in the range of 80...630 A)
Suppression of harmonics	RMS: No suppression

Table 32. RESVMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n ±5.0% (when all three voltages are in the range of 9.6...14.4 kV or 19.2...28.8 kV)
Suppression of harmonics	RMS: No suppression

Table 33. PEMMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 80...630 A Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71 ±1.0% for Active power P (±0.5% at +25°C) ±3.0% for Reactive Q and Apparent Power S (±1% at +25°C) ±0.03 for power factor
Suppression of harmonics	RMS: No suppression

Table 34. EMMTR Technical data

Characteristic	Value
Operation accuracy	At frequency f = f_n All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 80...630 A Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71 ±3.0% for energy
Suppression of harmonics	RMS: No suppression

000719
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Table 35. PHPTOG Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ ±1.5% of the set value
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 36. DPHPTOG Technical data

Characteristic	Value
Operation accuracy	Depending on the nominal frequency of the current measured: $f = f_n$ Current: ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±2°
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 37. EFPTOG Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ ±10% of the set value in range of 4...25 A ±1.5% of the set value in range of 25...1000 A (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 38. DEFPTOG Technical data

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_n$ Current: ±10% of the set value in range of 4...25 A ±1.5% of the set value in range of 25...1000 A Voltage: ±1.5% of the set value Phase angle: ±3° (Current measurement based on internal calculation)
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 39. MFAPSDE Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5% in the range of 483 V...9.6 kV ±0.5% in the range of 9.6...23.8 kV
Operate time accuracy	±1.0% of the set value or ±50 ms

Table 40. PHSVPR Technical data

Characteristic	Value
Operation accuracy	At frequency $f = f_n$ ±5% in the range of 483 V...9.6 kV ±0.5% in the range of 9.6...23.8 kV

7. Module dimensions

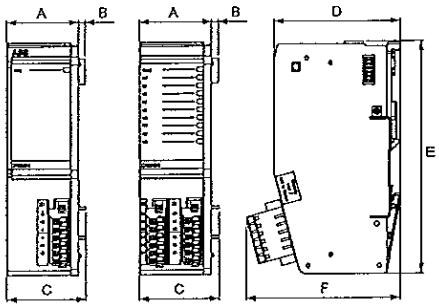

Figure 12. Dimension and mounting details of the PSM/PSL/DI/SI/SO/SL/RTD/AOM4/SCI/SH/SCM3L modules

A 45 mm
B 4.5 mm
C 51 mm
D 81 mm
E 145 mm
F 99 mm

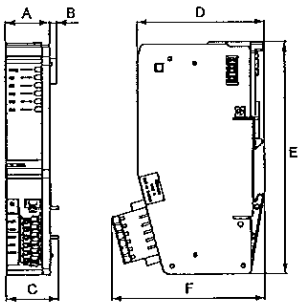

Figure 13. Dimension and mounting details of the digital output module DOM4

A 27.5 mm
B 4.5 mm
C 33 mm
D 81 mm
E 145 mm
F 99 mm

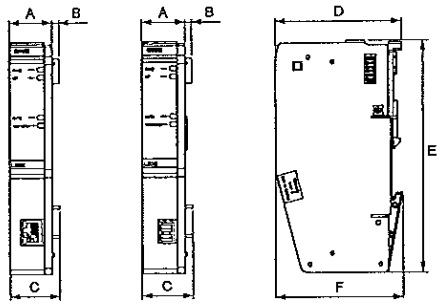

Figure 14. Dimension and mounting details of the communication module LECM

A 27.5 mm
B 4.5 mm
C 33 mm
D 81 mm
E 145 mm
F 81 mm

000720

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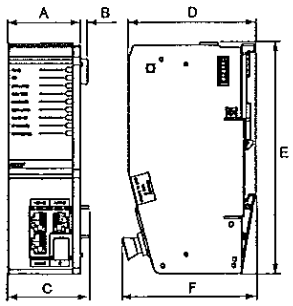

Figure 15. Dimension and mounting details of the SIMSF module

A 46 mm
B 4.25 mm
C 51 mm
D 31 mm
E 145.5 mm
F 85 mm

8. Assembly diagram

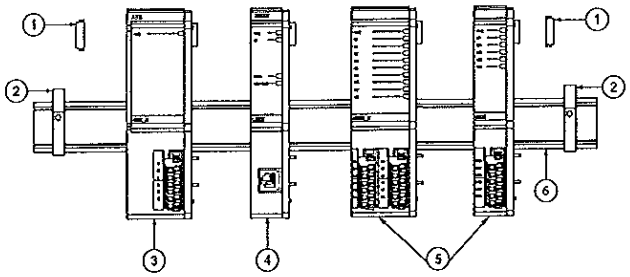

Figure 16. Assembly drawings of RIO600 modules

1 Rubber cap
2 End clamp
3 PSM module
4 LECM module
5 Modules (DIM/DOM4/RTD4/AOM4/SIMSF/SCM5H/SCM5L)
6 DIN Rail

The total width of the assembly can be calculated by adding together the length of all modules.

The width of the end clamp depends on the selected part. This mounting uses the Weidmuller part EW 35, which is 8.5 mm wide.

9. Ordering data

Table 41. Ordering details for RIO600 modules

Item	Order number
Digital input module with 8 inputs, high-voltage power supply	M0D600ADINSH
Digital input module with 8 inputs, low-voltage power supply	M0D600ADINSL
Digital output module with 4 outputs	M0D600ADOM4R
RTD/mA input module with 4 inputs	M0D600ARTD4
Analog output module with 4 outputs	M0D600AAOM4
Sensor input module	M0D600ASIMSF
Smart control module with 4 inputs and 4 high-speed outputs, high-voltage power supply	M0D600ASCM5H
Smart control module with 4 inputs and 4 high-speed outputs, low-voltage power supply	M0D600ASCM5L
High-power supply module	M0D600APSMH07
Low-power supply module	M0D600APSML07
Communication module with RJ-45 port	M0D600FLECM5R
Communication module with multi-mode fiber-optic LC port	M0D600BLECMFO

10. Tools

The present status information of RIO600 can be viewed from the Web browser-based user interface (Web HMI) and the parameter setting values can be viewed or changed from the PCM600 tool in combination with the RIO600-specific connectivity package.

The Protection and Control IED Manager PCM600 with the RIO600 connectivity package is used for configuring RIO600 in the offline or online mode to connect to the other protection relays or substation gateways in the IEC 61850 station bus. When the Web browser-based user interface is used, RIO600 can be accessed remotely with a Web browser.

The RIO600 connectivity package is a collection of software tools with specific device information which enables system products and tools to connect and interact with RIO600. The connectivity packages supports system integration and engineering and its minimizing device configuration and setup time.

RIO600 parameters can be configures with Parameter Setting in PCM600. Internal and station communication based logics are engineered in graphical Application Configuration and in Signal Matrix. IEC 61850 peer-to-peer communication can be configured in PCM600 as well.

Table 42. Tools

Description	Version
PCM600	2.7 Hotfix 1 or later
Web browser	IE 9.0 or later
RIO600 Connectivity Package	1.7 or later

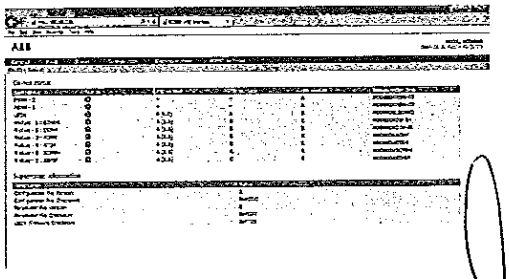

Figure 17. General view of RIO600 Web HMI

000721
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11. Connection and terminal diagrams

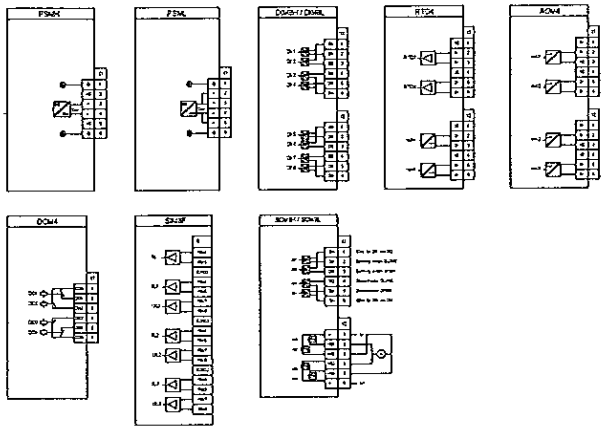

Figure 18. Connection and terminal diagram of RIO600 modules

12. Document revision history

Document revision/date	Product version	History
A/2011-12-23	1.0	First release
B/2012-12-15	1.1	Content updated
C/2013-09-30	1.2	Content updated
D/2014-09-29	1.5	Content updated
E/2015-04-01	1.6	Content updated
F/2015-05-05	1.7	Content updated

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за участие в открита процедура за възлагане на обществена поръчка с предмет:

„Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Зенит" от линеен ножов разединител 110 kV на ПС „Хаджи Димитър" до линеен ножов разединител 110 kV в ПС „Подуяне", реф. № РРС 17 – 169

Техническо предложение

Техническа документация

Приложение № 7 към Предложение за изпълнение на поръчката по т.15.7. от Техническото предложение – Заверени копия на документи за цифров локален контролер за поле „Секциониране" 110 kV:

- Приложение № 7.2. към т.15.7.2. от Техническото предложение – Други по преценка на участника (декларации за съответствие, протоколи от типови изпитания и др.).

