

Figure 2. Functionality overview of default configuration with vector inputs

Table 1. Supported functions

Function	ISO #1500	A (T/A/Y/H)	B (seconds)
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1
Three-phase non-directional overcurrent protection, high stage	PHNPTOC	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1
Three-phase directional overcurrent protection, low stage	DRHPTOC	2	2
Three-phase directional overcurrent protection, high stage	DPHPTOC	2	2
Three-phase voltage-dependent overcurrent protection	PHVPOC	2	2
Non-directional earth-fault protection, low stage	ENLPTOC	2	2
Non-directional earth-fault protection, high stage	ENHPTOC	1	1
Non-directional earth-fault protection, instantaneous stage	ENIPTOC	1	1
Directional earth-fault protection, low stage	DELPTOC	3	3
Directional earth-fault protection, high stage	DEHPTOC	1	1
Admittance-based earth-fault protection	EPFADN	3	3 ⁽¹⁾
Wattmeter-based earth-fault protection	WVWDE	3	3 ⁽¹⁾
Multi-frequency admittance-based earth-fault protection	MFAFSDOE	1	1 ⁽¹⁾
Transient/intermittent earth-fault protection	INTPTIEF	1	1 ⁽¹⁾
Harmonic-based earth-fault protection	HAEPFIOC	1	1
Negative-sequence overcurrent protection	NSPTOC	2	2
Phase discontinuity protection	PHNSPTOC	1	1
Residual overvoltage protection	ROVPTOV	3	3 ⁽¹⁾
Three-phase undervoltage protection	PHPTUV	4	4
Single-phase undervoltage protection, secondary side	PH1PTUV	1	1
Three-phase overvoltage protection	PHPTOV	3	3
Single-phase overvoltage protection, secondary side	PH1PTOV	1	1
Positive-sequence undervoltage protection	PSPTUV	2	2
Negative-sequence overvoltage protection	NSPTOV	2	2
Frequency protection	FRFRD	6	6
Three-phase thermal protection for feeders, cables and distribution transformers	THPTTR	1	1
Loss of phase (undersupply)	PHLPTUC	1	1
Circuit breaker failure protection	CCBFRF	3	3
Three-phase inrush detector	PH3PHAR	1	1
Master trip	TRFPTRC	4	4
Arc protection			
High-impedance fault detection	PHZ	1	1
Load shedding and restoration	LSHDPFRQ	6	6
Multipurpose protection	MWSPGAPC	18	18

Table 1. Supported functions, continued

Function	ISO #1500	A (T/A/Y/H)	B (seconds)
Automatic switch-to-fault logic (SOF)	CYPSOF	1	1
Voltage vector shift protection	WVSPAM	(1)	(1)
Directional reactive power undervoltage protection	DQPTUV	(2)	(2)
Undervoltage protection	DUPPOPR	(2)	(2)
Reverse power/directional overvoltage protection	DRPPDPR	(2)	(2)
Low-voltage ride-through protection	LVRTPTUV	(2)	(1)
High-impedance differential protection for phase A	HAPDF	1	1
High-impedance differential protection for phase B	HBPDF	1	1
High-impedance differential protection for phase C	HCPDF	1	1
Circuit breaker unresponsive position start-up	UPCALH	3	3
Three-independent-phase non-directional overcurrent protection, low stage	PHLPTOC	2	2
Three-independent-phase non-directional overcurrent protection, high stage	PHNPTOC	2	2
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PHSPTOC	1	1
Directional three-independent-phase directional overcurrent protection, low stage	DRHPTOC	2	2
Directional three-independent-phase directional overcurrent protection, high stage	DPHPTOC	2	2
Three-phase overload protection for shunt capacitor banks	COUPTOC	(1)	(1)
Current unbalance protection for shunt capacitor banks	CCUPTOC	(1)	(1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC	(1)	(1)
Control			
Circuit-breaker control	CBXCBR	3	3
Disconnector control	DCXCBR	4	4
Earthing switch control	ESSXSM	3	3
Disconnector position indication	DCSXSM	4	4
Earthing switch indication	ESSXSM	3	3
Auto-reclosing	DARFSC	2	2
Synchronization and energizing check	SECRSYN	1	(1) ⁽¹⁾
Condition monitoring and expansion			
Circuit-breaker condition monitoring	SSCBR	3	3
Trip circuit expansion	TCSSCBR	2	2
Current circuit supervision	CCSPVC	1	1
Current transformer supervision for high-impedance protection scheme for phase A	HCCASPVC	1	1
Current transformer supervision for high-impedance protection scheme for phase B	HCCBSPVC	1	1

Table 1. Supported functions, continued

Function	ISO #1500	A (T/A/Y/H)	B (seconds)
Current transformer supervision for high-impedance protection scheme for phase C	HCCCSPVC	1	1
Fuse failure supervision	SEOSPVC	1	1
Run-time counter for machines and devices	MDSOPT	2	2
Measurement			
Three-phase current measurement	CARIGU	1	1
Sequence current measurement	CSMSQI	1	1
Residual current measurement	RESRANU	1	1
Three-phase voltage measurement	VANU	1	1
Single-phase voltage measurement	VANMU	1	(1) ⁽¹⁾
Residual voltage measurement	RESVANU	1	1
Sequence voltage measurement	VMSQI	1	1
Three-phase power and energy measurement	PEMEGU	1	1
Load profile record	LDPRLFC	1	1
Frequency measurement	FANU	1	1
Fault location			
Fault locator	SCEFRLO	(1)	(1)
Power quality			
Current total demand distortion	CDTHD	1	1
Voltage total harmonic distortion	VVTHD	1	1
Voltage sag/swell	PHOVSR	1	1
Voltage unbalance	VSVUR	1	1
Other			
Minimum pulse timer (2 pos)	TPGAPC	4	4
Minimum pulse timer (2 pos, second resolution)	TPSAPC	2	2
Minimum pulse timer (2 pos, minute resolution)	TPMAGPC	2	2
Pulse timer (1 pos)	TPGAPC	2	2
Time delay off (8 pos)	TOGAPC	4	4
Time delay on (8 pos)	TOAGAPC	4	4
Set/reset (8 pos)	SRGAPC	4	4
Move (8 pos)	MVGAPC	4	4
Integer value move	MVNAGPC	4	4
Analog value scale	SCAGAPC	4	4
Generic control point (10 pos)	SPCGAPC	3	3
Remote generic control points	SPRGMGAPC	1	1
Local generic control points	SPGLGAPC	1	1
Generic up-down counters	UDCNT	12	12

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Table 1. Supported functions, continued

Function	REQ 61/650	A (CTA/VTM)	B (SECURE)
Programmable buttons (16 buttons)	FKEYGG00	1	1
Logging functions			
Disturbance recorder	RDRZE	1	1
Fault recorder	FLTRFRD	1	1
Sequence event recorder	SEV	1	1

[2...N] = 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) See table 1 for the measured phase voltage
- 2) See table 1, see REF 61/650-1 UE

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 with/without-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 oversfrequency, 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 multi-frequency admittance-based earth-fault protection providing selective directional earth-fault protection for high-impedance earthed networks. The operation is based on multi-frequency 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/struck 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 striking 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 (OUP) 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 of distribution networks. The relay fits both isolated neutral networks and networks with resistance- or impedance-earthed neutrals. Furthermore, based on its advanced inter-connection 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 R0600 Remote I/O device.

The relay offers extensive possibilities to tailor the configurations to application requirements. The tool suite for all R6000 relays is Protection and Control IED Manager PC/MS/OS, 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.

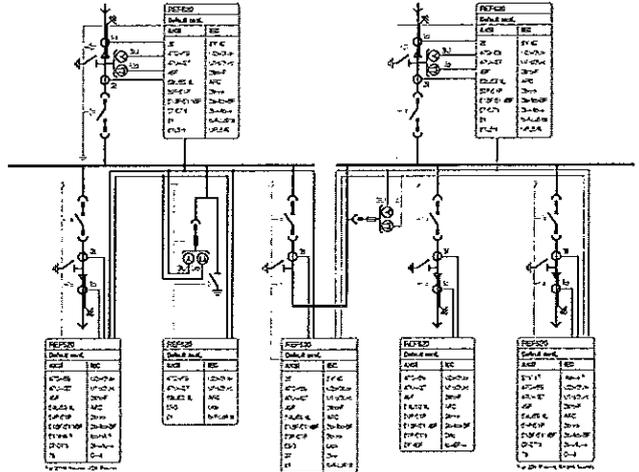


Figure 3. Single busbar #B 2 section switchgear with conventional instrument transformers

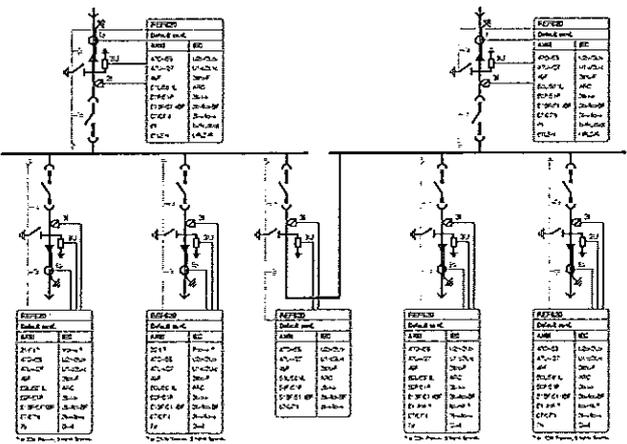


Figure 4. Single busbar AIS switchgear 2 section with sensors

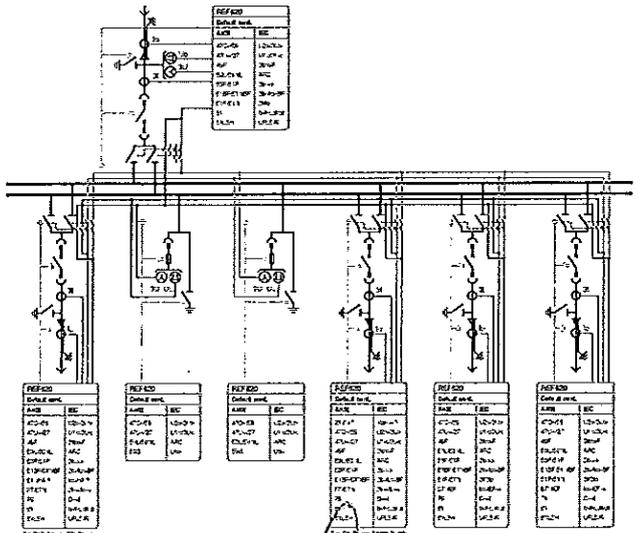


Figure 5. OBB AIS system with one incoming only (with some arcing faults simulated)

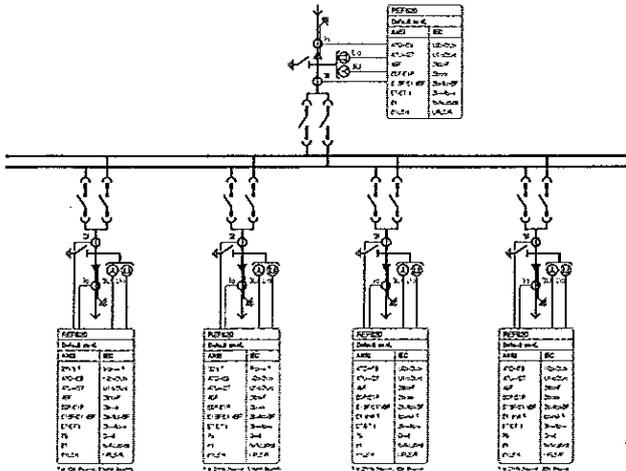


Figure 6. Back-to-back arrangement of AIS switchgear (two single-busbar panels with back walls facing each other, with two circuit breakers and a higher number of disconnectors switches: A type of DBB system)

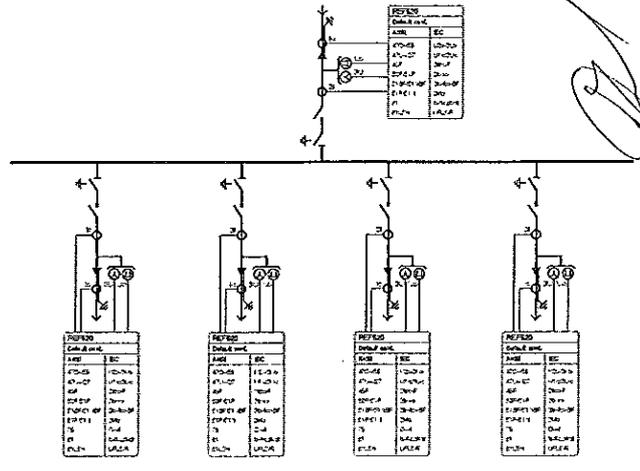


Figure 7. SBB GIS switchgear with the possibility to control the three-position disconnector switch

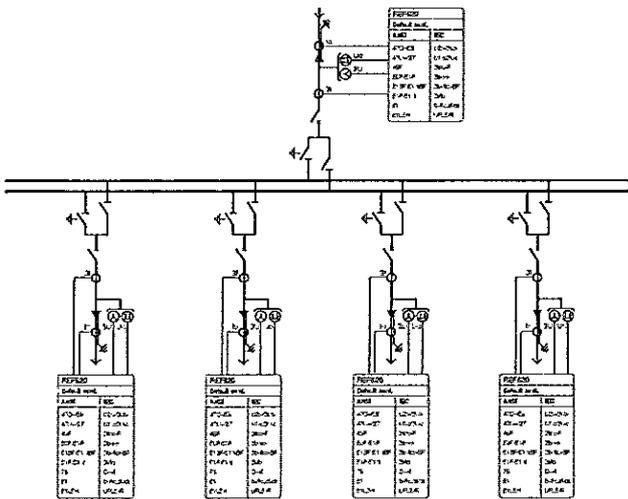


Figure 8. DBB GIS switchgear with the possibility to control the three-position disconnector switch

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, multiple 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.

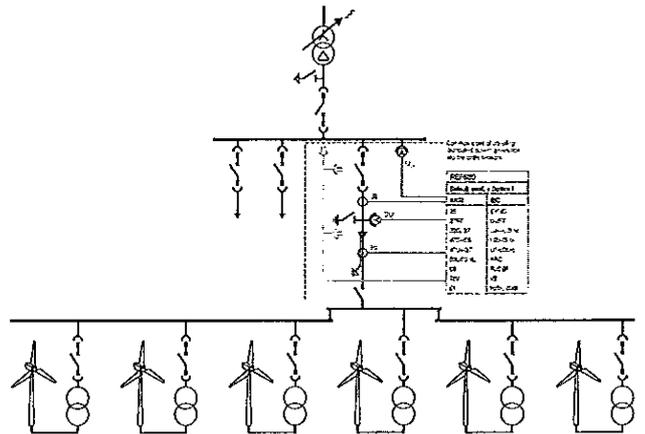


Figure 9. Application example of wind power plant as distributed power generation connected into the utility network

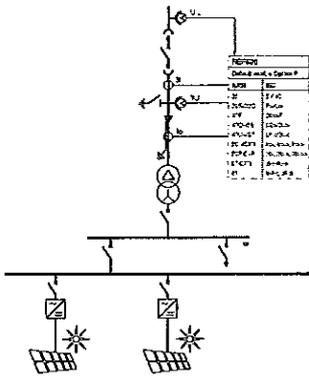


Figure 10. Application example of solar power plant as distributed power generation coupled into the utility network

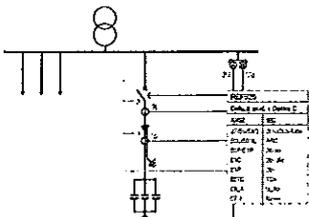


Figure 11. Protection of a single star connected capacitor bank

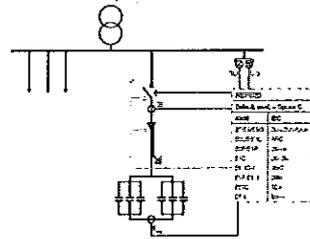


Figure 12. Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral

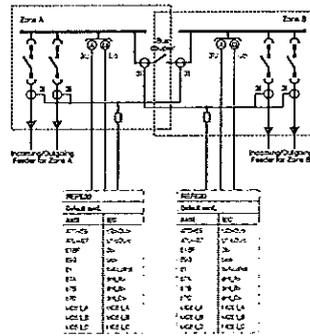


Figure 13. Application example of busbar differential protection covering two zones

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 PCAS600 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.

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 600A	5.1 or later

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 600A.

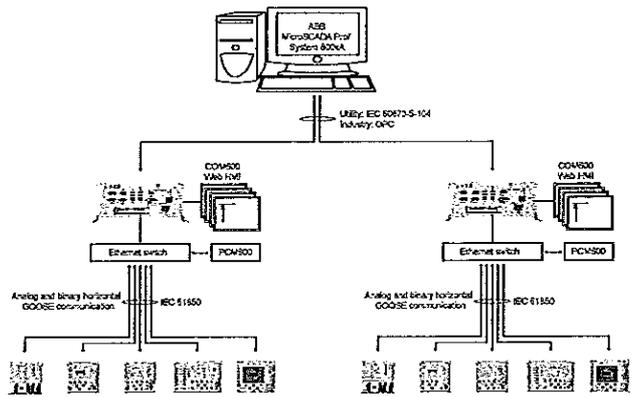


Figure 14. ABB power system example using Relay relays, Substation Management Unit COM600 and MicroSCADA Pro/System 600A

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 provides 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 main 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 PCAS600.

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

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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 without a five programmable autoreclosing events 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 provide 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 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 edges 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 analysis 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 the 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 status of the relay hardware and the operation of the relay software. Any fault or malfunction detected is used to alarm 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 transformer.

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 or operator 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 PC/MSC00.

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 synchrocheck 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 are required 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 selectable 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 PC/MSC00.

See the Input/output overview table and the terminal diagram 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 usable 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 PC/MSC00 tool and then utilized in the relay configuration.

Table 3. Input/output overview

Default config.	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	6	2	
		AB					4 PO + 10 SO			
		AC					4 PO + 10 SO + 3 HSO			
		NN					4 PO + 10 SO			
		NN					4 PO + 10 SO			
B	AC	AA	1		3	24	4 PO + 14 SO	6	2	
		AB					4 PO + 10 SO			
		AC					4 PO + 10 SO + 3 HSO			
		NN					4 PO + 10 SO			
		NN					4 PO + 10 SO			

220 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.

All binary inputs and outputs contacts are freely configurable with the signal matrix or application configuration functionality of PC/MSC00.

See the Input/output overview table and the terminal diagram 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 usable 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 PC/MSC00 tool and then utilized in the relay configuration.

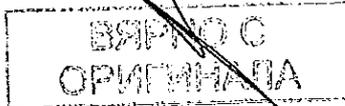
The relay also supports IEC 61850 process bus by sending sampled values of analog currents and voltages and by receiving sampled values of voltages. With this functionality the galvanic interpanel wiring can be replaced with Ethernet communication. The measured values are transferred as sampled values 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) protocol 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 meeting 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 providing zero-time recovery and continuous checking of redundancy to avoid failures.

The relay can send binary and analog signals to other devices using the IEC 61850-S-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.



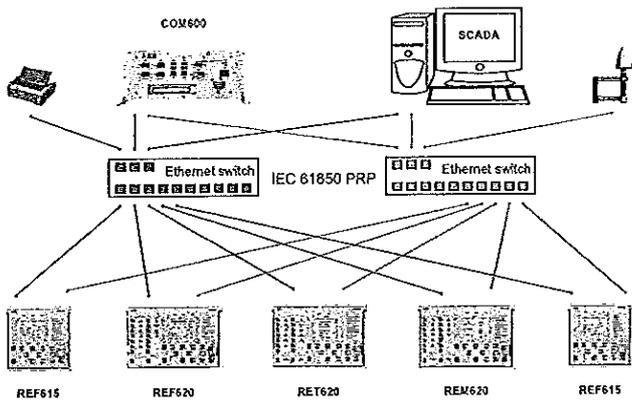


Figure 15. Parallel redundancy protocol (PRP) solution

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.

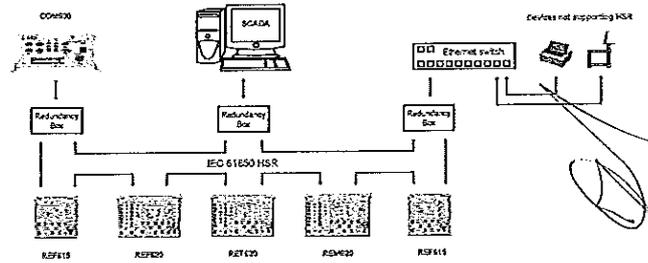


Figure 16. High availability seamless redundancy (HSR) solution

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.

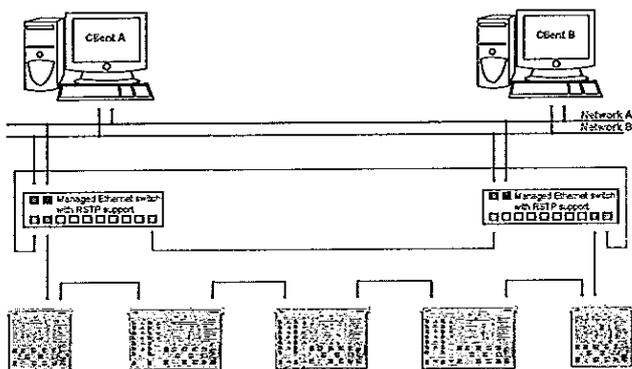


Figure 17. Self-healing Ethernet ring solution

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 (Pulse-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.

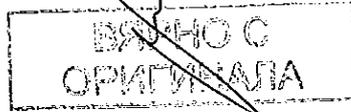
The IEEE 1588 support is included in all variants having a redundant Ethernet communication module.

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

Interface/Protocol	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/RS-485	Fiber-optic RT
IEC 61850-8-1	*	*	*	*
IEC 61850-3-2 IEC	*	*	*	*
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
	Cass 245 mm
Height	Frame 177 mm, 4U
	Cass 150 mm
Depth	231 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 _{nom} , nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz 48, 60, 110, 125, 220, 250 V DC	24, 30, 48, 60 V DC
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U ₀ , rated	
U _{min} variation	33...115% of U ₀ (33...264 V AC)	50...120% of U ₀ (12...72 V DC)
Start-up threshold	60...120% of U ₀ (33.4...330 V DC)	12.2 V DC (24 V DC ± 6%)
Burden of auxiliary voltage supply under quiescent (P ₀) operating condition	DC < 18.0 W (nominal) ¹⁾ < 22.5 W (max. ²⁾	DC < 18.5 W (nominal) ¹⁾ < 22.5 W (max. ²⁾
	AC < 18.0 W (nominal) ¹⁾ < 23.0 W (max. ²⁾	
Flg _{pl} 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 by rated auxiliary, energizing, voltage and the energizing terminal is energized without any delay, under a long-term test.
2) During the power consumption measurement, the relay is powered by rated auxiliary, energizing, voltage and the energizing terminal is energized by a constant current load full at the rated voltage.

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Table 7. Energizing inputs

Description	Value	
Rated frequency	50/60 Hz	
Current inputs	Rated current, I _n	0.21 A ¹⁾ 1.5 A ²⁾
	Thermal withstand capability:	
	- Continuously	4 A 20 A
	- For 1 s	150 A 500 A
Voltage inputs	Dynamic current withstand:	
	- Half-wave value	250 A 1250 A
	Input impedance	< 100 mΩ < 20 mΩ
	Rated voltage	60...210 V AC
Voltage withstand:	- Continuous	240 V AC
	- For 10 s	300 V AC
	Burden at rated voltage	< 0.65 VA

1) Drawing value 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...5000 mV ¹⁾
	Continuous voltage withstand	125 V
	Input impedance at 50/60 Hz	2...3 MΩ ²⁾
Voltage sensor input	Rated voltage	6...30 V ³⁾
	Continuous voltage withstand	50 V
	Input impedance at 50/60 Hz	3 MΩ

1) Equals the current range of I_n < 200 A and 1.5 A, 2 mV/1 A respectively.
2) Depending on the used terminal current transformer.
3) The input is converted to 2 mV/1 A with average burden area of 10 mm².

Table 9. Binary inputs

Description	Value
Operating range	±22% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...370.0 mW
Threshold voltage	18...176 V DC
Reaction time	< 3 ms

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Table 10. RTD/RTA 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 0.00518 (DIN 43760) TCR 0.00518 TCR 0.00518 TCR 0.00427	
	Supported resistance range	0...2 kΩ		
	Maximum lead resistance (three-wire measurement)	25 Ω per lead		
	Excitation	24 V (inputs to protective earth)		
	Response time	< 4 s		
	RTD resistance warning current	Maximum 0.33 mA rms		
	Operation accuracy	Resistance	± 2.2% or ± 1 Ω	Temperature ± 1°C 10 Ω copper: ± 2°C
		Supported current range	0...30 mA	
	mA inputs	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) 1000 S²⁾
1100 S²⁾, S²⁾ when any of the protection relay is associated with B2005E.
4110 S²⁾, S²⁾ when REF620 is protected with B2005E.
1110 S²⁾, S²⁾ when REF620 is protected with B2005E.

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Table 12. Signal outputs and R/F 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 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
Minimum contact load	10 mA at 5 V AC/DC

1) 1000 S²⁾
1100 S²⁾, S²⁾ when any of the protection relay is associated with B2005E.
4110 S²⁾, S²⁾ when REF620 is protected with B2005E.
1110 S²⁾, S²⁾ when REF620 is protected with B2005E.

Table 13. Double-pole power outputs with TCS function X100: P03 and P04

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
Tripp-out 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 (1.5 V)

1) P03/04: P03, P04/04: P03, P04/04: P03 and P04/04: P03, P04

Table 14. Single-pole power output relays X100: P01 and P02

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	6 A
Makes and carry for 3.0 s	15 A
Makes and carry for 0.5 s	33 A
Breaking capacity when the control-circuit time constant L/R <43 ms, at 48/110/220 V DC	5 A/3 A/1 A
Operate time	<1 ms
Reset	<20 ms, resistive load

1) 100% HSO, 100% HSO, when 1% of the previous value, 1 or 10 ms and 100%.

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 MB/s

Table 17. Station communication link, fiber optic

Connector	Fiber type ¹⁾	Wave length	Typical max. length ²⁾	Permitted path attenuation ³⁾
LC	MM2 62.5/125 or 50/125 µm glass fiber core	1300 nm	2 km	<3 dB
ST	MM2 62.5/125 or 50/125 µm glass fiber core	820...850 nm	1 km	<11 dB

1) Multimode OM3, OM4, singlemode B1.3
2) Maximum length based on the cable dispersion and backscattering of light and transmission in the cable
3) Maximum allowed attenuation (total) by connection and cable together

Table 18. I/O-3

Description	Value
IRIG time code format	B204, B205 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 B204 (I/O-3) manual

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...+120°C
Maximum service temperature range of the lens, IEC 1	+140°C
Minimum permissible bending radius of the connection fiber	100 mm

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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 61000-4-19 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		IEC 61000-4-6 IEC 60255-26, class IV IEC 61000-4-3 IEC 60255-26, class III EN 50224 IEC 60255-26, class III
10 V (rms) f = 150 MHz...30 MHz		
10 V (peak) f = 43...2700 MHz		
10 V (rms) f = 900 MHz		
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 1000 A/m	
• 1...3 s		
Pulse magnetic field immunity test		IEC 61000-4-9
1000 A/m 6.4/16 µs		
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions		IEC 61000-4-11
60%/10 ms		
60%/100 ms		
60%/1000 ms		
>95%/500 ms		
Power frequency immunity test		IEC 61000-4-15 IEC 60255-26, class A
• Common mode	100 V rms	

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Table 20. Degree of protection of bush-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 (<10%) ¹⁾
Relative humidity	<93%, non-condensing
Atmospheric pressure	88...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+85°C

1) Dependent on VDF and IEC performance levels for temperature range of -25...+55°C
2) For fully sealed construction, reference the maximum operating temperature is +70°C

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Table 22. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
• Differential mode	150 V rms	
Conducted common mode disturbances	15 Hz...150 MHz Test level 3 (15/1/0 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 <65 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	<41 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	<43 dB (µV/m) peak <40 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	IEC 60255-27
	500 V, 50 Hz, 1 min, communication	
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 60088-2-6 (part F) IEC 60255-21-1	Class 2
Shock and bump test	IEC 60088-2-27 (part E) shock IEC 60088-2-29 (part E) 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	95 h at +55°C 16 h at +35°C ¹⁾	IEC 60068-2-2
Dry cold test	95 h at -25°C 16 h at -4°C	IEC 60068-2-1
Damp heat test	6 cycles (12 h + 12 h) at +25°C...+55°C, humidity >93%	IEC 60068-2-33
Change of temperature test	5 cycles (3 h + 3 h) at -25°C...+55°C	IEC 60068-2-14
Storage test	95 h at -4°C 95 h at +55°C	IEC 60068-2-1 IEC 60068-2-2

1) For tests with an LC semiconductor module the maximum operating temperature is +70°C

Table 26. Product safety

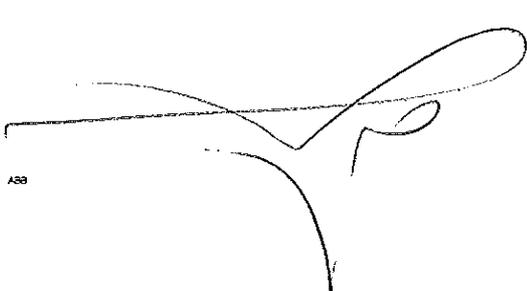
Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2013) EN 60255-1 (2009)

Table 27. EMC compliance

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

Table 28. RoHS compliance

Description	Reference
Complies with RoHS directive 2002/95/EC	



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

Parameter	Function	Value (Range)	Step
Start value	PHPTOC	0.05...5.00 × I _n	0.01
	PHPTOC and PHPTOC	0.10...43.00 × I _n	0.01
Time multiplier	PHPTOC	1.00...15.00 × t _n	0.01
	PHPTOC	0.05...15.00	0.01
Operate delay time	PHPTOC	43...200000 ms	10
	PHPTOC	43...200000 ms	13
	PHPTOC	20...200000 ms	13
Operating curve type ¹⁾	PHPTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PHPTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHPTOC	Definite time	

1) For curve reference, see Technical characteristics table

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

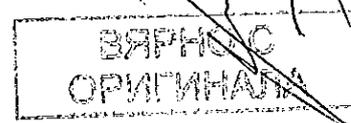
Characteristics	Value
Operation accuracy	Depending on the frequency of the current/voltage measured, f, 42 Hz
	Current: ±1.5% of the set value or ±0.002 × I _n Voltage: ±1.5% of the set value or ±0.002 × U _n Phase angle: ±2°
Start time ^{1,2)}	Minimum 19 ms
	Typical 43 ms
Reset time	Typically 40 ms
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
Operate time accuracy in inverse time mode	±5.0% of the theoretical value or ±20 ms ³⁾
Suppression of harmonics	DFT: -50 dB at I = n × I _n , where n = 2, 3, 4, 5, ...

1) Measurement mode is P₁ quantity, ±0.5% current, current delay time = 10 × I_n, voltage delay time = 10 × U_n, L = 50 Hz, full current in all phases and no external frequency, expected from national standards.
2) Indicates the delay of the signal output contact.
3) Maximum start value is 1.5 × I_n, start value multiplier in range of 1.0...15.

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

Characteristics	Value	
Operation accuracy	Depending on the frequency of the measured current: f, 42 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°	
Start time ^{1,2)}	Minimum	19 ms
	Typical	43 ms
	Maximum	47 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	
Operate time accuracy in inverse time mode	±5.0% of the theoretical value or ±20 ms ³⁾	
Suppression of harmonics	DFT: -50 dB at I = n × I _n , where n = 2, 3, 4, 5, ... Peak-to-Peak: No suppression P-to-P: No suppression	

1) Measurement mode is P₁ quantity, ±0.5% current, current delay time = 10 × I_n, voltage delay time = 10 × U_n, L = 50 Hz, full current in all phases and no external frequency, expected from national standards.
2) Indicates the delay of the signal output contact.
3) Maximum start value is 1.5 × I_n, start value multiplier in range of 1.0...15.

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

Parameter	Function	Value (Range)	Step
Start value	DPHPDOC	0.05...5.00 × I _n	0.01
	DPHPDOC	0.10...43.00 × I _n	0.01
Time multiplier	DPHPDOC	1.00...15.00 × t _n	0.01
	DPHPDOC	0.05...15.00	0.01
Operate delay time	DPHPDOC	43...200000 ms	10
	DPHPDOC	43...200000 ms	13
Operating curve type ¹⁾	DPHPDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHPDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPHPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
	DPHPDOC	-179...107°	1

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

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

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f, 42 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°
Start time ^{1,2)}	Minimum 19 ms
	Typical 43 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.98
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 I = n × I _n , where n = 2, 3, 4, 5, ...

1) Measurement mode is P₁ quantity, ±0.5% current, current delay time = 10 × I_n, voltage delay time = 10 × U_n, L = 50 Hz, full current in all phases and no external frequency, expected from national standards.
2) Indicates the delay of the signal output contact.
3) Maximum start value is 1.5 × I_n, start value multiplier in range of 1.0...15.

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

Parameter	Function	Value (Range)	Step
Start value	PFPVOC	$0.05 \dots 5.00 \times I_n$	0.01
Start value low	PFPVOC	$0.05 \dots 1.00 \times I_n$	0.01
Voltage high limit	PFPVOC	$0.01 \dots 1.00 \times U_n$	0.01
Voltage low limit	PFPVOC	$0.01 \dots 1.00 \times U_n$	0.01
Start value IRL	PFPVOC	0.8...10.0	0.1
Time multiplier	PFPVOC	0.05...15.00	0.01
Operating curve type ¹⁾	PFPVOC	Define 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	PFPVOC	40...200000 ms	10

1) For further details, see Section characteristics table

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

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \geq 2$ Hz EFLPTOC: $\pm 1.5\%$ of the set value or $\pm 0.032 \times I_n$ EFPFIOC and EFPFIOC: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$) $\pm 5.0\%$ of the set value (at currents in the range of $10 \dots 40 \times I_n$)
Start time I ²⁾	Minimum Typical Maximum EFPFIOC: $I_{FA} = 2 \times \text{set Start value}$ 10 ms 19 ms 23 ms $I_{FA} = 10 \times \text{set Start value}$ 11 ms 12 ms 14 ms EFPFIOC and EFLPTOC: $I_{FA} = 2 \times \text{set Start value}$ 23 ms 26 ms 29 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.55
Retardation time	<30 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in Inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁾
Suppression of harmonics	RMS: No suppression DFT: ≤ 0 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression

1) Measurement mode = 3-phase, depends on input current of set $\pm 2.0 \times I_n$, $I_n \geq 50$ mA; with 1-phase current with nominal frequency, depends on system angle, results based on an initial distribution of 1000 measurements
 2) Includes the delay of the signal input circuit
 3) Minimum start value $\geq 0.1 \times I_n$, start value multiples in range of 1.4...2.0

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

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

1) For further details, see Section characteristics table



Table 37. Directional earth-fault protection (DEFDPDEF)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \geq 2$ Hz DEFLPDEF: Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$; Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$; Phase angle: $\pm 2^\circ$ DEFHPDEF: Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$) $\pm 5.0\%$ of the set value (at currents in the range of $10 \dots 40 \times I_n$) Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$; Phase angle: $\pm 2^\circ$
Start time I ²⁾	Minimum Typical Maximum DEFHPDEF: $I_{FA} = 2 \times \text{set Start value}$ 42 ms 46 ms 49 ms DEFLPDEF: $I_{FA} = 2 \times \text{set Start value}$ 50 ms 62 ms 69 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.55
Retardation time	<30 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in Inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁾
Suppression of harmonics	RMS: No suppression DFT: ≤ 0 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression

1) Set operate delay, phase ± 0.2 s; operate delay time ≤ 0.2 s; Inverse mode: 3-phase, depends on input current of set $\pm 2.0 \times I_n$, $I_n \geq 50$ mA; with 1-phase current with nominal frequency, depends on system angle, results based on an initial distribution of 1000 measurements
 2) Includes the delay of the signal input circuit
 3) Minimum start value $\geq 0.1 \times I_n$, start value multiples in range of 1.4...2.0

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

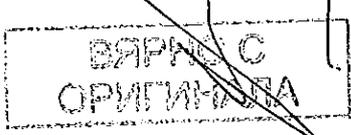
Parameter	Function	Value (Range)	Step
Start value	DEFLPDEF	$0.010 \dots 5.000 \times I_n$	0.005
	DEFHPDEF	$0.10 \dots 40.00 \times I_n$	0.01
Directional mode	DEFHPDEF	1 = Non-directional 2 = Forward 3 = Reverse	
	DEFLPDEF	0.05...15.00	0.01
Time multiplier	DEFHPDEF	0.05...15.00	0.01
	DEFLPDEF	40...200000 ms	10
Operate delay time	DEFHPDEF	40...200000 ms	10
	DEFLPDEF	40...200000 ms	10
Operating curve type ¹⁾	DEFHPDEF	Define or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFLPDEF	Define or Inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFHPDEF	1 = Phase angle 2 = I_{FA} 3 = I_{OC} 4 = Phase angle ± 0 5 = Phase angle ± 0	

1) For further details, see Section characteristics table

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

Characteristics	Value
Operation accuracy ¹⁾	At the frequency $f = f_n$ $\pm 1.0\%$ or ± 0.01 mS (in range of $0.5 \dots 100$ mS)
Start time ²⁾	Minimum Typical Maximum 56 ms 60 ms 64 ms
Reset time	40 ms
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 20 ms
Suppression of harmonics	≤ 0 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1) Up to $1.0 \times I_n$
 2) Includes the delay of the signal input circuit, results based on an initial 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	$0.61...2.00 \times U_n$	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 fit Ang	EFPADM	-90...30°	1
Susceptance fit Ang	EFPADM	-90...30°	1

Table 41. Wadmetric-based earth-fault protection (WFWDE)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_n , 42 Hz Current and voltage: ±1.5% of the set value or $\pm 0.002 \times I_n$ Power: ±3% of the set value or $\pm 0.002 \times P_n$
Start time ^{1,2}	Typically 63 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 IDMT mode	±5.0% 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. In adjust mode, the start time is the time from the voltage start value to the current start value. The start time is based on an initial current of 100% of the set value.
2. Indicates the delay of the signal about contact.

Table 42. Wadmetric-based earth-fault protection (WFWDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	WFWDE	2 = Forward 3 = Reverse	-
Current start value	WFWDE	$0.015...5.000 \times I_n$	0.001
Voltage start value	WFWDE	$0.010...1.000 \times U_n$	0.001
Power start value	WFWDE	$0.003...1.000 \times P_n$	0.001
Reference power	WFWDE	$0.050...1.000 \times P_n$	0.001
Characteristic angle	WFWDE	-178...152°	1
Time multiplier	WFWDE	0.05...2.00	0.01
Operating curve type ¹⁾	WFWDE	Definite or Inverse time Curve type: 5, 15, 20	-
Operate delay time	WFWDE	60...200000 ms	10
Min operate current	WFWDE	$0.010...1.000 \times I_n$	0.001
Min operate voltage	WFWDE	$0.010...1.000 \times U_n$	0.001

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

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: U_n , 42 Hz ±1.5% of the set value or $\pm 0.002 \times U_n$
Start time ¹⁾	Typically 35 ms
Reset time	Typically 40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

1. Indicates the delay of the signal about contact, results based on statistical distribution of 1000 measurements.

Table 44. Multi-frequency admittance-based earth-fault protection (MFADPSOE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	MFADPSOE	2 = Forward 3 = Reverse	-
Voltage start value	MFADPSOE	$0.61...1.00 \times U_n$	0.01
Operate delay time	MFADPSOE	60...200000 ms	10
Operating quantity	MFADPSOE	1 = Admittance 2 = Amplitude	-
Min operate current	MFADPSOE	$0.005...5.000 \times I_n$	0.001
Operation mode	MFADPSOE	1 = Interchange EF 3 = General EF 4 = Alarming EF	-
Peak counter limit	MFADPSOE	2...20	1

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

Characteristic	Value
Operation accuracy (No criteria with transient protection)	Depending on the frequency of the measured current: I_n , 42 Hz ±1.5% of the set value or $\pm 0.002 \times U_n$
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5$

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	$0.65...0.90 \times U_n$	0.01
Operation mode	INTRPTEF	1 = Interchange EF 2 = Transient EF	-
Peak counter limit	INTRPTEF	2...20	-
Min operate current	INTRPTEF	$0.01...1.00 \times I_n$	0.01

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_n , 42 Hz ±5% of the set value or $\pm 0.004 \times I_n$
Start time ^{1,2}	Typically 77 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 IDMT mode ³⁾	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at $f = f_n$ -3 dB at $f = 13 \times f_n$

1. For further information, refer to the Operating characteristics table.
2. Indicates the delay of the signal about contact.
3. Maximum start value is $15 \times I_n$. Start value multiples in range of 3...10.

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

Parameter	Function	Value (Range)	Step
Start value	HAEPFTOC	$0.05...5.00 \times I_n$	0.01
Time multiplier	HAEPFTOC	0.05...15.00	0.01
Operate delay time	HAEPFTOC	150...200000 ms	10
Operating curve type ¹⁾	HAEPFTOC	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	HAEPFTOC	100...200000 ms	10

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

Table 49. Negative-sequence overcurrent protection (NSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_n , 42 Hz ±1.5% of the set value or $\pm 0.002 \times I_n$
Start time ^{1,2}	Minimum Typical Maximum $I_{set} = 2 \times \text{set Start value}$ $I_{set} = 10 \times \text{set Start value}$ 23 ms 15 ms 26 ms 18 ms 23 ms 20 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Reoperation 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 set value or ±20 ms ³⁾
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5$

1. Negative sequence current below 10 A or 0.5 U_n or 50 Hz, results based on statistical distribution of 1000 measurements.

2. Indicates the delay of the signal about contact.

3. Minimum start value is $15 \times I_n$. Start value multiples in range of 1.5...10.

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

Parameter	Function	Value (Range)	Step
Start value	NSPTOC	$0.01...5.00 \times I_n$	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 information, refer to the Operating characteristics table.

Table 51. Phase discontinuity protection (PONSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: I_n , 42 Hz ±2% of the set value
Start time	<70 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Reoperation 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 $n = 2, 3, 4, 5$

Table 52. Phase discontinuity protection (PONSPTOC) main settings

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

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Table 53. Residual overvoltage protection (ROVPTOV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage: $f_n \pm 2$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 49 ms Typical: 51 ms Maximum: 54 ms $U_{pka} = 2 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁾
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = 1.5 × U_n, voltage before fault = 0.8 × U_n, U_n = 50 Hz, 3-phase voltage in the phase-to-phase with normal frequency, measured from minimum phase angle, results based on nominal operation at 100% measurement
- Includes the delay of the signal output contact
- Minimum Start value = 0.5 × U_n, Start value multiple in range of 0.5...2.0

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	49...300000 ms	1

Table 55. Three-phase undervoltage protection (PHPTUV)

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

- Start value = 1.5 × U_n, voltage before fault = 0.8 × U_n, U_n = 50 Hz, 3-phase voltage in the phase-to-phase with normal frequency, measured from minimum phase angle, results based on nominal operation at 100% measurement
- Includes the delay of the signal output contact
- Minimum Start value = 0.5 × U_n, Start value multiple in range of 0.5...2.0

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 ³⁾	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

- For further reference, see Operation characteristics table

Table 57. Single-phase undervoltage protection (PHAPTUV)

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

- Start value = 1.5 × U_n, voltage before fault = 0.8 × U_n, U_n = 50 Hz, 3-phase voltage in the phase-to-phase with normal frequency, measured from minimum phase angle, results based on nominal operation at 100% measurement
- Includes the delay of the signal output contact
- Minimum Start value = 0.5 × U_n, Start value multiple in range of 0.5...2.0

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 ³⁾	PHAPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

- For further reference, see Operation characteristics table

Table 59. Three-phase overvoltage protection (PHPTOV)

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

- Start value = 1.5 × U_n, voltage before fault = 0.8 × U_n, U_n = 50 Hz, 3-phase voltage in the phase-to-phase with normal frequency, measured from minimum phase angle, results based on nominal operation at 100% measurement
- Includes the delay of the signal output contact
- Minimum Start value = 0.5 × U_n, Start value multiple in range of 0.5...2.0

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

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.05...1.50 × U _n	0.01
Time multiplier	PHPTOV	0.05...15.00	0.01
Operate delay time	PHPTOV	40...300000 ms	10
Operating curve type ³⁾	PHPTOV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

- For further reference, see Operation characteristics table

Table 61. Single-phase overvoltage protection (PHAPTOV)

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

- Start value = 1.5 × U_n, voltage before fault = 0.8 × U_n, U_n = 50 Hz, 3-phase voltage in the phase-to-phase with normal frequency, measured from minimum phase angle, results based on nominal operation at 100% measurement
- Includes the delay of the signal output contact
- Minimum Start value = 0.5 × U_n, Start value multiple in range of 0.5...2.0

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

Parameter	Function	Value (Range)	Step
Start value	PHAPTOV	0.05...1.50 × U _n	0.01
Time multiplier	PHAPTOV	0.05...15.00	0.01
Operate delay time	PHAPTOV	40...300000 ms	10
Operating curve type ³⁾	PHAPTOV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

- For further reference, see Operation characteristics table

Table 63. Positive-sequence undervoltage protection (PSPTUV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage: $f_n \pm 2$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 50 ms Typical: 55 ms Maximum: 58 ms $U_{pka} = 0.99 \times \text{set Start value}$ $U_{pka} = 0.9 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Depends on the set <i>Relative hysteresis</i>
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = 1.5 × U_n, voltage before fault = 0.8 × U_n, U_n = 50 Hz, 3-phase positive sequence voltage with normal frequency, measured from minimum phase angle, results based on nominal operation at 100% measurement
- 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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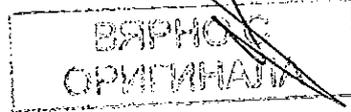


Table 65. Negative-sequence overvoltage protection (NSPTOV)

Characteristic	Value	
Operation accuracy	Depending on the frequency of the voltage measured: f_v , 12 Hz ±1.5% of the set value or ±0.002 × U_N	
Start time ¹⁾	Minimum	33 ms
	Typical	35 ms
	Maximum	37 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	OFF; 50 dB at $f = n \times f_v$, where $n = 2, 3, 4, 5, \dots$	

¹⁾ Negative-sequence voltage set value $U_{NSPTOV} \leq 1.2 \times U_N$, $f_v \leq 50$ Hz. Negative-sequence overvoltage with harmonic frequency protection is not possible in definite time mode based on internal detection of 1200 measurements.
²⁾ Within the range of the signal output current.