000723

1MRS757890

EU Declaration of Conformity

Issued	26.04.2013
Version	B/20.04.2016
Technical ref.	Mika Kortesniemi
Checked by	Asko Koiranen

Application of this document

This document is intended for use as an approval for CE-marking of below mentioned products:

Family of	620 series

Declaration

We ABB Oy, Medium Voltage Products, Distribution Automation
P.O. Box 699 FI-65101 Vaasa, FINLAND,
declare under our sole responsibility that the family:

Feeder Protection and Control	REF620
Motor Protection and Control	REM620
Transformer Protection and Control	RET620

to which this declaration relates is in conformity with the following directives:

Directives	EMC Directive 2014/30/EU Low Voltage Directive 2014/35/EU RoHS Directive 2011/65/EU
CE - marked	2013

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	EN 60255-26:	2013
	EN 61000-6-2:	2005
	EN 61000-6-4:	2007
	EN 60255-1:	2010
	EN 60255-27:	2013

Vaasa 20.04.2016

на основание чл. 2 от ЗЗЛД

Signed by:

Antti Hakala-Ranta, SVP Medium Voltage Products

ABB Oy, Medium Voltage Products
Distribution Automation
P.O Box 699, FI-65101 Vaasa, FINLAND
Tel: +358 10 22 11, Fax: +358 10 224 1094
www.abb.com/substationautomation

000724

ВЯРНО С ОРИГИНАЛА

ЗЛАСИН СМОЛЯН ООД

1MRS758050

EU Declaration of Conformity

Issued	26.11.2013
Version	B/20.04.2016
Technical ref.	Jatin Parmar
Checked by	Janne Starck

Application of this document

This document is intended for use as an approval for CE-marking of below mentioned products:

Family of	RIO600

Declaration

We ABB Oy, Medium Voltage Products, Distribution Automation
P.O. Box 699 FI-65101 Vaasa, FINLAND,
declare under our sole responsibility that the family:

Remote I/O	RIO600

to which this declaration relates is in conformity with the following directives:

Directives	EMC Directive 2014/30/EU Low Voltage Directive 2014/35/EU
CE - marked	2013

Application of the objects

The family is intended for use in the industrial environment and to protect high voltage or high power apparatus, and thus normally used in a harsh electromagnetic environment near high voltage apparatus.

References

Standards	EN 60255-26:	2013
	EN 61000-6-2:	2005
	EN 61000-6-4:	2007
	EN 60255-1:	2010
	EN 60255-27:	2013

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000725

ВЯРНО С ОРИГИНАЛА

"К.РАСИН" СМОЛЯН ООД

за участие в открита процедура за възлагане на обществена поръчка с предмет:

„Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Зенит" от линеен ножов разединител 110 kV на ПС „Хаджи Димитър" до линеен ножов разединител 110 kV в ПС „Подуяне", реф. № РРС 17 – 169

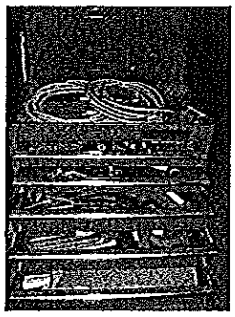
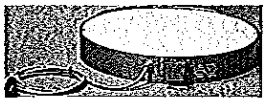
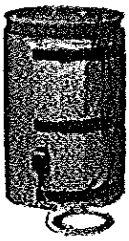
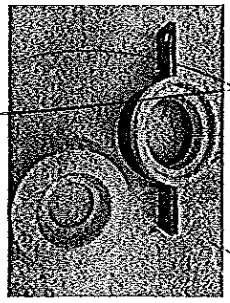
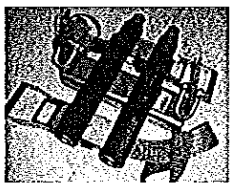
Техническо предложение

Техническа документация

Приложение/я № 8 към Предложение за изпълнение на поръчката по т.15.8. от Техническото предложение – Заверено копие на каталог и/или части от него за специализираните инструменти (описани в Таблица № 9 от Техническите спецификации и изисквания на възложителя за изпълнение на поръчката от документацията за участие) за обработка на сух силов кабел 110 kV и направа и монтаж на съединителни муфи и кабелни глави

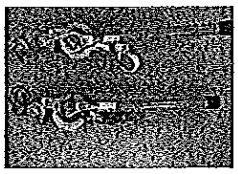
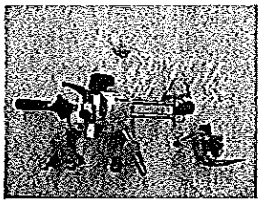
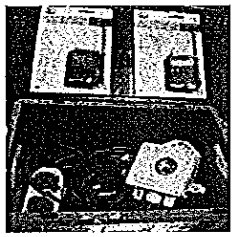
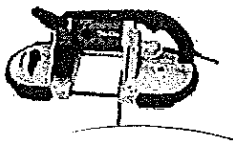
000726

Каталог специального инструмента для монтажа кабельной арматуры 110/220кВ Аркасил СК

№	Изображение	Наименование
1		Набор монтажного инструмента **Комплект 1010** (Монтажный инструмент включающий в себя необходимые позиции для разделки и монтажа кабеля высокого напряжения и кабельной арматуры)
2		Нагревательная плита (Предназначена для прогрева компаунда концевых муфт)
3		Нагревательная «рубашка» (Предназначена для прогрева компаунда концевых муфт)
4		Приспособление для натягивания силиконового изолятора (Приспособление состоит из прочных, мягких материалов, что не допускает повреждений на применяемой арматуре)
5		Устройство для крепления лебедок (Устройство фиксируется на кабель и имеет разъемы для крепления лебедок)

000727

ВЕРНО

№	Изображение	Наименование
6		Лебедка ленточная г/п 1000кг. (Предназначена для натягивания силиконового изолятора на кабель)
7		Машинка кабельная универсальная Unicut 30 (Предназначена для удаления полупроводящего экрана и изоляции с кабелей высокого напряжения с диаметром по изоляции 30мм- 85мм) Машинка кабельная универсальная Unicut 40 (Предназначена для удаления полупроводящего экрана и изоляции с кабелей высокого напряжения с диаметром по изоляции 70мм- 125мм)
8		Набор для прогрева кабелей **Комплект 1080** (Предназначен для прогрева кабелей высокого напряжения. Дополнительно в комплект входят задающие и контролирующие температуру приборы)
9		Пила ленточная по металлу (Предназначена для поперечного пила кабеля с диаметром до 125мм)

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000728

ВЕРНО С ОРИГИНАЛА

«КРАСИН» СМОЛЯН ООД

Kabeldon cable accessories and tools 1 - 420 kV

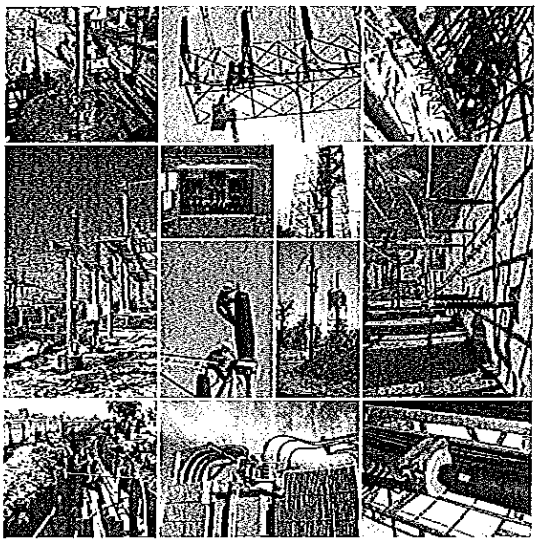


ABB AB

Introduction

We work to create safe electrical distribution via cable networks. To achieve this, we develop, manufacture and market a broad range of cable accessories, switching devices and enclosures. Our main groups of customers are power supply company, network companies, industrial companies and OEMs.

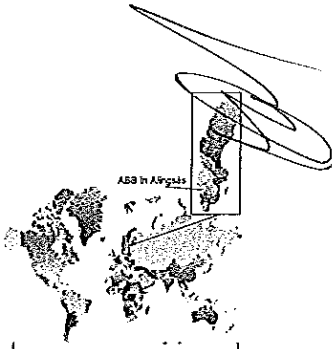
Our primary areas of expertise are electrical connections in cable systems and control of electrical field.
Our own testing plant is an important aid to product development.

Our factory is situated in Alingsås about 50 kilometres north-east of Gothenburg (Göteborg).
The production is automated and meets stringent quality and environmental requirements.

Quality and the environment are among our top priorities. They are important and self-evident parts of the strategic plan.

Our carefully considered investments in quality and the environment are based on modern principles. They lead to the fulfilment of ambitious goals for competitiveness and profitability, with a view to sustaining value to the customer.

We work continuously to improve our processes. Important foundations for this work are:
% ISO 9001 quality standard
% ISO 14001 environmental standard.



Kabeldon products are represented in cable networks all over the world.

Our business idea is:
"We provide companies that work with electric power with solutions which enable them to joint and connect cables easily and safely, and distribute electricity".

Catalogue
The introductory pages show the most important products in their proper environment. The entire range is then presented in three main parts.
– Cable accessories ≤ 1 kV
– Cable accessories 12-36 kV
– Cable accessories 52-420 kV
including product facts and ordering information in table form. An alphabetical list of contents and a list of contents by product category can be found in the end of this catalogue.

The product catalogue is also available on CD and at our webb sight.

We reserve the right to alter the design and range of our products.

ABB AB
Kabeldon
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www.abb.se/kabeldon

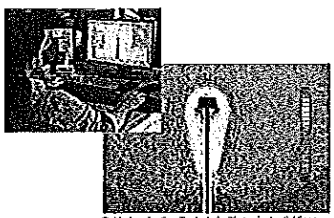
Fundamental technologies

We work on the basis of four fundamental technologies within which we have accumulated substantial expertise over many years.

Electrical connections
The safe and secure transfer of electric current between cable conductors or between a cable conductor and a device requires a good-quality electrical connection. We test and develop various methods, but in most cases we use screw technology. This gives us the possibility of offering complete solutions in line with our philosophy of easy and safe installation.

Screw connector for joint.

Controlling electrical fields
At high voltages the electrical fields must be controlled so that the strength of the insulation or the surrounding material is not put at risk. Depending on the voltage level, we work with different methods, e.g. geometrical, refractive or resistive field control. Geometrical field control is achieved with premoulded stress cones and splicing blocks. Resistive and refractive field control are achieved with special field-controlling materials integrated into prefabricated termination blocks.



Cable termination illustrated with equipotential lines.

Development of creepage current resistant materials
Outdoors, cable accessories are exposed to major stresses, e.g. UV radiation from the sun and creepage currents caused by precipitation and pollution. Cable accessories are installed everywhere on the face of the planet: in humid tropical environments, in extreme cold or in the swirling salt mist of coastal regions. We develop materials and designs for outdoor use that are only minimally affected by external factors. In the case of cable terminations, it's the insulators, both in the porcelain and the composite material. Practical endurance tests are an important part of our development work. In addition to Weather-O-Meter tests, salt-mist-chamber tests and other destructive long-term tests, the products are tested under extreme weather conditions.

Flashover during voltage withstand test of a cable termination.

Design of low voltage networks
Electrical distribution in cable networks calls for safe and rugged products to make it easier to connect cables and to withstand external factors such as humidity, vibration, etc., for a long time without causing malfunctions. Lengthy experience of our own manufacture of switching devices and hot-dip galvanized enclosures, as well as good customer relations, means that we can quickly adapt product development to suit the needs of the market.
A separate product catalogue for low voltage switchgears is available on request.

Distribution board.

Reasons for choosing Kabeldon cable accessories

A cable network must be capable of supplying electric power without interruption. If a failure does occur, it is usually the junction points on the network that are at fault, rarely the cable. So it pays to choose cable accessories with care.

Unique, long experience
Long experience brings great expertise. We have been manufacturing cable accessories for paper-insulated cables for about 70 years. When XLPE insulated cable began to be used just over 40 years ago, we were involved from the outset. Since then we have always been in the forefront of developments.

Manufacturing outdoor cable terminations for paper-insulated cables in 1962.

Leading research and development
Our watchwords are simplicity and safety.
Our core competence is our expertise in electrical connections in cable systems.
Successful product development requires proper resources. We have an advanced chemistry laboratory and profound expertise in the field of polymers, well-equipped high-voltage and high-current laboratories.

Better economy
Kabeldon cable accessories provide greater safety. This means major savings in the long term, as well as lower costs from simplified routines for purchasing, deliveries and stores.

Routine testing of high voltage cable joints.

Testing in progress in the high voltage laboratory.

Tests of rubber samples in the chemistry laboratory.

000729

Professional training
The technology of cables and their installation is constantly developing.
We offer broad-based training in cable technology and accessories.
Our instructors also take part in our development projects, so you can be sure that they possess access to the latest technology.
We arrange training programmes and practical exercises in the assembly of cable accessories up to 420 kV.
The length of time needed is due to the selection of the training.
All course participants will receive diploma or a training certificate after passing a theoretical and practical test.
If you would like to know more about the courses, contact our training department.


A training course with us gives access to the latest technology.

Standards

Definition of voltages
Cables and cable accessories are classified according to the voltages at which they operate. A rapid survey at standards all over the world shows that the designations are a little different. However, used designation in IEC gives a clear picture of used vocabulary. The voltages normally used in this context are:

U_0 =the rated r.m.s.(root mean square) power-frequency voltage between each conductor and screen or sheath for which cables and accessories are designed.

U =the rated r.m.s power-frequency voltage between two different conductors for which the cables and accessories are designed.

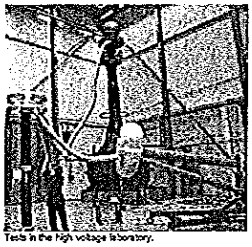
Note This quantity only affects the design of non radial field cables and accessories.

U_m =the maximum r.m.s power-frequency voltage between two different conductors for which the cables and accessories are designed. It is the highest voltage that can be sustained under normal operating conditions at any time and at any point in a system. It excludes temporary voltage variations due to fault conditions and the sudden disconnection of large loads.

Standards and type testing
Electrical components must meet numerous requirements in areas such as functional safety, technical performance, personal safety and so on. For cable accessories, compliance with the quality requirements is checked by type and routine testing. We perform these tests to various standards, both international and national.
These are the standards on which our tests are usually based:

IEC (International Electrotechnical Commission)
An international standard.

EN (European Norm)


Tests in the high voltage laboratory.

HD (Harmonization Document)
These standards were developed by CENELEC for the European countries. The aim is to use the same standards throughout Europe, to eliminate obstacles to trade. In most cases, these standards harmonize with IEC standards. Each European country publishes the standard as its own, and there may be some national deviations and special requirements.

IEEE (The Institute of Electrical and Electronics Engineers)
This standard is mainly used in the USA.

Earlier Swedish standards are being replaced by standards drawn up by CENELEC. For example, Swedish standard SEN 24 14 34 edition 2, 1977 for XLPE-insulated cables is replaced by SS 424 14 45 edition 1, which is identical to HD 628.1 S1 and HD 629.1 S1.
Some customers require special tests that are not included in the usual standards. We are usually able to meet their requirements.

EBR (El Building Rationalisation)
is a Swedish system for the rational planning, construction and maintenance of electricity distribution plants and facilities in the range 0.4 - 145 kV.

Standards

Voltage range U_m 1.2 kV
In this voltage range, the function of cable accessories is to provide mechanical protection and insulation. There is no need for controlling the electrical field.
In the past, there was no international standard, only national standards. CENELEC therefore produced an international standard, HD 623 S1, which is equivalent to Swedish standard, SS 424 14 44.
When the CENELEC standard is adopted in a country, it can be supplemented with one or more national options, for example requirements for impact resistance at low ambient temperature.

Voltage range U_m 7,2-42 kV
IEC: Current standards are IEC 61442, which covers test methods, and IEC 60502-4, which sets out the testing requirements.
IEC contains $U_m \leq 36$ kV.

CENELEC: Current standards are HD 628.1 S1, which covers test methods, and HD 629.1 S1, which sets out the testing requirements. The main difference between IEC and CENELEC is that CENELEC stipulates a longer period of temperature cycling under voltage.
A test conducted in accordance with CENELEC also satisfies the IEC requirements.
Standard HD 629.2 S1 applies to accessories for paper-insulated cables and transition joints.
To include the unusual voltages which occur in certain European countries, CENELEC has included more voltage classes than IEC.
In addition, CENELEC run up to U_m 42 kV.

CENELEC voltage classes

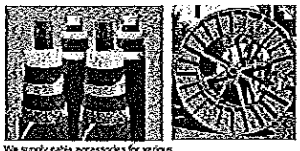
U_0	U	U_m
3.6	6	7.2
3.8	6.6	7.2
5	10	12
6.35	11	12
8.7	15	17.5
12	20	24
12.7	22	24
18	30	36
19	33	36
20.8	36	42

IEEE: The currently applicable standards are Std. 48 for terminations covering insulation classes 2.5-765 kV, and Std. 404 for joints rated at 2.5-500 kV. The test voltage for joints is generally lower than for equivalent terminations.
The voltage classes in IEEE are not identical with those in IEC. Some of the definitions also differ slightly between IEEE and IEC. This can make direct comparisons difficult.

Voltage range U_m 52-420 kV
IEC standard 60840 covers cable systems with voltages above 36 kV up to 170 kV. The third edition of the standard now also treats routine testing of cable accessories.
IEC standard 62067 covers cable systems with voltages above 170 kV up to 550 kV. The standard also states methods and requirements for the routine testing of cable accessories.
Both 60840 and 62067 deal with testing of outer protection for buried joints and screen separation kits. These tests are to qualify the electrical performance of the outer protection with special emphasis on watertightness.

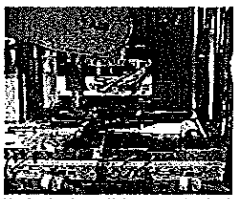
IEC voltage classes

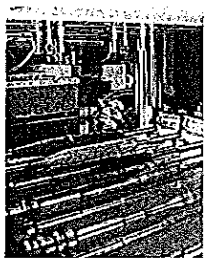
U_0	U	U_m
26	45-47	52
35	60-69	72.5
64	110-115	123
76	132-138	145
87	150-161	170
127	220-230	245
160	275-287	300
190	330-345	362
220	380-400	420

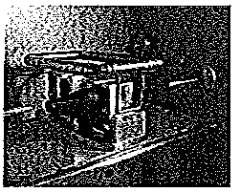

We supply cable accessories for various types of cables.

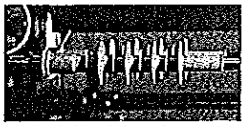
000739

Manufacturing and testing


Manufacturing of premoulded connectors takes place in accordance with a unique method, in which different layers are vulcanized together.


The three layers of the joint are vulcanized together in a unique manufacturing process.


The premoulded cable joints are routine tested after manufacturing.

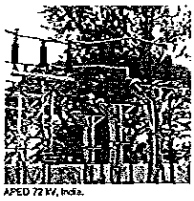

A snapshot of cable termination manufacture.


We test and develop electrical connections with reliable screw technique.

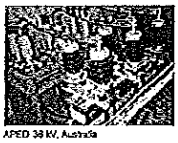

Research and development are the basis for manufacturing of our products.

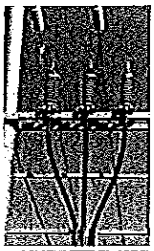
"КРАСИН" СМОЛЯН

Reference pictures
Cable terminations
APED, APSEA


APED 72 kV, India.


APED 72 kV, Sri Lanka.


APED 36 kV, Australia

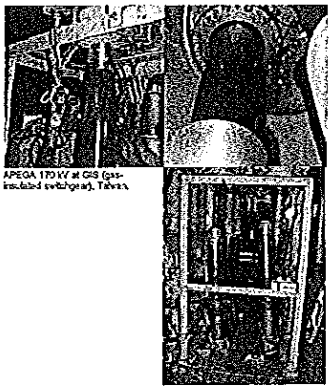



APSEA installed on the wallbushings, USA.


APED 72 kV, Port Hudland, the west Australia.


APSEA, Australia.

Reference pictures
Cable termination
APEGA GIS

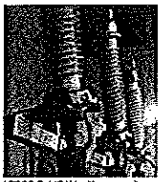

APEGA 170 kV at GIS (gas-insulated switchgear), Taiwan.


APEGA 1703, Malaysia.


APEGA 110 kV at GIS, Finland.

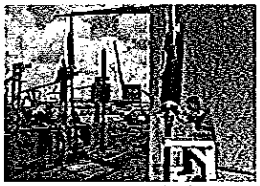

APEGA 170 kV at GIS, Australia.

Reference pictures
Cable termination
APECB

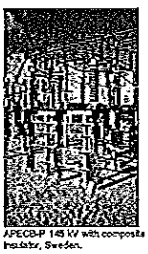

APECB-P 145 kV with composite insulator, Sweden.


APECB 145 kV with porcelain insulator, high voltage training, Malaysia.


APECB with porcelain insulator, assembled horizontally on the ground before lifted it into place, Greece.