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

Parameter	Function	Value (Range)	Step
Start value	NSPTOV	0.019...1.000 × U_N	0.001
Operate delay time	NSPTOV	43...12000 ms	1

Table 67. Frequency protection (FRPFRO)

Characteristic	Value	
Operation accuracy	f-Hz	±5 mHz
	d/dt	±50 mHz/s (in range $f \leq 50$ Hz) ±2.0% of the set value (in range 5 Hz/s < $f \leq 15$ Hz/s)
Start time	f-Hz	<30 ms
	d/dt	<120 ms
Reset time	<150 ms	
Operate time accuracy	±1.0% of the set value or ±33 ms	

Table 68. Frequency protection (FRPFRO) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRO	1 = Fract	0.0001
		2 = Frang	
		3 = d/dt	
		4 = Fract + d/dt	
		5 = Fract + d/dt	
		6 = Fract OR d/dt	
		7 = Fract OR d/dt	
Start value Frang	FRPFRO	0.9000...1.2000 × f_N	0.0001
Start value Fract	FRPFRO	0.8000...1.1000 × f_N	0.0001
Start value d/dt	FRPFRO	-0.2000...0.2000 × f_N/s	0.0025
Operate Tim Fract	FRPFRO	63...200000 ms	10
Operate Tim d/dt	FRPFRO	120...200000 ms	10

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_c , 12 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⁾ Disturb current = 1.2 × Rated test temperature

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

Parameter	Function	Value (Range)	Step
Env temperature Set	TIPTR	-50...150°C	1
Current reference	TIPTR	0.05...4.00 × I_N	0.01
Temperature rise	TIPTR	0.8...200.0°C	0.1
Time constant	TIPTR	60...60000 s	1
Maximum temperature	TIPTR	25.0...200.0°C	0.1
Alarm value	TIPTR	25.0...150.0°C	0.1
Reference temperature	TIPTR	20.0...150.0°C	0.1
Current multiplier	TIPTR	1...5	1
Initial temperature	TIPTR	-50.0...100.0°C	0.1

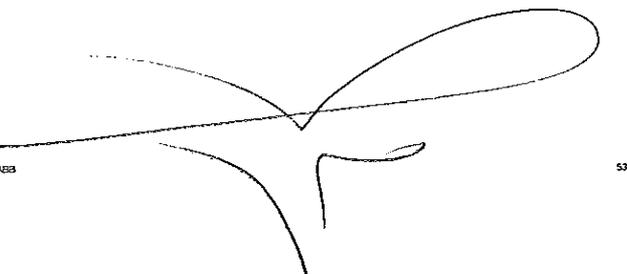


Table 71. Loss of phase, undercurrent (PHPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_c , 12 Hz ±1.5% of the set value or ±0.002 × I_N
	Typically <55 ms
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 uncurrent 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...1.50 × I_N	0.01
Operate delay time	PHPTUC	50...200000 ms	10

Table 73. Circuit breaker failure protection (CCBSBF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_c , 12 Hz ±1.5% of the set value or ±0.002 × I_N
	±1.0% of the set value or ±20 ms
Operate time accuracy	±1.0% of the set value or ±20 ms
Reset time ¹⁾	Typically 40 ms
Retardation time	<20 ms

¹⁾ The value time delay or minimum pulse width

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

Parameter	Function	Value (Range)	Step
Current value	CCBSBF	0.05...2.00 × I_N	0.01
Current value Res	CCBSBF	0.05...2.00 × I_N	0.01
CB failure mode	CCBSBF	1 = Current 2 = Breaker status 3 = Both	
CB fail resp mode	CCBSBF	1 = CB 2 = Without check 3 = Current check	
Run time	CCBSBF	0...60000 ms	10
CB failure delay	CCBSBF	0...60000 ms	10
CB fail delay	CCBSBF	0...60000 ms	10

Table 75. Three-phase Inrush detector (INSHAR)

Characteristic	Value
Operation accuracy	At the frequency $f = f_c$ Current measurement: ±1.5% of the set value or ±0.002 × I_N Ratio I2/I1 measurement: ±5.0% of the set value
	±35 ms / -0 ms
Reset time	±35 ms / -0 ms
Reset ratio	Typically 0.99
Operate time accuracy	±35 ms / -0 ms

Table 76. Three-phase Inrush detector (INSHAR) main settings

Parameter	Function	Value (Range)	Step
Start value	INSHAR	5...10%	1
Operate delay time	INSHAR	25...60000 ms	1

Table 77. Arc protection (ARCSARC)

Characteristic	Value			
Operation accuracy	±1% of the set value or ±0.01 × I_N			
	Minimum	Typical	Maximum	
Operate time	Operation mode = "Light current" ¹⁾	9 ms ²⁾	12 ms ³⁾	15 ms ⁴⁾
	Operation mode = "Light only" ²⁾	4 ms ³⁾	6 ms ⁴⁾	9 ms ⁴⁾
Reset time	Typically 43 ms ³⁾	10 ms ⁴⁾	12 ms ⁴⁾	
	<55 ms ⁴⁾	0 ms ⁴⁾	7 ms ⁴⁾	
Reset ratio	Typically 0.99			

¹⁾ Phase I_2/I_1 ratio = 10 × I_N , current below fault = 2.0 × set value start value, $f_c \leq 50$ Hz. I_N is nominal frequency, multi-tap based on internal description of 200 measurements.
²⁾ It adds the delay of the heavy-duty, solid contact.
³⁾ Normal power factor.
⁴⁾ Improved input.

Table 78. Arc protection (ARCSARC) main settings

Parameter	Function	Value (Range)	Step
Phase start value	ARCSARC	0.50...43.00 × I_N	0.01
Ground start value	ARCSARC	0.05...4.00 × I_N	0.01
Operation mode	ARCSARC	1 = Light equipment 2 = Light only 3 = BI excluded	

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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Table 80. Load-shedding and restoration (LSHDFFRQ) main settings

Characteristic	Value
Operation accuracy	±10 mHz
Start time	±50 ms
Reset time	<120 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

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

Parameter	Function	Value (Range)	Step
Load shed mode	LSHDFFRQ	1 = Freq; 6 = Freq; OR d% 8 = Freq; AND d%	-
Restora mode	LSHDFFRQ	1 = Disabled 2 = Auto 3 = Manual	-
Start value Freq	LSHDFFRQ	0.80...1.20 × I _n	0.01
Start value d%	LSHDFFRQ	0.200...0.050 × I _n	0.050
Operate Tim Freq	LSHDFFRQ	80...200000 ms	10
Operate Tim d%	LSHDFFRQ	120...200000 ms	10
Restora start Val	LSHDFFRQ	0.80...1.200 × I _n	0.01
Restora delay time	LSHDFFRQ	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-out-to-fault (CVPSOF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: I _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
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at I = n × I _n , where n = 2, 3, 4, 5...

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

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

Table 86. Voltage vector shift protection (VSPFAM)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: I _n ±1 Hz
Operate time ^{1,2}	Typically 53 ms

1. I_n = 50 Hz, results based on statistical distribution of 1000 measurements
2. Includes the delay of the signal about contact

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

Parameter	Function	Value (Range)	Step
Start value	VSPFAM	2.0...30.0°	0.1
Over Volt 50 kV value	VSPFAM	0.40...1.50 × U _n	0.01
Under Volt 50 kV value	VSPFAM	0.15...1.00 × U _n	0.01
Phase supervision	VSPFAM	7 = Ph A + B + C 8 = Ph sequence	-

Table 88. Directional reactive power undervoltage protection (DQPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: I _n ±2 Hz Reactive power range PF1 < 0.71 Power: ±3.0% or ±0.012 × S _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 I = n × I _n , where n = 2, 3, 4, 5...

1. Start value ±0.5% × S_n, reaches zero before full × 0.2 × start value, reaches cover overvoltage 2 times, results based on statistical distribution of 1000 measurements
2. Includes the delay of the signal about 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 factor reduction	DQPTUV	0...10°	1

Table 90. Underpower protection (DUPDPDR)

Characteristic	Value
Operation accuracy ¹	Depending on the frequency of the measured current and voltage: I _n ±2 Hz Power measurement accuracy ±3% of the set value or ±0.002 × S _n Phase angle: ±2°
Start time ^{1,2}	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 I = n × I _n , where n = 2, 3, 4, 5...

1. Measurement mode = "Ph Seq" default
2. U × I_n, I_n = 50 Hz, results based on statistical distribution of 1000 measurements
3. Includes the delay of the signal about contact

Table 91. Underpower protection (DUPDPDR) main settings

Parameter	Function	Value (Range)	Step
Start value	DUPDPDR	0.01...2.00 × S _n	0.01
Operate delay time	DUPDPDR	40...300000 ms	10
Full reversal	DUPDPDR	1 = True	-
Double time	DUPDPDR	0...60000 ms	1000

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

Characteristic	Value
Operation accuracy ¹	Depending on the frequency of the measured current and voltage: I _n ±2 Hz Power measurement accuracy ±3% of the set value or ±0.002 × S _n Phase angle: ±2°
Start time ^{1,2}	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 I = n × I _n , where n = 2, 3, 4, 5...

1. Measurement mode = "Ph Seq" default
2. U × I_n, I_n = 50 Hz, results based on statistical distribution of 1000 measurements
3. Includes the delay of the signal about contact

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

Parameter	Function	Value (Range)	Step
Start value	DOPDPDR	0.01...2.00 × S _n	0.01
Operate delay time	DOPDPDR	40...300000 ms	10
Directional mode	DOPDPDR	2 = Forward 3 = Reverse	-
Power angle	DOPDPDR	50...50°	1

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: I _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 I = n × I _n , where n = 2, 3, 4, 5...

1. Tests for Number of Set pulses = 1 out of 3, results based on statistical distribution of 1000 measurements
2. Includes the delay of the signal about contact

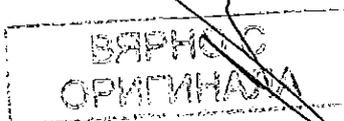


Table 95. Low-voltage ride-through protection (LVRTIUV) main settings

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

Table 96. High-impedance differential protection (HiZDDF) main settings

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured, f, 62 Hz ±1.5% of the set value or ±0.002 × I _n
Start time ^{1,2}	Minimum: I _{th} = 2.0 × set Start value Typical: 12 ms Maximum: I _{th} = 10 × set Start value 12 ms 14 ms
Reset time	<40 ms
Reset ratio	Typically 0.99
Retraction time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

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

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

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

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



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

Characteristic	Function	Value
Operation accuracy	PHIPTOC	Depending on the frequency of the current measured, f, 62 Hz ±1.5% of the set value or ±0.002 × I _n
	PHIPTOC and PHIPPTOC	±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}	PHIPTOC: I _{th} = 2 × set Start value I _{th} = 10 × set Start value PHIPTOC and PHIPPTOC: I _{th} = 2 × set Start value	Minimum: 15 ms Typical: 18 ms Maximum: 17 ms 11 ms 14 ms 17 ms 23 ms 25 ms 23 ms
Reset time		<40 ms
Reset ratio		Typically 0.99
Retraction 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 ₀ , where n = 2, 3, 4, 5... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression

1) Measurement must be taken at a value of 10 × I_n or higher.
2) Includes the delay of the signal input device.
3) Minimum Start value = 2.0 × I_n. Start value multiplier in range of 1.0...20.

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

Parameter	Function	Value (Range)	Step
Start value	PHIPTOC	0.05...5.00 × I _n	0.01
	PHIPPTOC	0.10...40.00 × I _n	0.01
	PHIPPTOC	1.00...40.00 × I _n	0.01
Time multiplier	PHIPTOC	0.05...15.00	0.01
	PHIPPTOC	0.05...15.00	0.01
Operate delay time	PHIPTOC	40...200000 ms	10
	PHIPPTOC	40...200000 ms	10
	PHIPPTOC	20...300000 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	
	PHIPPTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPPTOC	Definite time	

1) For time reference, refer to the operating curve selection table.

Table 101. Directional three-independent-phase directional overcurrent protection (DPH3DDOC)

Characteristic	Function	Value
Operation accuracy	DPH3DDOC	Depending on the frequency of the current measured, f, 62 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°
	DPH3DDOC	±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}	I _{th} = 2 × set Start value	Minimum: 38 ms Typical: 40 ms Maximum: 43 ms
Reset time		<40 ms
Reset ratio		Typically 0.99
Retraction 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 ₀ , where n = 2, 3, 4, 5... Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression

1) Measurement must be taken at a value of 10 × I_n or higher.
2) Includes the delay of the signal input device.
3) Minimum Start value = 2.0 × I_n. Start value multiplier in range of 1.0...20.

Table 102. Directional three-independent-phase directional overcurrent protection (DPH3DDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPH3DDOC	0.05...5.00 × I _n	0.01
	DPH3DDOC	0.10...40.00 × I _n	0.01
Time multiplier	DPH3DDOC	0.05...15.00	0.01
Operate delay time	DPH3DDOC	40...200000 ms	10
Operating curve type ¹⁾	DPH3DDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPH3DDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPH3DDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPH3DDOC	-175...150°	1

1) For time reference, refer to the operating curve selection table.

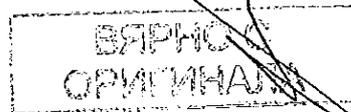


Table 103. Three-phase overload protection for shunt capacitor banks (COUPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current I, ± 2 Hz, and no harmonics
Start value	5% of the set value or $0.002 \times I_n$
Start time for overload stage ^{1,2}	Typically 75 ms
Start time for under current stage ^{3,4}	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	15% of the theoretical value or ± 20 ms
Suppression of harmonics for under current stage	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1. Fundamental current, current $\leq 1.5 \times I_n$, harmonic current $\leq 1.5 \times I_n$ results based on statistical detection of 120 measurements
 2. Includes the delay of the signal output circuit
 3. Harmonic current (only for $I_n \leq 1.2 \times I_n$), harmonic current $\leq 0.3 \times I_n$ results based on statistical detection of 120 measurements
 4. Harmonic current (only for $I_n \leq 1.2 \times I_n$), harmonic current $\leq 0.3 \times I_n$ results based on statistical detection of 120 measurements

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

Parameter	Function	Value (Range)	Step
Start value overload	COUPTOC	$0.03 \dots 1.50 \times I_n$	0.01
Alarm start value	COUPTOC	$0.3 \dots 125\%$	1
Start value Us Cur	COUPTOC	$0.15 \dots 0.75 \times I_n$	0.01
Time multiplier	COUPTOC	$0.05 \dots 2.00$	0.01
Alarm delay time	COUPTOC	$50 \dots 600000$	100
Us Cur delay time	COUPTOC	$100 \dots 10000$	100

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current I, ± 2 Hz
Start value	1.5% of the set value or $0.002 \times I_n$
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 $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1. Fundamental frequency, current $\leq 1.0 \times I_n$, current below $I_n \leq 0.5 \times I_n$, harmonic current $\leq 1.0 \times I_n$ results based on statistical detection of 120 measurements
 2. Includes the delay of the signal output circuit

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

Parameter	Function	Value (Range)	Step
Alarm mode	CUSPTOC	1 = Normal 2 = Element counter	-
Start value	CUSPTOC	$0.01 \dots 1.00 \times I_n$	0.01
Alarm start value	CUSPTOC	$0.01 \dots 1.00 \times I_n$	0.01
Time multiplier	CUSPTOC	$0.05 \dots 15.00$	0.01
Operating curve type ¹	CUSPTOC	1 = 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	CUSPTOC	$50 \dots 200000$ ms	10
Alarm delay time	CUSPTOC	$50 \dots 200000$ ms	10

1. For further information, refer to the operating characteristic 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, ± 2 Hz
Operate value accuracy	$\pm 3\%$ of the set value or $\pm 0.002 \times I_n$ (for 2 nd order Harmonics) $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (for 3 rd order < Harmonics < 10th order) $\pm 5\%$ of the set value or $\pm 0.004 \times I_n$ (for Harmonics >= 10th order)
Reset time	Typically 45 ms or maximum 50 ms
Retardation time	Typically 0.95
Retardation time	< 30 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ 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	$0.03 \dots 0.50 \times I_n$	0.01
Start value	SRCPTOC	$0.03 \dots 0.50 \times I_n$	0.01
Tuning harmonic Num	SRCPTOC	1...11	1
Operate delay time	SRCPTOC	$120 \dots 300000$ ms	1
Alarm delay time	SRCPTOC	$120 \dots 300000$ ms	1

Table 109. Operation characteristics

Parameter	Value (Range)
Operating curve type	1 = ANSI Ed. Inv. 2 = ANSI Vary. 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 Vary. Inv. 11 = IEC Inv. 12 = IEC Ed. 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	$\pm 1.0\%$ 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, I, ± 1 Hz Voltage: $\pm 0.0\%$ of the set value or $\pm 0.1 \times U_n$ Frequency: ± 10 mHz Phase angle: $\pm 3^\circ$
Reset time	< 50 ms
Reset ratio	Typically 0.95
Operate time accuracy in definite time mode	$\pm 1.0\%$ 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, 1 Any 5 = Dead L, Bus Any 6 = One Live, Dead 7 = Not Both Live	-
Difference voltage	SECRSYN	$0.01 \dots 0.53 \times U_n$	0.01
Difference frequency	SECRSYN	$0.001 \dots 0.100 \times f_n$	0.001
Difference angle	SECRSYN	$5 \dots 90^\circ$	1
Syncheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	-
Dead line value	SECRSYN	$0.1 \dots 0.8 \times U_n$	0.1
Live line value	SECRSYN	$1.0 \dots 1.0 \times U_n$	0.1
Close pulse	SECRSYN	$200 \dots 60000$ ms	10
Max. energizing V	SECRSYN	$0.20 \dots 1.15 \times U_n$	0.01
Control mode	SECRSYN	1 = Continuous 2 = Command	-
Phase shift	SECRSYN	$-180 \dots 180^\circ$	1
Minimum Syn time	SECRSYN	$0 \dots 60000$ ms	10
Maximum Syn time	SECRSYN	$100 \dots 8000000$ ms	10
Energizing time	SECRSYN	$100 \dots 60000$ ms	10
Closing time of CB	SECRSYN	$40 \dots 250$ ms	10

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Condition monitoring and supervision functions

Table 113. Circuit-breaker condition monitoring (CSOBR)

Characteristic	Value
Current measuring accuracy	$\pm 1.5\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$) $\pm 5.0\%$ (at currents in the range of $10 \dots 40 \times I_n$)
Operate time accuracy	$\pm 1.5\%$ 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⁾ For any of the sides of the output current

Table 115. Current circuit supervision (CCSPVC) main settings

Parameter	Function	Value (range)	Step
Set value	CCSPVC	$0.05 \dots 0.20 \times I_n$	0.01
Max operate current	CCSPVC	$1.00 \dots 5.00 \times I_n$	0.01

Table 116. Current transformer supervision for high-impedance protection scheme (HCCO-S-PVC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f_n = 42$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
Reset time	<40 ms
Reset ratio	Typically 0.95
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms

Table 117. Fuse failure supervision (FEQSPVC)

Characteristic	Value		
Operate time ¹⁾	NPS function	$U_{F10} = 1.1 \times \text{set Neg. Seq. voltage Lev}$	<33 ms
		$U_{F10} = 5.0 \times \text{set Neg. Seq. voltage Lev}$	<18 ms
	Delta function	$\Delta U = 1.1 \times \text{set Voltage change rate}$	<30 ms
		$\Delta U = 2.0 \times \text{set Voltage change rate}$	<24 ms

¹⁾ Indicates the side of the output current, f_n is 42 Hz. In all voltage supervision legends, ΔU is the voltage change rate, U_{F10} is the voltage level at 100 ms after

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

Description	Value
Motor runtime measurement accuracy ¹⁾	$\pm 0.5\%$

¹⁾ In the reading for a given interval, with a time resolution

Measurement functions

Table 119. Three-phase current measurement (CMV00)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n = 42$ Hz $\pm 0.5\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.01 \dots 4.00 \times I_n$)
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 120. Sequence current measurement (CSMV00)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n = 42$ Hz $\pm 1.0\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.01 \dots 4.00 \times I_n$)
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 121. Residual current measurement (RESVM00)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: $f_n = 42$ Hz $\pm 0.5\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.01 \dots 4.00 \times I_n$)
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 122. Three-phase voltage measurement (VMV00)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: $f_n = 42$ Hz At voltages in range $0.01 \dots 1.15 \times U_n$ $\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 123. Single-phase voltage measurement (VMV00)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: $f_n = 42$ Hz At voltages in range $0.01 \dots 1.15 \times U_n$ $\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 124. Residual voltage measurement (RESVM00)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n = 42$ Hz $\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 125. Sequence voltage measurement (VSMV00)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: $f_n = 42$ Hz At voltages in range $0.01 \dots 1.15 \times U_n$ $\pm 1.0\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

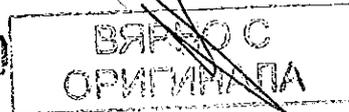
Table 126. Three-phase power and energy measurement (PBMV00)

Characteristic	Value
Operation accuracy	At all three currents in range $0.10 \dots 1.20 \times I_n$ At all three voltages in range $0.50 \dots 1.15 \times U_n$ At the frequency $f_n = 42$ Hz $\pm 1.5\%$ for apparent power S $\pm 1.5\%$ for active power P and active energy ¹⁾ $\pm 1.5\%$ for reactive power Q and reactive energy ²⁾ ± 0.15 for power factor
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

¹⁾ PFI < 0.1
²⁾ PFI < 0.1

Table 127. Frequency measurement (FMV00)

Characteristic	Value
Operation accuracy	± 10 mHz (in measurement range 45...75 Hz)



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Fault location functions

Table 128. Fault locator (SCEFRFLO)

Characteristics	Value
Measurement accuracy	At the frequency $f = f_0$ Impedance: $\pm 2.5\%$ or $\pm 0.25 \Omega$ Distance: $\pm 2.5\%$ or $\pm 0.18 \text{ km}$, 0.1 mls X0FC_CALC: $\pm 2.5\%$ or $\pm 50 \Omega$ FLT_FERR_B.D: $\pm 5\%$ or ± 0.25

Table 129. Fault locator (SCEFRFLO) main settings

Parameter	Function	Value (Range)	Step
Z Max phase load	SCEFRFLO	1.0...1000.00 D	0.1
Ph leakage Fe	SCEFRFLO	20...1000000 D	1
Ph capacitive React	SCEFRFLO	10...1000000 D	1
R1 line section A	SCEFRFLO	0.000...1000.000 D/pu	0.001
X1 line section A	SCEFRFLO	0.000...1000.000 D/pu	0.001
R0 line section A	SCEFRFLO	0.000...1000.000 D/pu	0.001
X0 line section A	SCEFRFLO	0.000...1000.000 D/pu	0.001
Unb Len section A	SCEFRFLO	0.000...1000.000 pu	0.001

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Power quality functions

Table 130. Voltage variation (PHQVVR)

Characteristics	Value
Operation accuracy	$\pm 1.5\%$ of the set value or $\pm 0.2\%$ of reference voltage
Reset ratio	Typically 0.99 (SwR), 1.04 (Op, Interruption)

Table 131. Voltage variation (PHQVVR) main settings

Parameter	Function	Value (Range)	Step
Voltage dip set 1	PHQVVR	100...100.0%	0.1
Voltage dip set 2	PHQVVR	100...100.0%	0.1
Voltage dip set 3	PHQVVR	100...100.0%	0.1
Voltage swell set 1	PHQVVR	100...140.0%	0.1
Voltage swell set 2	PHQVVR	100...140.0%	0.1
Voltage swell set 3	PHQVVR	100...140.0%	0.1
Voltage Int set	PHQVVR	0.0...100.0%	0.1
Va Dir Max	PHQVVR	100...3400000 ms	100

Table 132. Voltage unbalance (VSOVUS)

Characteristics	Value
Operation accuracy	$\pm 1.5\%$ of the set value or $\pm 0.002 \times U_0$
Reset ratio	Typically 0.99

Table 133. Voltage unbalance (VSOVUS) main settings

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

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Other functions

Table 134. Pulse Smer (PTOAPC)

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

Table 135. Time delay off (B pos) (TOFFAOC)

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

Table 136. Time delay on (B pos) (TONAOC)

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

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22. Local HMI

The relay supports process information and status monitoring from the relay's local HMI via its display and indicator/alarm LEDs. The local HMI 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 PCM400.

The local HMI also includes 11 programmable LEDs. These LEDs can be configured to show alarms and indications as needed by PCM400 graphical configuration tool. The LEDs include two separately controllable colors, red and green, making one LED able to indicate better the different status of the monitored object.

The relay also includes 16 configurable manual push buttons, which can freely be configured by the PCM400 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 indicator/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.

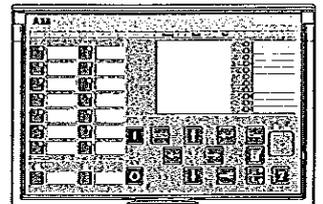


Figure 18. Example of the LHM

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 CombiSec 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 in 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: 248 ±1 mm

Handwritten signature

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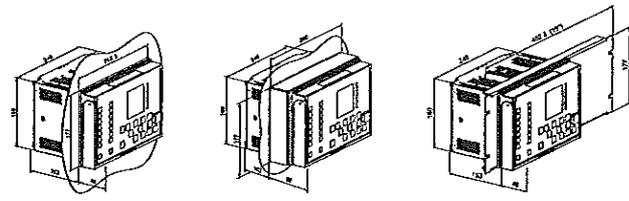


Figure 19. Flush mounting Figure 20. Semi-flush mounting Figure 21. Rack mounting

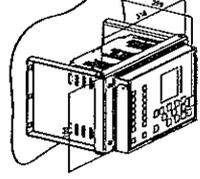
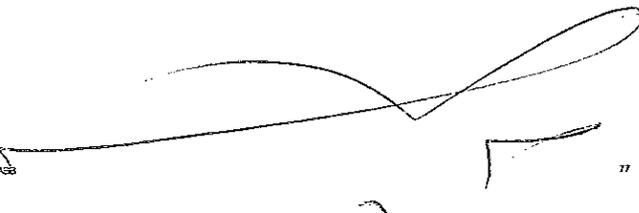


Figure 22. Wall mounting

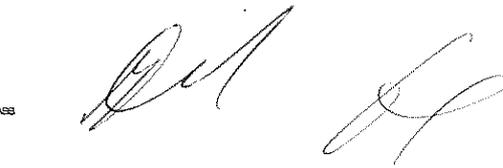
24. Relay case and plug-in unit
For safety reasons, the relay cases for current measuring relays are provided with automatically operating contacts for short-circuiting the CT secondary circuits when a relay unit is withdrawn from its case. The relay case is further provided with a mechanical coding 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.



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3	Communication (Serial/Ethernet)	
10	Serial RS 485, incl. an input for PRO-B + Ethernet 100Base FX (14U)	AA
	Serial RS 485, incl. an input for PRO-B + Ethernet 100Base TX (14U)	AD
	Serial RS 485, incl. an input for PRO-R	AN
	Serial glass fibre (S) + Ethernet 100Base TX (14U) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for PRO-B (cannot be combined with any protection)	AR
	Serial glass fibre (S) + Ethernet 100Base TX and FX (14U), 24U) with HSR/PPP	AW
	Serial glass fibre (S) + Ethernet 100Base TX (24U) with HSR/PPP	BD
	Serial glass fibre (S) + Ethernet 100Base TX and FX (24U, 14U) with HSR/PPP	BE
	Serial glass fibre (S) + Ethernet 100Base TX and FX (14U, 24U) with HSR/PPP and EO61550-9-2LE	BF
	Serial glass fibre (S) + Ethernet 100Base TX (24U) with HSR/PPP and EO61550-9-2LE	B3
	Serial glass fibre (S) + Ethernet 100Base TX and FX (24U, 14U) with HSR/PPP and EO61550-9-2LE	B4
	Serial glass fibre (S) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for PRO-B (cannot be combined with any protection)	BN
	RS 232/485 (including PRO-B) + Ethernet 100Base TX (14U) (cannot be combined with any protection)	CB
	RS 232/485 + RS 485 (allowing S) (including PRO-B) (cannot be combined with any protection)	CN
	Ethernet 100Base FX (14U)	NA
	Ethernet 100Base TX (14U)	ND
	Ethernet 100Base TX and FX (14U, 24U) with HSR/PPP	N7
	Ethernet 100Base TX (24U) with HSR/PPP	ND
	Ethernet 100Base TX and FX (24U, 14U) with HSR/PPP	NE
	Ethernet 100Base TX and FX (14U, 24U) with HSR/PPP and EO61550-9-2LE	NF
	Ethernet 100Base TX (24U) with HSR/PPP and EO61550-9-2LE	N3
	Ethernet 100Base TX and FX (24U, 14U) with HSR/PPP and EO61550-9-2LE	N1
	No communication module	NN

If serial communication is chosen, please choose a serial communication module including Ethernet for example "BD" if a service bus for POA500 or the WebM3 is required.

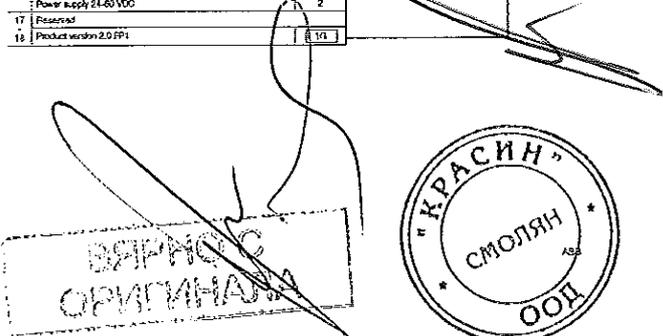


25. Selection and ordering data
The relay type and serial number label identifies the protection and control relay. The label is placed above the PMI on the upper part of the plug-in unit. An order code label is placed on the side of the plug-in unit as well as inside the case. The order code consists of a string of letters and digits generated from the relay's hardware and software modules.
Product Selection Tool (PST), a Next-Generation Order Management Tool, supports order code creation for ABB Distribution Automation IEC products with emphasis on but not limited to the Ration 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.
Use ABB Library to access the selection and ordering information and to generate the order number.

#	Description	
1	IED	
	IED series IED (including case)	N
	Complete Relay with optional casing	S
2	Standard	
	IED	B
	CM	O
3	Main application	
	Feeder protection and control	F
4	Functional application	
	Example configuration	N
5-6	Analog inputs and outputs	
	4 I, 15 A + 5U + 2GB + 1190	AA
	4 I & 0.21 A + 5U + 2GB + 1190	AS
	3 analog EI + 3I + 1C1 + 1GB + 146U	AU
7-8	Optional board	
	Optional I/O Board 450	AA
	Optional I/O Board 15 + 2-A in	AS
	Optional Fast I/O Board + 3-60	AO
	No optional board	NN

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#	Description	
11	Communication protocols	
	IED 6150 (for Ethernet communication modules and IEDs without a communication module)	A
	Modules for Ethernet/serial or Ethernet + serial communication module	B
	IED 6150 + Module for Ethernet or serial + Ethernet communication module	C
	IED 6150-5-170 (for serial or Ethernet + serial communication module)	D
	IED 6150-5-170 (for serial or Ethernet + serial communication module)	F
	IED 6150 + IED 6070-5-100 (for serial + Ethernet communication module)	G
	IED 6150 + DP3 (for Ethernet or serial + Ethernet communication module)	H
12	Language	
	English	1
	English and Chinese	2
13	Front panel	
	Large LCD with Single Line Diagram - IED	B
	Large LCD with Single Line Diagram - CM	U
14	Option 1	
	Any protection package (a communication module cannot be combined with any module option DN, DD, OD and OX)	B
	None	NN
15	Option 2	
	Fixed locator	F
	Capacitor bank protection package	C
	Interlocking/interlocking/Distributed generation protection package	D
	Power protection package	P
	All options/Fixed locator + Capacitor bank protection + Interlocking/interlocking/Distributed generation protection + Power protection	L
	None	NN
16	Power supply	
	Power supply 45-250 VDC, 120-240 VAC	1
	Power supply 24-60 VDC	2
17	Reserved	
18	Product version 2.0 FP1	1M



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Example code: NBFNAANNABC1BNN11G

Your ordering code:

Digit (n)	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

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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
Serial-bus mounting kit	2RCA33573A0001
Wall mounting kit	2RCA330234A0001
1P rack mounting kit with cut-out for one relay	2RCA331135A0001
1P rack mounting kit for one relay and one RTXP24 test switch (the test switch and wire harness are not included in the delivery)	2RCA332818A0001
Mounting bracket for one relay with test switch RTXP in 4U CombiCase (90HT 1P variant C) (the test switch, wire harness and CombiCase RSH1 1P variant C are not included in the delivery)	2RCA332325A0001
Functional earthing flange for RFD modules	2RCA332978A0001 ¹⁾

1) Central to be used when the IED is mounted with the CombiCase 1P equipment frame 2RCA332325A0001.

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 PCMS00 tool in combination with the relay-specific connectivity package.

The Protection and Control IED Manager PCMS00 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 PCMS00, 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 tool	Version
PCMS00	2.6 (Patch 20150205) 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

Feeder Protection and Control REF620 Product version: 2.0 FPI	1MRS757844 E
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Table 140. Supported functions

Function	Web HMI	PCMS00
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 (SignalMatic)	•	•
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	•	•
XSD 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.

Feeder Protection and Control REF620 Product version: 2.0 FPI	1MRS757844 E
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28. Connection diagrams

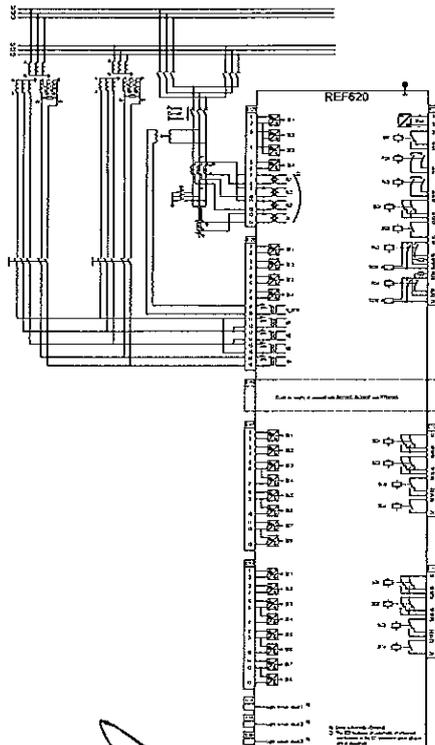
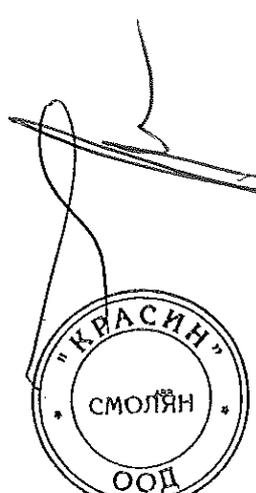


Figure 24. Connection diagram for the configuration with IEDs and VFDs



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ВЯНО С
ОРИГИНАЛА

КВАСИН
СМОЛЯН
ООД

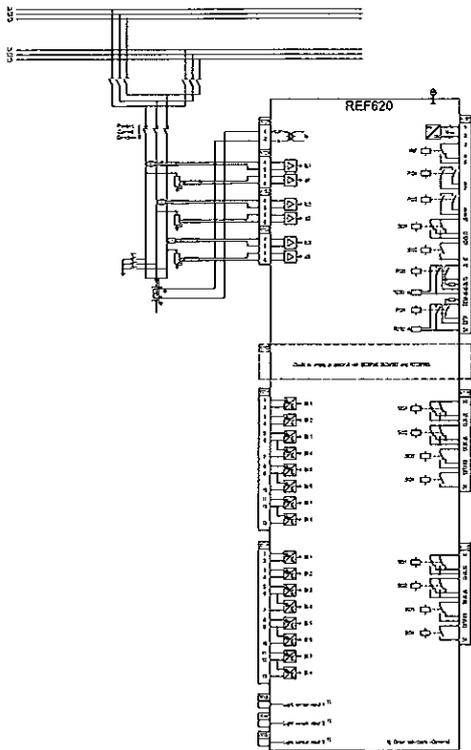


Figure 25. Connection diagram for the configuration with sensors

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30. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Raton® 620 series. Certificate number: 74108008-OPE/ANC 15-2318.

DNV GL has issued an IEC 61850 Edition 1 Certificate Level A1 for Raton® 620 series. Certificate number: 74108008-OPE/ANC 15-2323.

Additional certificates can be found on the product page.

31. References

The www.abb.com/ru/substationsautomation 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 documents.

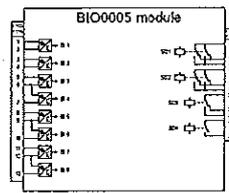


Figure 26. Optional BIO0005 module (lot X105)

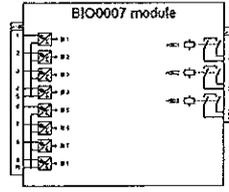


Figure 27. Optional BIO0007 module for fast outputs (lot X109)

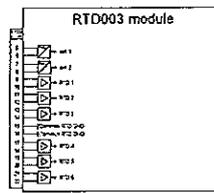


Figure 28. Optional RTD003 module (lot X105)

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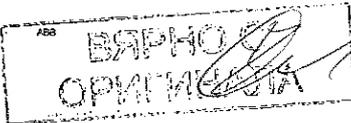
32. Functions, codes and symbols

Table 141. Functions included in the relay

Function	IEC 61850	IEC 60817	ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHPTOC1	30> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, High stage	PHHPTOC1 PHHPTOC2	30>> (1) 30>> (2)	51P-2 (1) 51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHPTOC1	30>>> (1)	50P51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	30> (1)	47-1 (1)
Three-phase directional overcurrent protection, high stage	DPHLPDOC2	30> (2)	47-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1 DPHHPDOC2	30>> (1) 30>> (2)	47-2 (1) 47-2 (2)
Three-phase voltage-dependent overcurrent protection	PHPVOC1 PHPVOC2	3(U)> (1) 3(U)> (2)	51V (1) 51V (2)
Non-directional earth-fault protection, low stage	ENLPTOC1 ENLPTOC2	10> (1) 10> (2)	51N-1 (1) 51N-1 (2)
Non-directional earth-fault protection, high stage	ENHPTOC1	10>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	ENIPTOC1	10>>> (1)	50N51N (1)
Directional earth-fault protection, low stage	DEFLPDEF1 DEFLPDEF2	10> (1) 10> (2)	47N-1 (1) 47N-1 (2)
Directional earth-fault protection, high stage	DEFLPDEF3 DEHNPDEF1	10> (3) 10>> (1)	47N-1 (3) 47N-2 (1)
Airborne-based earth-fault protection	EFPAD1 EFPAD2 EFPAD3	Y0> (1) Y0> (2) Y0> (3)	21YN (1) 21YN (2) 21YN (3)
Waveform-based earth-fault protection	WPWDE1 WPWDE2 WPWDE3	F0> (1) F0> (2) F0> (3)	32N (1) 32N (2) 32N (3)
Multi-frequency admittance-based earth-fault protection	MFADFS0E1	10> Y (1)	67N (1)
Transient intermittent earth-fault protection	INTRITEF1	10> IEF (1)	67NEF (1)
Harmonics-based earth-fault protection	HAEPFTOC1	10> HA (1)	51NHA (1)
Negative-sequence overcurrent protection	NSPPTOC1 NSPPTOC2	I2> (1) I2> (2)	45 (1) 45 (2)
Phase discontinuity protection	PDNSPTOC1	I21> (1)	45PD (1)
Residual overvoltage protection	ROVPTOV1 ROVPTOV2 ROVPTOV3	U0> (1) U0> (2) U0> (3)	59G (1) 59G (2) 59G (3)

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Table 141. Functions included in the relay, continued

Function	IEO 81650	IEO 80817	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	PHPTUV1	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	PHPTOV1	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	FRFR01	b1<c,d< (1)	81 (1)
	FRFR02	b1<c,d< (2)	81 (2)
	FRFR03	b1<c,d< (3)	81 (3)
	FRFR04	b1<c,d< (4)	81 (4)
	FRFR05	b1<c,d< (5)	81 (5)
	FRFR06	b1<c,d< (6)	81 (6)
	FRFR07	b1<c,d< (7)	81 (7)
	FRFR08	b1<c,d< (8)	81 (8)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTR1	3*oF (1)	49F (1)
Loss of phase (undercurrent)	PHPTUC1	3U< (1)	37 (1)
Circuit breaker or failure protection	COBRBRF1	3*o-oBF (1)	51BF/51NF (1)
	COBRBRF2	3*o-oBF (2)	51BF/51NF (2)
Three-phase fault detector	COBRBRF1	3*o-oBF (1)	51BF/51NF (1)
	COBRBRF2	3*o-oBF (2)	51BF/51NF (2)
Master trip	TRPTTR1	3*o (1)	83 (1)
	TRPTTR2	Master Trip (1)	84/86 (1)
	TRPTTR3	Master Trip (2)	84/86 (2)
	TRPTTR4	Master Trip (4)	84/86 (4)
Arc protection	ARCSARC1	ARC (1)	50USNL (1)
	ARCSARC2	ARC (2)	50USNL (2)
	ARCSARC3	ARC (3)	50USNL (3)
High-impedance fault detection	PHZI	HF (1)	HFZ (1)

Table 141. Functions included in the relay, continued

Function	IEO 81650	IEO 80817	ANSI
Load shedding and restoration	LSHOPFR01	UFLSR (1)	41LSH (1)
	LSHOPFR02	UFLSR (2)	41LSH (2)
	LSHOPFR03	UFLSR (3)	41LSH (3)
	LSHOPFR04	UFLSR (4)	41LSH (4)
	LSHOPFR05	UFLSR (5)	41LSH (5)
	LSHOPFR06	UFLSR (6)	41LSH (6)
	LSHOPFR07	UFLSR (7)	41LSH (7)
	LSHOPFR08	UFLSR (8)	41LSH (8)
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-on/bulk logic (SOF)	CYPSOF1	CYPSOF (1)	SOP/T2/50 (1)
Voltage vector shift protection	VSPVM1	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	DUPPDR1	P< (1)	32U (1)
	DUPPDR2	P< (2)	32U (2)
Reverse power/directional overpower protection	DOPPDR1	P>0 (1)	32R/32O (1)
	DOPPDR2	P>0 (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	HAPDF1	#F_A (1)	87A (1)
High-impedance differential protection for phase B	HBPDF1	#F_B (1)	87B (1)
High-impedance differential protection for phase C	HCPDF1	#F_C (1)	87C (1)

Table 141. Functions included in the relay, continued

Function	IEO 81650	IEO 80817	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	PHILOTOC1	3I_3> (1)	51P-1,3 (1)
Three-independent-phase non-directional overcurrent protection, high stage	PHILOTOC2	3I_3> (2)	51P-1,3 (2)
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PHILOTOC3	3I_3> (3)	51P-2,3 (1)
Directional three-independent-phase directional overcurrent protection, low stage	DPHILODOC1	3I_3> (1)	67-1,3 (1)
Directional three-independent-phase directional overcurrent protection, high stage	DPHILODOC2	3I_3> (2)	67-1,3 (2)
Three-phase overcurrent protection for shunt capacitor banks	COLOTOC1	3I_3> (1)	67-2,3 (1)
Current unbalance protection for shunt capacitor banks	CURPTOC1	#I-C (1)	51NC-1 (1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC1	TD> (1)	55TD (1)
Control	CBXCBR1	I<=0 CB (1)	I<=0 CB (1)
	CBXCBR2	I<=0 CB (2)	I<=0 CB (2)
	CBXCBR3	I<=0 CB (3)	I<=0 CB (3)
Disconnecter control	DCXSVM1	I<=0 DCC (1)	I<=0 DCC (1)
	DCXSVM2	I<=0 DCC (2)	I<=0 DCC (2)
	DCXSVM3	I<=0 DCC (3)	I<=0 DCC (3)
	DCXSVM4	I<=0 DCC (4)	I<=0 DCC (4)
Earthing switch control	ESXSVM1	I<=0 ESC (1)	I<=0 ESC (1)
	ESXSVM2	I<=0 ESC (2)	I<=0 ESC (2)
	ESXSVM3	I<=0 ESC (3)	I<=0 ESC (3)
	ESXSVM4	I<=0 ESC (4)	I<=0 ESC (4)
Disconnecter position indication	DCXSVM1	I<=0 DC (1)	I<=0 DC (1)
	DCXSVM2	I<=0 DC (2)	I<=0 DC (2)
	DCXSVM3	I<=0 DC (3)	I<=0 DC (3)
	DCXSVM4	I<=0 DC (4)	I<=0 DC (4)
Earthing switch indication	ESXSVM1	I<=0 ES (1)	I<=0 ES (1)
	ESXSVM2	I<=0 ES (2)	I<=0 ES (2)
	ESXSVM3	I<=0 ES (3)	I<=0 ES (3)
	ESXSVM4	I<=0 ES (4)	I<=0 ES (4)
Autotransforming	DARREC1	O=>I (1)	78 (1)
	DARREC2	O=>I (2)	78 (2)
Synchronization and energizing check	SECRDYM1	SYNK (1)	25 (1)

Table 141. Functions included in the relay, continued

Function	IEO 81650	IEO 80817	ANSI	
Condition monitoring and supervision	SBCSR1	CBOM (1)	CBOM (1)	
	SBCSR2	CBOM (2)	CBOM (2)	
	SBCSR3	CBOM (3)	CBOM (3)	
Trip circuit supervision	TCSOCR1	TCS (1)	TCS (1)	
	TCSOCR2	TCS (2)	TCS (2)	
Current circuit supervision	CCSPVC1	MCS M (1)	MCS M (1)	
	HZCCSPVC1	MCS LA (1)	MCS LA (1)	
	HZCCSPVC2	MCS LB (1)	MCS LB (1)	
Current transformer supervision for high-impedance protection schemes for phase A	HZCCSPVC1	MCS LA (1)	MCS LA (1)	
	HZCCSPVC2	MCS LB (1)	MCS LB (1)	
	HZCCSPVC3	MCS LC (1)	MCS LC (1)	
Fuses failure supervision	SEOSPV1	FUSEF (1)	69 (1)	
	MDSOPT1	OPTS (1)	OPTM (1)	
Runtime counter for machines and devices	MDSOPT2	OPTS (2)	OPTM (2)	
	MDSOPT1	OPTS (1)	OPTM (1)	
Measurement	Three-phase current measurement	CIMXU1	3I (1)	3I (1)
		CSVSO11	I1, I2, I3 (1)	I1, I2, I3 (1)
		RESCURXU1	I0 (1)	I0 (1)
	Residual current measurement	VMXU1	3U (1)	3V (1)
		VMAXU2	U_A (2)	V_A (2)
	Three-phase voltage measurement	RESVMU1	U0 (1)	U0 (1)
		VSMO11	U1, U2, U0 (1)	U1, U2, U0 (1)
		PEVMU1	P, E (1)	P, E (1)
	Single-phase voltage measurement	VMAXU2	U_A (2)	V_A (2)
		RESVMU1	U0 (1)	U0 (1)
Residual voltage measurement	VSMO11	U1, U2, U0 (1)	U1, U2, U0 (1)	
	PEVMU1	P, E (1)	P, E (1)	
Three-phase power and energy measurement	LDRPRC1	LOADPROF (1)	LOADPROF (1)	
	PMDU1	P (1)	P (1)	
Load profile record	LDRPRC1	LOADPROF (1)	LOADPROF (1)	
	PMDU1	P (1)	P (1)	
Frequency measurement	FMDU1	f (1)	f (1)	
	FMDU1	f (1)	f (1)	
Fault location	SCEFRLO1	FLOC (1)	F1FL (1)	
	SCEFRLO1	FLOC (1)	F1FL (1)	
Power quality	CNHM1	PMNH (1)	PMNH (1)	
	VNHN1	PMNH (1)	PMNH (1)	
	PHZVVR1	PMU (1)	PMU (1)	
	VSUVB1	PMU (1)	PMU (1)	
Other	TPGAPC1	TP (1)	TP (1)	
	TPGAPC2	TP (2)	TP (2)	
	TPGAPC3	TP (3)	TP (3)	
	TPGAPC4	TP (4)	TP (4)	

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ВАРИАНТ
ОРИГИНАЛ



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

Table 141. Functions included in the relay, continued

Function	IEQ 61850	IEQ 60917	ANSI
Minimum pulse timer (2 pcs, second resolution)	TPSAPC1	TPS (1)	TPS (1)
	TPSAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution)	TPMAGPC1	TPM (1)	TPM (1)
	TPMAGPC2	TPM (2)	TPM (2)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay of (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)
Release (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)	MVAGPC1	MV (1)	MV (1)
	MVAGPC2	MV (2)	MV (2)
	MVAGPC3	MV (3)	MV (3)
	MVAGPC4	MV (4)	MV (4)
Integer value move	MVHAGPC1	MVH (1)	MVH (1)
	MVHAGPC2	MVH (2)	MVH (2)
	MVHAGPC3	MVH (3)	MVH (3)
	MVHAGPC4	MVH (4)	MVH (4)
Analog value scaling	SCAAGPC1	SCA4 (1)	SCA4 (1)
	SCAAGPC2	SCA4 (2)	SCA4 (2)
	SCAAGPC3	SCA4 (3)	SCA4 (3)
	SCAAGPC4	SCA4 (4)	SCA4 (4)
Generic control point (16 pcs)	SPOGAPC1	SPC (1)	SPC (1)
	SPOGAPC2	SPC (2)	SPC (2)
	SPOGAPC3	SPC (3)	SPC (3)
Remote generic control points	SPCRGAPC1	SPCR (1)	SPCR (1)
Local generic control points	SPOLGAPC1	SPOL (1)	SPOL (1)

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

Table 141. Functions included in the relay, continued

Function	IEQ 61850	IEQ 60917	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)	FXEYD001	FXEY (1)	FXEY (1)
Logging functions			
	Disturbance recorder	RDRE1	DR (1)
Fault recorder	FLTR/PRC1	FAULTREC (1)	FAULTREC (1)
Sequence event recorder	SER1	SER (1)	SER (1)

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

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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ВЕРИТЕЛЬНО-ОРИГИНАЛ



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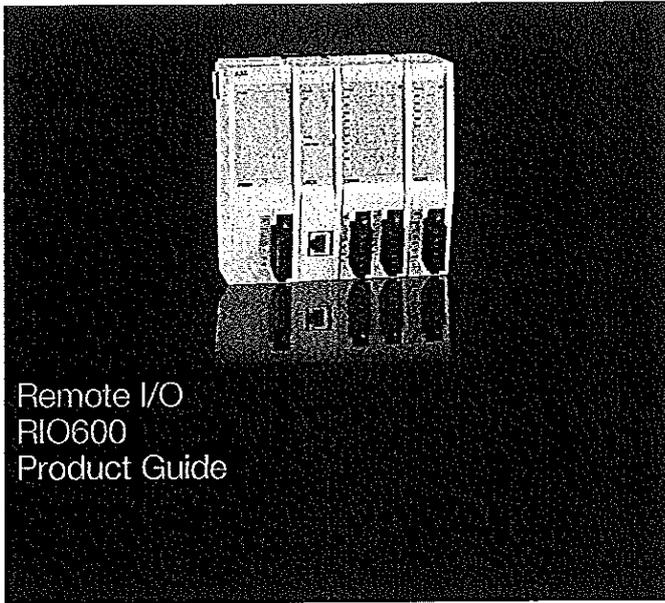
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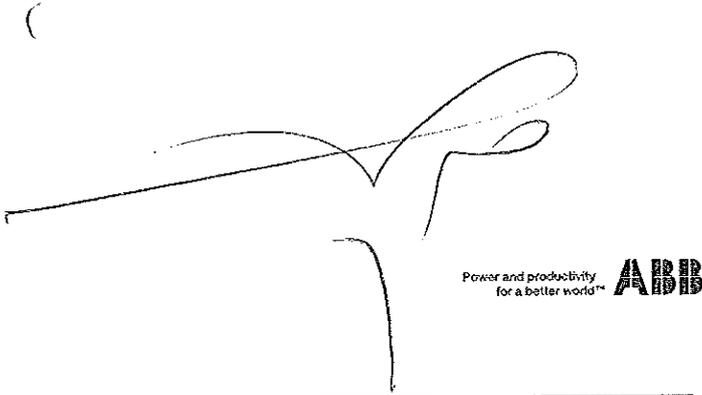


Remote I/O
RIO600
Product Guide

Remote I/O	1MAS767487 F
RIO600	
Product version: 1.7	

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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.

enables the control of a combined three-position switch (disconnecter and earthing switch) used in gas insulated switchgears or standard two-position switches like disconnecter 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.