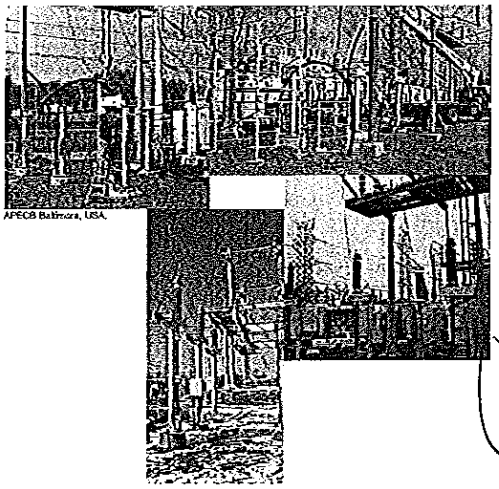

APECB, Greece.


APECB-P 145 kV with composite insulator, Sweden.


APECB-P 145 kV with composite insulator, Sweden.


APECB assembled horizontally on the ground before lifted it into place, Australia.

Reference pictures
Cable termination
APECB 84-420 kV


APECB Baltimore, USA.


Base part and cable clamp.


Stress cone.


Cover, clamp and bolt.

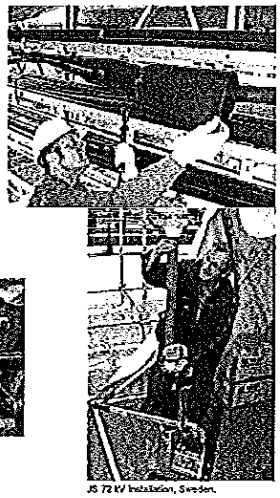
000731

ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЕНСК

Reference pictures
Premoulded cable joints
JS 52-123 kV

JS 123 kV, Mexico.



JS 72 kV Installation, Sweden.

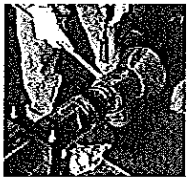
Reference pictures
Prefabricated cable joint
SMPGB

SMPGB 170 kV with sheath sectionalizing, Ireland.

SMPGB 145 PAL, Hungary.

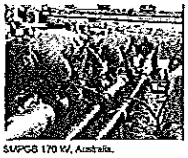
SMPGB 170 kV with sheath sectionalizing, Mexico.

SMPGB, Australia.



SMPGB 170 kV with sheath sectionalizing.

Installation tool, RKM 170 for mounting SMPGB on a 170 kV cable.



SMPGB 170 kV, Australia.

Reference pictures
Tape joint
SMX

SMX 72 kV which supply a casino at Macaus harbour in China with electricity.

SMX 52 kV, Libya.

Reference pictures
Cable distribution cabinets
for 12-24 kV
HDC 250 and HDC 630

Installation of HDC 630 at Farsund, Norway.

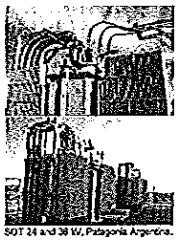
Töreboda Energi, Mariestad, Sweden.

000732

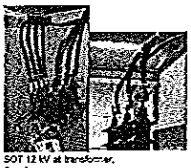
ВЕРНО С ОРИГИНАЛА
"КРАСИН" СМОЛЯН

Reference pictures
Prefabricated cable termination
SOT


SOT 24 kV, Australia.


SOT 24 and 36 kV, Patagonia Argentina.


SOT 24 kV connect switchgear to transformer.

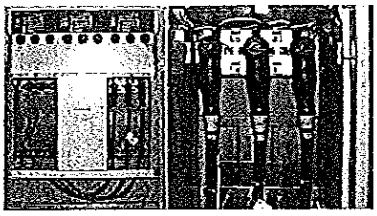

SOT 12 kV at transformer, Sweden.

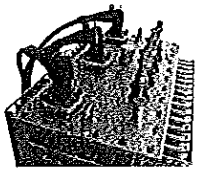

SOT 24 kV, Sweden.


SOT 12 kV in a switchgear box, Sweden.


SOT 24 kV installed in wind power stations on the east coast of England.

Reference pictures
Prefabricated cable connector
SOC


SOC in Eston switchgear, Sweden.


SOC 250 A installed on a transformer.


SOC 630 A in ASB Safering, Sweden.


SOC 630 A in Holec switchgear, Sweden.

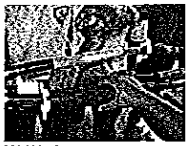
Reference pictures
Prefabricated cable joint SOJ
Transition joint SMTXB


SOJ 24 kV, Portugal.


SOJ 12 kV, China.


SOJ is used for jointing of the winding in a Powerformer, Sweden.


SOJ with armouring lid, ARM.

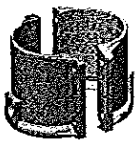

SOJ, Malaysia.


SOJ 24 kV, with screw technique, Australia.


SOJ 12 kV on a cable with copper tape screen, China.


Transition joints SMTXB 12 kV, The Netherlands.

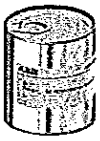
General accessories for paper-insulated cable joints and transition joints


GC
The kit contains one sealing ring, screws and two epoxy clamp halves for Ø 100 mm joint tubes. The clamps are made from glass fibre reinforced polymer. The bolt and washer are moulded into the material. Used on the XLPE side of the transition joints SMTXB 1502/1522/1532 when installing 1-core cables with an outer diameter greater than 40 mm.


IA 2502 - 2513
Bituminized paper for filling, for example in cable clamps.


RKM 402
Funnel for oil filling.


IA 1003
Stress controlling tape.


IA 2112 - 2113
Impregnated crepe paper tape.


ICP
Impregnated carbon crepe paper (conductive).

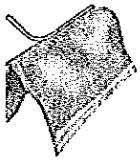
Designation	Use	Length m	Width mm	Thickness mm	Weight kg/set
GC	SMTXB with Ø 100 joint tube	Cable Ø 40-45	–	–	0.72
IA 1003	Paper-insulated cable joint	–	–	–	0.13
IA 2112	Paper-insulated cable joint	9	10	–	0.40
IA 2113	Paper-insulated cable joint	9	24	–	0.60
IA 2502	For filling cable clamps	3	83	0.5	0.20
IA 2504	For filling cable clamps	14	200	0.5	1.40
IA 2513	For filling cable clamps	10	83	0.5	0.50
IA 2519	For filling cable clamps	14	100	0.5	0.75
ICP		–		–	0.30
RKM 402	For oil filling	–		–	0.10

000733

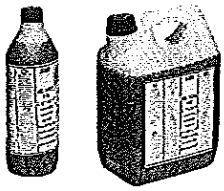
ВЯРНО С ОРИГИНАЛА

"КРАСНИН" СМОЛЕНСК

Accessories for paper-insulated cable joints and transition joints



IG 1201
Cold insulating bitumen compound for cable clamps.



IG 1601, IG 1604
Insulating oil, for joints and terminations for paper-insulated cables 12-52 kV. Need not be heated at temperatures exceeding +10°C.

IG 1717, 1718
Insulating film made of transparent polyester for transition joints and for paper-insulated cables 12-24 kV, type SMTXB and SMTD.

IK 1002
Linen yarn.

IK 1003
Polyester tape.

Designation	Length m	Width mm	Volume l	Weight kg/item
IG 1201	–	–	–	1.3
IG 1601	–	–	1.0	1.0
IG 1604	–	–	4.0	4.1
IG 1717	1.7	457	–	0.3
IG 1718	1.5	711	–	0.2
IK 1002	5	–	–	0.2
IK 1003	4x1.5	2.5	–	0.1

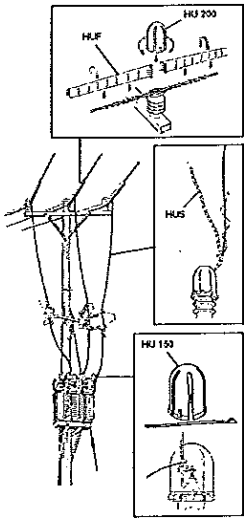
- Protects bird life
- Prevents short-circuit caused by birds
- UV-resistant material

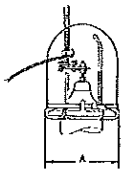
Bird protection for pole-mounted transformers, support insulators, etc

Use:
Used for bird protection on the high-voltage bushings for pole-mounted transformers. To prevent short-circuits caused by larger birds, HU is also placed on the surge arresters, but for total protection HU should be combined with an insulated down-conductor. This is done with insulation spiral HUS.
On post insulators, HU is used in combination with two wings HUF, which protect the overhead line closest to the insulator from short-circuiting.

Standards:
HU is designed for bushings with a diameter of 120-220 mm according to DIN 42531 standard.

Design:
All components are made of UV-resistant plastic.





Designation	Bushing diameter A min	max	Pieces/kit	Length ft	Weight kg/item
	mm				
HU 150	120	180	3	–	0.6
HU 200	160	220	3	–	0.8
HUF	–	–	6	0.6	1.1
HUS	–	–	1	30	1.6

Tapes

IA 2333 - 2338
Insulating vulcanizing tape.

IA 2339
Insulating vulcanizing tape.

IA 2342
Silicon rubber tape.

IA 2343
Silicon rubber tape.

IA 2352
Semiconducting tape.

IA 2362
Filling tape.

IA 2421
Electrical tape.

IA 2441 - 2444
Protective tape.

RULLE
Two-layer insulating tape made of EPDM and butyl rubber.

Designation	Length m	Width mm	Thickness mm	Weight kg/item
IA 2333	9	38	0.8	0.50
IA 2337	9	19	0.5	0.20
IA 2338	9	38	0.5	0.40
IA 2339	2	25	0.75	0.10
IA 2342	9	25	0.5	0.18
IA 2343	2.5	25	0.5	0.30
IA 2352	4.5	19	0.8	0.10
IA 2362	1.5	38	3.2	0.30
IA 2421	10	19	0.18	0.06
IA 2441	10	25	0.4	0.20
IA 2443	10	50	0.4	0.30
IA 2444	30.5	50	0.4	0.97
RULLE 1	3.5	60	2.0	0.69
RULLE 2	5.5	60	2.0	0.96

000734

Other accessories

IK 1105, 1103
Abrasive cloth.

IK 1405, IK 1406
Lashing wire (tin-coated copper wire).

IK 1401, IK 1407
Lashing wire (tin-coated copper wire).

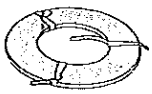
IK 1602
Lashing wire (galvanized steel wire).

IK 2221
Silicone grease, 25 g.

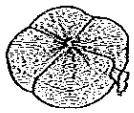
IK 2233
Grease, type AP paste, 10 g.