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.

With the RTDmA 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 valve 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.

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.

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%.

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.

The FPI module incorporates the latest fault detection algorithms used in the Relion family. With easy-to-use multi-frequency admittance-based (MFA) earth-fault detection algorithm, it accurately detects both, resistive and inductive 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 ungrounded networks where accurate and selective earth-fault detection is more challenging due to low fault currents.

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

temperatures, electromagnetic interference and stringent industry standards.

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

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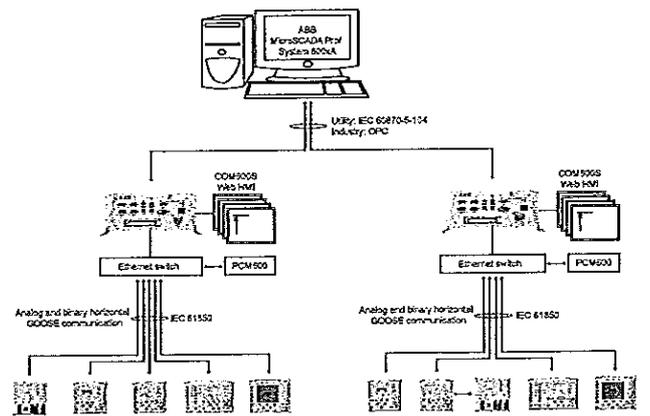


Figure 1. Connection overview of RIO600
RIO600 is designed using a modular architecture where the I/O control functionality is built on modules. The RIO600 modules can be stacked on a standard DIN rail to achieve the required configuration. The minimum configuration required for RIO600 contains a power supply module, communication module and an I/O module.

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Table 1. RIO600 module types

Module type	Description
Power supply modules	
PSMH	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	
DMSH	High-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
DMBL	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, Ni200 and Ni250) and mA input (0...20 mA configurable). Individual channels are non-isolated from each other
Analog output module	
ADMA	Four individually isolated channels of configurable mA outputs driving 0...20 mA signal
Sensor input module	
SMVF	Sensor input module with combined three-phase current and voltage signals
Smart control module	
SCA5H	High-voltage range, smart control module with five application types • 4/40 – four input and four output channels • Three-position switch • Disconnecter • Circuit breaker • Earthing switch
SCM5L	Low-voltage range, smart control module with five application types • 4/40 – four input and four output channels • Three-position switch • Disconnecter • 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

Description	LECM with copper interface		LECM with fiber interface	
	Modules	Channels	Modules	Channels
Digital input modules (DMSH/DMBL)	5	40	5	40
Digital output modules	5	20	4	16
RTD modules	5	20	4	16
Analog output modules	2	8	1	4
SMVF modules	5	-	4	-
Smart control modules (SCM5H/SCM5L)	3	24	2	16

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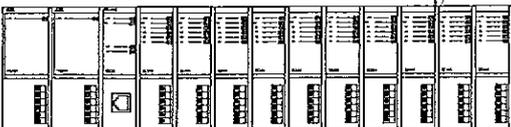


Figure 3. RIO600 configuration: 43 channels with 40 DO (10 x DOM4)

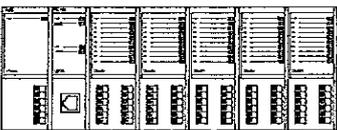


Figure 4. RIO600 configuration: 40 channels with 40 DI (8 x DMSH)

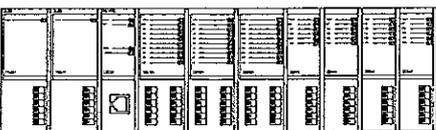


Figure 5. RIO600 configuration: 43 channels with 24 DI and 16 DO (3 x DMSH + 4 x DOM4)

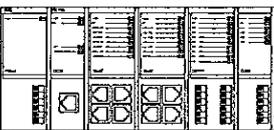


Figure 6. RIO600 configuration: 2 x SMVF + 1 x DMSH + 1 x DOM4

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

Description	LECM with copper interface		LECM with fiber interface	
	Modules	Channels	Modules	Channels
Digital input modules (DMSH/DMBL)	5	40	5	40
Digital output modules	10	40	9	35
RTD modules	10	40	9	35
Analog output modules	4	16	3	12
SMVF modules	5	-	5	-
Smart control modules (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 PCA600. 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.

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-DMBL, PSML-LECM-DMSH or PSML-PSMH-LECM-DMSH-DMBL-DOA.

- 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

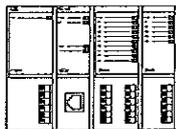


Figure 2. RIO600 configuration with 12 channels with 8 DI and 4 DO (1 x DMSH + 1 x DOM4)

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3. Applications

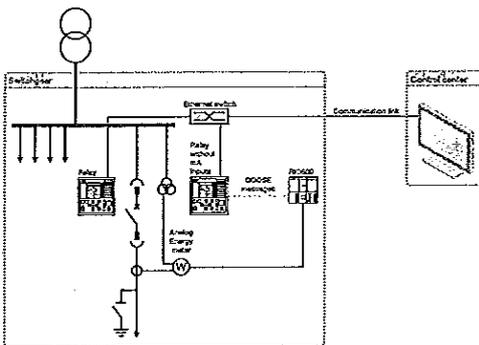


Figure 7. RIO600 as an external metering input for the protection relay

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

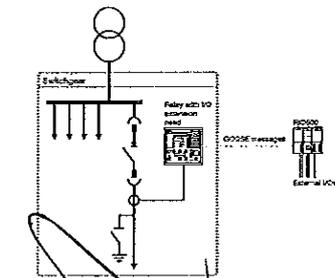


Figure 8. RIO600 as an I/O extension



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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.

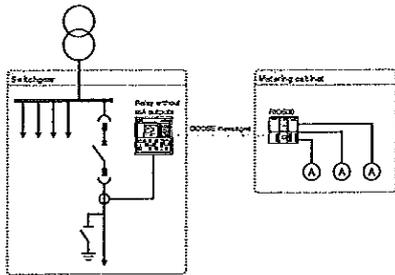


Figure 8. RIO600 communicating analog signals for the external meters

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

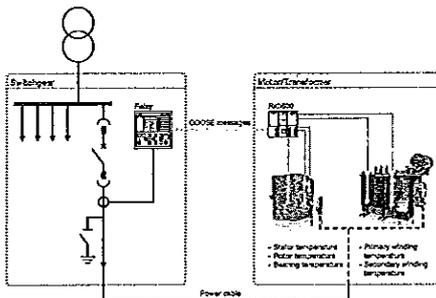


Figure 9. Temperature measurement using RIO600

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.

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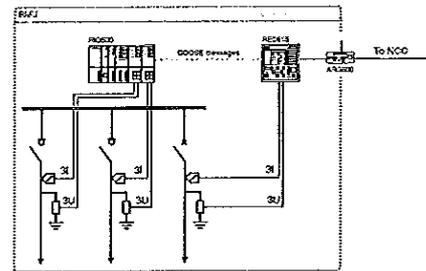


Figure 11. RMU fault passage indication using RIO600

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 starting 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 (no-contact) of RIO600.

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

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

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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 Mb/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 COM600 and a Web browser over the same communication bus.

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6. Technical data

Table 4. Module weights

Description	Value
PSMH/PSML	235 g
LECM	123 g
DSMH/DSML	208 g
DOM4	163 g
RTD4	209 g
ACM4	208 g
SMVF	160 g
SCMH/SCML	219 g

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

Description	Value
Width	2,5 mm (To be fixed at the ends of assembled modules)

Table 6. Power supply

Description	PSMH	PSML
U_{nom} nominal	100, 110, 120, 220, 240 V AC; 50 and 60 Hz 110, 125, 220, 240 V DC	24, 30, 48, 60 V DC
U_{var} variation	85...110% of U_{nom} nominal (85...284 V AC) 85...100% of U_{nom} nominal (85...240 V DC)	50...120% of U_{nom} nominal (12...72 V DC)
Startup threshold		19.2 VDC (24 V DC + 80%)
Maximum interruption time in the auxiliary DC without resetting the RIO modules	100 ms at U_{nom} nominal	50 ms at U_{nom} 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		
• Off-nominal (P) 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 + DSMH	All DIs activated	2 W
PSM + LECM + DMV4	All DIs activated	4 W
PSM + LECM + DSMH (2)	All DIs activated	12 W
PSM (2) + LECM + DSMH (2)	All DIs activated	11 W
PSM (2) + LECM + DMV4 (2)	All DIs activated	11 W
PSM (2) + LECM + DSMH (10)	All DIs activated	22 W

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Table 7. Binary inputs

Description	DCM8H	DCM8L
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...325 mW	30...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s (flashing time)	5 ms...4.0 s (flashing 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 48V/1.5/220 V DC	1 A/0.25 A/0.15 A

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Table 9. mA/RTD Input (RTD4 module)

Description	Value			
RTD inputs	Supported RTD sensors	100 Ω platinum 250 Ω platinum 100 Ω nickel 100 Ω nickel 250 Ω nickel 250 Ω platinum 100 Ω nickel 100 Ω nickel 250 Ω nickel	TCR 0.00385 (IEC 4376-7) TCR 0.00385 TCR 0.00618 (IEC 4376-7) TCR 0.00618 TCR 0.00913	
	Maximum lead resistance (three-wire measurement)	100 Ω platinum	200 Ω per lead	
		250 Ω platinum	200 Ω per lead	
		100 Ω nickel 100 Ω nickel 250 Ω nickel	200 Ω per lead 200 Ω per lead 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 (AO4)

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

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Table 11. Sensor input module (SISF)

Description	Value	
Preferred ABB sensors	<ul style="list-style-type: none"> Combined sensor KEYCY 24 RE1, KEYCY3 RE1, KEYCY 40.5 RE1, KEYCO A Combination of current sensor KECA B3 C85 or KECA D85 and voltage sensor KEVA 24 C10, 24 C21, 24 C22, 24 C23, 17.5 B21, 17.5 B21, 24 B21, or 24 B21 	
Current measurement	Range	4...2000 A
	Accuracy	±5% or ±1 A in the range of 4...30 A ±1% in the range of 60...450 A ±10% in the range of 4500...2000 A
Line voltage measurement	Range	480 V...48 kV
	Accuracy	±5% in the range of 480...5500 V ±0.5% in the range of 9.6...48 kV
Power measurements P, Q, S and PF	Range	8.5...23.8 kW 80...550 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 ±3.0% for energy
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz: ±0.2 Hz For 60 Hz: ±0.2 Hz
Average operating current, voltage and power	Average operating current, voltage, power as per selection 3 circ/10 circ/15 circ/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	<ul style="list-style-type: none"> Current THD (Total harmonic 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, 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

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Table 11. Sensor input module (SISF), 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: <ul style="list-style-type: none"> ±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...325 mW	30...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s (flashing time)	5 ms...4.0 s (flashing 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 port attenuation*
RJ45	Shielded twisted pair cable, at minimum CAT5e	10/100 Mbps/s	30 m		
LC	Multimode OM3/OM4 125 µm or 50/125 µm glass fibre core	100 Gbps/s	2 km	1310 nm	<1 dB

* Maximum allowed attenuation based on connection and cable transfer

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Table 15. Degree of protection by enclosure

Description	Value
Degree of protection	IP20 ¹⁾

¹⁾ If 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	88...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 this 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 100% 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 C37.50-2005
Power consumption of auxiliary supply	• Quiescent load • Maximum load	IEC 60255-1 and IEEE C37.50-2005
Reversal of DC power supply polarity	1 minute for each polarity	IEC 60255-27
Startup time test	<30 s	

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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 C37.50-2005
Breaking capacity for DC, UR, 540 ms	Signaling contacts • 48 V, 1.00 A • 110 V, 0.25 A • 220 V, 0.18 A	IEC 60255-1, IEC 61810-1 and IEEE C37.50-2005
Mechanical durability	10000 operations	IEC 60255-1, IEC 61810-1 and IEEE C37.50-2005

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 C37.50-2005
Impulse voltage tests	5 kV, 1.2/50 µs, 0.5 J	IEC 60255-27 and IEEE C37.50-2005
Insulation resistance measurements	>10 MΩ, 500 V DC	IEC 60255-27

¹⁾ Pollution tests are not applicable for I/O

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Table 22. Electromagnetic compatibility and immunity tests

Description	Type test value	Reference
Electrostatic discharge	8 kV	IEC 60255-26 and IEC 61000-4-2, Level 3
• Air discharge		
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, 1800 MHz	IEC 61000-4-3, Level 3
Power frequency (50 Hz) magnetic field		IEC 60255-26 and IEC 61000-4-4
• Continuous	100 A (RMS)/m 300 A (RMS)/m	
• 3 s		
Pulsed magnetic field	1000 A/m, 8.4/16 µs TrTf; 5 pulses positive/negative, 10 s (rise interval)	IEC 61000-4-9, Level 5
Conducted disturbance induced by radio frequency fields, Amplitude modulated	0.15...1 MHz: 10 V (unmod, RMS); 80% AM (1 MHz); 150 Ω source impedance 27 and 69 MHz (spot frequencies); 10 V (unmod, RMS); 80% AM (1 MHz); 150 Ω source impedance	IEC 60255-26 and IEC 61000-4-6, Level 3
Fast low-energy transient (ELF) (including functional earth port)	5/50 ns TrTf; 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 (RF) 100 kHz and 1 MHz burst	100 kHz and 1 MHz frequency; 75 ns Tr; 43 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 TrTf (open circuit) 8/20 µs TrTf (short circuit)	IEC 60255-26 and IEC 61000-4-5
• Auxiliary power supply and input/output ports ¹⁾	24 kVp (L-G) ± 2 kVp (L-L)	
• Communication port	42 kVp (L-G) 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 25/30 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 6 s	IEC 60255-26 and IEC 61000-4-23
Ripple voltage	15% U _n frequencies of ripple 100/120 Hz (for 50/60 Hz)	IEC 60255-26, IEC 61000-4-17 and IEEE C37.50-2005
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 startup	60 s	

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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	
Enulsion tests		IEC 60255-26
• Radiated		
30...230 MHz	<40 dB (V/m) quasi-peak, measured at 10 m distance	
230...1000 MHz	<47 dB (V/m) quasi-peak, measured at 10 m distance	
• Conducted		
0.15...0.50 MHz	<79 dB (V) quasi-peak <66 dB (V) average	
0.5...30 MHz	<73 dB (V) quasi-peak <60 dB (V) average	

¹⁾ When not a conductor is present, the test voltage is 15 kV (L-G) at 1 Hz/1 s

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 C37.50.1-2002
Fast transient SWC test	All ports: ±4 kV common mode/differential mode	IEEE C37.50.1-2002
Radio frequency interference tests	20 V/m (prior to modification) f = 80...1000 MHz (AM) f = 900 MHz (FM)	IEEE C37.50.2-2004
Electrostatic discharge test	±15 kV air discharge	IEEE C37.50.3-2001

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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 = 13...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 sine histories in each axis	Single axis sine sweep	

Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 56 h at +70°C	IEC 60068-2-2 and IEEE C37.90-2005
Dry cold test	• 56 h at -55°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 24 h	IEC 60068-2-78 and IEEE C37.90-2005
Change of temperature test	• 5 cycles (3 h + 3 h) at -25...+55°C	IEC 60068-2-14
Storage test	• 56 h at -45°C • 56 h at +55°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 (2005) EN 60255-26 (2007)

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Functions available in SIMSE

Table 28. Functions available in SIMSE

Function	IEC 61850		IEC 60817	IEC-ANSI
	Edition 1	Edition 2		
Measurement functions				
Three-phase current measurement	CMXUJ	CMXUJ	3I	3I
Three-phase voltage measurement	VMXUJ	VMXUJ	3U	3U
Residual current measurement	RESCMXUJ	RESCMXUJ	Ia	Ia
Residual voltage measurement	RESVMXUJ	RESVMXUJ	Uo	Uo
Three-phase power and energy measurement	PEMXUJ	PEMXUJ	P	P
Three-phase power direction	PWRDIR	PWRDIR	E	E
Energy monitoring	EMNTR	EMNTR	E	E
Current, voltage and power average and peak measurement	CAVSTA	CAVMXUJ CAVMXUJ CAVMXUJ		
	VVSTA	VVMXUJ VVMXUJ VVMXUJ		
	PEMSTA	PEVMXUJ PEVMXUJ		

Power quality measurement functions (harmonics)

Current total demand distortion monitoring	CMTHI	CMTHI	POM3I	POM3I
Voltage total demand distortion monitoring	VMTHI	VMTHI	POM3V	POM3V
Detection and indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3b	3IP
Three-phase directional overcurrent fault detection	DHPTOC	DHPTOC	3b->	3IP
Non-directional earth-fault detection	EFPTOC	EFPTOC	3b	3IN
Directional earth-fault detection	DEFPPTOC	DEFPPTOC	3b->	3IN
Multi-frequency admittance-based earth-fault indication	MFAPSDE	MFAPSDE	3b->Y	3YN
Voltage presence indication	PHSVPR	PHSVPR	PHSVPR	PHSVPR

Table 29. CMXUJ Technical data

Characteristics	Value
Operation accuracy	At frequency f = fi ±5% or ±1 A in the range of 4...10 A ±1% in the range of 10...100 A ±10% in the range of 100...800 A
Suppression of harmonics	RMS: No suppression

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Table 27. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

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Table 30. VMXUJ Technical data

Characteristics	Value
Operation accuracy	At frequency f = fi ±5% in the range of 450 V...5.6 kV ±0.5% in the range of 9.8...28.8 kV ±1% in the range of 28.8...45 kV
Suppression of harmonics	RMS: No suppression

Table 31. RESCMXUJ Technical data

Characteristics	Value
Operation accuracy	At frequency f = fi ±5.0% (when all three phase currents in the range of 60...630 A)
Suppression of harmonics	RMS: No suppression

Table 32. RESVMXUJ Technical data

Characteristics	Value
Operation accuracy	At frequency f = fi ±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. PEMXUJ Technical data

Characteristics	Value
Operation accuracy	At frequency f = fi All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 60...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) ±0.63 for power factor
Suppression of harmonics	RMS: No suppression

Table 34. EMNTR Technical data

Characteristics	Value
Operation accuracy	At frequency f = fi All three voltages in range of 9.6...14.4 kV or 19.2...28.8 kV All three current in range of 60...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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Remote I/O	1MRS757487 F
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Table 35. PRPTOC Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = I_c$ ±1.5% of the set value
Operate time accuracy (EMT)	±1.0% of the set value or ±20 ms

Table 36. DPVPTOC Technical data

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

Table 37. EPPTOC Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = I_c$ ±10% 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 (EMT)	±1.0% of the set value or ±20 ms

Table 38. DEFPPTOC Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = I_c$ 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: ±3° (Current measurement based on external calculation)
Operate time accuracy (EMT)	±1.0% of the set value or ±20 ms

Table 39. MFAPSDE Technical data

Characteristics	Value
Operation accuracy	All frequency $f = I_c$ ±5% in the range of 413 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. PHSVPA Technical data

Characteristics	Value
Operation accuracy	All frequency $f = I_c$ ±5% in the range of 413 V...9.6 kV ±0.5% in the range of 9.6...28.8 kV

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7. Module dimensions

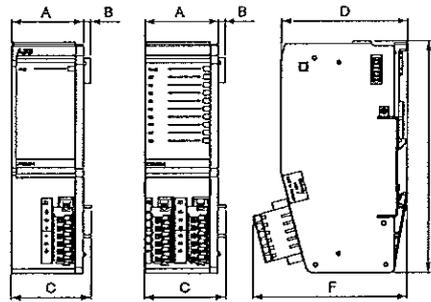


Figure 12. Dimension and mounting details of the PSVM/PSVLM/PSVLM/PSVLM/STO/ADAM/SCMB/USOML modules

- A 48 mm
- B 4.5 mm
- C 51 mm
- D 81 mm
- E 146 mm
- F 99 mm

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RI0600	
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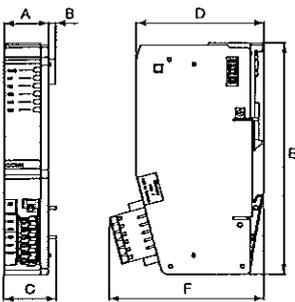


Figure 13. Dimension and mounting details of the digital output module DOM4

- A 27.5 mm
- B 4.5 mm
- C 33 mm
- D 81 mm
- E 146 mm
- F 99 mm

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RI0600	
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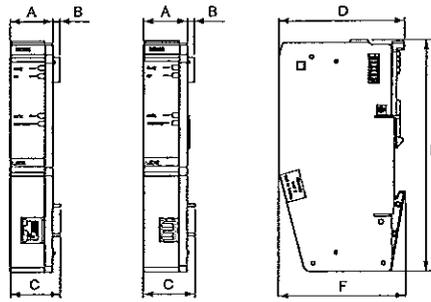


Figure 14. Dimension and mounting details of the communication module LCOM

- A 27.5 mm
- B 4.5 mm
- C 33 mm
- D 81 mm
- E 146 mm
- F 81 mm

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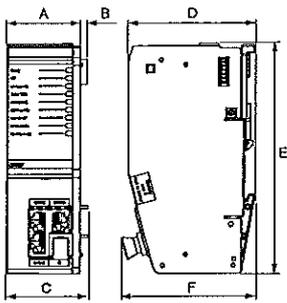


Figure 15. Dimension and mounting details of the SIM3F module

- A 45 mm
- B 4.25 mm
- C 51 mm
- D 81 mm
- E 145.5 mm
- F 85 mm

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8. Assembly diagram

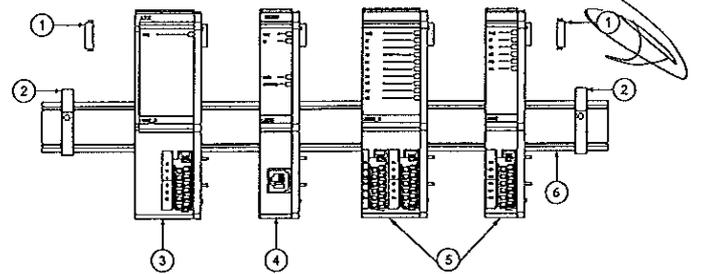


Figure 15. Assembly drawings of RI0600 modules

- 1 Rubber cap
- 2 End clamp
- 3 PSM module
- 4 LECM module
- 5 Module (SIM3F/SOM3H/SOM3L)
- 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 Weidmüller part EW 35, which is 8.5 mm wide.

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9. Ordering data

Table 41. Ordering details for RI0600 modules

Item	Order number
Digital input module with 8 inputs, high-voltage power supply	MODE55ADN3H
Digital input module with 8 inputs, low-voltage power supply	MODE55ADM3L
Digital output module with 4 outputs	MODE55AOM3R
RTD mA input module with 4 inputs	MODE55ARTD4
Analog output module with 4 outputs	MODE55AOM3L
Sensor input module	MODE55ASR3F
Smart control module with 4 inputs and 4 high-speed outputs, high-voltage power supply	MODE55AOCM3H
Smart control module with 4 inputs and 4 high-speed outputs, low-voltage power supply	MODE55AOCM3L
High-power supply module	MODE55P5M3R7
Low-power supply module	MODE55P5M3L7
Communication module with RJ-45 port	MODE55FLECM3R
Communication module with multimode fiber-optic LC port	MODE55BLECM3F

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10. Tools

The present status information of RI0600 can be viewed from the Web browser-based user interface (Web HMI) and the parameter setting values can be viewed or changed from the PCMA600 tool in combination with the RI0600-specific connectivity packages.

The Protection and Control IED Manager PCMA600 with the RI0600 connectivity package is used for configuring RI0600 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, RI0600 can be accessed remotely with a Web browser.

The RI0600 connectivity package is a collection of software tools with specific device information which enables system products and tools to connect and interact with RI0600. The connectivity packages support system integration and engineering and its minimizing device configuration and setup time.

RI0600 parameters can be configured with Parameter Setting in PCMA600. Internal end station communication based logic are engineered in Graphical Application Configuration and in Signal Matrix. IEC 61850 peer-to-peer communication can be configured in PCMA600 as well.

Table 42. Tools

Description	Version
PCMA600	2.7 Hotfix 1 or later
Web browser	IE 8.0 or later
RI0600 Connectivity Package	1.7 or later

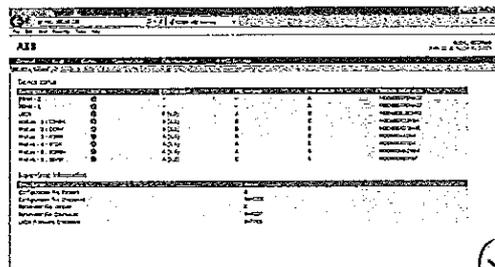
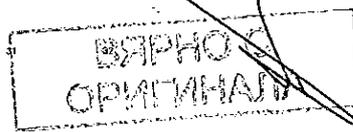


Figure 17. Screenshot view of RI0600 Web HMI

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11. Connection and terminal diagrams

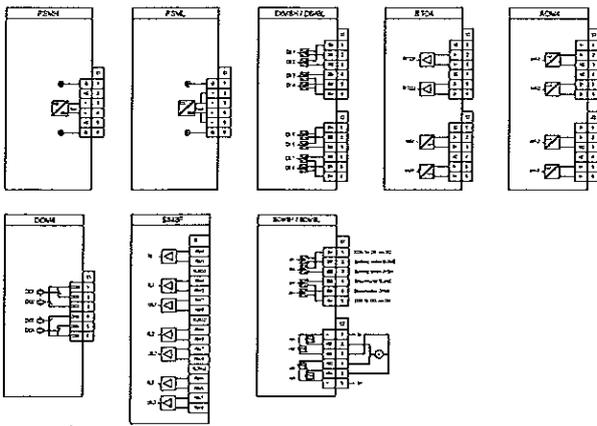


Figure 11. Connection and terminal diagrams of RIO600 modules

12. Document revision history

Document revision/Date	Product version	History
A/2011-12-23	L0	First release
B/2012-10-19	L1	Content updated
C/2013-09-30	L2	Content updated
D/2014-09-29	L5	Content updated
E/2015-04-31	L6	Content updated
F/2016-05-09	L7	Content updated

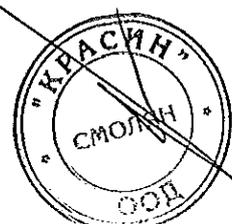
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ВЯРНО С
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Power and productivity
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за участие в открита процедура за възлагане на обществена поръчка с предмет:

„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.)

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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 Koironen

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
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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:

[Redacted signature box]

Antti Hakala-Kanta, SVI Medium Voltage Products



ABB Oy, Medium Voltage Products
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P.O. Box 699, FI-65101 Vaasa, FINLAND
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ВЯРНО С
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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
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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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20.04.2016

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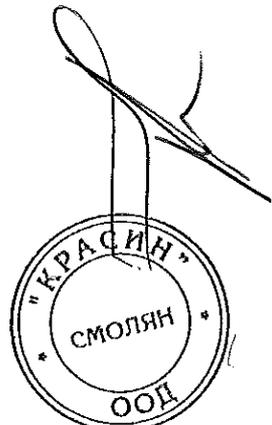
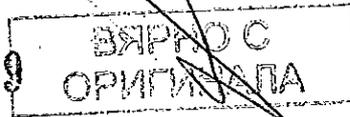
Signed by:

Antti Hakala-Kanta, 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

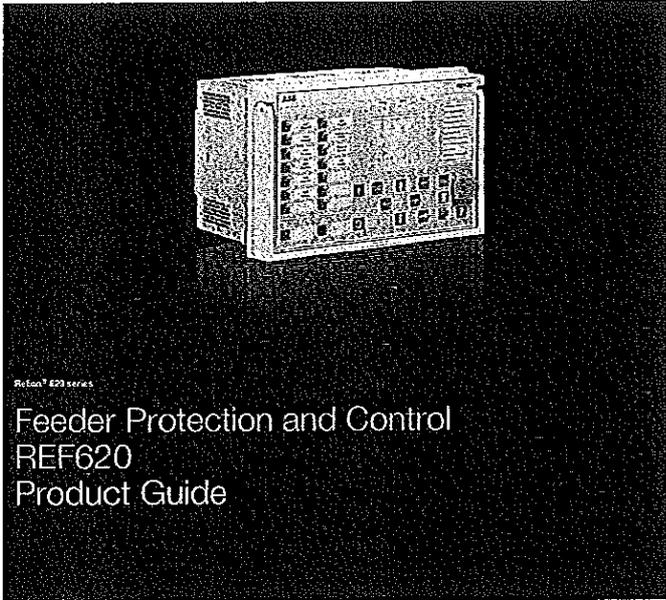


Техническа документация

Приложение № 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

000650



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

Contents

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ABB

Power and productivity
for a better world™



Feeder Protection and Control	1MRS757844 E
REF620	
Product version: 2.0 FPI	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 Refcon® 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-20-302.

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

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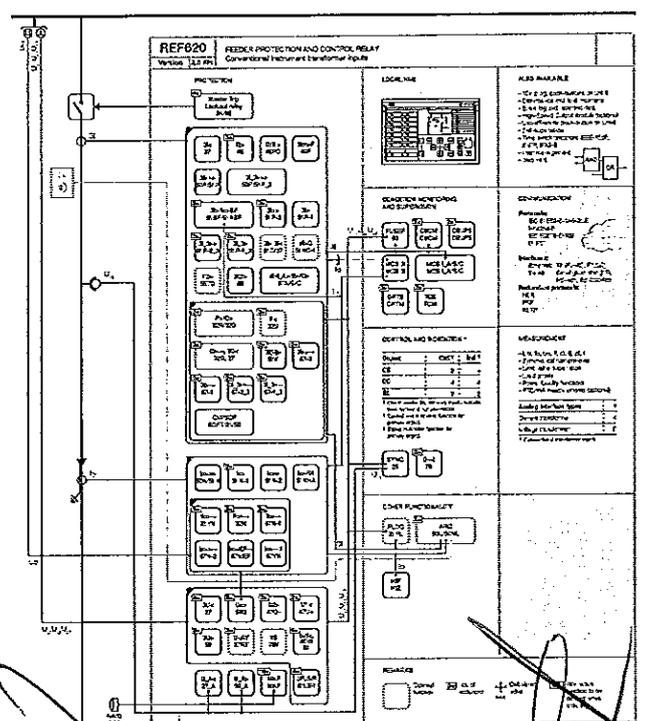


Figure 1. Functionality overview of default configuration with conventional instrument transformer inputs

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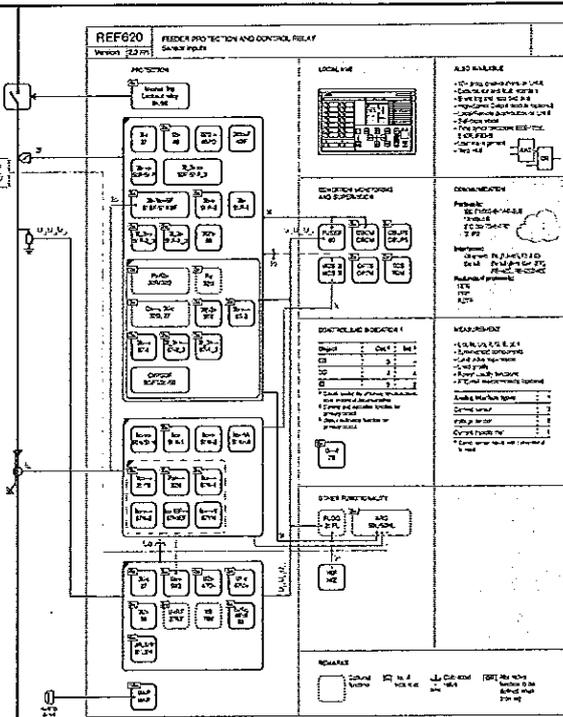


Figure 2. Functionality overview of default configuration with sensor inputs

Table 1. Supported functions

Function	EO #1850	A (OTW/Vt)	B (Sensors)
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1
Three-phase non-directional overcurrent protection, high stage	PHRPTOC	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1
Three-phase directional overcurrent protection, low stage	DPHLPTOC	2	2
Three-phase directional overcurrent protection, high stage	DPHRPTOC	2	2
Three-phase voltage-dependent overcurrent protection	PHVPTOC	2	2
Non-directional earth-fault protection, low stage	ENLPTOC	2	2
Non-directional earth-fault protection, high stage	ENRPTOC	1	1
Non-directional earth-fault protection, instantaneous stage	ENIPTOC	1	1
Directional earth-fault protection, low stage	DELPTOC	3	3 ⁽¹⁾
Directional earth-fault protection, high stage	DELRPTOC	1	1 ⁽¹⁾
Admittance-based earth-fault protection	EPFADM	3	3 ⁽¹⁾
Wide-area-based earth-fault protection	WPAWME	2	3 ⁽¹⁾
Multi-frequency admittance-based earth-fault protection	MFADPSDE	1	1 ⁽¹⁾
Transfer/interruption earth-fault protection	INTPTIEF	1	1 ⁽¹⁾
Harmonic-based earth-fault protection	HAEPTOC	1	1
Negative-sequence overcurrent protection	NSPTOC	2	2
Phase discontinuity protection	PHASPTOC	1	1
Residual overvoltage protection	ROVPTOV	2	3 ⁽¹⁾
Three-phase undervoltage protection	PHPTUV	4	4
Single-phase undervoltage protection, secondary side	PHSPTUV	1	1
Three-phase overvoltage protection	PHPTOV	3	3
Single-phase overvoltage protection, secondary side	PHSPTOV	1	1
Positive-sequence undervoltage protection	PSPTUV	2	2
Negative-sequence overvoltage protection	NSPTOV	2	2
Frequency protection	FRFREQ	6	6
Three-phase thermal protection for feeders, cables and distribution transformers	THPTTR	1	1
Loss of phase (undercurrent)	PHPTUC	1	1
General breaker failure protection	CCBSBFC	3	3
Three-phase break detector	IN3PHAR	1	1
Master trip	TRIPTRC	4	4
Arc protection	ARCSPAC	(3)	(3)
High-impedance fault detection	PHZE	1	1
Load shedding and restoration	LSHDDPRQ	6	6
Multi-purpose protection	MAPAPC	16	16

Table 1. Supported functions, continued

Function	EO #1850	A (OTW/Vt)	B (Sensors)
Automatic switch-to-bus logic (SOT)	CVPSOF	1	1
Voltage vector shift protection	WSPFAM	(1)	(1)
Directional reactive power undervoltage protection	DOPTUV	(2)	(2)
Underpower protection	DUPTDPR	(2)	(2)
Reverse power/directional overpower protection	DOPTDPR	(2)	(2)
Low-voltage ride-through protection	LVRTPTUV	(1)	(1)
High-impedance differential protection for phase A	HAPDF	1	1
High-impedance differential protection for phase B	HBPDF	1	1
High-impedance differential protection for phase C	HCPDF	1	1
Circuit breaker unresponsive position start-up	UPCALH	3	3
Three independent-phase non-directional overcurrent protection, low stage	PHLPTOC	2	2
Three independent-phase non-directional overcurrent protection, high stage	PHRPTOC	2	2
Three independent-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1
Directional three-independent-phase directional overcurrent protection, low stage	DPHLPTOC	2	2
Directional three-independent-phase directional overcurrent protection, high stage	DPHRPTOC	2	2
Three-phase overload protection for shunt capacitor banks	COUPTOC	(1)	(1)
Current unbalance protection for shunt capacitor banks	CUSPTOC	(1)	(1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC	(1)	(1)
Control			
Circuit-breaker control	CBKCAR	3	3
Disconnecter control	DCASMI	4	4
Earthing switch control	ESXSMI	3	3
Disconnecter position indication	DCSXSMI	4	4
Earthing switch indication	ESXSXSMI	3	3
Auto-reclosing	DARPEC	2	2
Synchronism and energizing check	SECRSYN	1	(1) ⁽²⁾
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBA	3	3
Trip circuit supervision	TCCSBA	2	2
Current circuit supervision	CCSPVC	1	1
Current transformer supervision for high-impedance protection scheme for phase A	HZCCSPVC	1	1
Current transformer supervision for high-impedance protection scheme for phase B	HZCCSPVC	1	1

Table 1. Supported functions, continued

Function	EO #1850	A (OTW/Vt)	B (Sensors)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCSPVC	1	1
Fuse failure supervision	SSOSFVC	1	1
Runtime counter for machines and devices	MMSOFT	2	2
Measurement			
Three-phase current measurement	CM3MU	1	1
Sequence current measurement	CS3MU	1	1
Residual current measurement	RESC3MU	1	1
Three-phase voltage measurement	VM3MU	1	1
Single-phase voltage measurement	VSM3MU	1	(1) ⁽²⁾
Residual voltage measurement	RESV3MU	1	1
Sequence voltage measurement	VSM3MU	1	1
Three-phase power and energy measurement	PEM3MU	1	1
Load profile record	LDRPLRC	1	1
Frequency measurement	FR3MU	1	1
Fault location			
Fault locator	SCFPFLC	(1)	(1)
Power quality			
Current total harmonic distortion	CMTHD	1	1
Voltage total harmonic distortion	VMTHD	1	1
Voltage variation	PHOVVR	1	1
Voltage unbalance	VSVQUB	1	1
Other			
Minimum pulse timer (2 pos)	TPGAPC	4	4
Minimum pulse timer (2 pos, second resolution)	TPSGAPC	2	2
Minimum pulse timer (2 pos, minute resolution)	TPMGAPC	2	2
Pulse timer (8 pos)	PTGAPC	2	2
Time delay off (8 pos)	TONGAPC	4	4
Time delay on (8 pos)	TONGAPO	4	4
Set-reset (8 pos)	SRGAPC	4	4
Move (8 pos)	MVGAPC	4	4
Integer value counter	INVGAPC	4	4
Analog value counter	SCAGAPC	4	4
Generic control point (10 pos)	SPCGAPC	3	3
Permits generic control points	SPCRGAPC	1	1
Local generic control points	SPCLGAPC	1	1
Generic up-down counters	LDFCNT	12	12

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Table 1. Supported functions, continued

Function	IEC 61850	A (TIA/EIA)	B (Sarens)
Programmable buttons (18 buttons)	FKEYGGIO	1	1
Logging functions			
Disturbance recorder	RDRE	1	1
Fault recorder	FLTPFRCD	1	1
Sequence event recorder	SER	1	1

1, 2, ... = Number of IEC 61850 instances. The frequency of a protection function represents the number of identical protection function blocks available in the standard configuration.

0 = optional

1) Use as indicated from the manual at present version
2) Available only with IEC 61850-2 IED

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, harmonic-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 variant 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 detection also during intermittent/struck 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 striking 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 (OU) 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.

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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 RO620 Remote I/O device.

The relay offers extensive possibilities to tailor the configurations to application requirements. The tool suite for the Refcon relay is Protection and Control IED Manager PCU620, which contains all the necessary tools for configuring the device, including functionality, parameterization, the IED 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 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.

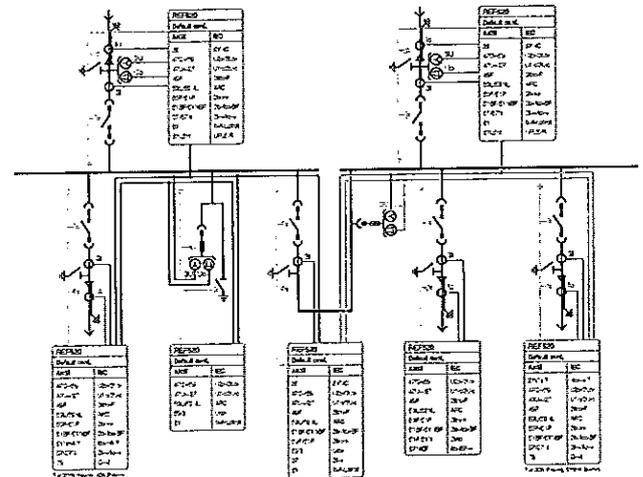


Figure 3. Single busbar AIS 2 section switchgear with conventional instrument transformers

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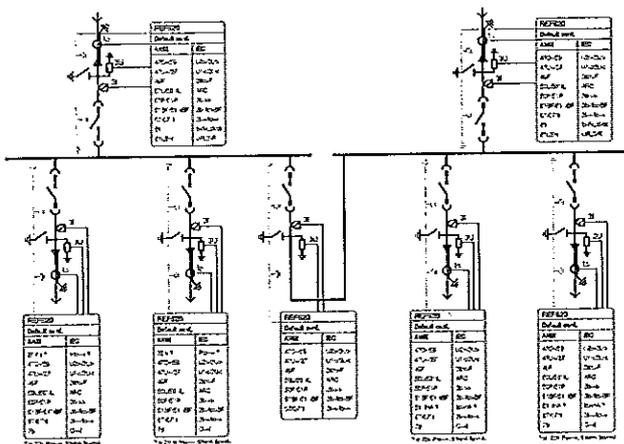


Figure 4. Single busbar AIS switchgear 2 section with sensors

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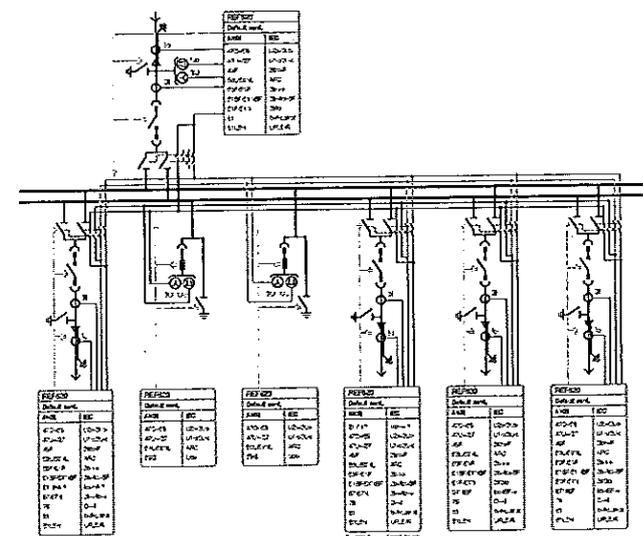


Figure 5. DBS AIS system with one breaker only (with some arrangements simplified)

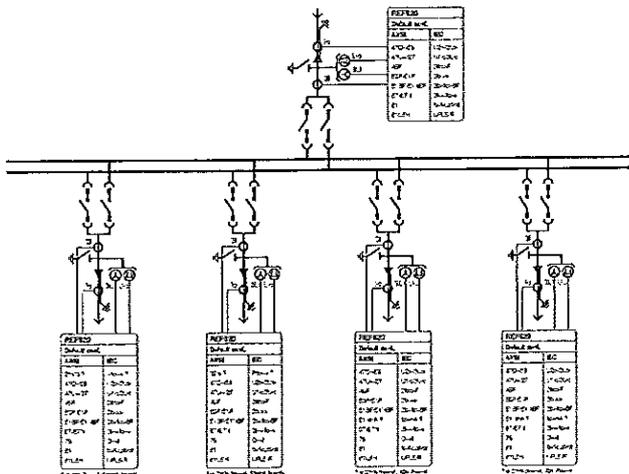


Figure 6. Back-to-back arrangement of AIS switchgear (two single-busbar panels with back walls facing each other), with two circuit breakers and a higher number of disconnectors available; A type of DBS system

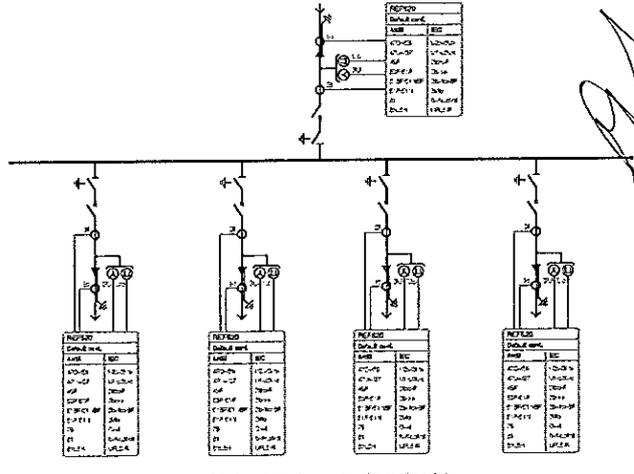


Figure 7. DBS GIS switchgear with the possibility to control the three-position disconnect switch

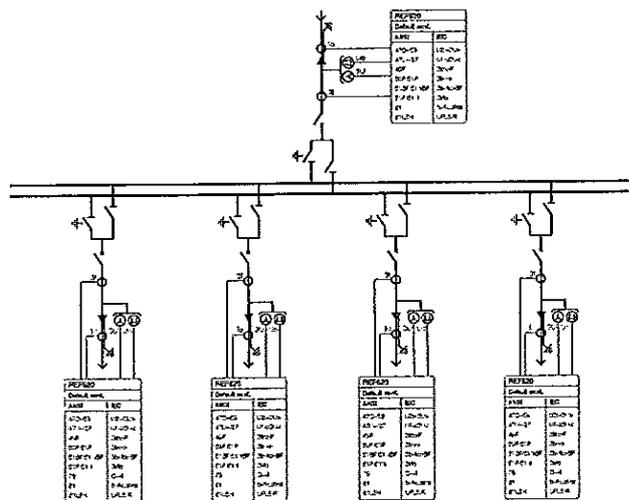


Figure 8. DBS GIS switchgear with the possibility to control the three-position disconnect switch

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, multibreak 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.

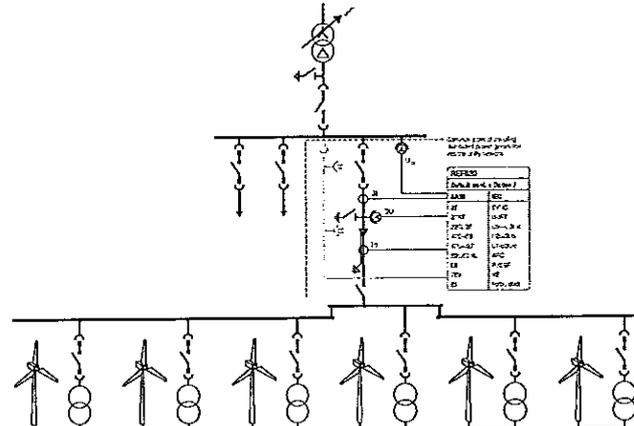


Figure 9. Application example of wind power plant as distributed power generation coupled into the utility network

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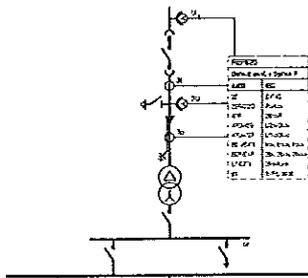


Figure 10. Application example of solar power plant as distributed power generation coupled into the utility network

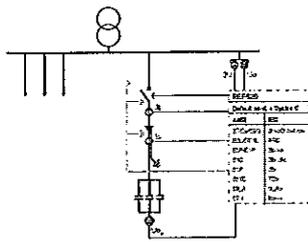


Figure 11. Protection of a single star connected capacitor bank

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 completion 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 PCMS00 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 800	3.3 FP2 or later 3.4 or later (Edition 2)
System 800xA	5.1 or later

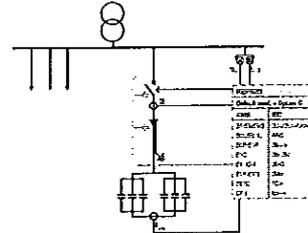


Figure 12. Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral

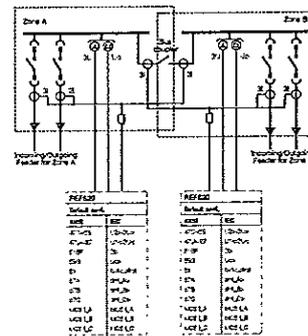


Figure 13. Application example of busbar differential protection covering two zones

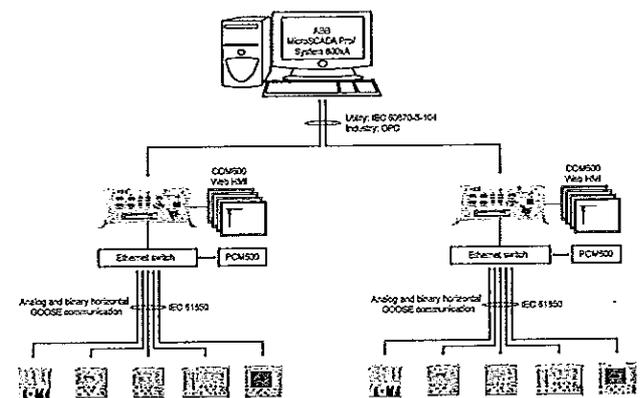


Figure 14. ABB power system example using Relion relays, Substation Management Unit COM600 and MicroSCADA Pro/Systems 800xA

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 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.

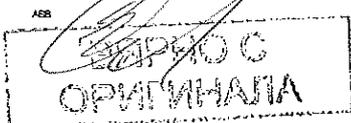
Two physical binary inputs and two physical binary outputs are provided in the relay for each operable primary device taken into use. Depending on the chosen hardware configuration of the relay, the number of binary inputs and binary outputs varies. In case the amount of available binary inputs or outputs 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 usable in the relay

configuration. The binary inputs and outputs of the external I/O module can be used for the least 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 scheme required by the application is configured using the Signal Matrix or the Application Configuration tools in PCMS00.

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 a 2-process bus



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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 protection 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 features store 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 provide a short-term three-second average and a long-term demand for total demand distortion TOD and total harmonic distortion THD.

9. Fault location

The relay features an optional impedance-measuring fault location function suitable for locating short-circuit 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 value. 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.

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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 ordered using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNO 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 18 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...178 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 PCW600.

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 RO600, increases the number of binary inputs and outputs available in the relay configuration. In this case, the external inputs and outputs are connected to the relay via IEC 61850 GOOSE to reach its reaction times between the relay and RO600 information. The needed binary input and output connections between the relay and RO600 units can be configured in a PCW600 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	Comb. 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 + 3HSO		
		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 + 3HSO		
		NN				16	4 PO + 10 SO		

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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 analysis 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 a 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 PCW600.

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 synchrocheck 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... 230 V.

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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-ZG 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 sets 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 the 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 (c10 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.

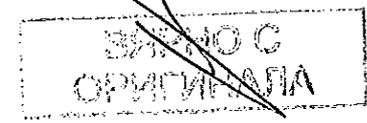
The relay also supports IEC 61850 process bus by sending sampled values of analog currents and voltages and by receiving sampled values of voltages. With this functionality the galvanic Ethernet wiring can be replaced with Ethernet communication. The measured values are transferred as sampled values 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) and 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 62433-3 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 the stringent real-time requirements of substation automation.

In PRP, each network node is attached to two independent substations, as defined by the IEC 61850 standard (c10 ms separated to ensure failure independence and can have different topologies. The networks operate in parallel, thus providing zero-time recovery and continuous checks of redundancy to avoid failures.

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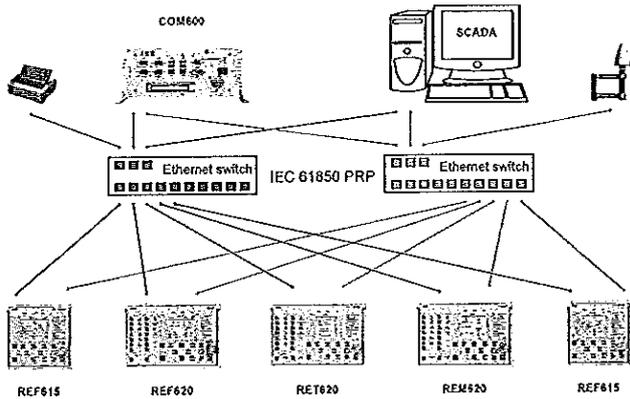


Figure 15. Parallel redundancy protocol (PRP) solution

HSR applies the PRP principle of parallel operation to a single ring. For each message sent, the nodes send 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 nodes. 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.

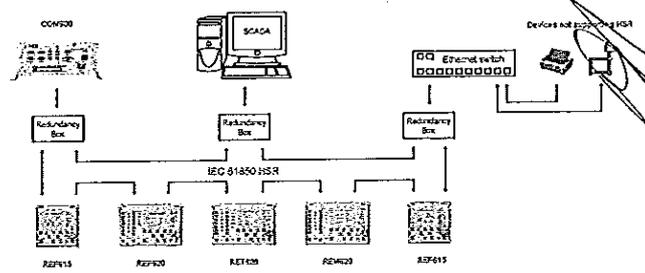


Figure 16. High availability seamless redundancy (HSR) solution

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 (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.

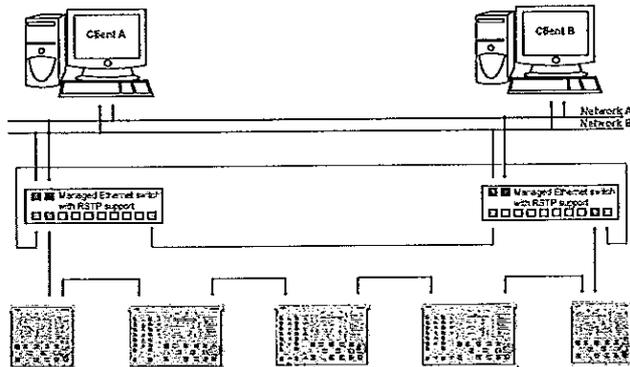


Figure 17. Self-healing Ethernet ring solution

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 or 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

Interface/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 IEC	*	*	-	-
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 292.2 mm
	Case 285 mm
Height	Frame 177 mm (H)
	Case 160 mm
Depth	203 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
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U _{aux} rated	
U _{aux} variation	35...115% of U _n (38...264 V AC)	60...125% of U _n (12...72 V DC)
	60...125% of U _n (38...264 V DC)	
Start-up threshold		19.2 V DC (24 V DC ± 80%)
Burden of auxiliary voltage supply under quiescent (P ₀) operating condition	DC <15.0 W (nominal) <22.5 W (max ²⁾)	DC <18.5 W (nominal) <22.5 W (max ²⁾)
	AC <19.0 W (nominal) <23.0 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 connected to rated auxiliary voltage and the energizing current is energized without any delay, until being active.
2) During the power consumption measurement, the relay is connected to rated auxiliary voltage and the energizing current is energized to a value at least half of the energy stored.
3) The relay is connected to 24 V DC with a 10 A, 2.0 mH inductor.

Table 7. Energizing inputs

Description	Value	
Rated frequency	50/60 Hz	
Current inputs	Rated current, I _n	0.2/1 A ¹⁾
	Thermal withstand capability:	
	• Continuously	4 A
	• For 1 s	100 A
Voltage inputs	Dynamic current withstand:	
	• Half-wave value	250 A
	• Input impedance	<120 mΩ
	Rated voltage	60...213 V AC
Voltage withstand:	• Continuous	243 V AC
	• For 10 s	365 V AC
	Burden at rated voltage	<0.05 VA

1) Working current for residual current input.
2) Rated current with a rated current.

Table 8. Energizing inputs (sensors)

Description	Value	
Current sensor input	Rated current voltage (in secondary side)	15...5000 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) Exceed the current range of 10...1000 A with a 10 A, 2.0 mH inductor.
2) Depending on the used terminal type (terminal type).
3) The relay is connected to 24 V DC with a 10 A, 2.0 mH inductor.

Table 9. Binary inputs

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.8...1.9 mA
Power consumption	31.0...370.0 mW
Threshold voltage	18...176 V DC
Reaction time	<3 ms

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Table 10. RTD/A 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 (EN 43760) TCR 0.00385 TCR 0.00518 (EN 43762) 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	±2.0% or ±1 Ω
		Temperature	±11°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 LR <40 ms, at 45/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

1) 45/0-30/110/220 V AC, when any of the protection relays is powered with B30002.
45/0-30/110/220 V AC, when REF620 is powered with B30002.
45/0-30/110/220 V AC, when REF620 is powered with B30002.
45/0-30/110/220 V AC, when REF620 is powered with B30002.

Table 12. Signal outputs and RVF 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 for 0.5 s	15 A
Breaking capacity when the control-circuit time constant LR <40 ms, at 45/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	10 mA at 5 V AC/DC

1) 45/0-30/110/220 V AC, when any of the protection relays is powered with B30002.
45/0-30/110/220 V AC, when REF620 is powered with B30002.
45/0-30/110/220 V AC, when REF620 is powered with B30002.

Table 13. Double-pole power outputs with TCS function X100, P03 and P04

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 LR <40 ms, at 45/110/220 V DC (two contacts connected in a series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Tripping 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	25 V AC/DC (15...20 V)

1) P30002: P03, P30003: P04, P30004: P04 and P30005: P04.

Table 14. Single-pole power output relays X100, P01 and P02

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 LR <40 ms, at 45/110/220 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 LR < 40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Operate time	< 1 ms
Reset	< 20 ms, resistive load

¹⁾ IEC 60947-1, IEC 60947-2, Annex 61, of the referenced IEC 60947-1 and IEC 60947-2

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⁾ 480 nm max-wavelength, 3 dB angle-divergence fiber
²⁾ Maximum length depends on the cable attenuation and bulk, the amount of splices and connectors in the path.
³⁾ See amount allowed attenuation caused by connectors and cable together

Table 18. IRIG-B

Description	Value
IRIG line code format	B024, B025 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 IEC 60044-8 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	+130°C
Minimum permissible bending radius of the connection fiber	100 mm

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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	-43...+55°C (< 1 h) ¹⁾
Relative humidity	< 93%, non-condensing
Atmospheric pressure	88...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+85°C

¹⁾ Operation at 55°C and 85°C continuous, within the temperature range -25...+55°C
²⁾ For details see IEC 60068-2-14 and IEC 60068-2-27

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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 II 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		IEC 61000-4-8 IEC 60255-26, class II IEC 61000-4-3 IEC 60255-26, class III EN 50204 IEC 60255-26, class III
• 10 V (rms) f = 150 kHz...80 MHz		
• 10 V/m (rms) f = 80...3700 MHz		
• 10 V/m f = 500 MHz		
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 61000-4-6
• Continuous	500 A/m	
• 1...3 s	1000 A/m	
Pulse magnetic field immunity test		IEC 61000-4-8
• 1000 A/m 6.4/16 µs		
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions		IEC 61000-4-11
• 32%/10 ms		
• 63%/100 ms		
• 63%/1000 ms		
• 95%/5000 ms		
Power frequency immunity test		IEC 61000-4-16 IEC 60255-26, class A
• Common mode	300 V rms	

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Table 23. 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 (15/10 V rms)	IEC 61000-4-16
Emission tests		EN 50111, class A IEC 60255-26 CISPR 11 CISPR 12
• Conducted		
0.15...0.50 MHz	< 79 dB (µV) quasi peak < 65 dB (µV) average	
0.5...30 MHz	< 73 dB (µV) quasi peak < 60 dB (µV) average	
• Radiated		
30...200 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	< 53 dB (µV/m) peak < 40 dB (µV/m) average, measured at 3 m distance	

Table 24. Insulation tests

Description	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min	IEC 60255-27
• 500 V, 50 Hz, 1 min, communication		
Impulse voltage test	9 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 25. Mechanical tests

Description	Reference	Requirement
Vibration tests (harmonic)	IEC 60068-2-6 (test Fc) IEC 60255-21-1	Class 2
Shock and bump test	IEC 60068-2-27 (test Es shock) IEC 60068-2-29 (test Es bump)	Class 2
Subsidence test	IEC 60255-21-2	Class 2
	IEC 60255-21-3	Class 2

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Table 26. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55°C • 16 h at +35°C ¹⁾	IEC 60568-2-2
Dry cold test	• 96 h at -25°C • 16 h at -40°C	IEC 60568-2-1
Damp heat test	• 6 cycles (12 h + 12 h) at +25°C...+55°C, humidity > 91%	IEC 60568-2-33
Change of temperature test	• 5 cycles (1 h + 3 h) at -25°C...+55°C	IEC 60068-2-14
Storage test	• 96 h at -40°C • 96 h at +55°C	IEC 60568-2-1 IEC 60568-2-2

1) For info, IEC 60068-2-14 indicates the maximum operating temperature is +70°C

Table 28. Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60205-27 (2013) EN 62255-1 (2025)

Table 27. EMC compliance

Description	Reference
EMC directive	2004/104/EC
Standard	EN 62255-25 (2013)

Table 29. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

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Operation functions

Table 26. Three-phase non-directional overcurrent protection (PHPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current, f_s , 62 Hz ±1.5% of the set value or ±0.002 × I_n
Start time ¹⁾²⁾	Minimum Typical Maximum PHPTOC: $I_{n,sa} = 2 \times \text{set Start value}$ $I_{n,sa} = 10 \times \text{set Start value}$ PHPTOC and PHPTOC: $I_{n,sa} = 2 \times \text{set Start value}$ 23 ms 19 ms 23 ms 11 ms 12 ms 14 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.56
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	ISM; No suppression DFT: -43 dB at $f = n \times f_s$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression P-to-P: backlog: No suppression

1) At device start, $t_{start} = 200 \text{ ms}$. Current below set + 0.5% of I_n .
2) Includes the delay of the signal input circuit.
3) Includes the delay of the hardware output circuit.

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

Parameter	Function	Value (Range)	Step
Start value	PHPTOC	0.05...5.00 × I_n	0.01
	PHPTOC	0.10...40.00 × I_n	0.01
	PHPTOC	1.00...40.00 × I_n	0.01
Time multiplier	PHPTOC	0.05...15.00	0.01
	PHPTOC	0.05...15.00	0.01
	PHPTOC	0.05...15.00	0.01
Operate delay time	PHPTOC	43...200000 ms	10
	PHPTOC	43...200000 ms	10
	PHPTOC	25...200000 ms	10
Operating curve type ¹⁾	PHPTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PHPTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHPTOC	Definite time	

1) For further information, see Operation functions table

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the current/voltage measured, f_s , 62 Hz DHPDOC: 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° DPHPDOC: 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 $I_{n,sa} = 2.0 \times \text{set Start value}$ 33 ms 43 ms 47 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.56
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: -53 dB at $f = n \times f_s$, where $n = 2, 3, 4, 5, \dots$

1) Measurement mode and $I_{n,sa} = 200 \text{ ms}$. Current below set + 0.5% of I_n , voltage below set + 0.5% of U_n .
2) Includes the delay of the signal input circuit.
3) Includes the delay of the hardware output circuit.

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

Parameter	Function	Value (Range)	Step
Start value	DHPDOC	0.05...5.00 × I_n	0.01
	DHPDOC	0.10...40.00 × I_n	0.01
	DHPDOC	0.05...15.00	0.01
Time multiplier	DHPDOC	43...200000 ms	10
	DHPDOC	43...200000 ms	10
Operating curve type ¹⁾	DHPDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DHPDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DHPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DHPDOC	-175...182°	1

1) For further information, see the Operation functions table

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage, f_s , 62 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 20 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.56
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	-53 dB at $f = n \times f_s$, where $n = 2, 3, 4, 5, \dots$

1) Measurement mode and $I_{n,sa} = 200 \text{ ms}$. Current below set + 0.5% of I_n , $U_n = 20 \text{ V}$, but current in one phase and voltage in another phase must be present at least one phase.
2) Includes the delay of the signal input circuit.
3) Includes the delay of the hardware output circuit.

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

Parameter	Function	Value (Range)	Step
Start value	PHVOC	$0.05...5.00 \times I_n$	0.01
Start value low	PHVOC	$0.05...1.00 \times I_n$	0.01
Voltage high limit	PHVOC	$0.01...1.00 \times U_n$	0.01
Voltage low limit	PHVOC	$0.01...1.00 \times U_n$	0.01
Start value I _{th}	PHVOC	$0.5...15.0$	0.1
Time multiplier	PHVOC	$0.05...15.00$	0.01
Operating curve type ¹⁾	PHVOC	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	PHVOC	$40...200000$ ms	10

¹⁾ For further information, see Selection characteristics table

Table 35. Non-directional earth-fault protection (EFPTOC) main settings

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \geq 52$ Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ EFPTOC and EFPTOC: $\pm 1.5\%$ of set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1...10 \times I_n$) $\pm 5.0\%$ of the set value (at currents in the range of $10...40 \times I_n$)
Start time ^{1,2)}	Minimum Typical Maximum EFPTOC: $I_{set} = 2 \times$ set Start value: 18 ms 19 ms 25 ms $I_{set} = 10 \times$ set Start value: 11 ms 12 ms 14 ms EFPTOC and EFPTOC: $I_{set} = 2 \times$ set Start value: 23 ms 26 ms 29 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.58
Retardation time	<30 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms 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 made at default setting in single current of the fault $I_{set} = 0.3 \times I_n$, $f = 50$ Hz, with fault current set nominal frequency equal to the system phase angle, results based on statistical distribution of 1000 measurements
²⁾ Includes the delay of the signal input contact
³⁾ No reserve time value $\pm 0.5\%$, Start value includes a range of 1.5...20

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

Parameter	Function	Value (Range)	Step
Start value	EFPTOC	$0.010...5.000 \times I_n$	0.005
	EFPTOC	$0.10...40.00 \times I_n$	0.01
Time multiplier	EFPTOC	$1.00...45.00 \times I_n$	0.01
	EFPTOC	$0.05...15.00$	0.01
Operate delay time	EFPTOC	$60...200000$ ms	10
	EFPTOC	$40...200000$ ms	10
Operating curve type ¹⁾	EFPTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFPTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFPTOC	Definite time	

¹⁾ For further information, see Selection characteristics table

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Table 37. Directional earth-fault protection (DEFPDEF) main settings

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: $f_n \geq 52$ Hz Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$ DEFPDEF: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1...10 \times I_n$) $\pm 5.0\%$ of the set value (at currents in the range of $10...40 \times I_n$) Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$
Start time ^{1,2)}	Minimum Typical Maximum DEFPDEF: $I_{set} = 2 \times$ set Start value: 42 ms 46 ms 49 ms DEFPDEF: $I_{set} = 2 \times$ set Start value: 58 ms 62 ms 66 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.58
Retardation time	<30 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms 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 0.25 s (inverse curve type IEC), delay time, I_{set} value, mode = default depends on single current of the fault $I_{set} = 0.3 \times I_n$, $f = 50$ Hz, with fault current set nominal frequency equal to the system phase angle, results based on statistical distribution of 1000 measurements
²⁾ Includes the delay of the signal input contact
³⁾ No reserve time value $\pm 0.5\%$, Start value includes a range of 1.5...20

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

Parameter	Function	Value (Range)	Step
Start value	DEFPDEF	$0.010...5.000 \times I_n$	0.005
	DEFPDEF	$0.10...40.00 \times I_n$	0.01
Directional mode	DEFPDEF	1 = Non-directional 2 = Forward 3 = Reverse	
	DEFPDEF		
Time multiplier	DEFPDEF	$0.05...15.00$	0.01
	DEFPDEF	$0.05...15.00$	0.01
Operate delay time	DEFPDEF	$60...200000$ ms	10
	DEFPDEF	$40...200000$ ms	10
Operating curve type ¹⁾	DEFPDEF	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFPDEF	Definite or Inverse time Curve type: 1, 3, 5, 17	
Operation mode	DEFPDEF	1 = Phase angle 2 = $\cos \theta$ 3 = $\sin \theta$ 4 = Phase angle 60 5 = Phase angle 85	
	DEFPDEF		

¹⁾ For further information, see Selection characteristics table

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

Characteristics	Value
Operation accuracy ¹⁾	At the frequency $f = f_n$ $\pm 1.0\%$ or ± 0.01 ms (at 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	$\pm 1.0\%$ 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⁾ $I_{set} = 1.0 \times I_n$
²⁾ Includes the delay of the signal input 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 = Co 3 = Bc 4 = Yo, Co 5 = Yo, Bc 6 = Co, Bc 7 = Yo, Co, Bc	-
Operate delay time	EFPADM	60...200000 ms	10
Circle radius	EFPADM	0.05...500.00 mS	0.01
Circle substance	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 18 Ang	EFPADM	-39...30°	1
Susceptance 18 Ang	EFPADM	-39...30°	1

Table 41, Walden-based earth-fault protection (WPADE)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: I _g , 52 Hz ±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⁾	Typically 43 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
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 ₀ , where n = 2, 3, 4, 5...

1) In stand during the peak, U_n = 1.05 U_n, U_n is given in earth voltage during operation at 50 Hz. Harmonic n is given in dB at the measured current I_g, 52 Hz, results based on statistical distribution of 1000 measurements.
2) Indicates the delay of the signal output contact.

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Table 42, Walden-based earth-fault protection (WPADE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	WPADE	2 = Forward 3 = Reverse	-
Current start value	WPADE	0.01...5.000 × I _n	0.001
Voltage start value	WPADE	0.01...1.000 × U _n	0.001
Power start value	WPADE	0.001...1.000 × P _n	0.001
Reference power	WPADE	0.050...1.000 × P _n	0.001
Characteristic angle	WPADE	-179...180°	1
Time multiplier	WPADE	0.05...2.00	0.01
Operating curve type ¹⁾	WPADE	Default or Inverse time Curve type: 1, 15, 20	-
Operate delay time	WPADE	60...200000 ms	10
Min operate current	WPADE	0.010...1.000 × I _n	0.001
Min operate voltage	WPADE	0.01...1.00 × U _n	0.01

1) For further information, refer to the Technical characteristics table.

Table 43, Multi-frequency admittance-based earth-fault protection (MFADPSDE)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage: I _g , 52 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) Indicates the delay of the signal output contact, results based on statistical distribution of 1000 measurements.

Table 44, Multi-frequency 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...200000 ms	10
Operating quantity	MFADPSDE	1 = Adaptive 2 = Amp/∠α	-
Min operate current	MFADPSDE	0.005...5.000 × I _n	0.001
Operation mode	MFADPSDE	1 = Inverse time EF 3 = General EF 4 = Alternating EF	-
Peak counter limit	MFADPSDE	2...20	1

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

Characteristics	Value
Operation accuracy (No criteria with transient protection)	Depending on the frequency of the measured current: I _g , 52 Hz ±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 ₀ , 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	43...200000 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 (HAEPFTOC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: I _g , 52 Hz ±5.0% of the set value or ±0.004 × I _n
Start time ¹⁾	Typically 77 ms
Reset time	Typically 43 ms
Reset ratio	Typically 0.95
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in IDMT mode ²⁾	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f ₀ , where n = 2, 3, 4, 5 -3 dB at f = 13 × f ₀

1) In stand during the peak, U_n = 1.05 U_n, U_n is given in earth voltage during operation at 50 Hz. Harmonic n is given in dB at the measured current I_g, 52 Hz, results based on statistical distribution of 1000 measurements.
2) Maximum Start value = 2.5 × I_n, Start value multiplies in range of 1.5...20.

Table 48, Harmonics-based earth-fault protection (HAEPFTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	HAEPFTOC	0.05...5.00 × I _n	0.01
Time multiplier	HAEPFTOC	0.05...15.00	0.01
Operate delay time	HAEPFTOC	100...200000 ms	10
Operating curve type ¹⁾	HAEPFTOC	Define 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	HAEPFTOC	100...200000 ms	10

1) For further information, refer to the Technical characteristics table.

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Table 49, Negative-sequence overcurrent protection (NSPTOC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: I _g , 52 Hz ±1.5% of the set value or ±0.002 × I _n
Start time ¹⁾	Minimum 23 ms Typical 15 ms Maximum 28 ms 20 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
Retardation time	<95 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in Inverse time mode ²⁾	±5.0% of the theoretical value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f ₀ , where n = 2, 3, 4, 5...

1) Inverse sequence current below 60 Hz, I_g = 50 Hz, results based on statistical distribution of 1000 measurements.
2) Maximum Start value = 2.5 × I_n, Start value multiplies 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	43...200000 ms	10
Operating curve type ¹⁾	NSPTOC	Default 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 information, refer to the Technical characteristics table.

Table 51, Phase disorderly protection (PONSPTOC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: I _g , 52 Hz ±2% of the set value
Start time	<70 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
Retardation time	<95 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 ₀ , where n = 2, 3, 4, 5...

Table 52, Phase disorderly protection (PONSPTOC) main settings

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

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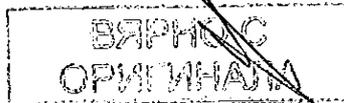


Table 53. Residual overvoltage protection (ROVTOV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage f_m , 62 Hz ±1.5% of the set value or ±0.002 × U_N
Start time t_{st}	Minimum Typical Maximum
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
Operate time accuracy in inverse time mode	±5.0% of the theoretical value or ±20 ms ¹⁾
Suppression of harmonics	DFT: -53 dB at $f = n \times f_m$, where $n = 2, 3, 4, 5, \dots$

1) Start value = 1.0 × U_N , voltage before fault = 0.8 × U_N , $f_m = 50$ Hz, unbalanced phase voltage with nominal frequency, injected from one phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum start value = 1.05 × U_N , start value multiplier in range of 1.05...1.20

Table 54. Residual overvoltage protection (ROVTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	ROVTOV	0.910...1.000 × U_N	0.001
Operate delay time	ROVTOV	43...300000 ms	

Table 55. Three-phase undervoltage protection (PHPTUV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage f_m , 62 Hz ±1.5% of the set value or ±0.002 × U_N
Start time t_{st}	Minimum Typical Maximum
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 ¹⁾
Suppression of harmonics	DFT: -53 dB at $f = n \times f_m$, where $n = 2, 3, 4, 5, \dots$

1) Start value = 1.0 × U_N , voltage before fault = 0.8 × U_N , $f_m = 50$ Hz, unbalanced phase voltage with nominal frequency, injected from one phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum start value = 0.95 × U_N , start value multiplier in range of 1.05...1.20

Table 59. Three-phase overvoltage protection (PHPTOV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage f_m , 62 Hz ±1.5% of the set value or ±0.002 × U_N
Start time t_{st}	Minimum Typical Maximum
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 ¹⁾
Suppression of harmonics	DFT: -53 dB at $f = n \times f_m$, where $n = 2, 3, 4, 5, \dots$

1) Start value = 1.0 × U_N , voltage before fault = 0.8 × U_N , $f_m = 50$ Hz, unbalanced phase voltage with nominal frequency, injected from one phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum start value = 1.05 × U_N , start value multiplier in range of 1.05...1.20

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

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.95...1.60 × U_N	0.01
Time multiplier	PHPTOV	0.05...15.00	0.01
Operate delay time	PHPTOV	43...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 Section characteristics table

Table 61. Single-phase overvoltage protection (PHAPTUV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage f_m , 62 Hz ±1.5% of the set value or ±0.002 × U_N
Start time t_{st}	Minimum Typical Maximum
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 ¹⁾
Suppression of harmonics	DFT: -53 dB at $f = n \times f_m$, where $n = 2, 3, 4, 5, \dots$

1) Start value = 1.0 × U_N , voltage before fault = 0.8 × U_N , $f_m = 50$ Hz, unbalanced phase voltage with nominal frequency, injected from one phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum start value = 1.05 × U_N , start value multiplier in range of 1.05...1.20

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

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	0.95...1.20 × U_N	0.01
Time multiplier	PHPTUV	0.05...15.00	0.01
Operate delay time	PHPTUV	63...300000 ms	10
Operating curve type ¹⁾	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference, see Section characteristics table

Table 57. Single-phase undervoltage protection (PHAPTUV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage f_m , 62 Hz ±1.5% of the set value or ±0.002 × U_N
Start time t_{st}	Minimum Typical Maximum
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 ¹⁾
Suppression of harmonics	DFT: -53 dB at $f = n \times f_m$, where $n = 2, 3, 4, 5, \dots$

1) Start value = 1.0 × U_N , voltage before fault = 0.8 × U_N , $f_m = 50$ Hz, unbalanced phase voltage with nominal frequency, injected from one phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum start value = 0.95 × U_N , start value multiplier in range of 0.95...1.20

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

Parameter	Function	Value (Range)	Step
Start value	PHAPTUV	0.95...1.20 × U_N	0.01
Time multiplier	PHAPTUV	0.05...15.00	0.01
Operate delay time	PHAPTUV	63...300000 ms	10
Operating curve type ¹⁾	PHAPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference, see Section characteristics table

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

Parameter	Function	Value (Range)	Step
Start value	PHAPTUV	0.95...1.60 × U_N	0.01
Time multiplier	PHAPTUV	0.05...15.00	0.01
Operate delay time	PHAPTUV	43...300000 ms	10
Operating curve type ¹⁾	PHAPTUV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

1) For further reference, see Section characteristics table

Table 63. Positive-sequence undervoltage protection (PSPTUV)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage f_m , 62 Hz ±1.5% of the set value or ±0.002 × U_N
Start time t_{st}	Minimum Typical Maximum
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: -53 dB at $f = n \times f_m$, where $n = 2, 3, 4, 5, \dots$

1) Start value = 1.0 × U_N , voltage before fault = 0.8 × U_N , $f_m = 50$ Hz, unbalanced phase voltage with nominal frequency, injected from one 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	0.910...1.200 × U_N	0.001
Operate delay time	PSPTUV	43...120000 ms	10
Voltage block value	PSPTUV	0.01...1.00 × U_N	0.01



Table 65. Negative-sequence overvoltage protection (NSPTOV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured, f_v , 12 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 13 ms Typical: 35 ms Maximum: 37 ms
Reset time	Typically 60 ms
Reset ratio	Typically 0.98
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or 120 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1. Response time to other faults: $\pm 0.2 \times U_n$ at 50 Hz, response time to other faults with normal frequency, result based on statistical distribution of 100 measurements
2. Indicate the delay of the signal about current

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

Parameter	Function	Value (Range)	Step
Start value	NSPTOV	0.01...1.00 $\times U_n$	0.01
Operate delay time	NSPTOV	13...120000 ms	1

Table 67. Frequency protection (FRFFRO)

Characteristic	Value
Operation accuracy	b-dc 15 mHz d/dc $\pm 0.5\%$ of the set value (in range 10-30 <math>\leq 50 Hz) $\pm 0.2\%$ of the set value (in range 5 Hz <math>\leq 10 Hz <math>\leq 15 Hz)
Start time	b-dc <40 ms d/dc <120 ms
Reset time	<150 ms
Operate time accuracy	$\pm 1.0\%$ of the set value or 120 ms

Table 71. Loss of phase, undercurrent (PHPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured, f_c , 12 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
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	$\pm 1.0\%$ of the set value or 120 ms

Table 72. Phase undercurrent protection (PHPTUC) main settings

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

Table 73. Circuit breaker failure protection (CCBRBF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current, f_c , 12 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
Operate time accuracy	$\pm 1.0\%$ of the set value or 120 ms
Reset time ¹	Typically 10 ms
Retardation time	<20 ms

1. The pulse time, during the current pulse length

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

Parameter	Function	Value (Range)	Step
Current block value	CCBRBF	0.05...2.00 $\times I_n$	0.01
Current value Pas	CCBRBF	0.05...2.00 $\times I_n$	0.01
CB failure mode	CCBRBF	1 = Current 2 = Breaker status 3 = Both	-
CB fail pickup mode	CCBRBF	1 = Off 2 = Without check 3 = Current check	-
Pickup time	CCBRBF	0...50000 ms	10
CB failure delay	CCBRBF	0...50000 ms	10
CB fault delay	CCBRBF	0...50000 ms	10

Table 68. Frequency protection (FRFFRO) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRFFRO	1 = Freq 2 = Freq 3 = d/c 4 = Freq + d/c 5 = Freq + d/c 6 = Freq OR d/c 7 = Freq OR d/c	-
Start value Freq	FRFFRO	0.9000...1.2000 $\times f_n$	0.0001
Start value d/c	FRFFRO	0.8000...1.1000 $\times f_n$	0.0001
Start value d/c	FRFFRO	-0.2000...0.2000 $\times f_n$	0.0025
Operate time Freq	FRFFRO	80...200000 ms	10
Operate time d/c	FRFFRO	120...200000 ms	10

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current, f_c , 12 Hz Current measurement: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of 0.01...4.00 $\times I_n$)
Operate time accuracy ¹	$\pm 2.0\%$ of the theoretical value or ± 0.50 s

1. Theoretical current > 1.2 \times conventional current

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

Parameter	Function	Value (Range)	Step
Env temperature set	TIPTR	-50...100 °C	1
Constant reference	TIPTR	0.05...4.00 $\times I_n$	0.01
Temperature rise	TIPTR	0.0...200.0 °C	0.1
Time constant	TIPTR	60...50000 s	1
Maximum temperature	TIPTR	20.0...200.0 °C	0.1
Alarm value	TIPTR	20.0...150.0 °C	0.1
Redline temperature	TIPTR	20.0...150.0 °C	0.1
Current multiplier	TIPTR	1...5	1
Initial temperature	TIPTR	-50.0...100.0 °C	0.1

Table 80. Load-shedding and restoration (LSHOPFRQ)

Characteristics	Value
Operation accuracy	±1% Hz
Start time	t_c t_d : ±100 mHz (n range [5%] < 5 Hz) ±2.0% of the set value (n range 5 Hz < [5%] < 15 Hz)
Reset time	t_c t_d : < 120 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

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

Parameter	Function	Value (Range)	Step
Load shed mode	LSHOPFRQ	1 = Freq 2 = Freq OR d/dt 3 = Freq AND d/dt	-
Restore mode	LSHOPFRQ	1 = Disabled 2 = Auto 3 = Manual	-
Start value Freq	LSHOPFRQ	0.800...1.200 × f_n	0.001
Start value d/dt	LSHOPFRQ	-0.200...0.005 × f_n	0.005
Operate Tim Freq	LSHOPFRQ	53...200000 ms	10
Operate Tim d/dt	LSHOPFRQ	120...200000 ms	10
Restore start Val	LSHOPFRQ	0.800...1.200 × f_n	0.001
Restore delay time	LSHOPFRQ	53...200000 ms	10

Table 82. Multipurpose protection (MAPGAPC)

Characteristics	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-on-to-fault (CVSOPF)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage 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
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

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Table 85. Automatic switch-on-to-fault (CVSOPF) main settings

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

Table 86. Voltage vector shift protection (VVSPPAM)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n , ±1 Hz
Operate time ^{1,2}	±1% Typically 53 ms

1. f_n ± 1 Hz, result based on statistical distribution of 1000 measurements
2. Includes the delay of the signal about 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 BK value	VVSPPAM	0.43...1.50 × U_n	0.01
Under Volt BK value	VVSPPAM	0.15...1.00 × U_n	0.01
Phase supervision	VVSPPAM	7 = Ph A + B + C 8 = Ph sequence	-

Table 88. Directional reactive power undervoltage protection (DOPTUV)

Characteristics	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 0.50
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1. Q_n set value × 0.02 × I_n , reactive power value
2. U_n set value × 0.02 × I_n , reactive power value
3. Includes the delay of the signal about contact

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

Parameter	Function	Value (Range)	Step
Voltage start value	DOPTUV	0.23...1.23 × U_n	0.01
Operate delay time	DOPTUV	100...300000 ms	10
Min reactive power	DOPTUV	0.01...0.53 × S_n	0.01
Min Pq Seq current	DOPTUV	0.02...0.23 × I_n	0.01
Pwr factor reduction	DOPTUV	0...10°	1

Table 90. Underpower protection (DUPPDR)

Characteristics	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 ^{1,2}	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 $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1. Absolute error mode = "Pst Def" default
2. U_n × I_n × 0.02, result based on statistical distribution of 1000 measurements
3. Includes the delay of the signal about contact

Table 91. Underpower protection (DUPPDR) main settings

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

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

Characteristics	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 ^{1,2}	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 $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1. Absolute error mode = "Pst Def" default
2. U_n × I_n × 0.02, result based on statistical distribution of 1000 measurements
3. Includes the delay of the signal about contact

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

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

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

Characteristics	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 $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1. f_n ± 1 Hz, result based on statistical distribution of 1000 measurements
2. Includes the delay of the signal about 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 4 3 = Exactly 2 of 3 2 = 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...19	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

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Table 99. Three-independent-phase non-directional overcurrent protection (PH3PTOC)

Characteristics	Function	Value
Operation accuracy	PH3PTOC	Depending on the frequency of the current measured, f, 52 Hz ±1.5% of the set value or ±0.002 × I _n
Start time ⁽¹⁾	PH3PTOC and PH3PTOC	±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)
	PH3PTOC: I _{peak} = 2 × set Start value I _{peak} = 10 × set Start value	Minimum: 15 ms Typical: 10 ms Maximum: 17 ms
Reset time	PH3PTOC and PH3PTOC: I _{peak} = 2 × set Start value	23 ms
	PH3PTOC and PH3PTOC: I _{peak} = 10 × set Start value	25 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
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms ⁽²⁾
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: 200% tolerance on signal current before fault = 0.2 × I_n, 50 Hz; 100% tolerance on signal current before fault = 0.2 × I_n, 60 Hz. Full current on all phases with respect to phase angle, expected from an external disturbance of 100% measurement.
⁽²⁾ Includes the delay of the signal input device.
⁽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 (PH3PTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PH3PTOC	0.05...5.00 × I _n	0.01
	PH3PTOC	0.10...40.00 × I _n	0.01
Time multiplier	PH3PTOC	1.00...40.00 × I _n	0.01
	PH3PTOC	0.05...15.00	0.01
Operate delay time	PH3PTOC	0.05...15.00	0.01
	PH3PTOC	40...200000 ms	10
	PH3PTOC	40...200000 ms	10
Operating curve type ⁽¹⁾	PH3PTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PH3PTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PH3PTOC	Definite time	

⁽¹⁾ For further information, see Operating characteristics table.

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Table 96. High-impedance differential protection (H3PDF)

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured, f, 52 Hz ±1.5% of the set value or ±0.002 × I _n
Start time ⁽¹⁾	Minimum: 12 ms Typical: 15 ms Maximum: 24 ms
	I _{peak} = 2 × set Start value I _{peak} = 10 × set Start value
Reset time	<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

⁽¹⁾ Measurement mode: 200% tolerance on signal current before fault = 0.2 × I_n, 50 Hz; 100% tolerance on signal current before fault = 0.2 × I_n, 60 Hz. Full current on all phases with respect to phase angle, expected from an external disturbance of 100% measurement.
⁽²⁾ Includes the delay of the signal input device.