Designation	Length m	Diameter mm	Coarseness	Weight kg/Item
IK 1105	1	–	120	0.1
IK 1103	1	–	220	0.1
IK 1401	2	1.4	–	0.1
IK 1405	5	1.4	–	0.1
IK 1406	9.5	1.4	–	0.2
IK 1407	5	1.0	–	0.2
IK 1602	4	1.5	–	0.1
IK 2221	–	–	–	0.03
IK 2233	–	–	–	0.02

Other accessories

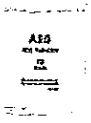


IA 1701
Earthing braid, sold by the metre, 10 mm².



IA 1705
Copper net for e.g. SMXB, sold by the metre, approx. 10 mm².

IA 1710
Earthing braid with lining, 22 mm².



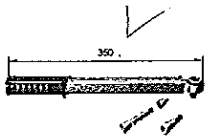
IK 2230
Washing cloth, 3 alcohol-soaked paper cloths 200 x 300 mm.

MBR 250
Stainless marking tape, 100 units/roll.

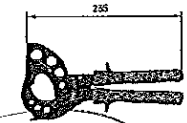
SKALUS
Peeling string for XLPE insulation.

Designation	Length m	Width mm	Thickness mm	Weight
IA 1701	–	16	1.0	0.10 kg/m
IA 1705	–	60	1.0	0.06 kg/m
IA 1710	0.4	27	0.1	0.08 kg/Unit
IK 2233	–	–	–	0.03 kg/Unit
MBR 250	0.25	–	1.0	0.50 kg/kg
SKALUS	2	–	1.0	0.02 kg/Unit

Tools

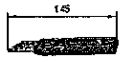


730 R
Torque wrench for screw connectors, screw cable lugs, overhead line clamps, etc. Supplied with 7 mm socket head, dissasign and 8 mm internal hexagon head.
Torque range 6-50 Nm.

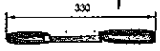


Intercable No. RKS 1607 054
Cable shears for cutting cable Ø max 54 mm.

RKM 1055
Splitting tool for longitudinal splitting off XLPE insulation with Ø 10-55 mm.



RKM 670
Cable knife, 30 mm blade.

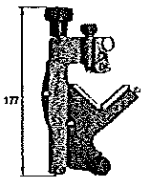


RKM 672
Sheath removing knife with two handles for plastic sheated cable.

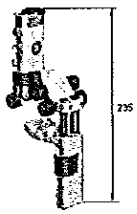
Designation	Description
730 R	Torque wrench
RKS 1607 054	Cable shears
RKM 1055	Peeling tool
RKM 670	Cable knife
RKM 672	Sheath removing knife

Tools

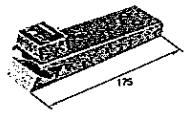
Intercable No. AV 6220
Sheath removing tool for PE-sheathed cable Ø > 20 mm.



Intercable No. FBS 1722 1
Stripping tool for the vulcanized, outer conducting layer of XLPE-insulated cable Ø 10-52 mm.
The tool is supplied in a rigid case with a tube of silicone grease.



GB-M20
Cutting tool for cable sheath and XLPE insulation.
Diameter: Ø 15-50 mm
Cutting depth: ≤ 8 mm



Model 1700 Series
Peeling tool for strippable outer conductive layer on XLPE insulated cable Ø 13-51 mm.

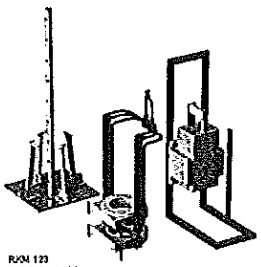
Designation	Description
AV 6220	Sheath removing tool
FBS-1722 1	Stripping tool
GB-M20	XLPE stripping tool
Model 1700 Series	Peeling tool

000735

ВЕРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

Equipment for installation of cable joints and terminations



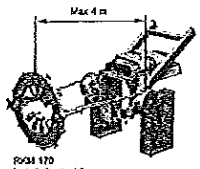
RXM 123
Installation tool for
JS and JX cable
joints.

RXM 853
Sawing tool to split an installation tube.

Installation kit
The kit consists of an installation cone, extraction sleeve halves and disassembly ring halves.
It is available in seven sizes that must be selected according to the cable oversheath.

Designation	Description	Net weight kg/kit
RXM 123	Installation tool	55.0
RXM 853	Saw to split an installation tube	0.8
Installation kit	Installation kit	5.0

Tool and accessories



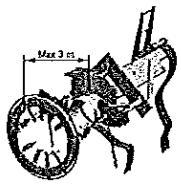
RXM 170
Installation tool for
SMPGB joint 145-170 kV.

Installation cone
For installing adapter.

Designation	Description	Weight kg/kit
RXM 170	Installation cone	42

Installation cone — Installation cone

Installation cone
For installing adapter.



RXM 362
Installation tool for SMPGB joint 362 kV.

To be ordered separately:

Designation	Description	Net weight kg/kit
RXM 362	Installation tool for SMPGB 362 kV	74

Earthing kits for cable terminations

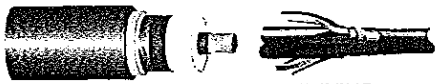
The earthing kit connects the screen of the cable at a termination. The earthing kit is designed to take care of the total screen cross section. It also provides the cable with a sealing.

Note that the earthing kit increases the cable outer diameter by 30 mm!

For corrugated screen made of
- *Aluminium use JSA 1 Al*
- *Copper use JSA 1 Pb*
- *Stainless steel contact us*

Cable with copper wire screen only. — No earthing kit is needed.

Cable with copper wire screen and metal-PE laminate. — Use earthing kit SCK 2.



Metal-sheathed cable with or without screen wires. — Use earthing kit JSA 1 Pb.

Cable with copper tape screen and cable with armouring. — Contact us.

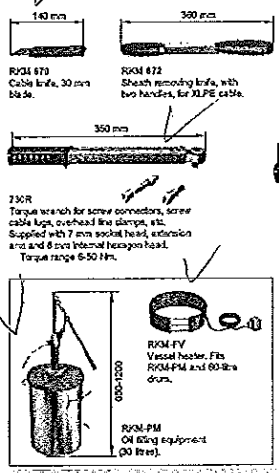
Designation	Diameter over overshealth mm	No of plates	Total Cu equivalent cross section in earthing kit mm²	No of Cu braids	For cables with
JSA 1 Al	–	–	130	6	Corrugated aluminium
JSA 1 Pb	63-120*	–	130	6	Lead sheathed or corrugated copper
JSA 1 Pb 10	120-150*	–	220	10	Lead sheathed or corrugated copper
JSA 1 Pb 15	150-200*	–	330	15	Lead sheathed or corrugated copper
SCK 2-1	13-26	1	–	–	Metal-PE laminated as radial watertightness
SCK 2-2	26-46	2	–	–	Metal-PE laminated as radial watertightness
SCK 2-3	46-66	3	–	–	Metal-PE laminated as radial watertightness
SCK 2-4	66-86	4	–	–	Metal-PE laminated as radial watertightness
SCK 2-5	86-106	5	–	–	Metal-PE laminated as radial watertightness
SCK 2-6	106-126	6	–	–	Metal-PE laminated as radial watertightness
SCK 2-7	126-146	7	–	–	Metal-PE laminated as radial watertightness

* Applicable for cable sheath ≤ 4 mm. For thicker metallic sheath contact us.

000736
ВЗРАЗ
ОРИГИНАЛ
КРАСНЫЙ ОКТЯБРЬ
СМОЛЯН
ООО

Tools and oil

All dimensions in mm



RKM 670
Cable knife, 30 mm blade.

RKM 672
Sheath removing knife, with two handles, for XLPE cable.

AV 6220
Sheath removing tool for PE-sheathed cable Ø > 20 mm.

730 R
Torque wrench for screw connectors, screw cable lugs, overhead line clamps, etc. Supplied with 7 mm socket head, extension and 6 mm internal hexagon head.
Torque range 8-50 Nm.

RKM 130
Torque wrench for screw connectors, screw cable lugs, overhead line clamps, etc. Torque wrench can be used with standard 1/2" sockets.
Torque range 25-130 Nm.

RKM-FV
Vessel heater. Fits RKM-PM and 60-litre drums.

RKM-PM
Oil filling equipment (30 litres).

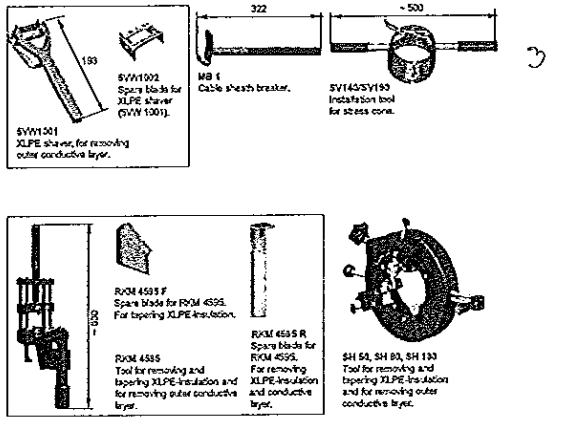
IG 1815
Syntetic insulating oil.

Designation	Description	Designation	Description
RKM 670	Cable knife	RKM 130	Torque wrench 25-130 Nm
RKM 672	Sheath removing knife	RKM-PM	Manual oil filling equipment
AV 6220	Sheath removing tool	RKM-FV	Vessel heater
730 R	Torque wrench 8-50 Nm		

Designation	Description	Contents litre	Vessel
IG 1801	Syntetic insulating oil	4	Tin
IG 1803	Syntetic insulating oil	2	Tin
IG 1804	Syntetic insulating oil	5	Tin
IG 1805	Syntetic insulating oil	60	Drum
IG 1807	Syntetic insulating oil	180	Drum

Tools

All dimensions in mm



SVW1001
XLPE shaver, for removing outer conductive layer.

SVW1002
Spare blade for XLPE shaver (SVW 1001).

MB 1
Cable sheath breaker.

SV145/SV193
Installation tool for stress cone.

RKM 4595 F
Spare blade for RKM 4595. For tapering XLPE-insulation.

RKM 4595
Tool for removing and tapering XLPE-insulation and for removing outer conductive layer.

RKM 4595 R
Spare blade for RKM 4595. For removing XLPE-insulation and conductive layer.

SH 50, SH 80, SH 130
Tool for removing and tapering XLPE-insulation and for removing outer conductive layer.