Table 97. High-impedance differential protection (H3PDF) main settings

Parameter	Function	Value (Range)	Step
Operate value	H3PDF	1.0...200.0 %I _n	1
Minimum operate time	H3PDF	20...300000 ms	10

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

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

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Table 101. Directional three-independent-phase directional overcurrent protection (DPH3PDOC)

Characteristics	Function	Value
Operation accuracy	DPH3PDOC	Depending on the frequency of the current measured, f, 52 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°
Start time ⁽¹⁾	DPH3PDOC	±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) Phase angle: ±2°
	I _{peak} = 2 × set Start value	Minimum: 33 ms Typical: 10 ms Maximum: 43 ms
Reset time		<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
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms ⁽²⁾
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: 200% tolerance on signal current before fault = 0.2 × I_n, 50 Hz; 100% tolerance on signal current before fault = 0.2 × I_n, 60 Hz. Full current on all phases with respect to phase angle, expected from an external disturbance of 100% measurement.
⁽²⁾ Includes the delay of the signal input device.
⁽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 (DPH3PDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPH3PDOC	0.05...5.00 × I _n	0.01
	DPH3PDOC	0.10...40.00 × I _n	0.01
Time multiplier	DPH3PDOC	0.05...15.00	0.01
Operate delay time	DPH3PDOC	40...200000 ms	10
Operating curve type ⁽¹⁾	DPH3PDOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPH3PDOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPH3PDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPH3PDOC	-175...185°	1

⁽¹⁾ For further information, see the Operating characteristics table.

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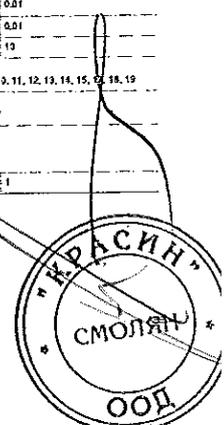


Table 103. Three-phase overload protection for short capacitor banks (COLPTOC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current, f , ± 2 Hz, and no harmonics 5% of the set value or $0.002 \times I_n$
Start time for overload stage ^{1,2}	Typically 75 ms
Start time for under current stage ^{3,4}	Typically 25 ms
Reset time for overload and alarm stage	Typically 60 ms
Reset ratio	Typically 0.55
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 $f = a \times f_n$, where $a = 2, 3, 4, 5, \dots$

- 1) Harmonic curve before fault $\times 1.3 \times I_n$, harmonic fault current $\times 1.3$. Start time results based on statistical distribution of 1000 measurements
- 2) Indicates the delay of the signal about contact
- 3) Normal current before fault $\times 1.1 \times I_n$, harmonic fault current $\times 1.3$. Start time results based on statistical distribution of 1000 measurements
- 4) Normal current before fault $\times 1.1 \times I_n$, harmonic fault current $\times 1.3$. Start time results based on statistical distribution of 1000 measurements

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

Parameter	Function	Value (Range)	Step
Start value overload	COLPTOC	$0.30 \dots 1.50 \times I_n$	0.01
Alarm start value	COLPTOC	$0.3 \dots 100\%$	1
Start value Un Cur	COLPTOC	$0.10 \dots 0.70 \times I_n$	0.01
Time multiplier	COLPTOC	$0.05 \dots 2.00$	0.01
Alarm delay time	COLPTOC	$500 \dots 600000$ ms	100
Un Cur delay time	COLPTOC	$100 \dots 120000$	100

Table 105. Current imbalance protection for short capacitor banks (CUBPTOC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current, f , ± 2 Hz 1.5% of the set value or $0.002 \times I_n$
Start time ^{1,2}	Typically 25 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.55
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 $f = a \times f_n$, where $a = 2, 3, 4, 5, \dots$

- 1) Forwarded frequency curve $\times 1.0 \times I_n$, current before fault $\times 1.0$, fault current $\times 1.0$. Start time results based on statistical distribution of 1000 measurements
- 2) Indicates the delay of the signal about contact

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Table 109. Operation characteristics

Parameter	Value (Range)
Operating curve type	1 = ANSI Ed. 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 Ed. 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)	0 = ANSI Def. Time 15 = IEC Def. Time 17 = Inv. Curve A 18 = Inv. Curve B 19 = Inv. Curve C 20 = Programmable 21 = Inv. Curve A 22 = Inv. Curve B 23 = Programmable

Table 106. Current imbalance protection for short capacitor banks (CUBPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm mode	CUBPTOC	1 = Normal 2 = Element counter	-
Start value	CUBPTOC	$0.01 \dots 1.50 \times I_n$	0.01
Alarm start value	CUBPTOC	$0.01 \dots 1.50 \times I_n$	0.01
Time multiplier	CUBPTOC	$0.05 \dots 15.00$	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	$50 \dots 200000$ ms	10
Alarm delay time	CUBPTOC	$50 \dots 200000$ ms	10

- 1) For further information, refer to the Operating Characteristics table

Table 107. Short capacitor bank switching resonance protection, current based (SRPPTOC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current, f , ± 2 Hz Operate value accuracy: $\pm 3\%$ of the set value or $\pm 0.002 \times I_n$ (for 2 nd order Harmonics) $\pm 1.0\%$ of the set value or $\pm 0.002 \times I_n$ (for 3 rd order < Harmonics < 10th order) $\pm 5\%$ of the set value or $\pm 0.004 \times I_n$ (for Harmonics = 10th order)
Reset time	Typically 45 ms or maximum 50 ms
Retardation time	Typically 0.25
Retardation time	< 15 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Suppression of harmonics	-50 dB at $f = f_n$

Table 108. Short capacitor bank switching resonance protection, current based (SRPPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm start value	SRPPTOC	$0.001 \dots 0.50 \times I_n$	0.01
Start value	SRPPTOC	$0.001 \dots 0.50 \times I_n$	0.01
Tuning harmonic Num	SRPPTOC	1...11	1
Operate delay time	SRPPTOC	$120 \dots 360000$ ms	1
Alarm delay time	SRPPTOC	$120 \dots 360000$ ms	1

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Control Functions

Table 110. Autoreclosing (PAREC)

Characteristics	Value
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 20 ms

Table 111. Synchronism and energizing check (SECRSYN)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage measured, f , ± 1 Hz Voltage: $\pm 0.0\%$ of the set value or $\pm 0.01 \times U_n$ Frequency: ± 0.1 mHz Phase angle: $\pm 3^\circ$
Reset time	< 50 ms
Reset ratio	Typically 0.55
Operate time accuracy in definite time mode	$\pm 1.0\%$ 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 2 = Both Dead 3 = Live L, Dead B 4 = Dead L, Live B 5 = Dead B, L, Any 6 = Dead L, B, Any 7 = One Live, Dead 8 = Not Both Live	-
Difference voltage	SECRSYN	$0.05 \dots 0.55 \times U_n$	0.01
Difference frequency	SECRSYN	$0.001 \dots 0.100 \times f_n$	0.001
Difference angle	SECRSYN	$5 \dots 50^\circ$	1
Syncheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	-
Dead line value	SECRSYN	$0.1 \dots 0.8 \times U_n$	0.1
Live line value	SECRSYN	$0.2 \dots 1.0 \times U_n$	0.1
Close pulse	SECRSYN	$250 \dots 80000$ ms	10
Max energizing V	SECRSYN	$0.50 \dots 1.15 \times U_n$	0.01
Control mode	SECRSYN	1 = Continuous 2 = Command	-
Phase shift	SECRSYN	$-180 \dots 180^\circ$	1
Minimum Syn time	SECRSYN	$0 \dots 60000$ ms	10
Maximum Syn time	SECRSYN	$100 \dots 800000$ ms	10
Energizing time	SECRSYN	$100 \dots 60000$ ms	10
Close time of CB	SECRSYN	$40 \dots 250$ ms	10

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Condition monitoring and supervision functions

Table 113. Circuit-breaker condition monitoring (BSCBR)

Characteristics	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)

Characteristics	Value
Operate time ¹⁾	<30 ms

¹⁾ Inducing the delay of the sub-circuit

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 118. Current transformer supervision for high-impedance protection scheme (I2CCHSPVC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: f _c ±2 Hz ±1.5% of the set value or ±0.002 × I _n
Reset time	<42 ms
Reset ratio	Typically 0.95
Retardation time	<35 ms
Operate time accuracy in de'fine time mode	±1.0% of the set value or ±20 ms

Table 117. Fuse failure supervision (EGSPVC)

Characteristics	Value
Operate time ¹⁾	NPS function U _{res} = 1.1 × set. Alg. Seq. voltage Lev <33 ms U _{res} = 5.0 × set. Alg. Seq. voltage Lev <18 ms Delta function dU = 1.1 × set. Voltage change rate <30 ms dU = 2.0 × set. Voltage change rate <24 ms

¹⁾ Indicates the delay of the signal sub-circuit, U_{res} = 35 °C, U_{res} = 0.8 voltage alarm threshold, NPS = 1 when main phase only, no fault in vertical direction of 100% measurement

Table 116. Runtime counter for machines and devices (MOSOPT)

Description	Value
Motor runtime measurement accuracy ¹⁾	±3.5%

¹⁾ Depending on a constant time, motor and synchronization

Measurement functions

Table 119. Three-phase current measurement (EVMX03)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: f _c ±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 = a × f _c , where a = 2, 3, 4, 5... RMS: No suppression

Table 120. Sequence current measurement (CSMS03)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current: f _c ±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 = a × f _c , where a = 2, 3, 4, 5... RMS: No suppression

Table 121. Residual current measurement (RESOM03)

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: f _c ±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 = a × f _c , where a = 2, 3, 4, 5... RMS: No suppression

Table 122. Three-phase voltage measurement (VMX03)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage measured: f _c ±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 = a × f _c , where a = 2, 3, 4, 5... RMS: No suppression

Table 123. Single-phase voltage measurement (VMX01)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage measured: f _c ±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 = a × f _c , where a = 2, 3, 4, 5... RMS: No suppression

Table 124. Residual voltage measurement (RESVM03)

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

Table 125. Sequence voltage measurement (VSM03)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage measured: f _c ±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 = a × f _c , where a = 2, 3, 4, 5... RMS: No suppression

Table 126. Three-phase power and energy measurement (PEMX03)

Characteristics	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 _c ±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⁾ ±0.01% for power factor
Suppression of harmonics	DFT: -50 dB at f = a × f _c , where a = 2, 3, 4, 5... ¹⁾ P1, Q1 and active [var] ±0.5 ²⁾ P1, Q1 and reactive [var] ±0.5

Table 127. Frequency measurement (FMX03)

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

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Fault location functions

Table 128. Fault locator (SCEFRLO)

Characteristics	Value
Measurement accuracy	At the frequency $f = 50$ Impedance: $\pm 2.5\%$ or $\pm 0.25 \Omega$ Distance: $\pm 2.5\%$ or $\pm 0.18 \text{ km}/0.1 \text{ m/s}$ XCDF_CALC: $\pm 2.5\%$ or $\pm 50 \Omega$ #FLT_PER_ILD: $\pm 5\%$ or ± 0.05

Table 129. Fault locator (SCEFRLO) main settings

Parameter	Function	Value (Range)	Step
ZM ix phase load	SCEFRLO	1.0...10000.00 Ω	0.1
Ph leakage Rcs	SCEFRLO	20...1000000 Ω	1
Ph capacitive React	SCEFRLO	10...10000000 Ω	1
R1 line section A	SCEFRLO	0.001...1000.000 Ω/μ	0.001
X1 line section A	SCEFRLO	0.000...1000.000 Ω/μ	0.001
R0 line section A	SCEFRLO	0.001...1000.000 Ω/μ	0.001
X0 line section A	SCEFRLO	0.001...1000.000 Ω/μ	0.001
Line Len section A	SCEFRLO	0.000...1000.000 μ	0.001

Power quality functions

Table 130. Voltage variation (PHQVVR)

Characteristics	Value
Operation accuracy	$\pm 1.5\%$ of the set value or $\pm 0.2\%$ of reference voltage
Reset ratio	Typically 0.99 (Swell), 1.04 (Dip, Interruption)

Table 131. Voltage variation (PHQVVR) main settings

Parameter	Function	Value (Range)	Step
Voltage dip set 1	PHQVVR	100...100.0%	0.1
Voltage dip set 2	PHQVVR	100...100.0%	0.1
Voltage dip set 3	PHQVVR	100...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)

Characteristics	Value
Operation accuracy	$\pm 1.5\%$ of the set value or $\pm 0.02 \cdot U_n$
Reset ratio	Typically 0.96

Table 133. Voltage unbalance (VSQVUB) main settings

Parameter	Function	Value (Range)	Step
Operation	VSQVUB	1 = on 2 = 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	-

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Other functions

Table 134. Pulse timer (PTQAPC)

Characteristics	Value
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 20 ms

Table 135. Time delay on (t pos) (TOFFAPC)

Characteristics	Value
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 20 ms

Table 136. Time delay on (t pos) (TONMAPC)

Characteristics	Value
Operate time accuracy	$\pm 1.0\%$ 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 HMI 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 PCAS600.

The local HMI also includes 11 programmable LEDs. These LEDs can be configured to show alarms and indications as needed by PCAS600 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 PCAS600 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/F) 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.

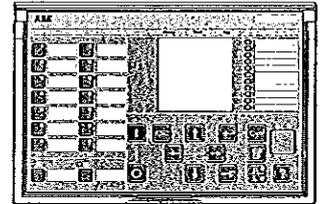


Figure 18. Example of the LUMI

23. Mounting methods

By means of appropriate mounting accessories the standard relay cases 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 Combibox equipment frames.

For the routine testing purposes, the relay cases can be equipped with test switches, type RDXP 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 RDXP 24 test switch to a 19" rack

- Panel cut-out for flush mounting
- Height: 162 ± 1 mm
- Width: 243 ± 1 mm

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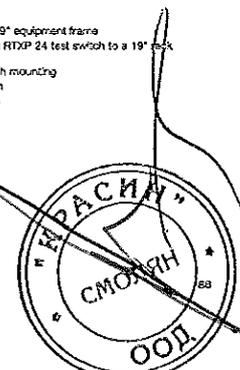
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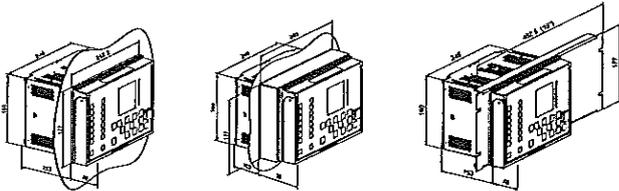


Figure 19. Flush mounting

Figure 20. Semi-flush mounting

Figure 21. Rack mounting

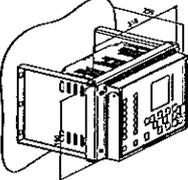


Figure 22. Wall mounting

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 cases 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.

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#	Description	
10	Serial RS 485, incl. an input for PRO-B + Ethernet 100Base FX (1xL4G)	AA
	Serial RS 485, incl. an input for PRO-B + Ethernet 100Base TX (1xL4G)	AD
	Serial RS 485, incl. an input for PRO-A	AN
	Serial glass fibre (S) + Ethernet 100Base TX (1xL4G) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for PRO-B (cannot be combined with arc protection)	AR
	Serial glass fibre (S) + Ethernet 100Base TX and FX (1xL4G, 2xL4G) with HSR/PPP	AO
	Serial glass fibre (S) + Ethernet 100Base TX (2xL4G) with HSR/PPP	BO
	Serial glass fibre (S) + Ethernet 100Base TX and FX (2xL4G, 1xL4G) with HSR/PPP	BE
	Serial glass fibre (S) + Ethernet 100Base TX and FX (1xL4G, 2xL4G) with HSR/PPP and EOS 150-9-ZLE	BF
	Serial glass fibre (S) + Ethernet 100Base TX (2xL4G) with HSR/PPP and EOS 150-9-ZLE	BO
	Serial glass fibre (S) + Ethernet 100Base TX and FX (2xL4G, 1xL4G) with HSR/PPP and EOS 150-9-ZLE	BE
	Serial glass fibre (S) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for PRO-B (cannot be combined with arc protection)	BR
	RS 232/485 (including PRO-B) + Ethernet 100Base TX (1xL4G) (cannot be combined with arc protection)	CB
	HS 232/485 + RS 485/485-Lite S1 (including PRO-B) (cannot be combined with arc protection)	CV
	Ethernet 100Base FX (1xL4G)	NA
	Ethernet 100Base TX (1xL4G)	ND
	Ethernet 100Base TX and FX (1xL4G, 2xL4G) with HSR/PPP	NF
	Ethernet 100Base TX (2xL4G) with HSR/PPP	NO
	Ethernet 100Base TX and FX (2xL4G, 1xL4G) with HSR/PPP	NE
	Ethernet 100Base TX and FX (1xL4G, 2xL4G) with HSR/PPP and EOS 150-9-ZLE	NF
	Ethernet 100Base TX (2xL4G) with I-SVTPT and EOS 150-9-ZLE	NO
	Ethernet 100Base TX and FX (2xL4G, 1xL4G) with HSR/PPP and EOS 150-9-ZLE	NI
	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 PRO-B500 or the RedRAM is required.

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25. Selection and ordering data

The relay type and serial number label identifies the protection and control relay. The label is placed above the FMI 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.

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 Ref60n 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.

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

#	Description	
1	IED	N
	IED series IED (including case)	S
	Complete Relay with optional coating	S
2	Standards	
	IEC	B
	CY	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) + 5U + 24S + 14SD	AA
	4 I, 0.2/1 A) + 5U + 24S + 14SD	AB
	5Inputs 24 + 24 + 10 I + 14S + 14SD	AD
7-8	Optional board	
	Optional I/Os (RTD, dNO)	AA
	Optional RTDs (RTD In + 2x A in)	AB
	Optional Fast I/Os (S1 + 3x SO)	AC
	No optional board	NN

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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 61850-5-113 (for serial or Ethernet + serial communication modules)	D
	IEC 61850-5-113 (for Ethernet or Ethernet + serial communication modules)	F
	IEC 61850 + IEC 60870-5-103 (for serial + Ethernet communication modules)	G
	IEC 61850 + IEC 61850-5-113 (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 - IED	B
	Large LCD with Single Line Diagram - UN	U
14	Option 1	
	Arc protection (requires a communication module, cannot be combined with comm. module options DN, DD, OD and ON)	B
	None	N
15	Option 2	
	Full IEC608	F
	Capacitor bank protection package	C
	Inverter/interconnection/Distributed generation protection package	D
	Power protection package	P
	All options (Full IEC608 + Capacitor bank protection + Inverter/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	10

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Example code: NBFHAAHABC18NN11G

Your ordering code:

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

Figure 21. 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	1MRS122634-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS122634-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS122634-5.0

Table 138. Mounting accessories

Item	Order number
6-pin flash mounting kit	2RCA292673A0001
Wall mounting kit	2RCA292694A0001
19" rack mounting kit with cut-out for one relay	2RCA231156A0001
19" rack mounting kit for one relay and one RTXP24 test switch (the test switch and wire harness are not included in the delivery)	2RCA232518A0001
Mounting bracket for one relay with test switch RTXP in RU CombiFac (RIGHT 19" variant C) (the test switch, wire harness and CombiFac (RIGHT 19" variant C are not included in the delivery)	2RCA232526A0001
Functional earthing blange for RTD modules	2RCA235978A0001

*) Cannot be used when the ED is mounted with the Conductor 19" equipment frame 2RCA232526A0001.

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 PC4600 tool in combination with the relay-specific connectivity package.

The Protection and Control LED Manager PC4600 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 PC4600, 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 tool	Version
PC4600	2.8 (Rollup 20150628) or later
Web browser-based user interface	IE 8.0, IE 9.0, IE 11.0 or IE 11.0
REF620 Connectivity Package	2.1 or later

Table 140. Supported functions

Function	Web HMI	PC4600
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	•	•
XDR parameter support (report)	•	•
Graphical display configuration	•	•
Application configuration	•	•
IEC 61850 communication configuration, GOOSE (communication configuration)	•	•
Practical 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

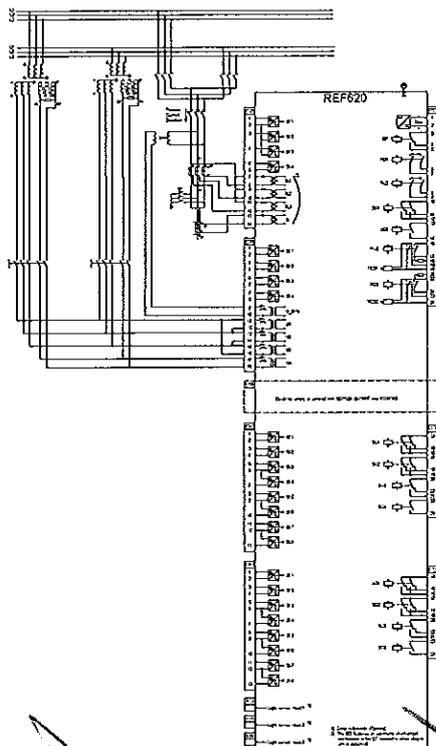


Figure 24. Connection diagram for the configuration with CTs and VTs



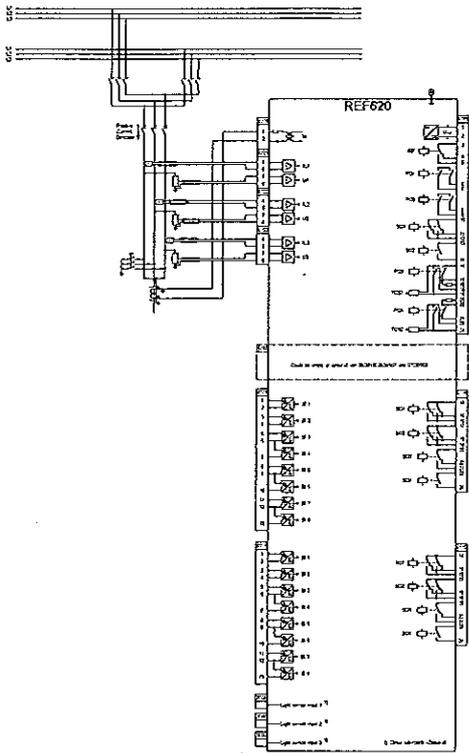


Figure 25. Connection diagram for the configuration with sensors

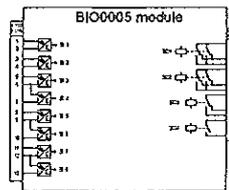


Figure 26. Optional BIO0005 module (slot X105)

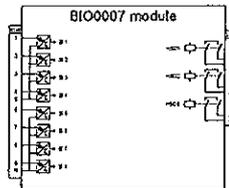


Figure 27. Optional BIO0007 module for fast outputs (slot X106)

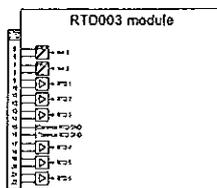


Figure 28. Optional RTD0003 module (slot X105)

30. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Refon® 620 series. Certificate number: 74108008-OP/EN/10 15-2319.

DNV GL has issued an IEC 61850 Edition 1 Certificate Level A1 for Refon® 620 series. Certificate number: 74108008-OP/EN/10 15-2323.

Additional certificates can be found on the [product page](#).

31. References

The [ABB.com](#) website 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 60017	ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3>> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	3>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC2	3>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHPTOC1	3>>> (1)	50P&51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3>> (1)	67-1 (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC2	3>> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3>> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage	DPHHPDOC2	3>> (2)	67-2 (2)
Three-phase voltage-dependent overcurrent protection	PHPVOC1	3(U)> (1)	51V (1)
Three-phase voltage-dependent overcurrent protection	PHPVOC2	3(U)> (2)	51V (2)
Non-directional earth-fault protection, low stage	EFLLPTOC1	1>> (1)	51N-1 (1)
Non-directional earth-fault protection, low stage	EFLLPTOC2	1>> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	1>>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	1>>>> (1)	50N&51N (1)
Directional earth-fault protection, low stage	DELLPDEF1	1>> (1)	67N-1 (1)
Directional earth-fault protection, low stage	DELLPDEF2	1>> (2)	67N-1 (2)
Directional earth-fault protection, low stage	DELLPDEF3	1>> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEHPDEF1	1>>> (1)	67N-2 (1)
Admittance-based earth-fault protection	EFPADM1	Y>> (1)	21YN (1)
Admittance-based earth-fault protection	EFPADM2	Y>> (2)	21YN (2)
Admittance-based earth-fault protection	EFPADM3	Y>> (3)	21YN (3)
Wattmetric-based earth-fault protection	WPWCE1	P>> (1)	32N (1)
Wattmetric-based earth-fault protection	WPWCE2	P>> (2)	32N (2)
Wattmetric-based earth-fault protection	WPWCE3	P>> (3)	32N (3)
Multi-frequency admittance-based earth-fault protection	MFADFSDEF1	1>> (Y) (1)	67YN (1)
Transients/intermittent earth-fault protection	INTPTIEF1	1>> (IEF) (1)	67SEF (1)
Harmonic-based earth-fault protection	HAEFTOC1	1>>HA (1)	51HA (1)
Negative-sequence overcurrent protection	NSPTOC1	12>> (1)	49 (1)
Negative-sequence overcurrent protection	NSPTOC2	12>> (2)	49 (2)
Phase discontinuity protection	PDNSPTOC1	R41> (1)	44PD (1)
Residual overvoltage protection	ROVPTOV1	1U>> (1)	59 (1)
Residual overvoltage protection	ROVPTOV2	1U>> (2)	59 (2)
Residual overvoltage protection	ROVPTOV3	1U>> (3)	59 (3)

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Table 141. Functions Included in the relay, continued

Function	IEO #1650	IEO #0817	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	PHSPTUV1	U _A < (1)	27_A (1)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
Single-phase overvoltage protection, secondary side	PHSPTOV1	U _A > (1)	59_A (1)
	PHSPTOV2	U _A > (2)	59_A (2)
Positive-sequence undervoltage protection	PSPTUV1	U ₁ < (1)	47U (1)
Negative-sequence overvoltage protection	NSPTOV1	U ₂ > (1)	47O (1)
	NSPTOV2	U ₂ > (2)	47O (2)
Frequency protection	FRFR01	f < f _{set} (1)	81 (1)
	FRFR02	f < f _{set} (2)	81 (2)
	FRFR03	f < f _{set} (3)	81 (3)
	FRFR04	f < f _{set} (4)	81 (4)
	FRFR05	f < f _{set} (5)	81 (5)
	FRFR06	f < f _{set} (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	TIPTTR1	3Th>F (1)	48F (1)
Loss of phase (undercurrent)	PHPTUC1	3U< (1)	3T (1)
Circuit breaker failure protection	CCBRBRF1	3I>+3SF (1)	51BF51NSF (1)
	CCBRBRF2	3I>+3SF (2)	51BF51NSF (2)
	CCBRBRF3	3I>+3SF (3)	51BF51NSF (3)
Three-phase inrush detector	INRPHAR1	3I> (1)	63 (1)
	TRPPTRC1	Master Trip (1)	8436 (1)
	TRPPTRC2	Master Trip (2)	8435 (2)
	TRPPTRC3	Master Trip (3)	8435 (3)
Arc protection	TRPPTRC4	Master Trip (4)	8434 (4)
	ARCSARC1	ARC (1)	50LSGNL (1)
	ARCSARC2	ARC (2)	50LSGNL (2)
High-impedance fault detection	ARCSARC3	ARC (3)	50LSGNL (3)
	PHZ1	HF (1)	8Z (1)

Table 141. Functions Included in the relay, continued

Function	IEO #1650	IEO #0817	ANSI	
Load shedding and restoration	LSHDFR01	UFLSR (1)	81LSH (1)	
	LSHDFR02	UFLSR (2)	81LSH (2)	
	LSHDFR03	UFLSR (3)	81LSH (3)	
	LSHDFR04	UFLSR (4)	81LSH (4)	
	LSHDFR05	UFLSR (5)	81LSH (5)	
	LSHDFR06	UFLSR (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)	
Automatic switch on-to-fault logic (SOF)	CYPSOF1	CYPSOF (1)	50FT2159 (1)	
	VYSPAM1	VS (1)	73V (1)	
Voltage vector shift protection	DOPTV1	Q> -> 3U< (1)	320/27 (1)	
	DOPTV2	Q> -> 3U< (2)	320/27 (2)	
Underpower protection	DUPDFR1	P< (1)	32U (1)	
	DUPDFR2	P< (2)	32U (2)	
Reverse power/directional overpower protection	DOPPDR1	P>Q> (1)	32P320 (1)	
	DOPPDR2	P>Q> (2)	32P320 (2)	
Low-voltage ride-through protection	LVRPTUV1	U<RT (1)	27RT (1)	
	LVRPTUV2	U<RT (2)	27RT (2)	
	LVRPTUV3	U<RT (3)	27RT (3)	
High-impedance differential protection for phase A	HAPDF1	dI _A > (1)	87A (1)	
High-impedance differential protection for phase B	HBPDF1	dI _B > (1)	87B (1)	
High-impedance differential protection for phase C	HCPDF1	dI _C > (1)	87C (1)	

Table 141. Functions Included in the relay, continued

Function	IEO #1650	IEO #0817	ANSI
Circuit breaker unresponsive 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	PHILPTOC1	3I ₃ > (1)	51P-1_3 (1)
	PHILPTOC2	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	PHISP1OC1	3I ₃ >>> (1)	50P5IP_3 (1)
Directional three independent phase directional overcurrent protection, low stage	DPHILPTOC1	3I ₃ > (1)	87-1_3 (1)
	DPHILPTOC2	3I ₃ > (2)	87-1_3 (2)
Directional three independent phase directional overcurrent protection, high stage	DPHILPTOC1	3I ₃ > (1)	87-2_3 (1)
	DPHILPTOC2	3I ₃ > (2)	87-2_3 (2)
Three-phase overheat protection for shunt capacitor banks	COLPTOC1	3I> X< (1)	51O37 (1)
Current unbalance protection for shunt capacitor banks	CURPTOC1	dC (1)	51NG-1 (1)
Shunt capacitor bank switching resonance protection, current based	SRCP1OC1	TD> (1)	55TD (1)
Circuit-breaker control	CBXCBR1	1<-> 0 CB (1)	1<-> 0 CB (1)
	CBXCBR2	1<-> 0 CB (2)	1<-> 0 CB (2)
	CBXCBR3	1<-> 0 CB (3)	1<-> 0 CB (3)
	CBXCBR4	1<-> 0 CB (4)	1<-> 0 CB (4)
Disconnecter control	DCXSWS1	1<-> 0 DCC (1)	1<-> 0 DCC (1)
	DCXSWS2	1<-> 0 DCC (2)	1<-> 0 DCC (2)
	DCXSWS3	1<-> 0 DCC (3)	1<-> 0 DCC (3)
	DCXSWS4	1<-> 0 DCC (4)	1<-> 0 DCC (4)
Earthing switch control	ESXSWS1	1<-> 0 ESC (1)	1<-> 0 ESC (1)
	ESXSWS2	1<-> 0 ESC (2)	1<-> 0 ESC (2)
	ESXSWS3	1<-> 0 ESC (3)	1<-> 0 ESC (3)
Disconnecter position indication	DCXSWS1	1<-> 0 DC (1)	1<-> 0 DC (1)
	DCXSWS2	1<-> 0 DC (2)	1<-> 0 DC (2)
	DCXSWS3	1<-> 0 DC (3)	1<-> 0 DC (3)
	DCXSWS4	1<-> 0 DC (4)	1<-> 0 DC (4)
Earthing switch indication	ESXSWS1	1<-> 0 ES (1)	1<-> 0 ES (1)
	ESXSWS2	1<-> 0 ES (2)	1<-> 0 ES (2)
	ESXSWS3	1<-> 0 ES (3)	1<-> 0 ES (3)
Autoreclosing	DARREC1	0 -> 1 (1)	73 (1)
	DARREC2	0 -> 1 (2)	73 (2)
Synchronism and energizing check	SECRS1YN	SYNC (1)	25 (1)

Table 141. Functions Included in the relay, continued

Function	IEO #1650	IEO #0817	ANSI
Condition monitoring and supervision			
Circuit-breaker condition monitoring			
	SSCBR1	CBGM (1)	CBGM (1)
	SSCBR2	CBGM (2)	CBGM (2)
	SSCBR3	CBGM (3)	CBGM (3)
Trip circuit supervision	TCSSCBR1	TCM (1)	TCM (1)
	TCSSCBR2	TCM (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
	HZCCASPCV1	MCS LA (1)	MCS LA (1)
	HZCCASPCV2	MCS LB (1)	MCS LB (1)
Current transformer supervision for high-impedance protection scheme for phase B	HZCCASPCV1	MCS LC (1)	MCS LC (1)
	HZCCASPCV2	MCS LC (2)	MCS LC (2)
Fuses failure supervision	SEOSPVC1	FUSEF (1)	89 (1)
	MDSOP1	OPTS (1)	OPTM (1)
Random counter for machines and devices	MDSOP2	OPTS (2)	OPTM (2)
Measurement			
Three-phase current measurement	CMR01	3I (1)	3I (1)
	CSMSG1	1I, 2I, 3I (1)	1I, 2I, 3I (1)
Residual current measurement	RESOMD01	I0 (1)	I0 (1)
	VAM001	3U (1)	3U (1)
Three-phase voltage measurement	VAM001	U _A , U _B , U _C (1)	V _A , V _B , V _C (1)
	VAM002	U _A , U _B , U _C (2)	V _A , V _B , V _C (2)
Single-phase voltage measurement	RESM001	U _A (1)	V _A (1)
	RESM002	U _B (1)	V _B (1)
Residual voltage measurement	VSM01	U ₁ , U ₂ , U ₀ (1)	V ₁ , V ₂ , V ₀ (1)
	FEM001	P, E (1)	P, E (1)
Three-phase power and energy measurement	LDFRUC1	LOADPROF (1)	LOADPROF (1)
	FEM002	P, E (2)	P, E (2)
Load profile record	LDFRUC1	LOADPROF (1)	LOADPROF (1)
Frequency measurement	FEM001	f (1)	f (1)
Fault location	SCFFFL01	FLOC (1)	21FL (1)
Power quality	CM01	PM01 (1)	PM01 (1)
	VM01	PM03 (1)	PM03 (1)
	PHV01	PM04 (1)	PM04 (1)
	VS01	PM05 (1)	PM05 (1)
Current total demand distortion	CM01	PM01 (1)	PM01 (1)
	VM01	PM03 (1)	PM03 (1)
Voltage total harmonic distortion	PHV01	PM04 (1)	PM04 (1)
	VS01	PM05 (1)	PM05 (1)
Voltage unbalance	VM01	PM03 (1)	PM03 (1)
Other	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)

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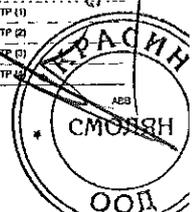


Table 141. Functions included in the relay, continued

Function	IEQ 61850	IEQ 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	MVHGAPC1	MVH (1)	MVH (1)
	MVHGAPC2	MVH (2)	MVH (2)
	MVHGAPC3	MVH (3)	MVH (3)
	MVHGAPC4	MVH (4)	MVH (4)
Analog value scaling	SCMGAPC1	SCM (1)	SCM (1)
	SCMGAPC2	SCM (2)	SCM (2)
	SCMGAPC3	SCM (3)	SCM (3)
	SCMGAPC4	SCM (4)	SCM (4)
Generic control point (18 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	IEQ 61850	IEQ 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 (18 buttons)	FBEGY0101	FKEY (1)	FKEY (1)
Logging functions			
Disturbance recorder	PDRE1	DR (1)	DR (1)
Fault recorder	FLTFPRC1	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/2015-10-11	2.0 FP1	Content updated to correspond to the product version

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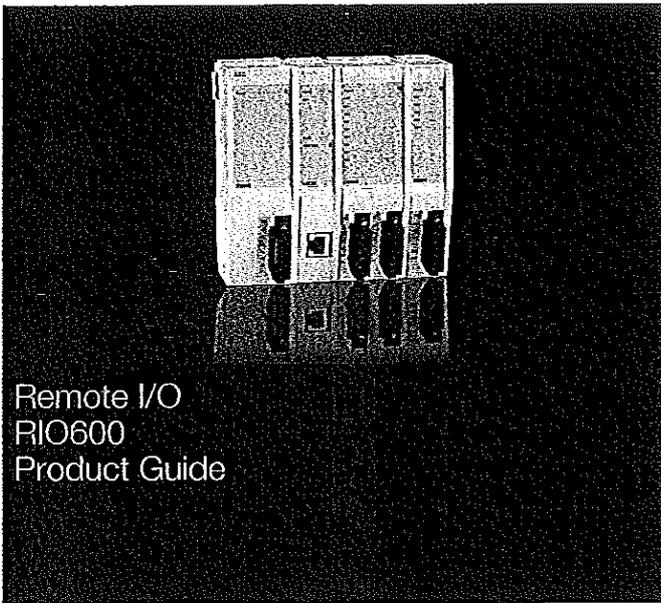
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Remote I/O
RIO600
Product Guide

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

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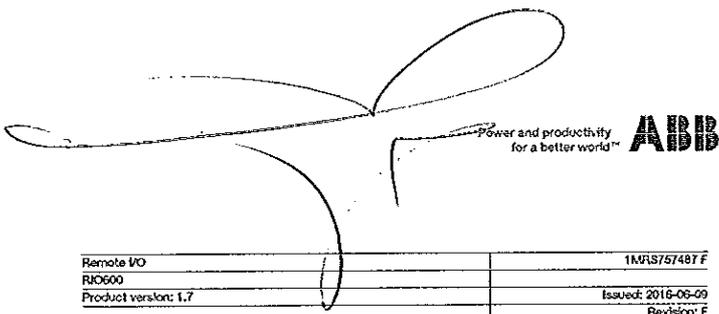
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Remote I/O	1MRS757487 F
RIO600	
Product version: 1.7	Issued: 2016-06-09 Revision: F

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1. Description
RIO600 is designed to expand the digital and analog I/O of ABB's Relion³ protection and control relays and to provide I/O for COM600 substation automation unit using the IEC 61850 and Modbus TCP communication. Both galvanic RL-45 and optical I/O 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 with 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 (disconnecter and earthing switch) used in gas insulated switchgear or standard two-position switchgear like disconnecter 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 multi-frequency 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 ungrounded networks where accurate and selective earth-fault detection is more challenging due to low fault currents.

temperatures, electromagnetic interference and stringent industry standards.

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

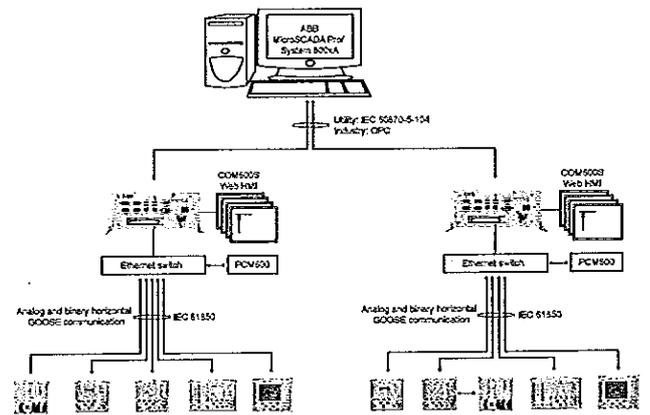


Figure 1. Connection overview of RIO600

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. RI0600 module types

Module type	Description	
Power supply modules	PSMH: 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	DIMH1: High-voltage range, eight optically isolated binary inputs with common return for pair of two inputs	
	DIMB1: Low-voltage range, eight optically isolated binary inputs with common return for pair of two inputs	
	DOM4: Four output contacts in each digital output module with two pairs of potential free contacts with common return	
	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	
	AGM4: Four individually isolated channels of configurable mA outputs driving 0...20 mA signal	
	SIM3F: Sensor input module with combined three-phase current and voltage signals	
	Smart control module	SCMH: High-voltage range, smart control module with five application types • 4DO – four input and four output channels • Three-position switch • Disconnecter • Circuit breaker • Earthing switch
		SCML: Low-voltage range, smart control module with five application types • 4DO – four input and four output channels • Three-position switch • Disconnecter • Circuit breaker • Earthing switch

The availability and combination of RI0600 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

Description	LECM with copper interface		LECM with fiber interface	
	Modules	Channels	Modules	Channels
Digital input modules (DIMH/DIML)	5	40	5	40
Digital output modules	5	20	4	18
RTD4 modules	5	20	4	18
Analog output modules	2	8	1	4
SIM3F modules	5	-	4	-
Smart control module (SCMH/SCML)	3	24	2	18

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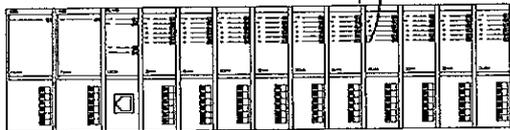


Figure 3. RI0600 configuration: 43 channels with 40 DO (10 x DOM4)

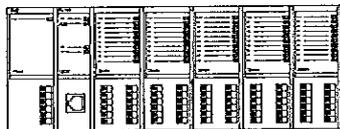


Figure 4. RI0600 configuration: 43 channels with 40 DI (5 x DIMB1)

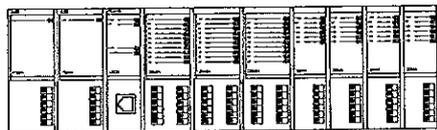


Figure 5. RI0600 configuration: 43 channels with 24 DI and 16 DO (3 x DIMH + 4 x DOM4)

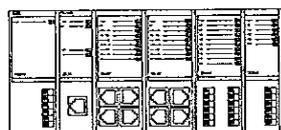


Figure 6. RI0600 configuration: 2 x SIM3F + 1 x DIMH + 1 x DOM4

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

Description	LECM with copper interface		LECM with fiber interface	
	Modules	Channels	Modules	Channels
Digital input modules (DIMH/DIML)	5	40	5	40
Digital output modules	10	40	9	35
RTD4 modules	10	40	9	35
Analog output modules	4	16	3	12
SIM3F modules	5	-	5	-
Smart control module (SCMH/SCML)	5	40	5	40

A combination of all the modules can be used in a single RI0600 stack. The total number of modules that can be supported by a number of power supply modules is automatically checked by PCAN600, 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.

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

RI0600 can be configured with a combination of low-voltage and high-voltage modules, for example, PSVH-LECM-DIMB1, PSVL-LECM-DIMH1 or PSVL-PSVH-LECM-DIMH-DIMB1-DOM4.

Indication LEDs
RI0600 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
- RPF LED which indicates a fault condition if it is steady ON
- Communication diagnostic LED on the communication module

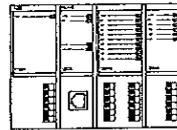


Figure 2. RI0600 configuration with 12 channels with 8 DI and 4 DO (1 x DIMH + 1 x DOM4)

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3. Applications

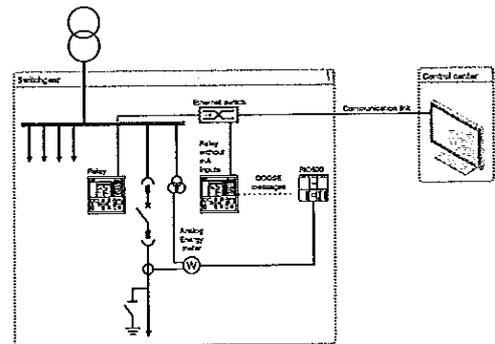


Figure 7. RI0600 as an external metering input for the protection relay

Figure 7 illustrates an application example in which RI0600 acts as an external metering input for the protection relay.

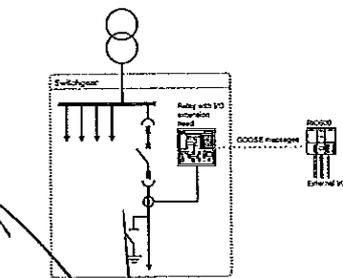


Figure 8. RI0600 as an IED interface

ВЕРИТЕ С
ОРИГИНАЛА

КРАСН
СМОЛЯН
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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.

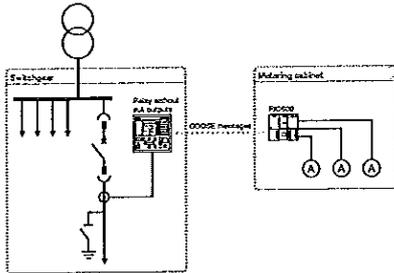


Figure 9. RIO600 communicating analog signals for the external meters

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

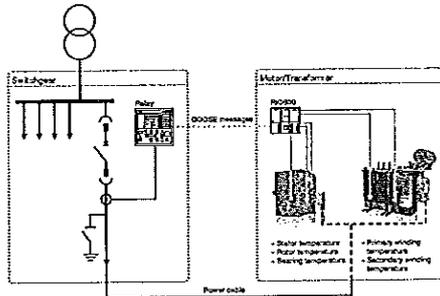


Figure 10. Temperature measurement using RIO600

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.

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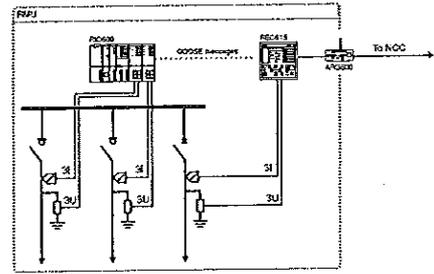


Figure 11. RMU for A passage indication using RIO600

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 (z/o-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 asset management purposes.

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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 61850-9-1 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 10 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 CAT5a 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 COM600 and a Web browser over the same communication bus.

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6. Technical data

Table 4. Module weights

Description	Value
PSM/PSML	235 g
LECM	123 g
DM8H/DM8L	275 g
DO4	163 g
DO4	229 g
AO4	259 g
SM1F	182 g
SOV8H/SOVS8L	215 g

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

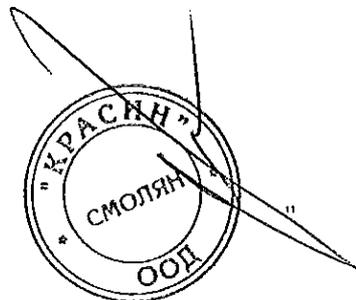
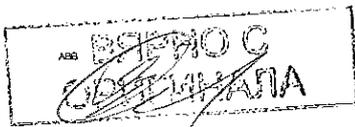
Description	Value
Width	4,5 mm (To be fixed at the ends of assembled modules)

Table 6. Power supply

Description	PSM/PSML	PSML
U _{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz 110, 120, 220, 250 V DC	24, 30, 48, 60 V DC
U _{aux} variation	85...115% of U _{aux} nominal (85...254 V AC) 80...125% of U _{aux} nominal (80...320 V DC)	50...120% of U _{aux} nominal (12...72 V DC)
Start-up threshold		19.2 V DC (24 V DC ± 6%)
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 cycle for each polarity	
Burden of auxiliary voltage supply		
• Quiescent (P _q) condition (none of the 20 I/O channels are activated)		<4.0 W nominal
• Operating condition (20 binary output channels in DO4 modules are activated)		<12.0 W (maximum)
Module configuration	Condition	Max. consumption for PSM and PSML
PSM + LECM + DM8H	All DIs activated	2 W
PSM + LECM + DM8L	All DIs activated	4 W
PSM + LECM + DO4	All DOs activated	12 W
PSM (2) + LECM + DM8H (5)	All DIs activated	11 W
PSM (2) + LECM + DM8L (5)	All DIs activated	11 W
PSM (2) + LECM + DO4 (10)	All DOs activated	22 W

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Table 7. Binary inputs

Description	DSMH	DSML
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...395 mW	33...133 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 DDM)

Description	Value
Operating time	<5 ms
Non-fault 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 48/112/220 V DC	1 A/0.25 A/0.15 A

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Table 9. m-ARTD Input (RTD module)

Description	Value		
RTD inputs	Supported RTD sensors	100 Ω platinum 250 Ω platinum 100 Ω nickel 100 Ω nickel 100 Ω nickel 120 Ω nickel 250 Ω nickel	TCR 0.00385 (DIN 43760) TCR 0.00385 TCR 0.00518 (DIN 43760) TCR 0.00518 TCR 0.00518 TCR 0.00518
	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
		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
	Isolation	4 kV	

Table 10. Analog output module (AOM)

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

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Table 11. Sensor input module (SIM)

Description	Value	
Preferred ABB sensors	Combined sensors KEYCY 24 FE1, KEYCY36 FE1, KEYCY 43.5 FE1, KEYCY A Combination of current sensor KECA 85 C85 or KECA D85 and voltage sensor KEVA 24 C10, 24 C21, 24 C22, 24 C23, 17.5 B23, 17.5 B24, B23, or 24 B21	
Current measurement	Range	4...8000 A
	Accuracy	±5% or ±1 A in the range of 4...80 A ±1% in the range of 80...4800 A ±1.5% in the range of 4800...8000 A
Line voltage measurement	Range	480 V...68 kV
	Accuracy	±5% in the range of 480...5600 V ±3.5% in the range of 9.8...68 kV
Power measurements: P, Q, S and PF	Range	9.8...28.8 kV 0...800 A
	Accuracy	±1.0% for active power P (±0.5% at +25°C) ±3.0% for reactive Q and apparent power S (±1.1% at +25°C) ±0.03 for power factor ±3.0% for energy
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz, ±0.05 Hz For 60 Hz, ±0.04 Hz
Average operating current, voltage and power	Average operating current, voltage, power as per selection: 3 min/13 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 THD (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: 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 ±1.5% of the set value Voltage: ±1.5% of the set value Phase angle: ±3° Operate time: ±1.0% of the set value or ±20 ms

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Table 11. Sensor input module (SIM), continued

Description	Value	
Non-directional earth-fault detection	Operating range	4...200 A (solidly compensated network) 200...1000 A (solidly grounded low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: I _n ±1.0% 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 (solidly compensated network) 200...1000 A (solidly grounded low impedance network)
	Accuracy	Depending on the nominal frequency of the current measured: I _n ±1.0% 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 external calculator)

Table 12. Binary inputs (Smart control module)

Description	DSMH	DSML
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...395 mW	30...133 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

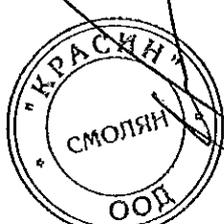
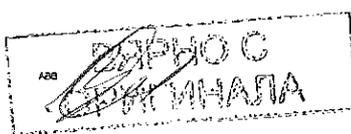
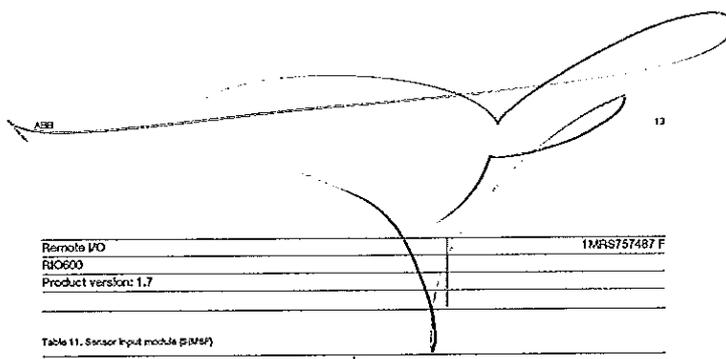
Table 13. High-speed outputs (Smart control module)

Description	DSMH	DSML
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	Wire length	Permitted path attenuation*
RJ-45	Shielded twisted pair cable, at minimum CAT5e	10/100 Mbps/s	30 m	-	-
LC	Multimode OM3/OM4 2.5/125 µm or OM2/125 µm glass fibre core	100 Mbps/s	2 km	1310 nm	±0.8

* Maximum allowed attenuation is based on correct pin and cable pairing



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Table 15. Degree of protection by enclosure

Description	Value
Degree of protection	IP20 ¹⁾

1) If a paper label is required, the label when the device is not in IP20 should provide protection IP20X.

Table 16. Environmental conditions

Description	Value
Operating temperature range	-25...+75°C
Relative humidity	<93%
Atmospheric pressure	88...106 kPa
Altitude	up to 2029 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 bush-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 C37.50-2005
Power consumption of auxiliary supply		IEC 60255-1 and IEEE C37.50-2005
• Quiescent load	<4 W	
• Maximum load	<12 W	
Reversal of DC power supply polarity	1 minute for each polarity	IEC 60255-27
Start-up time test	<30 s	

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Table 20. Contact tests

Description	Type test value	Reference
Make and carry	Signaling contacts • 5 A, continuous • 15 A for 3 s • 15 A for 0.5 s	IEC 60255-1, IEC 61810-1 and IEEE C37.50-2005
Carrying capacity for DC, LR, 510 ma	Signaling contacts • 48 V, 1.00 A • 112 V, 0.25 A • 220 V, 0.15 A	IEC 60255-1, IEC 61810-1 and IEEE C37.50-2005
Mechanical durability	10000 operations	IEC 60255-1, IEC 61810-1 and IEEE C37.50-2005

Table 21. Insulation tests

Description ¹⁾	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min 550 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 C37.50-2005
Impulse voltage tests	5 kV, 1.0/50 µs, 0.5 J	IEC 60255-27 and IEEE C37.50-2005
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27

1) Insulation tests are not applicable to SP-07

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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, 1800 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; 8.6118 µs Tr/Tf; 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...60 MHz; 10 V (arcsin, RMS); 80% AM (1 MHz); 150 Ω source impedance 27 and 65 MHz (spot frequencies); 12 V (arcsin, RMS); 80% AM (1 MHz); 150 Ω source impedance	IEC 60255-26 and IEC 61000-4-4, Level 3
Fast low-energy transient (FFT) (including functional earth port)	5/50 ns Tr/Tf; 5 kHz repetition frequency 4 kV (peak) for power supply input/output ports and 2 kV (peak) for communication ports	IEC 60255-26 and IEC 61000-4-4
Damped oscillatory waves (PDF) 100 kHz and 1 MHz burst	120 kHz and 1 MHz frequency; 75 ns Tr; 40 Hz and 600 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/Tf (open circuit) 8/20 µs Tr/Tf (short circuit)	IEC 60255-26 and IEC 61000-4-5
• Auxiliary power supply and input/output ports ¹⁾	24 kVp (L-Gnd) 22 kVp (L-L)	
• Communication port	42 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)	33% reduction for 25/33 cycles 60% reduction for 15/12 cycles 100% reduction for 0.5, 1.0, 2.5 and 5.0 cycles 100% reduction for 25/33 cycles	IEC 60255-26 and IEC 61000-4-11
Voltage dips, supply interruption and voltage variations on DC input power port (immunity tests)	33% 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 61000-4-23
Ripple voltage	15% U _n frequencies of ripple 100/120 Hz (for 50/60 Hz)	IEC 60255-26, IEC 61000-4-17 and IEEE C37.50-2005
Gradual shut-down/start-up time 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	

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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) 120 Ω coupling resistor 0.17 µF coupling capacitor	
Emission tests		IEC 60255-26
• 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 <68 dB (µV) average	
0.5...30 MHz	<79 dB (µV) quasi-peak <69 dB (µV) average	

1) If the I/O is employed as a general I/O, the limit applies to all I/Os, not all I/Os.

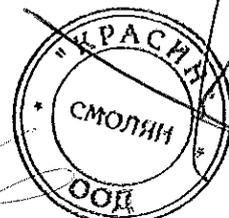
Table 23. Electromagnetic compatibility and immunity tests as per ANSI standards

Description	Type test value	Reference
1 MHz oscillatory SWC test	All ports: 42.5 kV common mode/differential mode	IEEE C37.50.1-2002
Fast transient SWC test	All ports: 45 kV common mode/differential mode	IEEE C37.50.1-2002
Radio frequency interference tests	20 V/m (prior to modulation) f = 80...1000 MHz (AM) f = 900 MHz (FM)	IEEE C37.50.3-2004
Electrostatic discharge test	±15 kV air discharge	IEEE C37.50.3-2001

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Remote I/O	1MRS767487 F
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RIC600	
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Table 24. Mechanical tests

Description	Type test value	Reference
Vibration tests (Inrush)	Class 1	IEC 60255-21-1
• Vibration response test	f = 13...150 Hz Peak acceleration: 0.5 g 1 sweep cycle in each axis	
• Vibration endurance test	f = 13...150 Hz Peak acceleration: 1.0 g 23 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 with standing 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: 15 ms Number of pulses in each direction: 1500	
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 27. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +75°C	IEC 60068-2-2 and IEEE C37.50-2005
Dry cold test	• 96 h at -25°C • 18 h at -40°C	IEC 60068-2-1 and IEEE C37.50-2005
Damp heat cyclic test	• 6 cycles (12h + 12h) at +25...+55°C, humidity >85%	IEC 60068-2-30
Damp heat steady state test	• Temperature 40°C • Humidity 93% • Duration 96 h	IEC 60068-2-78 and IEEE C37.50-2005
Change of temperature test	• 5 cycles (3 h + 3 h) at -25...+55°C	IEC 60068-2-14
Storage test	• 96 h at -40°C • 96 h at +55°C	IEC 60068-2-1, IEC 60068-2-2 and IEEE C37.50-2005

Table 26. EMC compliance

Description	Reference
EMO directive	2004/113/EC
Standard	EN 50283 (2003) EN 60255-24 (2007)

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RIC600	
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Functions available in SIM2F

Table 28. Functions available in SIM2F

Function	IEC 61850		IEC 60817	IEC-ANSI
	Edition 1	Edition 2		
Measurement functions				
Three-phase current measurement	CMXDU	CMXDU	3I	3I
Three-phase voltage measurement	VMXDU	VMXDU	3U	3U
Residual current measurement	RESCMXDU	RESCMXDU	I ₀	I ₀
Residual voltage measurement	RESVMXDU	RESVMXDU	U ₀	U ₀
Three-phase power and energy measurement	PEMXDU	PEMXDU	P	P
Three-phase power direction	PWRPDR	PWRPDR	-	-
Energy monitoring	EMXTR	EMXTR	E	E
Current, voltage and power average and peak measurement	CVSTA	CAVMXDU CMXMXDU PCAVMXDU	-	-
	VMSTA	VAVMXDU VMXMXDU	-	-
	PEMSTA	PEAVMXDU PEMXMXDU	-	-

Power quality measurement functions (harmonics)

Current total demand distortion monitoring	CMTH	CMTH	PCM3	PCM3
Voltage total demand distortion monitoring	VMTH	VMTH	PCM3U	PCM3V
Detection and indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3P	3IP
Three-phase directional overcurrent fault detection	DHPTOC	DHPTOC	3P->	3IP
Non-directional earth-fault fault detection	EPFTOC	EPFTOC	3P	3IN
Directional earth-fault fault detection	DEFTOC	DEFTOC	3P->	3IN
Multi-frequency admittance-based earth-fault indication	MFAPSD	MFAPSD	3P->Y	3IN
Voltage presence indication	PHSVPR	PHSVPR	PHSVPR	PHSVPR

Table 29. CMXDU Technical data

Characteristics	Value
Operation accuracy	At frequency f = 50 ±5% at 1 A in the range of 4...83 A ±1% in the range of 80...480 A ±10% in the range of 480...800 A
Suppression of harmonics	RMS: No suppression

Table 30. VMXDU Technical data

Characteristics	Value
Operation accuracy	At frequency f = 50 ±5% in the range of 450 V...9.8 kV ±0.5% in the range of 9.8...28.8 kV ±1% in the range of 28.8...48 kV
Suppression of harmonics	RMS: No suppression

Table 31. RESCMXDU Technical data

Characteristics	Value
Operation accuracy	At frequency f = 50 ±5.0% (when all three phase currents in the range of 80...830 A)
Suppression of harmonics	RMS: No suppression

Table 32. RESVMXDU Technical data

Characteristics	Value
Operation accuracy	At frequency f = 50 ±5.0% (when all three voltages are in the range of 9.8...14.4 kV or 19.2...28.8 kV)
Suppression of harmonics	RMS: No suppression

Table 33. PEMXDU Technical data

Characteristics	Value
Operation accuracy	At frequency f = 50 All three voltages in range of 9.8...14.4 kV or 19.2...28.8 kV All three current in range of 80...830 A Active power and energy in range PFI > 0.31 (Reactive power and energy in range PFI < 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

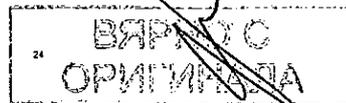
Table 34. EMXTR Technical data

Characteristics	Value
Operation accuracy	At frequency f = 50 All three voltages in range of 9.8...14.4 kV or 19.2...28.8 kV All three current in range of 80...830 A Active power and energy in range PFI > 0.71 Reactive power and energy in range PFI < 0.71 ±3.0% for energy
Suppression of harmonics	RMS: No suppression

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Remote I/O	1MRS757487 F
RI0600	
Product version: 1.7	

Table 35, PIPT00 Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_0$, ±1.5% of the set value
Operate time accuracy (DMT)	±1.0% of the set value or ±20 ms

Table 36, OPHPT00 Technical data

Characteristics	Value
Operation accuracy	Depending on the nominal frequency of the current measured: $f = f_0$, 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, EFPT00 Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_0$, ±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, DEFP00 Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_0$, 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, MFAPSDC Technical data

Characteristics	Value
Operation accuracy	At frequency $f = f_0$, ±5% in the range of 480 V...3.8 kV ±0.5% in the range of 3.8...38.8 kV
Operate time accuracy	±1.0% of the set value or ±50 ms

Table 40, PHSYPR Technical data

Characteristics	Value
Operation accuracy	At frequency $f = f_0$, ±5% in the range of 450 V...8.8 kV ±3.5% in the range of 8.8...24.8 kV

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Remote I/O	1MRS757487 F
RI0600	
Product version: 1.7	

7. Module dimensions

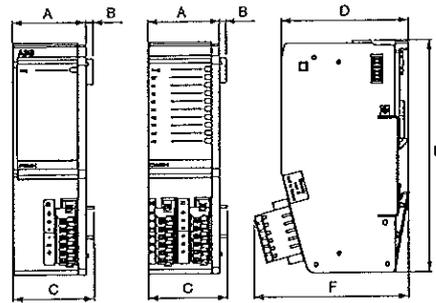


Figure 12. Dimension and mounting details of the PSM/PSM-DV-B/COM/URT-D/COM/SCMB/SCMSL modules

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

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Remote I/O	1MRS757487 F
RI0600	
Product version: 1.7	

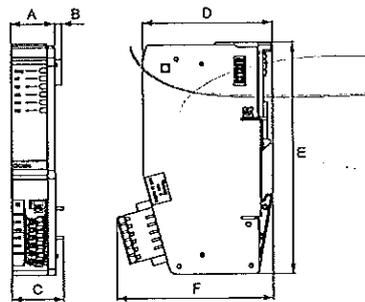


Figure 13. Dimension and mounting details of the digital output module DOME

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

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Remote I/O	1MRS757487 F
RI0600	
Product version: 1.7	

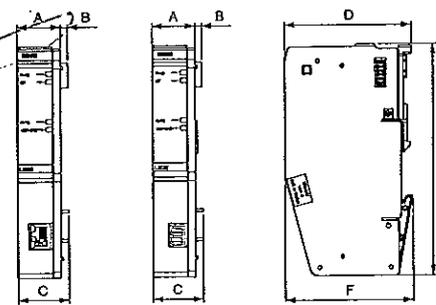


Figure 14. Dimension and mounting details of the communication module LECH

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

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

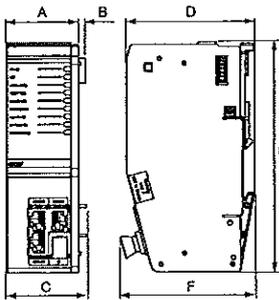


Figure 15. Dimension and mounting details of the RIO600 module

- A 45 mm
- B 4.25 mm
- C 51 mm
- D 81 mm
- E 145.5 mm
- F 85 mm

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

8. Assembly diagram

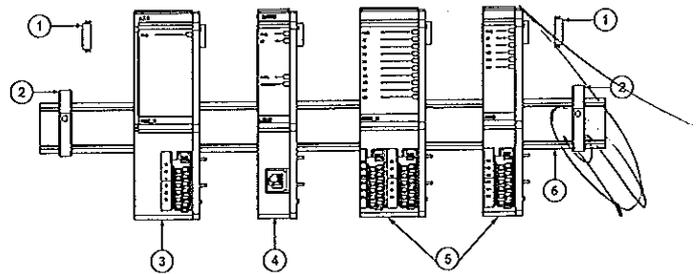


Figure 16. Assembly drawings of RIO600 modules

- 1 Rubber cap
- 2 End clamp
- 3 PSM module
- 4 LEM module
- 5 Modules (M, M, D, M, R, T, D, A, O, M, A, S, M, F, S, M, B, S, C, M, S, L)
- 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 Wedmufar part EW 35, which is 8.5 mm wide.

Remote I/O	1MRS757487 F
RIO600	
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9. Ordering data

Table 41. Ordering details for RIO600 modules

Item	Order number
Digital input module with 8 inputs, high-voltage power supply	MO0600AD82H
Digital input module with 8 inputs, low-voltage power supply	MO0600AD7H1L
Digital output module with 4 outputs	MO0600AD04H4R
RTD/A input module with 4 inputs	MO0600ARTD4
Analog output module with 4 outputs	MO0600AOM4
Sensor input module	MO0600ASMSF
Smart control module with 4 inputs and 4 high-speed outputs, high-voltage power supply	MO0600ASCMSH
Smart control module with 4 inputs and 4 high-speed outputs, low-voltage power supply	MO0600ASCMSL
High-power supply module	MO0600APSMH07
Low-power supply module	MO0600APSMLO7
Communication module with RJ-45 port	MO0600FLECMGR
Communication module with multimode fiber-optic LC port	MO0600FLECMFO

Remote I/O	1MRS757487 F
RIO600	
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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 configured 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

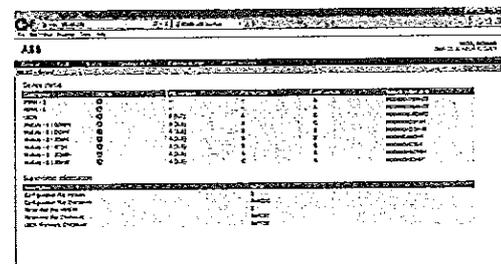
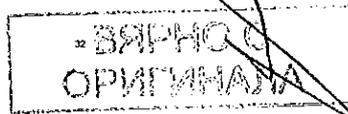


Figure 17. General view of RIO600 Web HMI



11. Connection and terminal diagrams

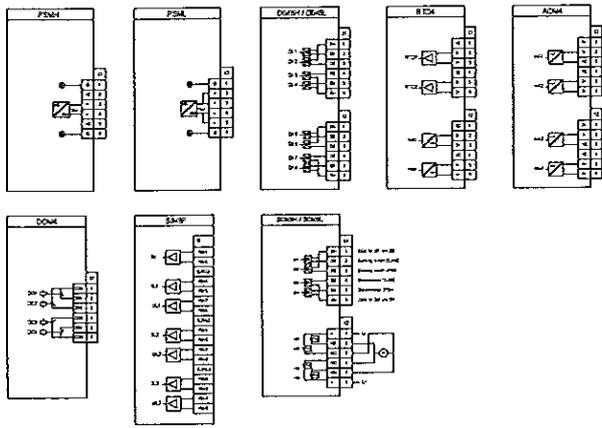
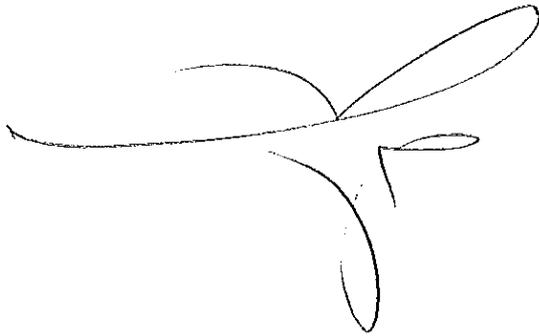


Figure 11. Connection and terminal diagram of RIO600 modules

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/2013-03-25	1.2	Content updated
D/2014-09-23	1.5	Content updated
E/2015-08-31	1.8	Content updated
F/2016-05-09	1.7	Content updated



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ВЕРНО С
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Power and productivity
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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 Kortensniemi
Checked by Asko Koironen

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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
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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:

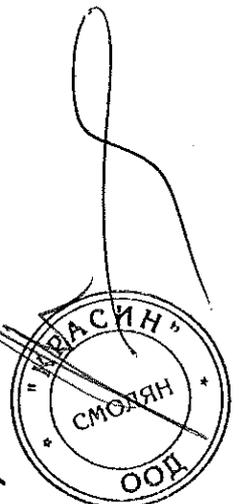
Antti Hakala-Ranta, SVP Medium Voltage Products



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Distribution Automation
P.O. Box 699, FI-65101 Vaasa, FINLAND
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ВЯРНО С
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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
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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

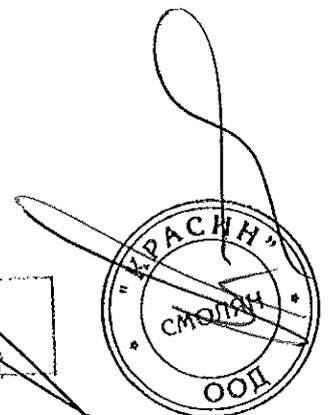
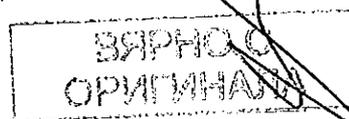
Signed by:

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

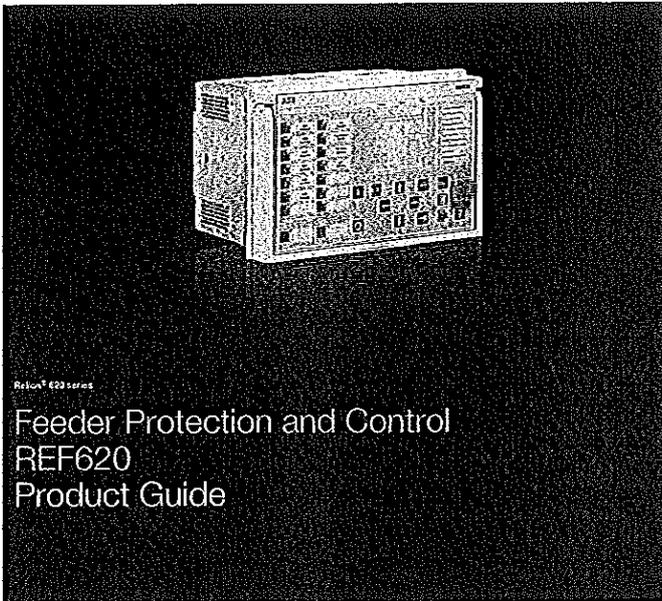


Техническа документация

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 „Секционирание“ 110 kV:

- Приложение № 7.1. към т.15.7.1. от Техническото предложение – Последно издание на каталога на производителя.

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Power and productivity
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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 (the 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 Edcon 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 PCAM000. Furthermore, the application configuration functionality of PCAM000 supports the creation of multi-layer logic functions using various logical elements, including timers and trip-stops. 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

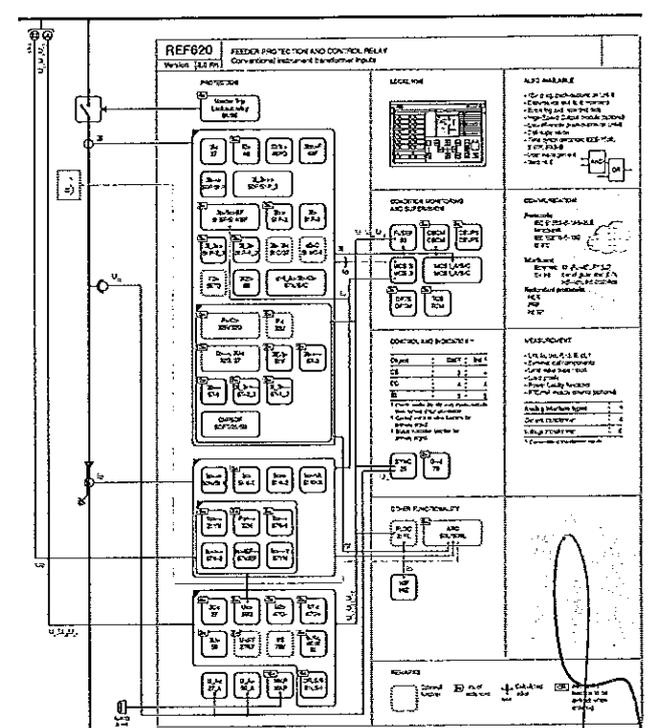
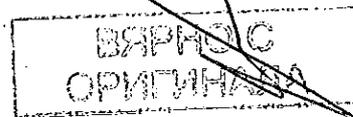


Figure 1. Functionality overview of default configuration with conventional transformer busformer inputs



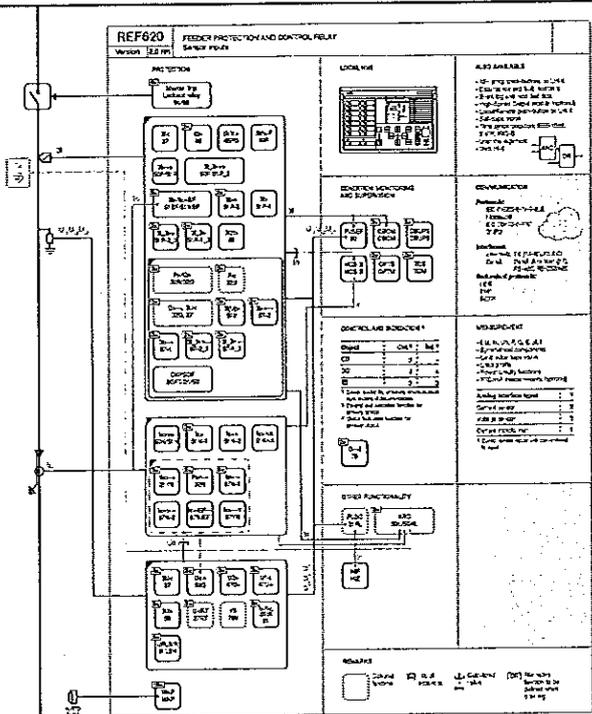


Figure 2. Functionality overview of default configuration with sensor inputs

Table 1. Supported functions

Function	IEO #1850	A (DTs/VTr)	B (Sensors)
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1
Three-phase non-directional overcurrent protection, high stage	PHRPTOC	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	PHPTOC	1	1
Three-phase directional overcurrent protection, low stage	DPHLPTOC	2	2
Three-phase directional overcurrent protection, high stage	DPHRPTOC	2	2
Three-phase voltage-dependent overcurrent protection	PHVPTOC	2	2
Non-directional earth-fault protection, low stage	ELFPTOC	2	2
Non-directional earth-fault protection, high stage	EHFPTOC	1	1
Non-directional earth-fault protection, instantaneous stage	EFPTOC1	1	1
Directional earth-fault protection, low stage	DELPTOC	3	3 ¹⁾
Directional earth-fault protection, high stage	DEHPTOC	1	1 ¹⁾
Admittance-based earth-fault protection	EFFADM	3	3 ¹⁾
Wattmeter-based earth-fault protection	WPTWDE	3	3 ¹⁾
Multi-frequency admittance-based earth-fault protection	MFADPDE	1	1 ¹⁾
Transient-intermittent earth-fault protection	TRTPTIEF	1	1 ¹⁾
Harmonics-based earth-fault protection	HAEPTOC	1	1
Negative-sequence overcurrent protection	NSPTOC	2	2
Phase discontinuity protection	PDNSPTOC	1	1
Residual overvoltage protection	RDPVTOV	3	3 ¹⁾
Three-phase undervoltage protection	PHPTUV	4	4
Single-phase undervoltage protection, secondary side	PH1PTUV	1	1
Three-phase overvoltage protection	PHPTOV	3	3
Single-phase overvoltage protection, secondary side	PH1PTOV	1	1
Positive-sequence undervoltage protection	PSPTUV	2	2
Negative-sequence overvoltage protection	NSPTOV	2	2
Frequency protection	FRFPFRQ	6	6
Three-phase thermal protection for feeders, cables and distribution transformers	THPTTR	1	1
Loss of phase (undercurrent)	PHPTUC	1	1
Circuit breaker failure protection	CCBSRFP	3	3
Three-phase inrush detector	INRPHUR	1	1
Master trip	TRPTTRC	4	4
Arc protection	ARCSDPPC	(1)	(1)
High-impedance fault detection	PHZ	1	1
Load-shedding and restoration	LSDHDFRQ	6	6
Multipurpose protection	MVAPPC	18	18

Table 1. Supported functions, continued

Function	IEO #1850	A (DTs/VTr)	B (Sensors)
Automatic switch-to-fault logs (SOF)	CYPSOF	1	1
Voltage vector shift protection	VVSPPAM	(1)	(1)
Directional reactive power undervoltage protection	DQPTUV	(2)	(2)
Underpower protection	DUPPPDR	(2)	(2)
Reversal power/directional overpower protection	DORPPDR	(2)	(2)
Low-voltage ride-through protection	LVKPTUV	(3)	(3)
High-impedance differential protection for phase A	HAPDF	1	1
High-impedance differential protection for phase B	HBPDF	1	1
High-impedance differential protection for phase C	HCPDF	1	1
Circuit breaker uncorresponding position start-up	UPCALH	3	3
Three-independent-phase non-directional overcurrent protection, low stage	PHLPTOC	2	2
Three-independent-phase non-directional overcurrent protection, high stage	PHRPTOC	2	2
Three-independent-phase non-directional overcurrent protection, instantaneous stage	PHPTOC	1	1
Directional three-independent-phase directional overcurrent protection, low stage	DPHLPTOC	3	3
Directional three-independent-phase directional overcurrent protection, high stage	DPHRPTOC	3	3
Three-phase overload protection for shunt capacitor banks	COLPTOC	(1)	(1)
Current unbalance protection for shunt capacitor banks	CURPTOC	(1)	(1)
Shunt capacitor bank switching resonance protection, current based	SRCPPTOC	(1)	(1)
Control			
Circuit-breaker control	CBXCBR	3	3
Disconnecter control	DCXSW	4	4
Earthing switch control	ESXSW	3	3
Disconnecter position indication	OCSXSW	4	4
Earthing switch indication	ESXSWI	3	3
Auto-reclosing	DARFRC	2	2
Synchronism and energizing check	SECRSYN	1	1 ¹⁾
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SACBR	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	HZCCASPV	1	1
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPV	1	1

Table 1. Supported functions, continued

Function	IEO #1850	A (DTs/VTr)	B (Sensors)
Current transformer supervision for high-impedance protection scheme for phase C	HZCCASPVC	1	1
Fuse failure supervision	SEOSPV	1	1
Runtime counter for machines and devices	MDSOPT	2	2
Measurement			
Three-phase current measurement	CV3AKU	3	3
Sequence current measurement	CSMSQI	1	1
Residual current measurement	RESOMOU	1	1
Three-phase voltage measurement	V3AKU	1	1
Single-phase voltage measurement	V1AKU	1	1 ¹⁾
Residual voltage measurement	RESVMOU	1	1
Sequence voltage measurement	VSMQI	1	1
Three-phase power and energy measurement	PE3MOU	1	1
Load profile record	LDRPLRC	1	1
Frequency measurement	FR3AKU	1	1
Fault location			
Fault locator	SCFFFLD	(1)	(1)
Power quality			
Current total demand distortion	CVTHZ	1	1
Voltage total harmonic distortion	VVTHZ	1	1
Voltage sags	PHOVSR	1	1
Voltage unbalance	VSVSUB	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	4	4
Time delay off (8 pcs)	TONGAPC	4	4
Time delay on (8 pcs)	TORGAPC	4	4
Sel/reset (8 pcs)	SRGAPC	4	4
Move (8 pcs)	MVGAPC	4	4
Integer value move	MOVGAPC	4	4
Analog value setting	SCAAGAPC	4	4
Generic control point (8 pcs)	SPGAPC	3	3
Reserved generic control points	SPRGAPC	1	1
Local generic control points	SPLCGAPC	1	1
Generic up-down counter	UDCNT	12	12

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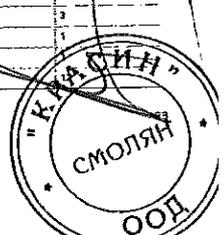


Table 1. Supported functions, continued

Function	IED #1650	A (CTs/VTs)	B (Sensors)
Programmable buttons (18 buttons)	FKEYG00	1	1
Logging functions			
Disturbance recorder	PDRE	1	1
Fault recorder	FILTRFRD	1	1
Sequence event recorder	SER	1	1

F1... = Number of IED1650 instances. The instances of a protection function represent the number of identical protection function blocks available in the standard configuration.
0 = optional

1. Use as indicated from the measured values (I, U, P, Q)
2. Available only with IED 11000-0-11E

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 admittance-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 detection also during intermittent/straggling 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 straggling 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 (DQ) 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 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...8 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 interconnection communication facilities, the relay can also be applied for protecting ring type and meshed distribution networks as well as radial networks.

The relay offers extensive possibilities to tailor the configurations to application requirements. This tool suits for all Reson relays in Protection and Control IED Manager POC600, which contains all the necessary tools for configuring the device, including functionality, parameterization, the HMI and communication.

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 RIO500 Remote I/O device.

REF620 is an ideal protection and control relay for more advanced feeder schemes. To further improve the arc protection option 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 0.1 ms period.

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

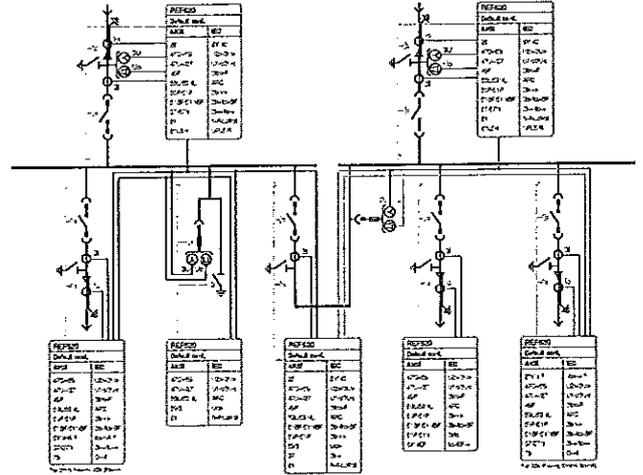


Figure 3. Single busbar AIS 2 section switchgear with conventional featured transformers

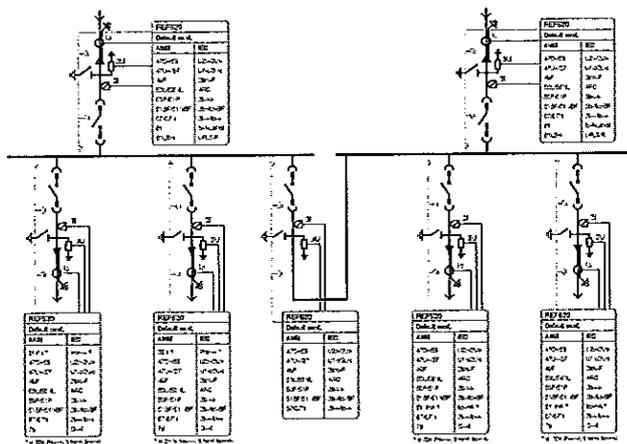


Figure 4. Single busbar AIS switchgear 2 section with sensors

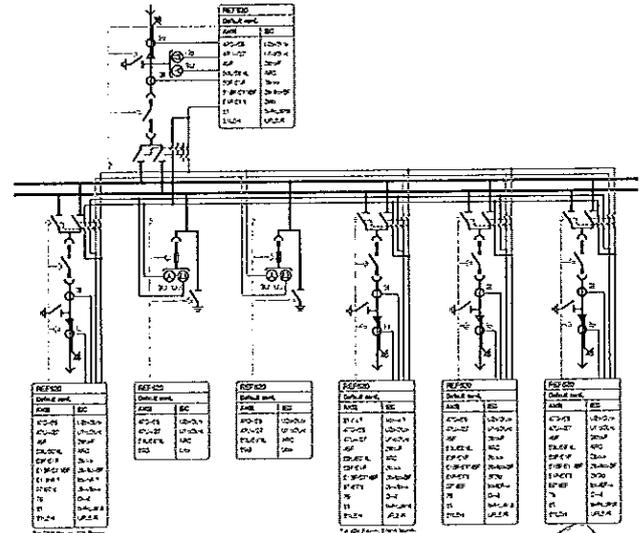


Figure 5. DBB AIS system with one incoming only (with some arrangements simplified)

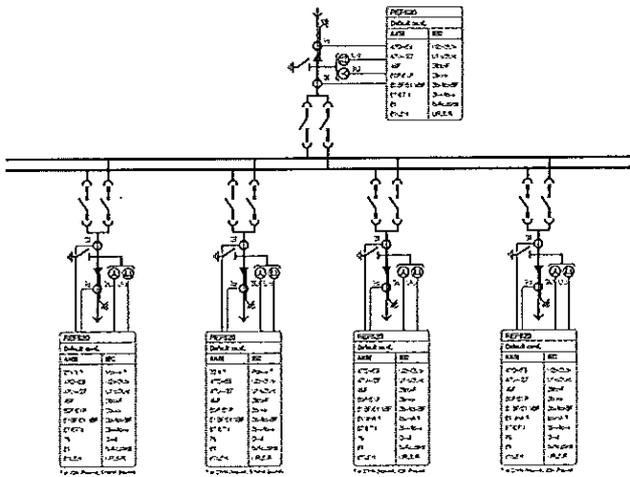


Figure 6. Back-to-back arrangement of AIS switchgear (two single-busbar panels with back walls facing each other), with two circuit breakers and a higher number of disconnectors available. A type of DBB system.

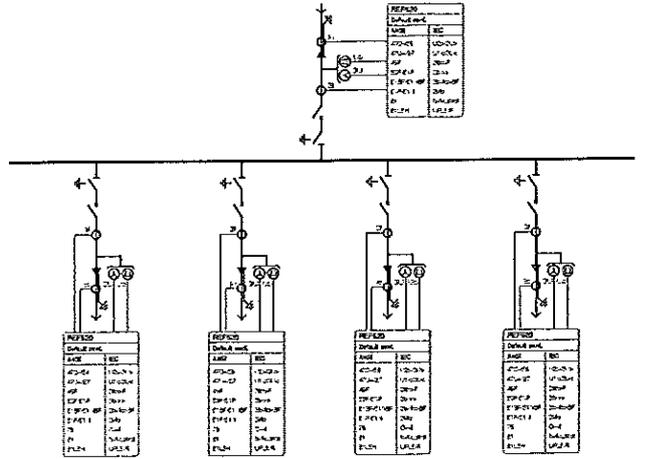


Figure 7. SBB GIS switchgear with the possibility to control the three-position disconnector switch.

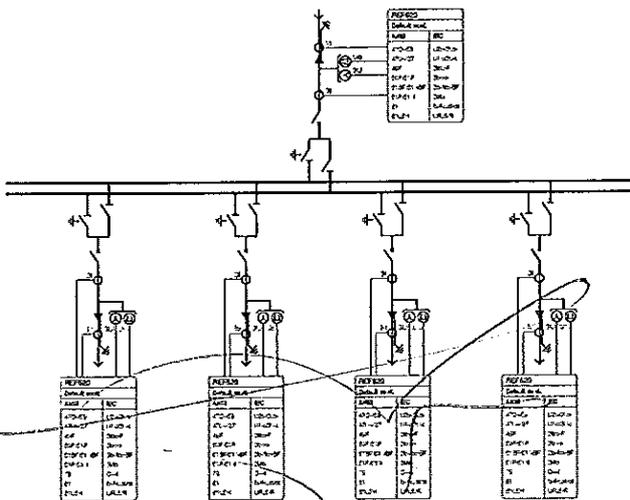


Figure 8. DBB GIS switchgear with the possibility to control the three-position disconnector switch.

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, multiple differential protection schemes can also be created. The relay includes an optional protection

packages 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.

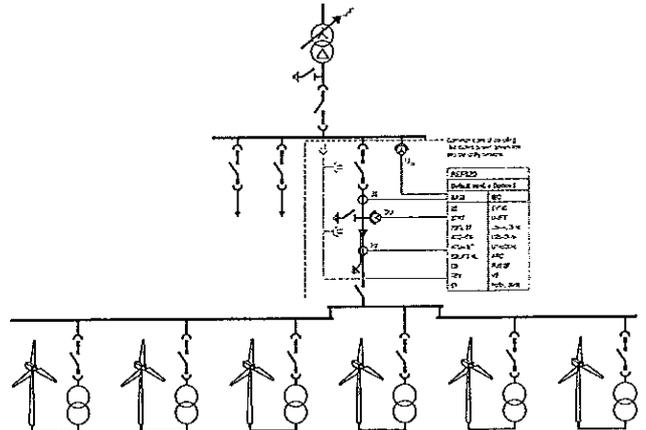


Figure 9. Application example of wind power plant as distributed power generation coupled into the utility network.

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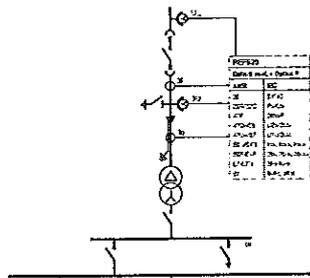


Figure 10. Application example of solar power plant as distributed power generation coupled into the utility network

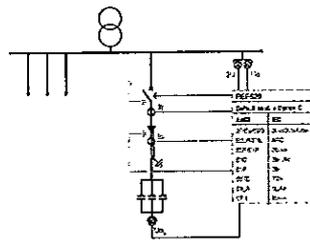


Figure 11. Protection of a single star connected capacitor bank

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 COM600 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 processes easily accessible. Substation devices and data 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 (E650n 2)
MicroSCADA Pro SYS E60	9.3 FP2 or later 9.4 or later (E650n 2)
System 800xA	6.1 or later

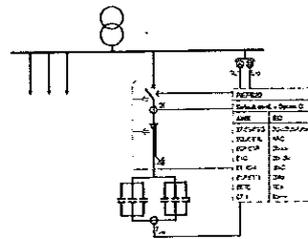


Figure 12. Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral

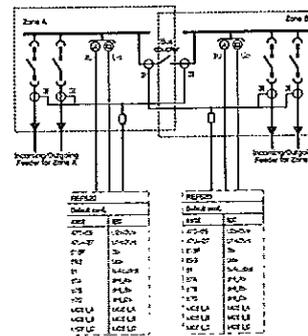


Figure 13. Application example of busbar differential protection serving two zones

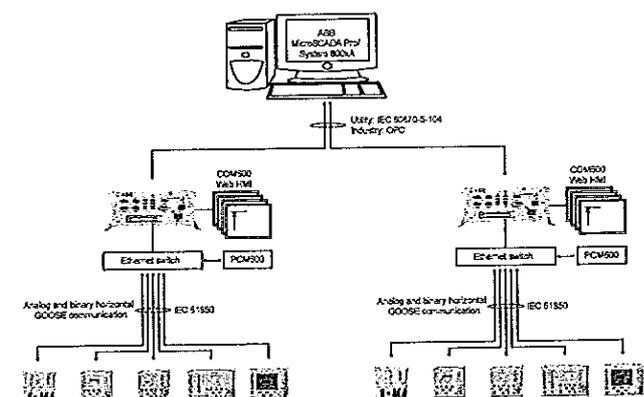


Figure 14. ABB power system example using Ref620 relays, Substation Management Unit COM600 and MicroSCADA Pro System 800xA

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.

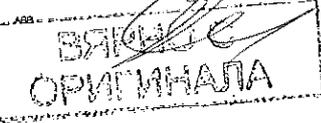
Two physical binary inputs and two physical binary outputs are needed in the relay for each controlled primary device taken into use. Depending on the chosen hardware configuration of the relay, the number of binary inputs and binary outputs varies. In case the amount of available binary inputs or outputs of the chosen hardware configuration is not sufficient, connecting an external input or output module, for example ROC900, 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 reusing 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 by 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 synchro-check 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. The synchro-check function can also be used with default configuration B when 0-2 access bus



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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 protection 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 interfaces 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 provide 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 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.

conventional microcircuit 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 PC1600.

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 an external input or output module, for example RIO600, increases the number of binary inputs and outputs usable 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 PC1600 tool and then utilized in the relay configuration.

11. Event log

To collect sequence-of-events information, the relay has a non-volatile memory with a capacity of storing 1024 events with an associated time stamp. 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 interfaces 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 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 periodically 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 PC1600.