Designation	Description	Diameter across XLPE-insulation Ø mm
SVW1001	XLPE shaver	
SVW1002	Spare blade	
RKM 4595	Tool for removing and tapering	45-95
RKM 4595 F	Spare blade for tapering the insulation	
RKM 4595 R	Spare blade for removing the insulation	
MB 1	Outer sheath breaker (pack of two)	
SH 50	XLPE-shaver	15-50
SH 80	XLPE-shaver	40-80
SH 130	XLPE-shaver	70-130
SV 145	Installation tool for stress cone, SKG	
SV 193	Installation tool for stress cone, SKUS	

- Non-magnetic
- Withstands high short-circuits

Universal clamps UKR 90, UKRA 90

All dimensions in mm

UKR 90

Use:
For fixing cables, tubes, hoses, etc. It does fix round profiles with diameters of 20-90 mm or angular profiles with circumferences of 60-300 mm.

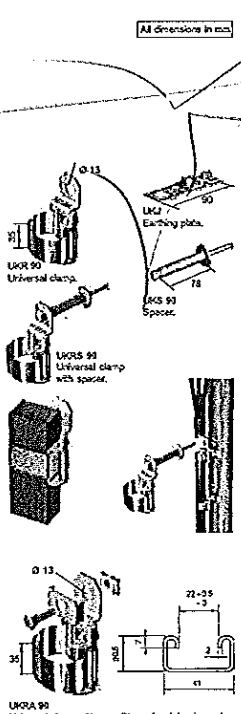
Design:
The bracket is made of hot-dip galvanized steel. The band is stainless steel SS 2333-02 with rounded edges and has a thickness of 0.2 mm. The band can be tightened and locked in one operation. The locking bolt is made of die-cast zinc alloy.

Typical applications:

UKRA 90

Use:
For fixing cables with diameters of 20-90 mm to the anchor bars in a cable distribution cabinet, etc.

Design:
The bracket is made of hot-dip galvanized steel. The band is stainless steel SS 2333-02 with rounded edges and has a thickness of 1.2 mm. The band can be tightened and locked in one operation. The locking bolt is made of die-cast zinc alloy.
A spring-loaded shaped nut with a reversible locking washer offers a choice of fixed or flexible position and direction.



UKJ
Earthing plate.

UKR 90
Universal clamp.

UKS 90
Spacer.

UKRS 90
Universal clamp with spacer.

UKRA 90
Universal clamp with bracket for anchor bar.

Dimensional drawings of the anchor bar.

Designation	Weight kg/box
UKR 90	0.17
UKRA 90	0.23
UKS	0.28
UKRS 90	0.45
UKJ	0.14

- Non-magnetic
- Withstands high short-circuits

Universal clamps UKR 200, UKRA 200

UKR 200

Application:
For bundling cables with diameters of 50-275 mm.

Design:
The bracket is made of hot-dip galvanized steel. The band is stainless steel SS 2333-02 with rounded edges and has a thickness of 0.2 mm. The band can be tightened and locked in one operation. The locking bolt is made of die-cast zinc alloy.

UKR 200
Universal clamp.

UKRF

Application:
For fixing cables, etc., to cable ladders.
For use together with UKR 200. The height of the ladder profile is approx. 16 mm and will fit within the specified dimensions.

Design:
The bracket is made from hot-dip galvanized steel.

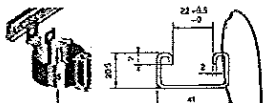
UKRF
Fixing bracket.

UKRS 200
Universal clamp UKR 200 with spacer.

UKRA 200

Application:
For fixing cables with diameters of 50-275 mm to the anchor bars.

Design:
The bracket is made of hot-dip galvanized steel. The band is stainless steel SS 2333-02 with rounded edges and a thickness of 0.2 mm. The locking bolt is made of die-cast zinc alloy and can be tightened and locked in one operation.
A spring-loaded shaped nut with a reversible locking washer offers a choice of fixed or flexible position and direction.



UKRA 200
Universal clamp with bracket for anchor bar.

Dimensional drawing of the anchor bar.

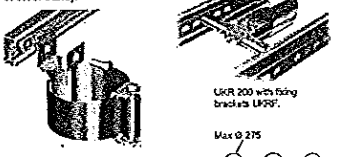
Designation	Weight kg/box
UKR 200	0.32
UKRA 200	0.45
UKRF	0.21
UKRS 200	0.61

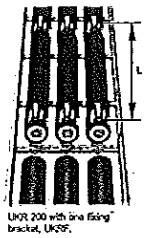
000737

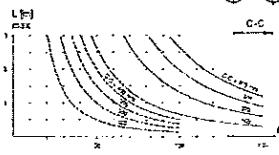
ВАРИАНТ ОРИГИНАЛА
"КРАСИН" СМОЛЕНСК ООО

Typical applications
UKR 200,UKRA 200

Flat configuration
(Results of testing with 2 turns of steel band).

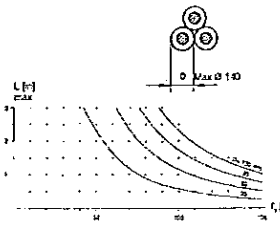


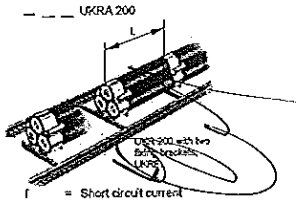




I_s = Short circuit current (peak value)
C-C = Distance between cable centres
L max = Distance between clamps
I [kA] —— UKR 200 with fixing bracket, UKRF

Trefoil configuration





I = Short circuit current (peak value)
D = Outer diameter of cable
L max = Distance between clamps
—— UKR 200 with fixing bracket, UKRF

000738

за участие в открита процедура за възлагане на обществена поръчка с предмет:

„Подмяна на маслонапълнена кабелна електропроводна линия 110 kV „Зенит" от линеен ножов разединител 110 kV на ПС „Хаджи Димитър" до линеен ножов разединител 110 kV в ПС „Подуяне", реф. № РРС 17 – 169

Техническо предложение

Техническа документация
Други по преценка на участника: Приложение № 9 към Предложение за изпълнение на поръчката по т.15.9. от Техническото предложение – Заверено/и копие/я на сертификат/и ISO 9001:2008 или еквивалент, на производителите на предложените материали, апаратура, оборудване и съоръжения.

000739

Превод от английски език

(Лого)

УДОСТОВЕРЕНИЕ

присъжда се на
АББ АБ, ШВЕЦИЯ,
Местоположения съгласно приложение

СЕРТИФИКАЦИОННО БЮРО „ВЕРИТАС" удостоверява, че **СИСТЕМИТЕ ЗА УПРАВЛЕНИЕ** на горната организация са проверени и са в съответствие с изискванията на стандартите за системи за управление, описани подробно по-долу:

Стандарит:

SS-EN ISO 9001:2008
SS-EN ISO 14001:2004
OHSAS 18001: 2007

ОБХВАТ НА ДОСТАВКАТА

Проучване и изработване, проектиране, производство, маркетинг, продажби, пуско-наладъчни дейности и поддържане и сервиз на продукти, резервни части, системи и инсталации за пренос и разпределение на електрическа енергия, за автоматизация и рационализация в различни сектори.

Дата на първоначално одобрение ISO 9001:	13 ноември 1992 г.
Дата на първоначално одобрение ISO 14001:	8 септември 1998 г.
Дата на първоначално одобрение OHSAS 18001:	22 април 2009г.

Подложен на непрекъсната задоволителна експлоатация на Системата за управление на организацията, този ***сертификат е валиден до 25 април 2018 год.***
За проверка на валидността на този сертификат се обадете на тел: ***+46 31606500.***
Допълнителни изяснения относно обхвата на този сертификат и приложимостта на изискванията на Системата за управление могат да се получат чрез консултация с организацията.

Подпис на Микаел Линдстрьом,Технически директор по сертифициране, СЕРТИФИКАЦИОННО БЮРО „ВЕРИТАС Швеция АБ"

Лого на АКРЕДИТИРАНЕ ШВЕДАК
1236 ISO/IEC 17021

Дата: 23 Април 2015

Номер на удостоверението: SE004225-1 / SE004224-1 / SE004226-1

Само електронно копие

000740

ВЯРНО С ОРИГИНАЛА

„КАСИН" СМОЛЯН ООД

Превод от английски език

Приложение към удостоверение № **SE002575-1 / SE002576-1 / SE002577-1**

издадено на 12 Септември 2011

В това приложение са показани местоположенията включени в удостоверението за:

АББ АБ, Швеция

АББ АБ, Швеция
721 83 Вастерас

Corp
Корпоративен, Вастерас / Лудвика
Изследвания, Вастерас

DM
Двигатели ниско напрежение, Вастерас
Машини, Вастерас
Роботи, Вастерас
Роботи, Гьотеборг
Продажби M&D, Вастерас
Продажби M&D, Сундсвал
Продажби M&D, Гьотеборг
Продажби M&D, Малмьо
Продажби M&D, Нюшьопинг
Продажби M&D, Лулеа
Продажби M&D, Йоншьопинг
Продажби M&D, Стокхолм
Продажби M&D, Йорншьолдсвик

Продукти ниско напрежение
Cewe-ontrol,Вастерас
Cewe-ontrol,Нюшьопинг
Системи ниско напрежение
Кабелни принадлежности,

Автоматизация на процесите
Измерване на сила, Вастерас
Целулоза и хартия, Вастерас
Мини, Вастерас
Валцови мелници, Вастерас
Металургия, Вастерас
Логистични центрове, Вастерас / Малмьо
Продукти и системи за индустрията,
Стокхолм / Гьотеборг / Малмьо
Кранови системи, Вастерас
Технологии за контрол, Вастерас / Малмьо

Дата: 24 Април 2012

Подпис на Микаел Линдстрьом,
Технически директор по сертифициране,
Сертифакационно Бюро „ВЕРИТАС Швеция АБ"

000741

ВЯРНО С ОРИГИНАЛА

ЕВРАСИН СМОЛЯН ООД

Продукти за енергетиката
Силови трансформатори, Лудвика
Компоненти, Лудвика
Фигехолм, Фигехолм
Композити, Питео
Прекъсвачи за високо напрежение, Лудвика
Компоненти за високо напрежение, Лудвика
Продажби, Вастерас
Кабелни принадлежности, Алингсос