19. Inputs and outputs

REF620 can be selected to measure currents and voltages either with conventional current transformers and voltage transformers or with current sensors and voltage sensors. The relay variant equipped with current and voltage sensors is provided with three phase current inputs, one residual-current input, three phase voltage inputs, one residual-voltage input and one phase-to-phase voltage for synchrocheck 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 0.02/1 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 adaptors. Furthermore, the adaptors 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 18 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, such as 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 temperature, pressure, inlets 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 microcircuit 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 PC1600.

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 an external input or output module, for example RIO600, increases the number of binary inputs and outputs usable 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 PC1600 tool and then utilized in the relay configuration.

Table 3. Input/output overview

Default conf.	Order code digit		Analog channels		Binary channels				
	6-6	7-6	CT	VT	Comb sensor	BI	BO	RTD	MA
A	AA/AS	AA	4	5	-	32	4 PO + 14 SO	-	-
		AB				24	4 PO + 10 SO		
		AC				32	4 PO + 10 SO + 3 HSO		
		NN				24	4 PO + 10 SO		
B	AC	AA	3	-	-	24	4 PO + 14 SO	-	-
		AB				16	4 PO + 10 SO		
		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 61850-9-2LE, IEC 60870-5-103, Modbus[®] and DNP3. Profibus DPV1 communication protocol is supported with using the protocol converter SPA-Z0302. 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 the 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-S-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 RamoVal 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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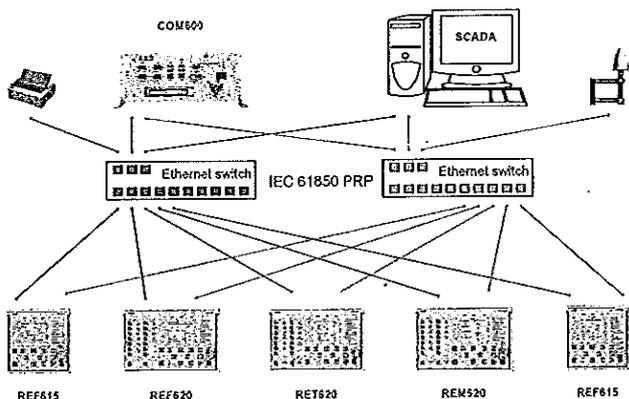


Figure 15. Parallel redundancy protocol (PRP) solution

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 frame 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.

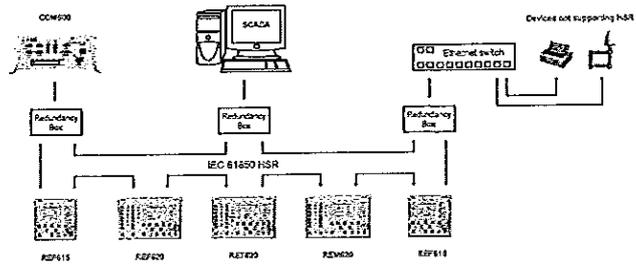


Figure 16. High availability seamless redundancy (HSR) solution

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 I 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.

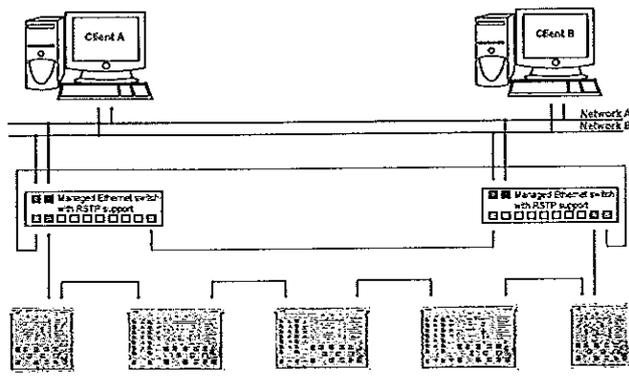
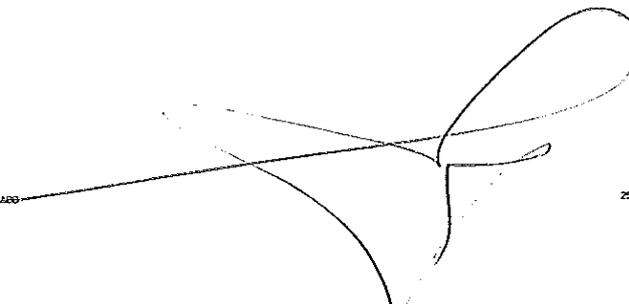


Figure 17. Self-healing Ethernet ring solution

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-TD) 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 testing 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

- 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 BMG 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.

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

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

Interface/Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/RS-485	Fiber-optic ST
IEC 61850-S-1	*	*	*	*
IEC 61850-S-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 232.2 mm Case 243 mm
Height	Frame 177 mm, 40 Case 150 mm
Depth	201 mm
Weight	Complete protection relay max. 5.9 kg Plug-in unit only max. 2.9 kg

Table 6. Power supply

Description	Type 1	Type 2
U _{aux} nominal	150, 110, 125, 220, 250 V AC, 50 and 60 Hz 48, 63, 110, 115, 220, 250 V DC	24, 30, 48, 60 V DC
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U ₁ , min	
U _{aux} variation	34...115% of U ₁ (34...264 V AC) 80...120% of U ₁ (84...300 V DC)	50...120% of U ₁ (12...72 V DC)
Startup threshold		13.2 V DC (24 V DC + 45%)
Burden of auxiliary voltage supply under quiescent (P ₀) operating condition	DC <18.0 W (nominal)* <22.5 W (max)* AC <19.0 W (nominal)* <23.0 W (max)*	DC <18.5 W (nominal)* <22.5 W (max)*
Flays in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	TAA/250 V	

*) During the power consumption measurement the temperature of the relay is maintained at 25°C. The maximum power consumption is measured at the maximum rated voltage and the maximum ambient and storage temperature. The maximum power consumption is measured at the maximum rated voltage and the maximum ambient and storage temperature. The maximum power consumption is measured at the maximum rated voltage and the maximum ambient and storage temperature.

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Table 7. Energizing inputs

Description	Value
Rated frequency	50/60 Hz
Current inputs	Rated current I _n 0.21 A ¹⁾ 1.5 A ²⁾
Thermal withstand capability:	
• Continuously	4 A 20 A
• For 1 s	120 A 500 A
Dynamic current withstand:	
• Reference value	250 A 1250 A
Input impedance	<100 mΩ <20 mΩ
Rated voltage	60...210 V AC
Voltage inputs	
Voltage withstand:	
• Continuous	245 V AC 360 V AC
• For 10 s	360 V AC
Burden at rated voltage	<0.05 VA

1) Drawing shows for nominal current input
2) Full-scale current with phase current

Table 8. Energizing inputs (person)

Description	Value
Current sensor input	Rated current voltage (in secondary side) 75...500 mV ¹⁾
Continuous voltage withstand	125 V
Input impedance at 50/60 Hz	2...3 MΩ ²⁾
Voltage sensor input	Rated voltage 6...30 V ³⁾
Continuous voltage withstand	50 V
Input impedance at 50/60 Hz	3 MΩ

1) Scale the current range of AC 300 A with 22.5 A, 200 V AC with 15 V
2) Depending on the used external hardware part
3) The range is 120 V to 2.4 V rated with sensor burden rate 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	1.4...1.9 mA
Power consumption	31.0...370.0 mW
Threshold voltage	15...178 V DC
Reaction time	<4 ms

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Table 10. RTD/INA 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 0.00518 (DIN 43760) 250 Ω nickel TCR 0.00518 10 Ω copper TCR 0.00418 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 ±2.0% or ±1 Ω Temperature ±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) 4300 FPI
4306, 5011, 5012, when any of the protection relay is equipped with B0006E
4310, 5011, 5012, when REF620 or REF700 is equipped with B0006E
4316, 5011, 5012, when REF620 or REF700 is equipped with B0006E

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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 for 0.5 s	15 A
Breaking capacity when the control-circuit time constant L/R <40 ms, at 45/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	10 mA at 5 V AC/DC

1) 4300 FPI
4306, 5011, 5012, when any of the protection relay is equipped with B0006E
4310, 5011, 5012, when REF620 or REF700 is equipped with B0006E
4316, 5011, 5012, when REF620 or REF700 is equipped with B0006E

Table 13. Double-pole power outputs with TCS function X100: PO0 and PO4

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, at 45/110/220 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...23 V)

1) 4300 FPI, 4306, 5011, 5012, when any of the protection relay is equipped with B0006E, PO4

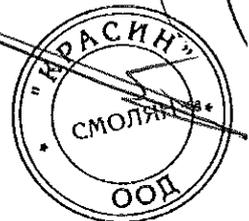
Table 14. Single-pole power output relays X100: PO1 and PO2

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R <40 ms, at 45/110/220 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	253 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 free constant L/R <43 ms, at 42/110/220 V DC	8 A/3 A/1 A
Operate time	<1 ms
Reset	<20 ms, resistive load

1) IEC 60947-1, IEC 60947-2, when used, if the protection relay is connected with IEC 60947-2

Table 16. Front port Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
Front	TCP/IP protocol	Standard Ethernet CAT 5 cable with RJ45 connector	10 Mbit/s

Table 17. Station communication I-2x, fiber optic

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

1) MMF multi-mode fiber, OM3 polychrome fiber
2) At maximum length, depending on the cable dispersion and quality, the amount of signal and crosstalk in the path.
3) At maximum allowed attenuation, taking into consideration and cable to patch

Table 18. IFO-B

Description	Value
IRIG time code format	B004, B006 ¹
Isolation	500 V 1 min
Modulation	Unmodulated
Logic level	5 V TTL
Current consumption	44 mA
Power consumption	<23 mW

1) According to the IFO-B IFO module

Table 19. Lens sensor and optical fiber for fire 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

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Table 20. Degree of protection of 6.3kV-mounted protection relay

Description	Value
Front side	IP 54
Rear side, connection terminals	IP 23

Table 21. Environmental conditions

Description	Value
Operating temperature range	-25...+55°C (continuous)
Short-time service temperature range	-40...+85°C (1 h) ^{1,2}
Relative humidity	<93%, non-condensing
Atmospheric pressure	85...109 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+55°C

1) Operation at MPEF and MFL performance outside the temperature range of -25...+55°C
2) For MFL, it will not be maintained on reaching the maximum level of temperature in °C

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Table 22. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III IEEE C37.90.1-2002
• Common mode	25 kV	
• Differential mode	25 kV	
1 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-13 IEC 60255-29, class III
• Common mode	25 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-27 IEEE C37.90.1-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test		IEC 61000-4-6 IEC 60255-26, class III IEC 61000-4-3 IEC 60255-26, class III EN 50204 IEC 60255-28, class III
• 10 V (rms) f = 150 kHz...80 MHz		
• 10 V (rms) f = 80...2700 MHz		
• 10 V (rms) f = 900 MHz		
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 60255-29
• 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 1000 A/m	
• 1...3 s		
Pulse magnetic field immunity test		IEC 61000-4-9
• 1000 A/m 8.4/16 µs		
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions		IEC 61000-4-11
• 33%/10 ms 63%/100 ms 63%/1000 ms >95%/5000 ms		
Power frequency immunity test		IEC 61000-4-18 IEC 60255-26, class A
• Common mode	300 V rms	

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Table 23. 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 (level 1/10 V rms)	IEC 61000-4-16
Emission tests		EN 50511, class A IEC 60255-23 CISPR 11 CISPR 12
• Conducted		
0.15...0.50 MHz	<78 dB (µV) quasi peak <68 dB (µV) average	
0.5...30 MHz	<73 dB (µV) quasi peak <59 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	<74 dB (µV/m) peak <54 dB (µV/m) average, measured at 3 m distance	
3...6 GHz	<30 dB (µV/m) peak <49 dB (µV/m) average, measured at 3 m distance	

Table 24. 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 25. Mechanical tests

Description	Reference	Requirement
Vibration tests (sinusoidal)	IEC 60255-2-6 (part F) IEC 60255-21-1	Class 2
Shock and bump test	IEC 60255-2-27 (part Es shock) IEC 60255-2-29 (part Es bump) IEC 60255-21-2	Class 2
Salt mist test	IEC 60255-21-3	Class 2

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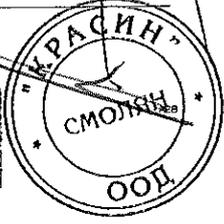


Table 25. Environmental tests

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 (1 h + 1 h) at +25°C...+55°C	IEC 60068-2-14
Storage test	96 h at -40°C 96 h at +85°C	IEC 60068-2-1 IEC 60068-2-2

¹⁾ For tests with an LC construction enhanced the relative humidity 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	Reference
Complies with RoHS directive 2002/95/EC	

Protection functions

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

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current I_m , ± 2 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ PHLPTOC $\pm 1.5\%$ of set value or $\pm 0.002 \times I_n$ PHPTOC and PHEPTOC $\pm 5.0\%$ of the set value (at currents in the range of $0.1...10 \times I_n$) $\pm 5.0\%$ of the set value (at currents in the range of $10...40 \times I_n$)
Start time ¹⁾²⁾	Minimum Typical Maximum PHLPTOC: $I_{set} = 2 \times \text{set Start value}$ $I_{set} = 10 \times \text{set Start value}$ 10 ms 18 ms 23 ms PHPTOC and PHEPTOC: $I_{set} = 2 \times \text{set Start value}$ 11 ms 12 ms 14 ms PHEPTOC and PHLPTOC: $I_{set} = 2 \times \text{set Start value}$ 23 ms 25 ms 29 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁾
Suppression of harmonics	RMS: No suppression DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression P-to-P-backup: No suppression

¹⁾ Set current I_{set} from 0.02 I_n to 10 I_n . Current values $I_{set} < 0.02 I_n$ and $I_{set} > 10 I_n$ are not supported. In definite time mode a default value of 10 ms is used. In inverse time mode a default value of 100 ms is used. In definite time mode a default value of 10 ms is used. In inverse time mode a default value of 100 ms is used.
²⁾ Includes the delay of the signal output contact.
³⁾ Includes the delay of the relay contact.

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

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

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

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

Characteristics	Value
Operation accuracy	Depending on the frequency of the current/voltage measured: f_m , ± 2 Hz DPHLPTOC Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$ DPHLPTOC Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ (at currents in the range of $0.1...10 \times I_n$) $\pm 5.0\%$ of the set value (at currents in the range of $10...40 \times I_n$) Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$
Start time ¹⁾²⁾	Minimum Typical Maximum $I_{set} = 2.0 \times \text{set Start value}$ 30 ms 43 ms 47 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁾
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

¹⁾ Measured time and accuracy, a default current value $I_{set} = 2 \times I_n$, voltage value $U_{set} = 1.0 \times U_n$, $f_m = 50$ Hz. In definite time mode a default value of 10 ms is used. In inverse time mode a default value of 100 ms is used.
²⁾ Includes the delay of the signal output contact.
³⁾ Maximum theoretical value $\pm 2.0 \times I_n$, 200000 ms in the range of 1.5...20

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

Parameter	Function	Value (Range)	Step
Start value	DPHLPTOC	0.05...5.00 $\times I_n$	0.01
	DPHPTOC	0.10...40.00 $\times I_n$	0.01
Time multiplier	DPHLPTOC	0.05...15.00	0.01
	DPHPTOC	40...200000 ms	10
Operating curve type ¹⁾	DPHLPTOC	Define or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHPTOC	Define or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPHLPTOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHLPTOC	-179...181°	

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

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

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_m , ± 2 Hz Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ¹⁾²⁾	Typically 25 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.95
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms
Suppression of harmonics	-50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

¹⁾ Measured time and accuracy, a default current value $I_{set} = 2.0 \times I_n$, $f_m = 50$ Hz. In definite time mode a default value of 10 ms is used. In inverse time mode a default value of 100 ms is used.
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 MUA	PHPVOC	0.8...19.0	0.1
Time multiplier	PHPVOC	0.05...15.00	0.01
Operating curve type ¹⁾	PHPVOC	Defines 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	43...200000 ms	10

¹⁾ For further information, see Selection characteristics table

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

Characteristic	Value	
Operation accuracy	Depending on the frequency of the measured current: I, 52 Hz	
	EFPTOC: ±1.5% of the set value or ±0.002 × I _n	
	EFHPTOC and EFPTOC: ±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	
	EFPTOC: I _{set} × 2 × set Start value	15 ms 19 ms 23 ms
	I _{set} × 10 × set Start value	11 ms 12 ms 14 ms
	EFHPTOC and EFPTOC: I _{set} × 2 × set Start value	23 ms 23 ms 23 ms
Reset time	Typically 43 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: -60 dB at f = n × I _n , where n = 2, 3, 4, 5... Peak-to-Peak: No suppression	

¹⁾ Measurement made at 50 Hz. Depends on ripple current before fault × 0.5 × I_n, I_n = 50 Hz, peak-to-peak current in forward direction, repeated from operational state, limited based on nominal maximum at 100% modulation.
²⁾ Includes the delay of the signal input contact.
³⁾ Maximum Start value × 0.5 × I_n. Start value multiplier in range of 1.0...20

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

Parameter	Function	Value (Range)	Step
Start value	EFPTOC	0.010...5.000 × I _n	0.005
	EFHPTOC	0.10...40.00 × I _n	0.01
	EFPTOC	1.00...43.00 × I _n	0.01
Time multiplier	EFPTOC	0.05...15.00	0.01
	EFHPTOC	0.05...15.00	0.01
	EFPTOC	43...200000 ms	10
Operate delay time	EFPTOC	43...200000 ms	10
	EFHPTOC	43...200000 ms	10
	EFPTOC	20...200000 ms	10
Operating curve type ¹⁾	EFPTOC	Defines or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Defines or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 17	
	EFPTOC	Defines time	

¹⁾ For further information, see Selection characteristics table

Table 37. Directional earth-fault protection (DEFAPDEF)

Characteristic	Value	
Operation accuracy	Depending on the frequency of the measured current: I, 52 Hz	
	DEFAPDEF: 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°	
	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 _{set} × 2 × set Start value	42 ms 48 ms 49 ms
	DEFAPDEF: I _{set} × 2 × set Start value	58 ms 62 ms 66 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: -60 dB at f = n × I _n , where n = 2, 3, 4, 5... Peak-to-Peak: No suppression	

¹⁾ Set operate delay time × 0.5 × I_n (Current limit) or 100 × I_n (Voltage limit). Measurement made at 50 Hz. Depends on ripple current before fault × 0.5 × I_n, I_n = 50 Hz, peak-to-peak current in forward direction, repeated from operational state, limited based on nominal maximum at 100% modulation.
²⁾ Includes the delay of the signal input contact.
³⁾ Maximum Start value × 0.5 × I_n. Start value multiplier in range of 1.0...20

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

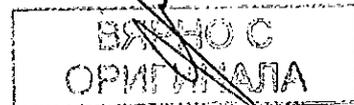
Parameter	Function	Value (Range)	Step
Start value	DEFAPDEF	0.010...5.000 × I _n	0.005
	DEFHPDEF	0.10...40.00 × I _n	0.01
Directional mode	DEFAPDEF	1 = Non-directional 2 = Forward 3 = Reverse	
Time multiplier	DEFAPDEF	0.05...15.00	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFAPDEF	60...200000 ms	10
	DEFHPDEF	40...200000 ms	10
Operating curve type ¹⁾	DEFAPDEF	Defines or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Defines or inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFAPDEF	1 = Phase angle 2 = Inhibit 3 = InCoE 4 = Phase angle 60 5 = Phase angle 80	

¹⁾ For further information, see the Operating parameters table

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

Characteristic	Value
Operation accuracy ¹⁾	At the frequency f = I _n : ±1.0% or ±0.01 mS (at range of 0.5...100 mS)
Start time ²⁾	Minimum Typical Maximum
	100 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 × I _n , where n = 2, 3, 4, 5...

¹⁾ I_n = 10 × I_n
²⁾ Includes the delay of the signal input contact, results based on statistical distribution of 1000 measurements



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Table 43. 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	-
Operate mode	EFPADM	1 = Yo 2 = Co 3 = Bo 4 = Yo, Co 5 = Yo, Bo 6 = Co, Bo 7 = Yo, Co, Bo	-
Operate delay time	EFPADM	63...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 IR Ang	EFPADM	-30...30°	1
Susceptance IR Ang	EFPADM	-30...30°	1

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current I _m , 42 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⁾	Typically 63 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.99
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	-53 dB at f = n × f ₀ , where n = 2, 3, 4, 5...

¹⁾ Includes the delay of the signal input contact.
²⁾ Includes the delay of the signal input contact.

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

Characteristic	Value
Operation accuracy (No criteria with transient protection)	Depending on the frequency of the measured current I _m , 42 Hz ±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: -53 dB at f = n × f ₀ , 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...2.50 × U _n	0.01
Operation mode	INTRPTEF	1 = Intermittent EF 2 = Transient EF	-
Peak current 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 I _m , 42 Hz ±5% of the set value or ±0.004 × I _n
Start time ¹⁾	Typically 77 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.99
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in IDMT mode ²⁾	±5.0% of the set value or ±20 ms
Suppression of harmonics	-53 dB at f = f ₀ -3 dB at f = 13 × f ₀

¹⁾ Fundament frequency current = 0.1 × I_n, harmonic current before 50 × 0.25 × I_n, harmonics at current 2.0 × start value not based on selected step size of 100% measurement.
²⁾ Includes the delay of the signal input contact.
³⁾ Maximum start value = 2.0 × I_n, start value multiples 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 the operating characteristics table.

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

Parameter	Function	Value (Range)	Step
Directional mode	WFWDE	2 = Forward 3 = Reverse	-
Current start value	WFWDE	0.010...5.000 × I _n	0.001
Voltage start value	WFWDE	0.010...1.000 × U _n	0.001
Power start value	WFWDE	0.005...1.000 × P _n	0.001
Reference power	WFWDE	0.050...1.000 × P _n	0.001
Characteristic angle	WFWDE	-175...157°	1
Time multiplier	WFWDE	0.05...2.00	0.01
Operating curve type ¹⁾	WFWDE	Definite or Inverse time Curve type: 5, 15, 20	-
Operate delay time	WFWDE	63...200000 ms	10
Min operate current	WFWDE	0.010...1.000 × I _n	0.001
Min operate voltage	WFWDE	0.01...1.00 × U _n	0.01

¹⁾ For further reference, see 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: 4, 42 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 input contact.

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	63...1200000	10
Operating quantity	MFADPSDE	2 = Admittance	-
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

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Table 49. Negative-sequence overcurrent protection (NSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current I _m , 42 Hz ±1.5% of the set value or ±0.002 × I _n
Start time ¹⁾	Minimum I _{max} = 2 × set Start value I _{max} = 13 × set Start value
Reset time	Typically 40 ms
Reset ratio	Typically 0.99
Rebation 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 ²⁾
Suppression of harmonics	DFT: -53 dB at f = n × f ₀ , where n = 2, 3, 4, 5...

¹⁾ Negative sequence current below 0.1 × I_n, 42 Hz, not based on selected step size of 100% measurement.
²⁾ Includes the delay of the signal input contact.
³⁾ Maximum start value = 2.0 × I_n, start value multiples a 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 the operating characteristics table.

Table 51. Phase discontinuity protection (PONSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current I _m , 42 Hz ±2% of the set value
Start time	< 70 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.99
Rebation time	±35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -53 dB at f = n × f ₀ , where n = 2, 3, 4, 5...

Table 52. Phase discontinuity protection (PONSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PONSPTOC	10...100%	-
Operate delay time	PONSPTOC	100...30000 ms	-
Min phase current	PONSPTOC	0.05...0.30 × I _n	-

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Table 53. Residual overvoltage protection (ROVTOV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage f_s , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 43 ms Typical: 51 ms Maximum: 54 ms $U_{res} = 2 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Typically 0.98
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = $1.0 \times U_n$, voltage before fault = $0.5 \times U_n$, $f_n = 50$ Hz, overvoltage in the phase-to-phase with normal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- Includes the delay of the signal input contact
- Maximum start value = $1.25 \times U_n$, start value multiples in range of 0.50...2.00

Table 54. Residual overvoltage protection (ROVTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	ROVTOV	0.010...1.000 $\times U_n$	0.001
Operate delay time	ROVTOV	40...300000 ms	1

Table 55. Three-phase undervoltage protection (PHPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured f_s , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 62 ms Typical: 66 ms Maximum: 70 ms $U_{res} = 0.9 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Depends on the set Relative hysteresis
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = $1.0 \times U_n$, voltage before fault = $1.1 \times U_n$, $f_n = 50$ Hz, undervoltage in the phase-to-phase with normal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- Includes the delay of the signal input contact
- Maximum start value = $1.25 \times U_n$, start value multiples in range of 0.50...2.00

Table 59. Three-phase overvoltage protection (PHPTOV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage f_s , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 23 ms Typical: 27 ms Maximum: 31 ms $U_{res} = 1.1 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Depends on the set Relative hysteresis
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = $1.0 \times U_n$, voltage before fault = $0.5 \times U_n$, $f_n = 50$ Hz, overvoltage in the phase-to-phase with normal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- Includes the delay of the signal input contact
- Maximum start value = $1.25 \times U_n$, start value multiples in range of 0.50...2.00

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

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.05...1.60 $\times U_n$	0.01
Time multiplier	PHPTOV	0.05...15.00	0.01
Operate delay time	PHPTOV	40...300000 ms	10
Operating curve type ³	PHPTOV	Definite or Inverse time Curve type: 5, 15, 17, 18, 19, 20	

- For further references, see Operation characteristics table

Table 61. Single-phase overvoltage protection (PHAPTOV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage f_s , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 25 ms Typical: 28 ms Maximum: 32 ms $U_{res} = 1.1 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Depends on the set Relative hysteresis
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = $1.0 \times U_n$, voltage before fault = $0.5 \times U_n$, $f_n = 50$ Hz, overvoltage in the phase-to-phase with normal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- Includes the delay of the signal input contact
- Maximum start value = $1.25 \times U_n$, start value multiples in range of 0.50...2.00

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

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	0.05...1.20 $\times U_n$	0.01
Time multiplier	PHPTUV	0.05...15.00	0.01
Operate delay time	PHPTUV	40...300000 ms	10
Operating curve type ³	PHPTUV	Definite or Inverse time Curve type: 5, 15, 21, 22, 23	

- For further references, see Operation characteristics table

Table 57. Single-phase undervoltage protection (PHAPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage f_s , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 64 ms Typical: 68 ms Maximum: 71 ms $U_{res} = 0.9 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Depends on the set Relative hysteresis
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = $1.0 \times U_n$, voltage before fault = $1.1 \times U_n$, $f_n = 50$ Hz, undervoltage in the phase-to-phase with normal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- Includes the delay of the signal input contact
- Maximum start value = $1.25 \times U_n$, start value multiples in range of 0.50...2.00

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

Parameter	Function	Value (Range)	Step
Start value	PHAPTUV	0.05...1.20 $\times U_n$	0.01
Time multiplier	PHAPTUV	0.05...15.00	0.01
Operate delay time	PHAPTUV	40...300000 ms	10
Operating curve type ³	PHAPTUV	Definite or Inverse time Curve type: 5, 15, 21, 22, 23	

- For further references, see Operation characteristics table

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

Parameter	Function	Value (Range)	Step
Start value	PHAPTOV	0.05...1.50 $\times U_n$	0.01
Time multiplier	PHAPTOV	0.05...15.00	0.01
Operate delay time	PHAPTOV	40...300000 ms	10
Operating curve type ³	PHAPTOV	Definite or Inverse time Curve type: 5, 15, 17, 18, 19, 20	

- For further references, see Operation characteristics table

Table 63. Positive-sequence undervoltage protection (PSPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage f_s , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$
Start time ^{1,2}	Minimum: 52 ms Typical: 56 ms Maximum: 59 ms $U_{res} = 0.99 \times \text{set Start value}$ $U_{res} = 0.9 \times \text{set Start value}$
Reset time	Typically 40 ms
Reset ratio	Depends on the set Relative hysteresis
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

- Start value = $1.0 \times U_n$, positive-sequence voltage before fault = $1.1 \times U_n$, $f_n = 50$ Hz, positive-sequence undervoltage with normal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
- Includes the delay of the signal input contact

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

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

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Table 65. Negative-sequence overvoltage protection (NSPTOV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured f_v , 12 Hz ±1.5% of the set value or ±0.002 × U_n
Start time ¹⁾	Minimum 13 ms 24 ms Typical 35 ms 25 ms Maximum 37 ms 28 ms
Reset time	Typically 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
Suppression of harmonics	1 OF1: -50 dB at $f = n \times f_v$, where $n = 2, 3, 4, 5, \dots$

1) Operate time accuracy is based on a 100 ms measurement period at 100 measurements. Includes the delay of the signal source.

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

Parameter	Function	Value (Range)	Step
Start value	NSPTOV	0.013...1.000 × U_n	0.001
Operate delay time	NSPTOV	43...120000 ms	1

Table 67. Frequency protection (FRPFRO)

Characteristic	Value
Operation accuracy	b: 5c ±5 mHz d: 1c ±50 mHz (in range [50] < 5 Hz) ±2.0% of the set value (in range 5 Hz < [50] < 15 Hz)
Start time	b: 5c d: 1c ±120 ms
Reset time	<150 ms
Operate time accuracy	±1.0% of the set value or ±30 ms

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Table 68. Frequency protection (FRPFRO) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRO	1 = Freq 2 = Freq 3 = d: 1c 4 = Freq + d: 1c 5 = Freq + d: 1c 6 = Freq OR d: 1c 7 = Freq OR d: 1c	
Start value Freq	FRPFRO	0.9999...1.0000 × f_n	0.0001
Start value Freqc	FRPFRO	0.8300...1.1000 × f_n	0.0001
Start value d: 1c	FRPFRO	-0.2500...0.2000 × f_n	0.0025
Operate Tri Freq	FRPFRO	83...200000 ms	10
Operate Tri d: 1c	FRPFRO	120...200000 ms	10

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current f_c , 12 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 ±0.5 s

1) Overload current > 1.2 × Current limit temperature

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

Parameter	Function	Value (Range)	Step
Env. temperature set	TIPTTR	-50...100°C	1
Current reference	TIPTTR	0.05...4.00 × I_n	0.01
Temperature rise	TIPTTR	0.0...200.0°C	0.1
Time constant	TIPTTR	63...60000 s	1
Maximum temperature	TIPTTR	20.0...200.0°C	0.1
Alarm value	TIPTTR	20.0...150.0°C	0.1
Radiate temperature	TIPTTR	23.0...150.0°C	0.1
Current multiplier	TIPTTR	1...5	1
Initial temperature	TIPTTR	-50.0...100.0°C	0.1

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Table 71. Loss of phase, undercurrent (PHPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured f_c , 12 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	53...200000 ms	10

Table 73. Circuit breaker failure protection (CCBSBF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current f_c , 12 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 45 ms
Retardation time	<20 ms

1) To pulse time before the minimum pulse length

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

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

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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 I-0 ms
Reset ratio	Typically 0.94
Operate time accuracy	±35 ms I-0 ms

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

Parameter	Function	Value (Range)	Step
Start value	INRPHAR	5...150%	1
Operate delay time	INRPHAR	25...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 9 ms ¹⁾ 4 ms ²⁾ Typical 12 ms ¹⁾ 6 ms ²⁾ Maximum 15 ms ¹⁾ 9 ms ²⁾ 12 ms ³⁾ 7 ms ⁴⁾
Reset time	Typically 40 ms ¹⁾ ±55 ms ²⁾
Reset ratio	Typically 0.96

1) After start value > 1.0 × I_n , current below I_n + 3.0 × (R / Z) for set time t_s , 10 ms, full unground frequency, no 41 hours to proceed to reduce of 200 requirements
2) Includes the delay of the inrush, solid contact
3) Normal close speed
4) High-speed speed

Table 78. Arc protection (ARCSARC) main settings

Parameter	Function	Value (Range)	Step
Phase start value	ARCSARC	0.5...4.00 × I_n	0.01
Ground start value	ARCSARC	1.05...8.00 × I_n	0.01
Operation mode	ARCSARC	1 = Light+ground 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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Table 80. Load-shedding and restoration (LSHOPFRQ)

Characteristic	Value
Operation accuracy	±10 mHz ±100 mHz (in range [5Hz] < [5 Hz]) ± 2.0% of the set value (in range 5 Hz < [5Hz] < 15 Hz)
Start time	<40 ms <120 ms <150 ms
Reset time	<150 ms
Operate time accuracy	±1.0% of the set value or ±53 ms

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

Parameter	Function	Value (Range)	Step
Load shed mode	LSHOPFRQ	1 = Freq 0 = Freq OR d% 4 = Freq AND d%	-
Restores mode	LSHOPFRQ	1 = Disabled 2 = Auto 3 = Manual	-
Start value Freq	LSHOPFRQ	0.625...1.250 × f _n	0.031
Start value d%	LSHOPFRQ	0.200...0.600 × f _n	0.050
Operate Tim Freq	LSHOPFRQ	40...200000 ms	10
Operate Tim d%	LSHOPFRQ	100...200000 ms	10
Restores start Val	LSHOPFRQ	0.800...1.200 × f _n	0.001
Restores delay time	LSHOPFRQ	40...200000 ms	10

Table 82. Multipurpose protection (MAPGAPC)

Characteristic	Value
Operation accuracy	±1.5% of the set value or ±20 ms

Table 83. Multipurpose protection (MAPGAPC) main settings

Parameter	Function	Value (Range)	Step
Start value	MAPGAPC	<1000.0...1000.0	0.1
Operate delay time	MAPGAPC	0...200000 ms	100
Operation mode	MAPGAPC	1 = Over 2 = Under	-

Table 84. Automatic switch-on-to-fault (CVPSOP)

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-on-to-fault logic (CVPSOP) main settings

Parameter	Function	Value (Range)	Step
SOTF reset time	CVPSOP	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) U_n = 20 Hz, results based on statistical distribution of 100 measurements
2) Includes the delay of the signal about correct

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 Bk value	VVSPPAM	0.40...1.50 × U _n	0.01
Under Volt Bk value	VVSPPAM	0.15...1.00 × U _n	0.01
Phase supervision	VVSPPAM	7 = Pb A + B + C 8 = Pos sequence	-

Table 88. Directional reactive power undervoltage protection (DOPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage, f _n , ±2 Hz Reactive power range [PF] < 0.21 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 0.56
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) Set value = 0.05 × U_n, results based on statistical distribution of 100 measurements
2) Includes the delay of the signal about correct

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

Parameter	Function	Value (Range)	Step
Voltage start value	DOPTUV	0.20...1.20 × U _n	0.01
Operate delay time	DOPTUV	100...300000 ms	10
Min reactive power	DOPTUV	0.01...0.50 × S _n	0.01
Min P _s Seq current	DOPTUV	0.02...0.20 × I _n	0.01
Pos sector reduction	DOPTUV	0...10°	1

Table 90. Underpower protection (DUPPDP)

Characteristic	Value
Operation accuracy ¹⁾	Depending on the frequency of the measured current and voltage, f _n , ±2 Hz Power measurement accuracy ±1% of the set value or ±0.002 × S _n Phase angle ±2°
Start time ²⁾³⁾	Typically 46 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	DFT: -50 dB at f = n × f _n , where n = 2, 3, 4, 5...

1) Measurement mode = P or S (kW)
2) U_n = 20 Hz, results based on statistical distribution of 100 measurements
3) Includes the delay of the signal about correct

Table 91. Underpower protection (DUPPDP) main settings

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

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

Characteristic	Value
Operation accuracy ¹⁾	Depending on the frequency of the measured current and voltage, f _n , ±2 Hz Power measurement accuracy ±1% of the set value or ±0.002 × S _n Phase angle ±2°
Start time ²⁾³⁾	Typically 46 ms
Reset time	Typically 30 ms
Reset ratio	Typically 0.54
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) Measurement mode = P or S (kW)
2) U_n = 20 Hz, results based on statistical distribution of 100 measurements
3) Includes the delay of the signal about correct

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

Parameter	Function	Value (Range)	Step
Start value	DOPDP	0.01...2.00 × S _n	0.01
Operate delay time	DOPDP	40...300000 ms	10
Directional mode	DOPDP	2 = Forward 3 = Reverse	-
Power angle	DOPDP	-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 46 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) Based on number of Start phases = 1 out of 3, results based on statistical distribution of 100 measurements
2) Includes the delay of the signal about correct

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

Parameter	Function	Value (Range)	Step
Voltage start value	LVRTU	$0.95 \dots 1.20 \times U_n$	0.01
Num of start phases	LVRTU	4 = Exactly 4 of 3 3 = Exactly 3 of 3 2 = Exactly 2 of 3	
Voltage selection	LVRTU	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	LVRTU	1...10	1
Voltage level 1	LVRTU	0.00...1.20 ms	0.01
Voltage level 2	LVRTU	0.00...1.20 ms	0.01
Voltage level 3	LVRTU	0.00...1.20 ms	0.01
Voltage level 4	LVRTU	0.00...1.20 ms	0.01
Voltage level 5	LVRTU	0.00...1.20 ms	0.01
Voltage level 6	LVRTU	0.00...1.20 ms	0.01
Voltage level 7	LVRTU	0.00...1.20 ms	0.01
Voltage level 8	LVRTU	0.00...1.20 ms	0.01
Voltage level 9	LVRTU	0.00...1.20 ms	0.01
Voltage level 10	LVRTU	0.00...1.20 ms	0.01
Recovery time 1	LVRTU	0...300000 ms	1
Recovery time 2	LVRTU	0...300000 ms	1
Recovery time 3	LVRTU	0...300000 ms	1
Recovery time 4	LVRTU	0...300000 ms	1
Recovery time 5	LVRTU	0...300000 ms	1
Recovery time 6	LVRTU	0...300000 ms	1
Recovery time 7	LVRTU	0...300000 ms	1
Recovery time 8	LVRTU	0...300000 ms	1
Recovery time 9	LVRTU	0...300000 ms	1
Recovery time 10	LVRTU	0...300000 ms	1

Table 96. High-impedance differential protection (HIDPF)

Characteristics	Value	
Operation accuracy	Depending on the frequency of the current measured, f , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$	
Start time ¹⁾²⁾	Minimum	12 ms
	Typical	16 ms
	Maximum	24 ms
Reset time	<40 ms	
Reset ratio	Typically 0.98	
Retardation time	<35 ms	
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms	

1) Measurement mode: default current limit = 0.5 $\times I_n$, 42 Hz, full current with normal frequency, injected from remote phase angle, results based on physical distribution of 100 measurements
2) Includes the delay of the signal logic output

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

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

Table 98. Circuit breaker unreclosing position start-up (UPCALM)

Characteristics	Value
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 20 ms

Table 99. Three-independent-phase non-directional overcurrent protection (PH3PTOC)

Characteristics	Value	
Operation accuracy	Depending on the frequency of the current measured, f , 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$	
Start time ¹⁾²⁾	Minimum	15 ms
	Typical	18 ms
	Maximum	17 ms
Reset time	<40 ms	
Reset ratio	Typically 0.98	
Retardation time	<35 ms	
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms	
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁾	
Suppression of harmonics	RMS: No suppression DFT: <0 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression	

1) Measurement mode: default current limit = 0.5 $\times I_n$, 42 Hz, full current with normal frequency, injected from remote phase angle, results based on physical distribution of 100 measurements
2) Includes the delay of the signal logic output
3) Minimum start value = 2.0 $\times I_n$, 50 Hz, full current with normal frequency, injected from remote phase angle, results based on physical distribution of 100 measurements

Table 100. Three-independent-phase non-directional overcurrent protection (PH3PTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PH3PTOC	$0.05 \dots 5.00 \times I_n$	0.01
	PH3PTOC	$0.10 \dots 40.00 \times I_n$	0.01
	PH3PTOC	$1.00 \dots 40.00 \times I_n$	0.01
Time multiplier	PH3PTOC	0.05...15.00	0.01
	PH3PTOC	0.05...15.00	0.01
	PH3PTOC	40...200000 ms	10
Operate delay time	PH3PTOC	40...200000 ms	10
	PH3PTOC	20...200000 ms	10
	PH3PTOC	40...200000 ms	10
Operating curve type ¹⁾	PH3PTOC	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PH3PTOC	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PH3PTOC	Definite time	

1) For full non-directional 3-phase characteristics built

Table 101. Directional three-independent-phase directional overcurrent protection (DPH3PDOO)

Characteristics	Value	
Operation accuracy	Depending on the frequency of the current measured, f , 42 Hz Current: $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$ Voltage: $\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$ Phase angle: $\pm 2^\circ$	
Start time ¹⁾²⁾	Minimum	33 ms
	Typical	40 ms
	Maximum	43 ms
Reset time	<40 ms	
Reset ratio	Typically 0.98	
Retardation time	<35 ms	
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms	
Operate time accuracy in inverse time mode	$\pm 5.0\%$ of the theoretical value or ± 20 ms ³⁾	
Suppression of harmonics	RMS: No suppression DFT: <0 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ Peak-to-Peak: No suppression Peak-to-Peak + backup: No suppression	

1) Measurement mode: default current limit = 0.5 $\times I_n$, 42 Hz, full current in the phase with normal frequency injected from remote phase angle, results based on physical distribution of 100 measurements
2) Includes the delay of the signal logic output
3) Minimum start value = 2.0 $\times I_n$, 50 Hz, full current with normal frequency, injected from remote phase angle, results based on physical distribution of 100 measurements

Table 102. Directional three-independent-phase directional overcurrent protection (DPH3PDOO) main settings

Parameter	Function	Value (Range)	Step
Start value	DPH3PDOO	$0.05 \dots 5.00 \times I_n$	0.01
	DPH3PDOO	$0.10 \dots 40.00 \times I_n$	0.01
Time multiplier	DPH3PDOO	0.05...15.00	0.01
	DPH3PDOO	40...200000 ms	10
Operating curve type ¹⁾	DPH3PDOO	Definite or Inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPH3PDOO	Definite or Inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
Directional mode	DPH3PDOO	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPH3PDOO	-175...150°	1

1) For full non-directional 3-phase characteristics built

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

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current; f_n , 62 Hz, and no harmonics 5% of the set value or $0.002 \times I_n$
Start time for overload stage ^{1,2}	Typically 75 ms
Start time for under current stage ^{2,3}	Typically 28 ms
Reset time for overload and alarm stage	Typically 60 ms
Reset ratio	Typically 0.94
Operate time accuracy in definite time mode	1% of the set value or 220 ms
Operate time accuracy in inverse time mode	10% of the theoretical value or 220 ms
Suppression of harmonics for under current stage	0dB; -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1) Harmonic curves before fault $\pm 0.5 \times I_n$, harmonic full current I_n + start rate, no data based on integral detection of 1200 measurements
2) Includes the delay of the signal output contact
3) Harmonic curves before fault $\pm 1.2 \times I_n$, harmonic full current I_n + start rate, no data based on integral detection of 1200 measurements

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

Parameter	Function	Value (Range)	Step
Start value overload	COUPTOC	$0.30...1.50 \times I_n$	0.01
Alarm start value	COUPTOC	10...120%	1
Start value Us Cur	COUPTOC	$0.10...0.70 \times I_n$	0.01
Time multiplier	COUPTOC	0.05...2.00	0.01
Alarm delay time	COUPTOC	500...6000000	100
Us Cur delay time	COUPTOC	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 , 62 Hz 1.5% of the set value or $0.002 \times I_n$
Start time ^{1,2}	Typically 28 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.94
Operate time accuracy in definite time mode	1% of the theoretical value or 220 ms
Operate time accuracy in inverse definite minimum time mode	5% of the theoretical value or 220 ms
Suppression of harmonics	0dB; -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

1) Fundamental frequency, current $\pm 0.5 \times I_n$, current before fault $\pm 0.2 \times I_n$, but current $\pm 2 \times I_n$ start value, no data based on integral detection of 1200 measurements
2) Includes the delay of the signal output contact

Table 109. Operation characteristics

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

Table 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	$0.01...1.00 \times I_n$	0.01
Alarm start value	CUBPTOC	$0.01...1.00 \times I_n$	0.01
Time multiplier	CUBPTOC	0.05...15.00	0.01
Operating curve type ¹	CUBPTOC	Defines 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 (SACPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current; f_n , 62 Hz Operate value accuracy: 23% of the set value or $\pm 0.002 \times I_n$, for 2 nd order Harmonics 21.5% of the set value or $\pm 0.002 \times I_n$, for 3 rd order < Harmonics < 10th order 16% of the set value or $\pm 0.004 \times I_n$, for Harmonics >= 10th order
Reset time	Typically 40 ms or maximum 50 ms
Retardation time	Typically 0.99
Retardation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or 220 ms
Suppression of harmonics	-50 dB at $f = f_n$

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

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

Control functions

Table 110. Autoreclosing (SARREC)

Characteristic	Value
Operate time accuracy	$\pm 1.0\%$ of the set value or 220 ms

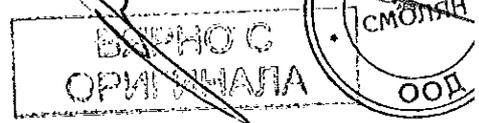
Table 111. Synchronism and energizing check (SECRSYN)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured; f_n , 62 Hz Voltage: $\pm 3.0\%$ of the set value or $\pm 0.01 \times U_n$ Frequency: ± 10 mHz Phase angle: $\pm 3^\circ$
Reset time	<50 ms
Reset ratio	Typically 0.99
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or 220 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 = Un L, Dead B 3 = Dead L, Live B 4 = Dead B, L Any 5 = Dead L, B, Any 6 = One Live, Dead 7 = Not Both Live	-
Difference voltage	SECRSYN	$0.01...0.50 \times U_n$	0.01
Differential frequency	SECRSYN	$0.001...0.100 \times f_n$	0.001
Difference angle	SECRSYN	5...90°	1
Synchrocheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	-
Dead line value	SECRSYN	$0.1...0.8 \times U_n$	0.1
Live line value	SECRSYN	$0.2...1.0 \times U_n$	0.1
Close pulse	SECRSYN	200...60000 ms	10
Max energizing V	SECRSYN	0.50...1.15 $\times U_n$	0.01
Control mode	SECRSYN	1 = Continuous 2 = Command	-
Phase shift	SECRSYN	-150...150°	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...60 ms	10

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Condition monitoring and supervision functions

Table 113. Circuit-breaker condition monitoring (SBCBR)

Characteristics	Value
Current measuring accuracy	$\pm 1.5\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.1 \dots 10 \times I_n$) $\pm 0.5\%$ (at currents in the range of $10 \dots 40 \times I_n$)
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 20 ms
Travelling time measurement	± 10 ms / -0 ms

Table 114. Current circuit supervision (CCSPVC)

Characteristics	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	$0.05 \dots 0.20 \times I_n$	0.01
Max operate current	CCSPVC	$1.00 \dots 5.00 \times I_n$	0.01

Table 116. Current transformer supervision for high-impedance protection scheme (I2000dPVC)

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured; f_n 42 Hz $\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$
Reset time	<40 ms
Reset ratio	Typically 0.98
Recalculation time	<35 ms
Operate time accuracy in definite time mode	$\pm 1.0\%$ of the set value or ± 20 ms

Table 117. Fuses failure supervision (SEOSPVC)

Characteristics	Value	
Operate time ¹⁾	NPS function $U_{res} = 1.1 \times \text{set Alg. Seq. voltage}$ Lev	<33 ms
	$U_{res} = 5.0 \times \text{set Alg. Seq. voltage}$ Lev	<18 ms
	Data function $\Delta U = 1.1 \times \text{set Voltage change rate}$	<30 ms
	$\Delta U = 2.0 \times \text{set Voltage change rate}$	<24 ms

¹⁾ Indicates the delay of the output trip if current, I_n is 20 Hz, or at voltage with normal frequency; ignores time relaxation on a single pulse based on electrical device (not on IEC measurement)

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Measurement functions

Table 119. Three-phase current measurement (C3M30)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current; f_n 42 Hz $\pm 0.5\%$ or $\pm 0.002 \times I_n$ (at currents in the range of $0.01 \dots 4.00 \times I_n$)
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 120. Sequence current measurement (CSM30)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current; f_n 42 Hz $\pm 1.0\%$ or $\pm 0.002 \times I_n$ at currents in the range of $0.01 \dots 4.00 \times I_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 121. Residual current measurement (RESUM30)

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured; f_n 42 Hz $\pm 0.5\%$ or $\pm 0.002 \times I_n$ at currents in the range of $0.01 \dots 4.00 \times I_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 122. Three-phase voltage measurement (3VM30)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage measured; f_n 42 Hz At voltages in range $0.01 \dots 1.15 \times U_n$ $\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 123. Single-phase voltage measurement (1VM30)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage measured; f_n 42 Hz At voltages in range $0.01 \dots 1.15 \times U_n$ $\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

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

Description	Value
Motor runtime measurement accuracy ¹⁾	$\pm 0.5\%$

¹⁾ Only relevant for current-based relay, active time synchronization

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Table 124. Residual voltage measurement (RESVM30)

Characteristics	Value
Operation accuracy	Depending on the frequency of the measured current; f_n 42 Hz $\pm 0.5\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$ RMS: No suppression

Table 125. Sequence voltage measurement (3VMSQ)

Characteristics	Value
Operation accuracy	Depending on the frequency of the voltage measured; f_n 42 Hz At voltages in range $0.01 \dots 1.15 \times U_n$ $\pm 1.0\%$ or $\pm 0.002 \times U_n$
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

Table 126. Three-phase power and energy measurement (PEM30)

Characteristics	Value
Operation accuracy	At all three currents in range $0.10 \dots 1.20 \times I_n$ At all three voltages in range $0.50 \dots 1.15 \times U_n$ At the frequency f_n 42 Hz $\pm 1.5\%$ for apparent power S $\pm 1.5\%$ for active power P and active energy ¹⁾ $\pm 1.5\%$ for reactive power Q and reactive energy ²⁾ ± 0.015 for power factor
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where $n = 2, 3, 4, 5, \dots$

¹⁾ P, Q, S when available
²⁾ P, Q, S when available

Table 127. Frequency measurement (FM30)

Characteristics	Value
Operation accuracy	± 0.1 mHz (in measurement range 35...15 Hz)

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Fault location functions

Table 128. Fault locator (SCEFRLO)

Characteristics	Value
Measurement accuracy	At 60 Hz frequency f = 60 Hz Impedance: ±2.5% or ±0.25 Ω Distance: ±2.5% or ±0.16 km/0.1 mi XCDF_CALC: ±2.5% or ±53 Ω FLT_PER_LED: ±5% or ±0.05

Table 129. Fault locator (SCEFRLO) main settings

Parameter	Function	Value (Range)	Step
Z Max phase load	SCEFRLO	1 Ω ... 10000.00 Ω	0.1
Ph leakage Rst	SCEFRLO	25 ... 1000000 Ω	1
Ph capacitive Rload	SCEFRLO	15 ... 1000000 Ω	1
R1 line section A	SCEFRLO	0.000 ... 1000.000 Ω/pu	0.001
X1 line section A	SCEFRLO	0.000 ... 1000.000 Ω/pu	0.001
R0 line section A	SCEFRLO	0.000 ... 1000.000 Ω/pu	0.001
X0 line section A	SCEFRLO	0.000 ... 1000.000 Ω/pu	0.001
Line Len section A	SCEFRLO	0.000 ... 1000.000 pu	0.001

Other functions

Table 134. Pulse error (PTGAPC)

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

Table 135. Time delay on (β pos) (TOFPAGC)

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

Table 136. Time delay on (β pos) (TONGAPC)

Characteristics	Value
Operate time accuracy	±1.0% of the set value or ±25 ms

Power quality functions

Table 130. Voltage variation (PHOVVR)

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

Table 131. Voltage variation (PHOVVR) main settings

Parameter	Function	Value (Range)	Step
Voltage dip set 1	PHOVVR	10.0 ... 100.0%	0.1
Voltage dip set 2	PHOVVR	10.0 ... 100.0%	0.1
Voltage dip set 3	PHOVVR	12.0 ... 100.0%	0.1
Voltage swell set 1	PHOVVR	100.0 ... 142.0%	0.1
Voltage swell set 2	PHOVVR	100.0 ... 142.0%	0.1
Voltage swell set 3	PHOVVR	100.0 ... 142.0%	0.1
Voltage Pk set	PHOVVR	0.0 ... 100.0%	0.1
Via Dur Max	PHOVVR	100 ... 3600000 ms	100

Table 132. Voltage unbalance (VSOVUB)

Characteristics	Value
Operation accuracy	±1.5% of the set value or ±0.002 * U _n
Reset ratio	Typically 0.96

Table 133. Voltage unbalance (VSOVUB) main settings

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

22. Local HMI

The relay supports process information and status monitoring from the relay's local HMI via its display and indicator/alarm LEDs. The local HMI 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 PCMA600.