Системи за енергетиката
Кабели за високо напрежение, Карлскруна
Високо постоянно напрежение, Лудвика
FACTS, Вастерас
Офшьорни Вятърни вризки, Вастерас
Подстанции, Вастерас
Вентикс, Вестерас
АП Продукти, Вестерас
АП Системи, Вестерас
Производство на електроенергия, Вестерас

Услуги
Вастерас
Данемора
Фигехолм
Финспонг
Гьотеборг
Хускварна
Карлскруна
Карлстад
Кируна
Галивар
Лудвика
Лулеа
Малмьо
Мьолндал
Норшьопинг
Улофстрьом
Питео
Шелефтео
Солентуна
Сторвик
Сундсвал
Удевала
Умео
Йорншьолдсвик

Дата: 24 Април 2012

Подпис на Микаел Линдстрьом,
Технически директор по сертифициране,
Сертификационно Бюро „ВЕРИТАС Швеция АБ"

000742

ВЯРНО С ОРИГИНАЛА

„КРАСИН" СМОЛЯН ООД

Annex to Certificate No. SE004225-1 / SE004224-1 / SE004226-1

issued 23 April 2015

This annex is stating the locations included
in the certificate issued for:

ABB AB, Sverige

ABB AB, Sverige
Ledning & Stab, Västerås

Corporate
Corporate, Västerås
Corporate, Ludvika
Corporate Research, Västerås

Discrete Automation and Motion
Ledning & Stab, Västerås

Motors & Generators
Synchronous Machines, Västerås
IEC LV Motors, Västerås
Service, Västerås

Robotics
Robotics, Västerås
Robotics, Mölndal

Domestic Sales
Domestic Sales, Västerås
Domestic Sales, Sundsvall
Domestic Sales, Göteborg
Domestic Sales, Malmö
Domestic Sales, Norrköping
Domestic Sales, Luleå
Domestic Sales, Jönköping
Domestic Sales, Stockholm
Domestic Sales, Örnsköldsvik
Domestic Sales, Karlstad
Domestic Sales, Kiruna
Domestic Sales, Storvik
Domestic Sales, Umeå

Low Voltage Products
Ledning & Stab, Västerås

Cewe, Nyköping

Meters, Nyköping

Control Products
Control Products, Västerås

LV-Systems
LV-Systems, Norrköping
LV-Systems, Västerås

Breakers & Switches
Kabeldon, Alingsås

Domestic Sales
Domestic Sales, Göteborg
Domestic Sales, Jönköping
Domestic Sales, Luleå
Domestic Sales, Malmö
Domestic Sales, Norrköping
Domestic Sales, Nyköping
Domestic Sales, Stockholm
Domestic Sales, Sundsvall
Domestic Sales, Umeå
Domestic Sales, Västerås

на основание чл. 2 от ЗЗЛД

Date: 19 May 2015

Mikael Lindström
Technical Manager,
Bureau Veritas Certification Sverige AB

000713

ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

Process Automation
Ledning & Stab, Västerås

Control Technologies
Control Technologies, Västerås, Malmö,
Sollentuna, Mölndal

Process Industries
Paper, Metals, Mining, Metallurgy, Västerås, Umeå

Measurement & Analytics
Force Measurement, Västerås
Instrumentation, Sollentuna, Mölndal

Marine and ports
Crane Systems, Västerås

Power Products
Ledning & Stab, Ludvika

Transformers
Power Transformers, Ludvika
Components, Ludvika
Figeholm, Figeholm
Figeholm Elboard, Figeholm
Composites, Piteå

High Voltage Products
High Voltage Breakers, Ludvika
High Voltage Service, Ludvika
High Power Lab, Ludvika
High Voltage Components, Ludvika och
Landskrona
Surge Arresters, Ludvika
Instrument Transformers, Ludvika
Capacitors, Ludvika
Swedewater, Landskrona
Cooling Systems, Landskrona
Kabeldon, Alingsås

Svensk Försäljning/Front End Sales, Västerås

Power Systems
Ledning & Stab, Västerås
Substations
Substations, Västerås
FACTS, Västerås
SA Products, Västerås
SA Systems, Västerås
Enterprise Software Västerås

Grid Systems
HVDC, Ludvika
High Voltage Cables, Karlskrona
Offshore Wind Connections, Västerås

Power Generation
Power Generation, Västerås

Service
Gällivare
Husqvarna
Karlstad
Kiruna
Luleå
Malmö
Mölndal
Norrköping
Olofström
Sollentuna
Storvik
Sundsvall
Uddevalla
Umeå
Västerås
Örnsköldsvik

на основание чл. 2 от ЗЗЛД

Date: 19 May 2015

Mikael Lindström
Technical Manager,
Bureau Veritas Certification Sverige AB

000744

ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

BUREAU VERITAS
Certification

Certification

Awarded to

ABB AB, Sverige

Locations according to annex

Bureau Veritas Certification certify that the Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standard detailed below

Standard

SS-EN ISO 9001: 2008
SS-EN ISO 14001: 2004
OHSAS 18001: 2007

Scope of supply

Research and development, design, manufacturing, marketing, sales, installation, commissioning, maintenance and services of products, spare parts, systems and plants for transmission and distribution of electric power, for automation and rationalization within various sectors and provide service and maintenance solutions for increased plant utilization and availability.

Ursprungligt datum ISO 9001:	13 November 1992 (Previously certified by Bureau Veritas Certification)
Ursprungligt datum ISO 14001:	8 September 1998 (Previously certified by Bureau Veritas Certification)
Ursprungligt datum OHSAS 18001:	22 April 2009 (Previously certified by Bureau Veritas Certification)

Subject to the continued satisfactory operation of the organisation's Management System, this certificate is valid until: **25 April 2018**

To check th на основание чл. 2 от ЗЗЛД applicability of the management system requirements may be obtained

Mikael Lindström, Technical Manager, Bureau Veritas Certification Sverige AB

Date: 23 April 2015

Certificate Number: SE004225-1 / SE004224-1 / SE004226-1

SWEDAC ACKREDITERING
1236
ISO/IEC 17021

Bureau Veritas Certification Sverige AB, Fabriksgatan 13, 412 50 GÖTEBORG, Sverige

000745

Electronic copy only
ВЯРНО С ОРИГИНАЛА
"КЯКСИН" ЕООД

BUREAU VERITAS Certification

ABB Oy

Valimopolku 4 A, FI-00380 Helsinki, Finland

This is a multi-site certificate, additional site(s) are listed on the next page(s)

Bureau Veritas Certification Holding SAS – UK Branch certify that the Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standards detailed below

STANDARD

ISO 9001:2015
ISO 14001:2015

SCOPE OF CERTIFICATION

Marketing, sales, research and development, design, engineering, production, delivery and maintenance, operational efficiency and lifecycle management services of automation and power technology products and systems for industry, utility, transport and infrastructure customers

Original cycle start date: *ISO 9001: 27 November 1995*
ISO 14001: 8 March 2002

Expiry date of previous cycle: 8 March 2017

Certification / Recertification audit date: 17 January 2017

Certification / Recertification cycle start date: 9 March 2017

Subject to the continued satisfactory operation of the organisation's Management System, this certificate expires on: 8 March 2020

Certificate Number: FIHSK8968319AB *Version 1, Revision date: 7 March 2017*

на основание чл. 2 от ЗЗЛД

Signed on behalf of BVCH SAS UK Branch

UKAS MANAGEMENT SYSTEMS

0008

Certification body address: Bureau Veritas Certification Holding SAS – UK Branch, 66 Prescot Street, London E1 8HG, United Kingdom
Certification office: Bureau Veritas Certification Finland, Sörnäisten rantatie 29, FI-00500 Helsinki, Finland

Further clarifications regarding the scope of this certificate and the applicability of the Management System requirements may be obtained by consulting the organisation. To check the validity of this certificate please call, tel. +358 10 830 8630.

000746

ЗАВЕРЕНО ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

BUREAU VERITAS Certification

ABB Oy

Standard

ISO 9001:2015
ISO 14001:2015

Scope of certification

ABB Oy, Head Office
Marketing, sales, research and development, design, engineering, production, delivery and maintenance, operational efficiency and lifecycle management services of automation and power technology products and systems for industry, utility, transport and infrastructure customers

Valimopolku 4 A, FI-00380 Helsinki, Finland

ABB Oy, Building Products (Wiring Accessories)
Sales, marketing, product development and manufacturing of conventional wiring accessories and installation materials for buildings

Porvoon Sisäkehä 2, FI-06100 Porvoo, Finland

ABB Oy, Control Technologies
Marketing, sales, projecting, application engineering, commissioning and service of process automation

Riihimiehentie 3, 01720 Vantaa

ABB Oy, Domestic Sales
Marketing, sales, engineering, delivery and maintenance, operational efficiency and lifecycle management services of automation and power technology products and systems for industry, utility, transport and infrastructure customers

Valimopolku 4 A, FI-00380 Helsinki, Finland
Strömbergin Puistotie 13 A, FI-65320 Vaasa, Finland

ABB Oy, Drives
Marketing, sales, development, design, engineering, manufacturing and delivery of variable speed drives products, drives packages, related services and software

Hiomotie 13, FI-00380 Helsinki, Finland
Strömbergintie 1 Aa, FI-00380 Helsinki, Finland
Valimopolku 4 A, FI-00380 Helsinki, Finland
Kiitotadantie 14, FI-01530 Vantaa, Finland

ABB Oy, Electrification Solutions
Marketing and sales of low voltage products and systems

Dynamotie 4 N, FI-65320 Vaasa, Finland

ABB Oy, Functions and Services
Functions and internal services to support the operative business units

Strömbergintie 1 B, FI-00380 Helsinki, Finland
Valimopolku 4 A, FI-00380 Helsinki, Finland
Sähkömäki 4, FI-65320 Vaasa, Finland
Dynamotie 1, FI-65320 Vaasa, Finland
Sähkötie 4 D, FI-65320 Vaasa, Finland

Certificate Number: FIHSK8968319AB *Version 1, Revision date: 7 March 2017*

на основание чл. 2 от ЗЗЛД

Signed on behalf of BVCH SAS UK Branch

UKAS MANAGEMENT SYSTEMS
0005

Certification body address: Bureau Veritas Certification Holding SAS – UK Branch, 66 Prescot Street, London E1 8HG, United Kingdom
Certification office: Bureau Veritas Certification Finland, Sörnäisten rantatie 29, FI-00500 Helsinki, Finland

For more clarifications regarding the scope of this certificate and the applicability of the Management System Requirements may be obtained by consulting this organization. To check the validity of this certificate please call: +358 10 830 8630

000747

ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

BUREAU VERITAS Certification

ABB Oy

Standard

ISO 9001:2015
ISO 14001:2015

Scope of certification

ABB Oy, Grid Automation
Marketing, sales, development, design, engineering, manufacturing and delivery of automation products, systems and related services

Virtaviiva 9 A, FI-65320 Vaasa, Finland

ABB Oy, Grid Integration
Marketing, sales, project management, engineering, supply management, delivery, installation and commissioning of grid integration systems and solutions and related life cycle services

Strömbergin Puistotie 4 A, FI-65320 Vaasa, Finland
Riihimiehentie 3, FI-01720 Vantaa, Finland

ABB Oy, Marine & Ports
Marketing, sales, development, engineering, projecting, commissioning and after sales services of power, propulsion and automation systems, and manufacturing of propulsion products, for marine industry

Merenkulkijankatu 1, FI-00980 Helsinki, Finland
Komentosilta 1, FI-00980 Helsinki, Finland
Rydöntie 7, FI-20360 Turku, Finland
Hadikatintie 1, FI-49460 Hamina, Finland

ABB Oy, Medium Voltage Products
Marketing, sales, development, design, engineering, manufacturing and delivery of low and medium voltage products, systems and related services

Muottitie 2 A, FI-65320 Vaasa, Finland
Dynamotie 4 N, FI-65320 Vaasa, Finland
Hermiankatu 6-8 L, FI-33720 Tampere, Finland

ABB Oy, Motors and Generators
Marketing, sales, research and development, engineering and manufacturing of induction and synchronous motors, generators, components and related after sales services

Strömbergintie 1 B, FI-00380 Helsinki, Finland
Juvan Teollisuuskatu 25, FI-02920 Espoo, Finland
Strömbergin Puistotie 5 A, FI-65320 Vaasa, Finland

ABB Oy, Solar
Marketing, sales, development, design and engineering of solar inverter products and related after sales services

Hiomotie 13, FI-00380 Helsinki, Finland

Certificate Number: FIHSK8968319AB *Version 1, Revision date: 7 March 2017*

на основание чл. 2 от ЗЗЛД

Signed on behalf of BVCH SAS UK Branch

UKAS MANAGEMENT SYSTEMS

0088

Certification body address: Bureau Veritas Certification Holding SAS – UK Branch, 66 Prescot Street, London E1 8HG, United Kingdom
Certification office: Bureau Veritas Certification Finland, Sörnäisten rantatie 29, FI-00500 Helsinki, Finland

Further clarifications regarding the scope of this certificate and the applicability of the Management System requirements may be obtained by consulting the organization. To check the validity of this certificate please call: tel. +358 10 830 6430

000748

ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

BUREAU VERITAS Certification

ABB Oy

Standard

ISO 9001:2015
ISO 14001:2015

Scope of certification

ABB Oy, Power Generation
Marketing, sales, execution, installation and commissioning of projects providing products, solutions and related life cycle services for utility and industry customers

Virtavüva 9 A, FI-65320 Vaasa, Finland
Hermiankatu 6-8L, FI-33720, Tampere, Finland

ABB Oy, Process Industries
Marketing, sales, projecting, application engineering, commissioning and service of process automation, drive and electrical systems and products for process industries

Strömbergintie 1 B, FI-00380 Helsinki, Finland
Strömbergin Puistotie 4 A, FI-65320 Vaasa, Finland
Kettukalliontie 9 F, FI-87100 Kajaani, Finland

ABB Oy, Protection and Connection
Marketing, sales, development, design, manufacturing and delivery of low voltage switch products

Muottitie 2 A, FI-65320 Vaasa, Finland

ABB Oy, Robotics
Marketing, sales, projects, engineering, service and maintenance, training, lifecycle management services of robot products and systems for industrial customers

Riihimiehentie 3,01720 Vantaa

ABB Oy, Transformers
Sales, design, manufacturing, site assembly, repair and other related services of power, distribution and special transformers and reactors

Strömbergin Puistotie 15 C, FI-65320 Vaasa, Finland

ABB Oy, Turbocharging
Marketing, sales and after sales services

Lyhtytie 20, FI-00750 Helsinki, Finland

Certificate Number: FIHSK8968319AB *Version 1, Revision date: 7 March 2017*

на основание чл. 2 от ЗЗЛД

Signed on behalf of BVCH SAS UK Branch

UKAS MANAGEMENT SYSTEMS
0008

Certification body address: Bureau Veritas Certification Holding SAS – UK Branch, 66 Prescot Street, London E1 8HG, United Kingdom
Certification office: Bureau Veritas Certification Finland, Sörnäisten rantatie 29, FI-00500 Helsinki, Finland

Further clarifications regarding the scope of this certificate and the applicability of the Management System requirements may be obtained by consulting the organization. To check the validity of this certificate please call, tel. +358 10 830 8630

000749

ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД

CERTIFICATE

Management system as per
ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that

ESTRALIN HVC

Estralin HVC LLC
2-nd Kabelnaya str., 2, bld. 24
111024, Moscow
Russia

applies a management system in line with the above standard for the following scope

Design and manufacture of high voltage cables, medium voltage cables and wires

Certificate Registration No. 44 100 127473
Audit Report No. 3516 7827

Valid until 2018-09-14
(until 2018-10-11 in case of Upgrade to ISO 9001:2015)
Initial certification 2012

на основание чл. 2 от ЗЗЛД

Certification Body
at TÜV NORD CERT GmbH

Essen, 2015-10-16

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarckstraße 20 45141 Essen www.tuev-nord-cert.com

DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-01

000750

ВЯРНО С ОРИГИНАЛА

"КЛАСИН" СМОЛЯН ООД

Превод от английски език, извършен от Даниела Кирилова Тодорова:

[ЛОГО на ТЮФ НОРД]

С Е Р Т И Ф И К А Т

Система за управление съгласно
ISO 9001 : 2008

В съответствие с процедурите на ТЮФ НОРД СЕРТ, с настоящото се сертифицира че

“ЕСТРАЛИН ХВС” ЛЛК
ул. 2-ра Кабелная 2, блвд. 24
111024, Москва
Руска Федерация

Прилага система за управление в съответствие с горепосочения стандарт за следния обхват

Проектиране и производство на високоволтови кабели, кабели и проводници средно напрежение

Рег. № на Сертификата 44 100 127473
Одитен Отчет No. 3516 7827

Валиден до 2018-09-14
(до 11.10.2018 в случай на ъпгрейд към ISO 9001:2015)
Първоначална сертификация 2012 г.

[подпис, не се чете]

Сертифициращо лице при
ТЮФ НОРД СЕРТ ГмбХ

Есен, 2015-10-16

Настоящата сертификация е проведена в съответствие с одитните и сертифициращи процедури на ТЮФ НОРД СЕРТ и е предмет на периодични контролни одити.

ТЮФ НОРД СЕРТ Лангемаркщрасе 20 45141 Есен www.tuev-nord-cert.com

[лога, не се чете]

000751

ВЪРНАТО С СЕРТИФИКАТА

“КРАСИН” СМОЛЯН ООД

TÜV NORD

CERTIFICATE

Management system as per
ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that

Arkasil SK LLC
proezd Zavoda Serp i Molot, 6, corpus 1
111250, Moscow
Russia

applies a management system in line with the above standard for the following scope

XLPE cable accessories 110-220 kV, design, production, training, installation and supervision

Certificate Registration No. 44 100 120774
Audit Report No. 3515 9118

Valid from 2015-05-23
Valid until 2018-05-22
Initial certification 2012

Certification Body
at TÜV NORD CERT GmbH

Essen, 2015-05-20

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarckstraße 20 45141 Essen www.tuev-nord-cert.com

DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-01

000752

TÜV NORD

СЕРТИФИКАТ

Системы менеджмента в соответствии с
ISO 9001 : 2008

В соответствии с процедурами TÜV NORD CERT настоящим подтверждается, что

АГКАСИЛ
ООО «АРКАСИЛ СК»
111250, Москва
проезд Завода Серп и Молот, д. 6, корп. 1
Россия

применяет систему менеджмента в соответствии с указанным стандартом для следующей области действия:

Разработка и производство, комплексная поставка, обучение, монтаж и шефнадзор за монтажом кабельной арматуры напряжением 110-220 кВ

Регистрационный номер сертификата: 44 100 120774
Отчёт об аудите №: 3515 9118

Действителен с: 2015-05-23
Действителен до: 2018-05-22
Дата первичной сертификации: 2012

Сертификационный орган
в TÜV NORD CERT GmbH

г. Эссен, 2015-05-20

Процесс сертификации проведён в соответствии с процедурами аудитирования и сертификации TÜV NORD CERT и подлежит регулярным надзорным аудитам.

TÜV NORD CERT GmbH Langemarckstraße 20 45141 Essen www.tuev-nord-cert.com

DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-01

000753

ВЕРНО С ОРИГИНАЛА

«КАСИН» СМОЛЯНОЙ ООД

Превод от английски език, извършен от Даниела Кирилова Тодорова:

[ЛОГО на ТЮФ НОРД]

С Е Р Т И Ф И К А Т

Система за управление съгласно **ISO 9001 : 2008**

В съответствие с процедурите на ТЮФ НОРД СЕРТ, с настоящото се сертифицира че

(ЛОГО)

Аркасил СК ЛЛК
Проезд Завода Серп и Молот, 6, корпус 1
111250, Москва
Руска Федерация

Прилага система за управление в съответствие с горепосочения стандарт за следния обхват

XLPE кабелни аксесоари 110 – 220 kV, дизайн, производство, обучение, монтаж и супервизия

Рег. № на Сертификата 44 100 120774
Одитен Отчет No. 3515 9118

Валиден от 2015-05-23
Валиден до 2018-05-22
Първоначална сертификация 2012 г.

[подпис, не се чете]

Сертифициращо лице при
ТЮФ НОРД СЕРТ ГмбХ

Есен, 2015-05-20

Настоящата сертификация е проведена в съответствие с одитните и сертифициращи процедури на ТЮФ НОРД СЕРТ и е предмет на периодични контролни одити.

ТЮФ НОРД СЕРТ Лангемаркщрасе 2045141 Есен www.tuev-nord-cert.com

[лога, не се чете]

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ВЯРНО С ОРИГИНАЛА

"КРАСИН" СМОЛЯН ООД