The local HMI also includes 11 programmable LEDs. These LEDs can be configured to show alarms and indications as needed by PCMA600 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 PCMA600 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.

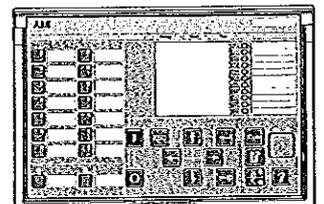


Figure 1A. Example of the HMI

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 Combix equipment frames.

For the routine testing purposes, the relay cases can be equipped with test switches, type RTP 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 RTP 24 test switch to a 19" rack

Panel cut-out for flush mounting

- Height: 162 ±1 mm
- Width: 248 ±1 mm

Panel cut-out for flush mounting

- Height: 162 ±1 mm
- Width: 248 ±1 mm

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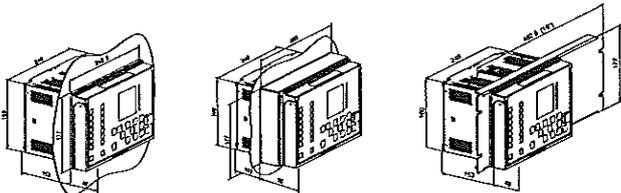


Figure 19. Flush mounting

Figure 20. Semi-flush mounting

Figure 21. Rack mounting

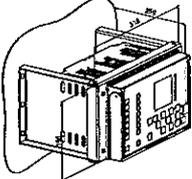


Figure 22. Wall mounting

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 HIM 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.

Product Selection Tool (PST), a Next-Generation Order Number Tool, supports order code creation for ABB Distribution Automation IEO products with emphasis on but not exclusively for the Relion product family. PST is an easy to use software 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.

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

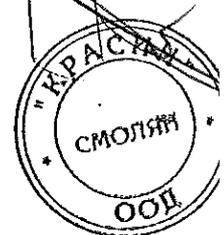
#	Description	
1	IED	
	IED series IED (including case)	N
	Complete Relay with conformal coating	S
2	Standard	
	IEO	B
	ON	C
3	Main application	
	Feeder protection and control	F
4	Functional application	
	Example configuration	N
5-6	Analog inputs and outputs	
	#I, 1/5 A) + 5U + 24V + 14G0	AA
	#I (0.2/1 A) + 5U + 24V + 14G0	A3
	Sensors (I + 5U) + 1U1 + 1S3 + 1RSU	A2
7-8	Optional board	
	Hybrid I/O (R/W, dIO)	AA
	Optional RTDs (RTD In + 2-A n)	A3
	Optional Fast I/Os (3B + 7-50)	AC
	No optional board	NN

#	Description	
3	Communication (Serial/Ethernet)	
	Serial RS 485, incl. an input for IED-B + Ethernet 100Base FX (14U4)	AA
	Serial RS 485, incl. an input for IED-B + Ethernet 100Base TX (14U4S)	AD
	Serial RS 485, incl. an input for IED-B	AN
	Serial glass fibre (S1) + Ethernet 100Base TX (14U4S) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for IED-B (cannot be combined with any protection)	AR
	Serial glass fibre (S1) + Ethernet 100Base TX and FX (14U4, 24U4S) with HSR/PPP	AS
	Serial glass fibre (S1) + Ethernet 100Base TX (24U4S) with HSR/PPP	BD
	Serial glass fibre (S1) + Ethernet 100Base TX and FX (24U4, 14U4S) with HSR/PPP	BE
	Serial glass fibre (S1) + Ethernet 100Base TX and FX (14U4, 24U4S) with HSR/PPP and EOC/RSO-9-2LE	BF
	Serial glass fibre (S1) + Ethernet 100Base TX (24U4S) with HSR/PPP and EOC/RSO-9-2LE	BD
	Serial glass fibre (S1) + Ethernet 100Base TX and FX (24U4, 14U4S) with HSR/PPP and EOC/RSO-9-2LE	BE
	Serial glass fibre (S1) + Serial RS 485 connector, RS 232/485 D-Sub 9 connector + input for IED-B (cannot be combined with any protection)	EN
	RS 232/485 (including IED-B + Ethernet 100Base TX (14U4S) (cannot be combined with any protection)	GB
	RS 232/485 + RS 485 (class A S1 (including IED-B) (cannot be combined with any protection)	GN
	Ethernet 100Base FX (14U4)	MA
	Ethernet 100Base TX (14U4S)	MB
	Ethernet 100Base TX and FX (14U4, 24U4S) with HSR/PPP	MD
	Ethernet 100Base TX (24U4S) with HSR/PPP	ND
	Ethernet 100Base TX and FX (14U4, 14U4S) with HSR/PPP	ME
	Ethernet 100Base TX and FX (14U4, 24U4S) with HSR/PPP and I/O11500-9-2LE	MF
	Ethernet 100Base TX (24U4S) with HSR/PPP and EOC/RSO-9-2LE	N3
	Ethernet 100Base TX and FX (24U4, 14U4S) with HSR/PPP and EOC/RSO-9-2LE	N1
	No communication module	NN

If serial communication is chosen, please choose a serial communication module including Ethernet (for example "AD") if a service bus for POM600 or the Web-IM is required.

#	Description	
11	Communication protocols	
	IEO (1150) for Ethernet communication modules and IEDs without a communication module	A
	Modbus for Ethernet/serial or Ethernet + serial communication module	B
	IEO (1150) + Modbus for Ethernet/serial + Ethernet communication module	C
	IEO (1150-100) for serial or Ethernet + serial communication module	D
	DNP3 for Ethernet/serial or Ethernet + serial communication module	F
	IEO (1150) + IEO (1020-5-100) for serial + Ethernet communication module	G
	IEO (1150) + IEDP3 for Ethernet or serial + Ethernet communication module	H
12	Language	
	English	1
	English and Chinese	2
13	Front panel	
	Large LCD with Single Line Displays - IEO	B
	Large LCD with Single Line Displays - ON	U
14	Option 1	
	Arc protection (requires a communication module, cannot be combined with com. module options ON, DD, OS and ON)	B
	None	N
15	Option 2	
	Fault locator	F
	Capacitor bank protection package	G
	Intra-connection/Distributed generation protection package	D
	Power protection package	P
	All options: Fault locator + Capacitor bank protection + Intra-connection/Distributed generation protection + Power protection	L
	None	N
15	Power supply	
	Power supply 45-250 VDC 100-240 VAC	1
	Power supply 24-60 VDC	2
17	Reserved	
18	Product version 2.0 FPI	P1

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Example code: NBFNAANNABC1BNN11G

Your ordering code:

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

Figure 23. Decoding key for complete protection relays

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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
Self-lubricating kit	2PCA037573A001
Wall mounting kit	2PCA037434A001
19" rack mounting kit with cut-out for one relay	2PCA031135A001
19" rack mounting kit for one relay and one RDXP24 test switch (the test switch and wire harness are not included in the delivery)	2PCA032215A001
Mounting bracket for one relay with test switch RDXP in 4U CombiFlex (RDOT 19" variant C) (the test switch, wire harness and CombiFlex RDXP 19" variant C are not included in the delivery)	2PCA032228A001
Functional starting range for RTD modules	2PCA03578A001 ¹⁾

¹⁾ Order by lead when the RTD is ordered with the CombiFlex equipment (part no. 2PCA032228A001).

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 PCMS00 tool in combination with the relay-specific connectivity package.

The Protection and Control IED Manager PCMS00 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 PCMS00, and it enables multiple updates of the additional HMI languages, thus offering flexible means for possible future language updates.

Table 139. Tools

Configuration and setting tools	Version
PCMS00	2.4 (Build 20150625) 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

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Table 140. Supported functions

Function	Web HMI	PCMS00
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)	•	•
DA-PI communication configuration (communication management)	•	•
IEC 60870-5-103 communication configuration (communication management)	•	•
Saving of relay parameter settings in the tool	•	•
Disturbance record analysis	•	•
XRD parameter report/print	•	•
Graphical display configuration	•	•
Application configuration	•	•
Phase diagram viewing	•	•
IEC 61850 communication configuration, GOOSE (communication configuration)	•	•
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 records in a non-volatile memory. The non-volatile memory is based on a memory type which does not need battery backup or regular component exchanges 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.

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29. Connection diagrams

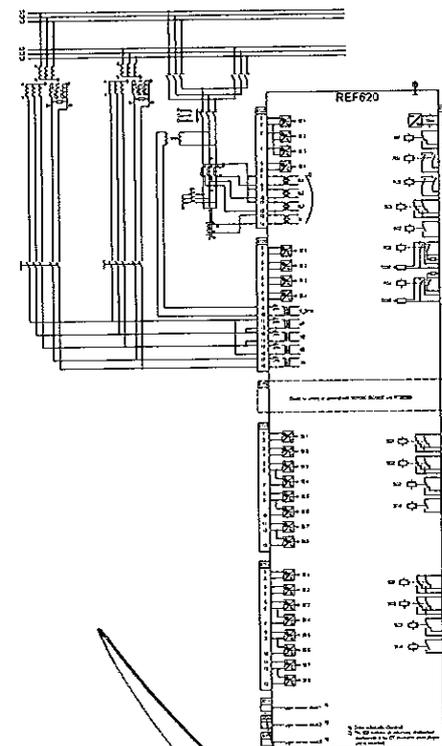
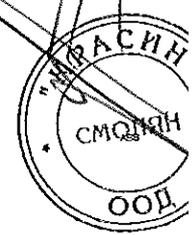


Figure 24. Connection diagram for the cooperation with OTs and VTs

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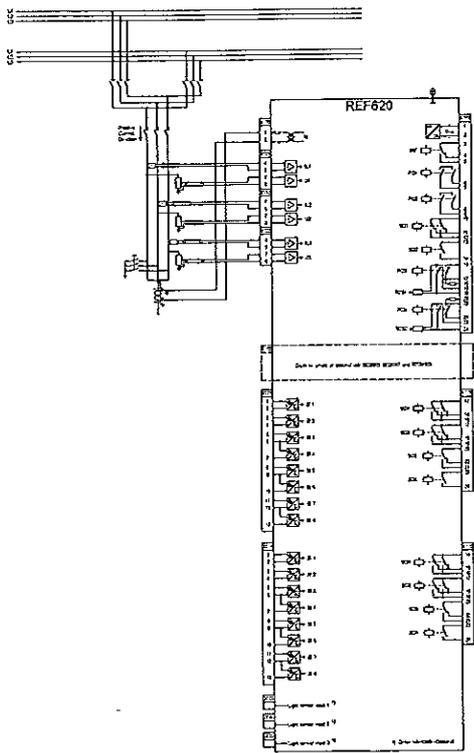


Figure 26. Connection diagram for the configuration with 641105

30. Certificates
DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for Reason® 620 series. Certificate number: 74108003-0PE/INC 15-2318.

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.

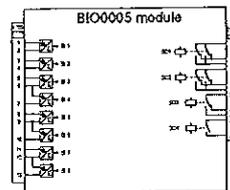


Figure 25. Optional BIO0005 module (slot X106)

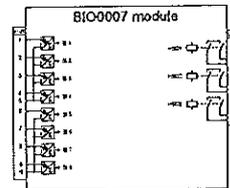


Figure 27. Optional BIO0007 module for fast outputs (slot X109)

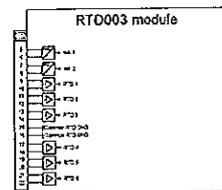


Figure 28. Optional RTD0003 module (slot X105)

32. Functions, codes and symbols

Table 141. Functions included in the relay

Function	IEC 61850	IEC 60817	ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3P> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage	PHRPTOC1 PHRPTOC2	3P>> (1) 3P>> (2)	51P-2 (1) 51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3P>>> (1)	50P-51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1 DPHLPDOC2	3P>→ (1) 3P>→ (2)	67-1 (1) 67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHRPDOC1 DPHRPDOC2	3P>>→ (1) 3P>>→ (2)	67-2 (1) 67-2 (2)
Three-phase voltage-dependent overcurrent protection	PHPVOC1 PHPVOC2	3(U)> (1) 3(U)> (2)	51V (1) 51V (2)
Non-directional earth-fault protection, low stage	EFLPTOC1 EFLPTOC2	I> (1) I> (2)	51N-1 (1) 51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	I>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	I>>> (1)	50N51N (1)
Directional earth-fault protection, low stage	DEFLPDEF1 DEFLPDEF2 DEFLPDEF3	I>→ (1) I>→ (2) I>→ (3)	67N-1 (1) 67N-1 (2) 67N-1 (3)
Directional earth-fault protection, high stage	DEHPTDEF1	I>>→ (1)	67N-2 (1)
Admittance-based earth-fault protection	EPFADM1 EPFADM2 EPFADM3	Y>→ (1) Y>→ (2) Y>→ (3)	21YN (1) 21YN (2) 21YN (3)
Wattmeter-based earth-fault protection	WPWDE1 WPWDE2 WPWDE3	P>→ (1) P>→ (2) P>→ (3)	32N (1) 32N (2) 32N (3)
Multi-frequency admittance-based earth-fault protection	MFADPDEF1	I>→ Y (1)	67YN (1)
Transfer tripping earth-fault protection	INTRTTEP1	I>→ REF (1)	67REF (1)
Hammock-based earth-fault protection	HAEFPTOC1	I>MA (1)	51NMA (1)
Negative-sequence overcurrent protection	NSPTOC1 NSPTOC2	I2> (1) I2> (2)	45 (1) 45 (2)
Phase discontinuity protection	PONSPTOC1	I2I1> (1)	45PD (1)
Residual overvoltage protection	ROVPTOV1 ROVPTOV2 ROVPTOV3	U>> (1) U>> (2) U>> (3)	53O (1) 53O (2) 53O (3)

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Table 141. Functions included in the relay, continued

Function	IEO #1650	IEO #0617	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	FSPTUV1	U1< (1)	47U1 (1)
	FSPTUV2	U1< (2)	47U1 (2)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O1 (1)
	NSPTOV2	U2> (2)	47O1 (2)
Frequency protection	FRFFRQ1	f<<f_N (1)	81 (1)
	FRFFRQ2	f<<f_N (2)	81 (2)
	FRFFRQ3	f<<f_N (3)	81 (3)
	FRFFRQ4	f<<f_N (4)	81 (4)
	FRFFRQ5	f<<f_N (5)	81 (5)
	FRFFRQ6	f<<f_N (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	THPTTRL	3>>F (1)	49F (1)
Loss of phase (undercurrent)	PHPTUC1	3K (1)	3F (1)
Circuit break or failure protection	CCSBRPF1	3>>3>BF (1)	51BF/51NBF (1)
	CCSBRPF2	3>>3>BF (2)	51BF/51NBF (2)
Three-phase fault detector	CCSBRPF3	3>>3>BF (3)	51BF/51NBF (3)
	CCSBRPF4	3>>3>BF (4)	51BF/51NBF (4)
Master trip	TRFPTRC1	Master Trip (1)	84S5 (1)
	TRFPTRC2	Master Trip (2)	84S5 (2)
	TRFPTRC3	Master Trip (3)	84S5 (3)
	TRFPTRC4	Master Trip (4)	84S5 (4)
Arc protection	ARCSARC1	ARC (1)	50USGNL (1)
	ARCSARC2	ARC (2)	50USGNL (2)
	ARCSARC3	ARC (3)	50USGNL (3)
High-impedance fault detection	PHZ1	HF (1)	HEZ (1)

Table 141. Functions included in the relay, continued

Function	IEO #1650	IEO #0617	ANSI	
Load shedding and restoration	LSHOFFR01	UFLSR (1)	41LSH (1)	
	LSHOFFR02	UFLSR (2)	41LSH (2)	
	LSHOFFR03	UFLSR (3)	41LSH (3)	
	LSHOFFR04	UFLSR (4)	41LSH (4)	
	LSHOFFR05	UFLSR (5)	41LSH (5)	
	LSHOFFR06	UFLSR (6)	41LSH (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-on-to-break logic (SOF)	CYPSOF1	CYPSOF (1)	50FTZ1-50 (1)	
Voltage vector shift protection	VYSPFAM1	VS (1)	78V (1)	
Occasional reactive power undervoltage protection	DOPTUV1	Q> -> 3U< (1)	32O27 (1)	
	DOPTUV2	Q> -> 3U< (2)	32O27 (2)	
Underpower protection	DUPDFR1	P< (1)	32U (1)	
	DUPDFR2	P< (2)	32U (2)	
Reverse power/directional overpower protection	DOPDFR1	P>D (1)	32V32O (1)	
	DOPDFR2	P>D (2)	32V32O (2)	
Low-voltage ride-through protection	LVRIPTUV1	U-RT (1)	27RT (1)	
	LVRIPTUV2	U-RT (2)	27RT (2)	
	LVRIPTUV3	U-RT (3)	27RT (3)	
High-impedance differential protection for phase A	HAPDF1	84S_A (1)	87A (1)	
High-impedance differential protection for phase B	HBPDF1	84S_B (1)	87B (1)	
High-impedance differential protection for phase C	HCPDF1	84S_C (1)	87C (1)	

Table 141. Functions included in the relay, continued

Function	IEO #1650	IEO #0617	ANSI
Circuit breaker unresponsive 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	PIKOPTOC1	I_3> (1)	51P_L_3 (1)
	PIKOPTOC2	I_3> (2)	51P_L_3 (2)
Three-independent-phase non-directional overcurrent protection, high stage	PIKOPTOC1	I_3>> (1)	51P_L_3 (1)
	PIKOPTOC2	I_3>> (2)	51P_L_3 (2)
Three-independent-phase non-directional overcurrent protection, intermediate stage	PIKOPTOC1	I_3>>> (1)	50PSIP_L_3 (1)
	PIKOPTOC2	I_3>>> (2)	50PSIP_L_3 (2)
Directional three-independent-phase directional overcurrent protection, low stage	DPHSPDOCC1	I_3> (1)	87_L_3 (1)
	DPHSPDOCC2	I_3> (2)	87_L_3 (2)
Directional three-independent-phase directional overcurrent protection, high stage	DPHSPDOCC1	I_3>> (1)	87_L_3 (1)
	DPHSPDOCC2	I_3>> (2)	87_L_3 (2)
Three-phase overload protection for shunt capacitor banks	COOPTOC1	3> 3I (1)	51O37 (1)
	COOPTOC2	3> 3I (2)	51O37 (2)
Current unbalance protection for shunt capacitor banks	CUPTOC1	3> C (1)	51NO-1 (1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC1	TD (1)	59TD (1)
Circuit-breaker control	CBXCER1	I<> O CB (1)	I<> O CB (1)
	CBXCER2	I<> O CB (2)	I<> O CB (2)
	CBXCER3	I<> O CB (3)	I<> O CB (3)
Disconnecter control	DCXSWM1	I<> O DCC (1)	I<> O DCC (1)
	DCXSWM2	I<> O DCC (2)	I<> O DCC (2)
	DCXSWM3	I<> O DCC (3)	I<> O DCC (3)
	DCXSWM4	I<> O DCC (4)	I<> O DCC (4)
Earthing switch control	ESSXSWM1	I<> O ESC (1)	I<> O ESC (1)
	ESSXSWM2	I<> O ESC (2)	I<> O ESC (2)
	ESSXSWM3	I<> O ESC (3)	I<> O ESC (3)
Disconnecter position indication	DCSASW1	I<> O DC (1)	I<> O DC (1)
	DCSASW2	I<> O DC (2)	I<> O DC (2)
	DCSASW3	I<> O DC (3)	I<> O DC (3)
	DCSASW4	I<> O DC (4)	I<> O DC (4)
Earthing switch indication	ESSXSWM1	I<> O ES (1)	I<> O ES (1)
	ESSXSWM2	I<> O ES (2)	I<> O ES (2)
	ESSXSWM3	I<> O ES (3)	I<> O ES (3)
Autoreclosing	DARREC1	O -> I (1)	73 (1)
	DARREC2	O -> I (2)	73 (2)
Synchronism and energizing check	SECRSYNI	SYNO (1)	25 (1)

Table 141. Functions included in the relay, continued

Function	IEO #1650	IEO #0617	ANSI
Condition monitoring and supervision	SSCSR1	CSCM (1)	CSCM (1)
	SSCSR2	CSCM (2)	CSCM (2)
	SSCSR3	CSCM (3)	CSCM (3)
	TCSSCR1	TCM (1)	TCM (1)
	TCSSCR2	TCM (2)	TCM (2)
	CCSPVC1	MCS 3I (1)	MCS 3I (1)
	HZCCSPVC1	MCS LA (1)	MCS LA (1)
	HZCCSPVC2	MCS LB (1)	MCS LB (1)
	HZCCSPVC3	MCS LC (1)	MCS LC (1)
	SEOSPV1	FUSEF (1)	80 (1)
	MDSOPT1	OPTS (1)	OPTM (1)
	MDSOPT2	OPTS (2)	OPTM (2)
Measurement	CMXU1	3I (1)	3I (1)
	CSUSO1	I1, I2, I3 (1)	I1, I2, I3 (1)
	RESOMXU1	Io (1)	Io (1)
	VMSU1	3U (1)	3V (1)
	VAMXU2	U_A (2)	V_A (2)
	RESVMXU1	Io (1)	Io (1)
	VMSU1	V1, U2, U3 (1)	V1, V2, V3 (1)
	PEMXU1	P, E (1)	P, E (1)
	LDFRUC1	LOADPROF (1)	LOADPROF (1)
	FMXU1	f (1)	f (1)
	SCERFLO1	FLOC (1)	21FL (1)
	Power quality	COMMI	POM3 (1)
VMIH1		POM3U (1)	POM3U (1)
PHOVV1		POMV (1)	POMV (1)
VSOVUB1		POVUB (1)	POVUB (1)
Other	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 60817	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 (3 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay of (3 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (3 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Seizure (3 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (3 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
	MVGAPC3	MV (3)	MV (3)
	MVGAPC4	MV (4)	MV (4)
Integer value move	MVHGAPC1	MVH (1)	MVH (1)
	MVHGAPC2	MVH (2)	MVH (2)
	MVHGAPC3	MVH (3)	MVH (3)
	MVHGAPC4	MVH (4)	MVH (4)
Analog value scaling	SCAHGAPC1	SCAH (1)	SCAH (1)
	SCAHGAPC2	SCAH (2)	SCAH (2)
	SCAHGAPC3	SCAH (3)	SCAH (3)
	SCAHGAPC4	SCAH (4)	SCAH (4)
Generic control point (10 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 60817	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 (18 buttons)	FKEYGGIO1	FKEY (1)	FKEY (1)
Disturbance recorder	DRRE1	DR (1)	DR (1)
Logging function	FLTRFREC1	FAULTREC (1)	FAULTREC (1)
Fault recorder	SR1	SR (1)	SR (1)
Sequence event recorder	SE1	SE (1)	SE (1)

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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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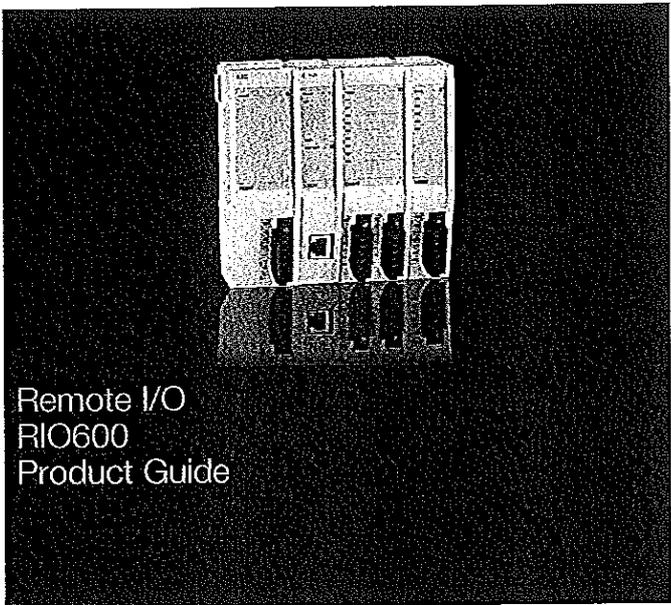
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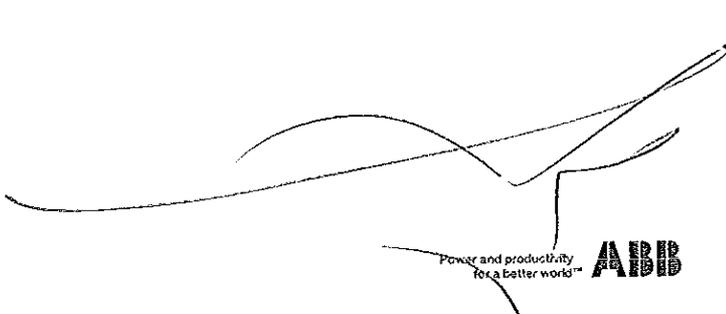


Remote I/O
RIO600
Product Guide

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

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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 Raton[®] 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 (disconnecter and earthing switch) used in gas insulated switchgears or standard two-position switches (disconnecter 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 Raton 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 Ω 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 ungrounded earthed networks where accurate and selective earth-fault detection is more challenging due to low fault currents.

temperatures, electromagnetic interference and stringent industry standards.

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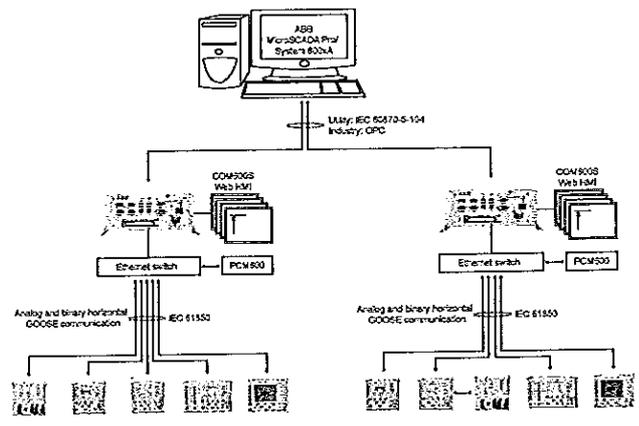


Figure 1. Connection overview of RIO600
RIO600 is designed using a modular architecture where the I/O control functionality is built on modules. The RIO600 modules can be stacked on a standard DIN rail to achieve the required configuration. The minimum configuration required for RIO600 contains a power supply module, a communication module and an I/O module.

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Table 1. RIO600 module types

Module type	Module	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	DMZH	High-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
		DMVL	Low-voltage range, eight optically isolated binary inputs with common return for pair of two inputs
	DOMH	Four output contacts in each digital output module with two pairs of potential free contacts with common return	
	RTDH	Four optically isolated channels supporting RTD sensors (Pt100, Pt250, Ni100, Ni120 and Ni50) and mA input (0...20 mA configurable). Individual channels are non-isolated from each other	
	ADOM	Four individually isolated channels of configurable mA outputs driving 0...20 mA signal	
	SIMF	Sensor input module with combined three-phase current and voltage signals	
	Smart control module	SCMH	High-voltage range, smart control module with five application types • 4NO – four input and four output channels • Three-position switch • Disconnecter • Circuit breaker • Earthing switch
		SCML	Low-voltage range, smart control module with five application types • 4NO – four input and four output channels • Three-position switch • Disconnecter • 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

Description	LECM with copper interface		LECM with fiber interface	
	Modules	Channels	Modules	Channels
Digital input modules (DMZH/DMVL)	5	40	5	40
Digital output modules	5	20	6	18
RTDH modules	5	20	4	16
Analog output modules	2	8	1	4
SIMF modules	5	-	4	-
Smart control modules (SCMH/SCML)	3	24	2	18

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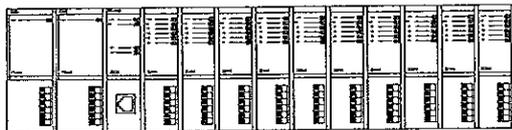


Figure 3. RIO600 configuration: 43 channels with 40 DI (10 x DOMH)

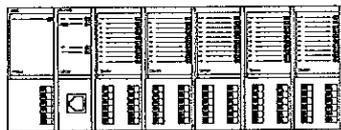


Figure 4. RIO600 configuration: 43 channels with 40 DI (5 x DMZH)

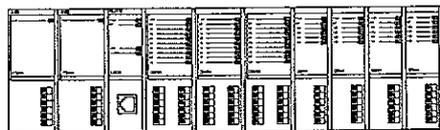


Figure 5. RIO600 configuration: 43 channels with 24 DI (3 x DMH) + 18 DO (3 x DOMH)

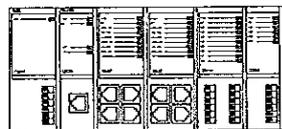


Figure 6. RIO600 configuration: 2 x SIMF + 1 x DMH + 1 x DOMH

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

Description	LECM with copper interface		LECM with fiber interface	
	Modules	Channels	Modules	Channels
Digital input modules (DMZH/DMVL)	6	40	5	40
Digital output modules	10	40	9	38
RTDH modules	10	40	9	38
Analog output modules	4	18	3	12
SIMF modules	5	-	5	-
Smart control modules (SCMH/SCML)	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 PCMS60. 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.

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-DIMVL, PSML-LECM-DIMZH or PSML-PSMH-LECM-DIMH-DIMVL-DOMH.

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
- RPF LED which indicates a fault condition if it is steady ON
- Communication diagnostic LED on the communication module

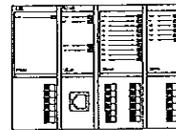


Figure 2. RIO600 configuration with 12 channels with 8 DI and 4 DO (1 x DMH + 1 x DOMH)

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3. Applications

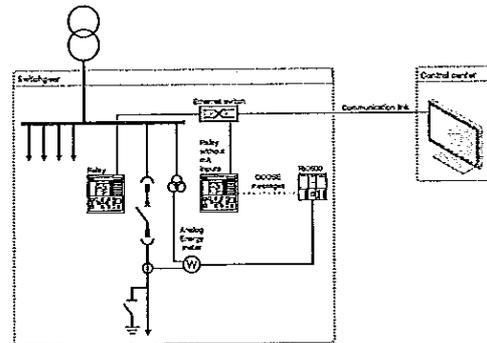


Figure 7. RIO600 as an external metering input for the protection relay

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

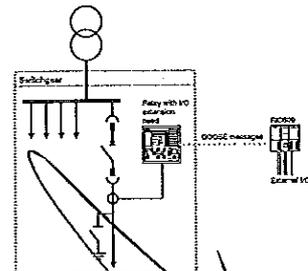
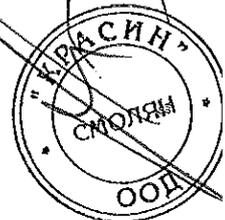


Figure 8. RIO600 as an I/O extension

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In Figure 9, RIO600 is used as an input/output extension to a protection relay or a COM600 substation automation unit.

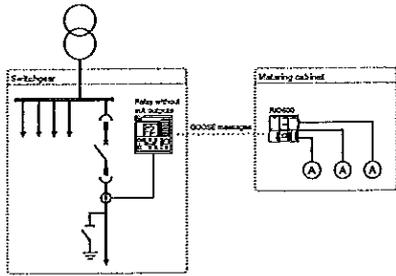


Figure 9. RIO600 communicating analog signals for the external meters

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

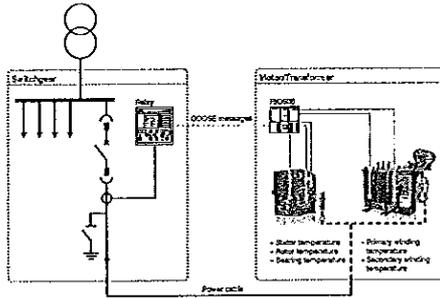


Figure 10. Temperature measurement using RIO600

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.

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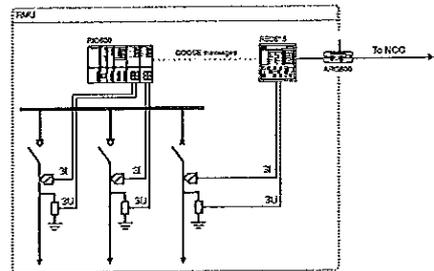


Figure 11. RVU fault passage indication using RIO600

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

4. Self-supervision

RIO600 has a built-in self-supervision feature which continuously monitors the status 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 (1-a-contact) of RIO600.

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

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

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5. Communication

RIO600 supports horizontal GOOSE (Generic Object Oriented Substation Eventing) 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 six 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 Mbps/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 PCN600 and a Web browser over the same communication bus.

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6. Technical data

Table 4. Module weights

Description	Value
PSM/PSML	236 g
LECM	123 g
DSM/DSML	256 g
DOM4	153 g
RTD4	256 g
ADM4	308 g
SNUP	180 g
SNV/SMCM	215 g

Table 5. Dimensions of the end clamp (EW 35, Woldrunder)

Description	Value
Width	8,5 mm (To be fixed at the ends of assembled modules)

Table 6. Power supply

Description	PSM	PSML
U_{DC} nominal	103, 110, 121, 223, 243 V AC, 50 and 63 Hz 110, 125, 220, 250 V DC	24, 33, 45, 60 V DC
U_{DC} variation	85...110% of U_{DC} nominal (89...254 V AC) 83...125% of U_{DC} nominal (88...300 V DC)	60...125% of U_{DC} 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 RIO modules	150 ms at U_{DC} nominal	50 ms at U_{DC} 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		
• Discreet (P) condition (none of the 20 I/O channels are activated)	<4.5 W nominal	
• Operating condition (20 binary output channels in DOM4 modules are activated)	<12.0 W (maximum)	
Module configuration	Condition	Max. consumption for PSM and PSML
PSM + LECM + DSM	All DIs activated	2 W
PSM + LECM + DSM	All DIs activated	4 W
PSM + LECM + DSM (S)	All DIs activated	12 W
PSM (2) + LECM + DSM (S)	All DIs activated	11 W
PSM (2) + LECM + DSM (S)	All DIs activated	22 W

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Table 7. Binary inputs

Description	DSMH	DSML
Rated voltage	110...250 V DC	24, 33, 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...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s (flaring time)	6 ms...4.0 s (flaring time)

Table 8. Signal outputs (Digital output module DSM)

Description	Value
Operating time	<5 ms
Nominal coil power	<500 mW
Rated voltage	250 V AC/DC
Conductance contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry for 0.8 s	16 A
Breaking capacity when the circuit time constant L/R <40 ms, at 45/115/223 V DC	1 A/9.25 A/0.15 A

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Table 9. mA/RTD input (RTD module)

Description	Value			
RTD inputs	Supported RTD sensors	150 Ω platinum 250 Ω platinum 120 Ω nickel 120 Ω nickel 250 Ω nickel 150 Ω platinum 250 Ω platinum 120 Ω nickel 120 Ω nickel 250 Ω nickel	TCR 0.00385 (DIN 43761) TCR 0.00385 TCR 0.00618 (DIN 43762) TCR 0.00618 TCR 0.00618 200 Ω per lead 200 Ω per lead 200 Ω per lead 200 Ω per lead 200 Ω per lead	
	Maximum lead resistance (three-wire measurement)	150 Ω platinum 250 Ω platinum	200 Ω per lead 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	<1 flaring 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 (AOM)

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



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Table 11. Sensor input module (SMP)

Description	Value	
Preferred ASB sensors	<ul style="list-style-type: none"> Combined sensors KEYCY 24 RE1, KEYCY38 RE1, KEYCY 43 RE1, KEYCO A Combination of current sensor KECA N3 C85 or KECA D85 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...4000 A
	Accuracy	±5% or ±1 A in the range of 4...83 A ±1% in the range of 83...4530 A ±1.0% in the range of 4800...8000 A
Line voltage measurement	Range	480 V...48 kV
	Accuracy	±5% in the range of 480...9200 V ±0.5% in the range of 9.8...45 kV
Power measurements: P, Q, S and PF	Range	9.8...29.8 kV 90...539 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) ±0.01 for power factor ±3.5% for energy
Line frequency measurement	Range	50 or 60 Hz
	Accuracy	For 50 Hz, ±0.05 Hz For 60 Hz, ±0.05 Hz Average operating current, voltage, power as per selection: 3 min/10 min/15 min/1 hour/2 hours/24 hours
Average operating current, voltage and power	Peak values for 1 day, 1 week, 1 month, 1 year	
General detection of the harmonics disturbances	<ul style="list-style-type: none"> Current THD (Total harmonic 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, 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: ±3° Operate time: ±1.0% of the set value or ±20 ms

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Table 11. Sensor input module (SMP), 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	DSM5H	DSM5L
Rated voltage	110...250 V DC	24, 33, 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...130 mW
Threshold voltage	78 V DC	13 V DC
Reaction time	5 ms...4.0 s (flaring time)	5 ms...4.0 s (flaring time)

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

Description	DSM5H	DSM5L
Operating time	<1 ms	<1 ms
Rated voltage	110...250 V DC	24, 33, 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 LCM)

Connector	Cable	Data transfer	Maximum distance	Wires 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	13 m	<1 dB

¹⁾ Maximum allowed attenuation based on cable losses and patch cord loss



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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...+75°C
Relative humidity	<93%
Atmospheric pressure	85...106 kPa
Altitude	up to 2500 m
Transport and storage temperature range	-42...+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 IEC 60255-27
Power consumption of auxiliary supply		IEC 60255-1 and IEC 60255-27
• Quiescent load	<4 W	
• Maximum load	<12 W	
Reversal of DC power supply polarity	1 minute for each polarity	IEC 60255-27
Start-up time test	<30 s	

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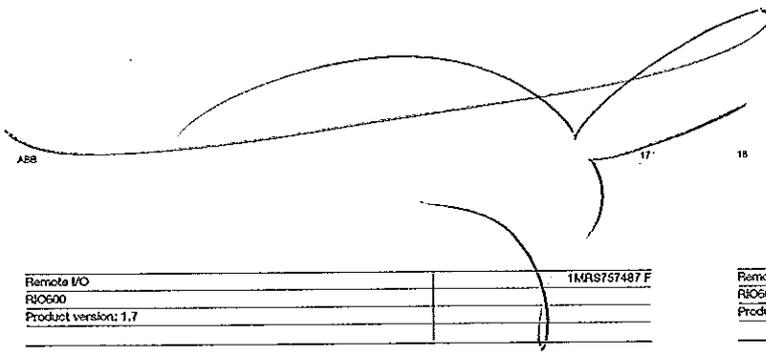
Table 20. Contact tests

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 IEC 60379-2005
Breaking capacity for DC, L/R 540 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 IEC 60379-2005
Mechanical durability	10000 operations	IEC 60255-1, IEC 61810-1 and IEC 60379-2005

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 IEC 60379-2005
Impulse voltage tests	1 kV, 1.250 µs, 0.5 J	IEC 60255-27 and IEC 60379-2005
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27

¹⁾ Insulation tests are not applicable to DP-REF



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Table 22. Electromagnetic compatibility and immunity tests

Description	Type test value	Reference
Electrostatic discharge		IEC 60255-28 and IEC 61000-4-2, Level 3
• Air discharge	8 kV	
Radio frequency electromagnetic field (amplitude modulation)	10 V/m (RMS) f = 85...1000 MHz and 1.4...2.7 GHz	IEC 60255-28 and IEC 61000-4-3, Level 3
Radio frequency electromagnetic field from digital radio telephones (pulse modulated)	10 V/m (RMS) f = 800 MHz, 1800 MHz	IEC 61000-4-3, Level 3
Power frequency (50 Hz) magnetic field		IEC 60255-28 and IEC 61000-4-4
• Continuous	100 A (RMS)/m	
• 3 s	300 A (RMS)/m	
Pulsed magnetic field	1000 A/m, 6.4/16 µs Tr/Fd; 5 pulses positive/negative; 10 s (rise interval)	IEC 61000-4-3, Level 5
Conducted disturbance induced by radio frequency fields, Amplitude modulated	0.15...0.18 MHz; 10 V (ar mod, RMS); 80% AM (1 MHz); 150 Ω source impedance 27 and 88 MHz (spot frequencies); 10 V (ar mod, RMS); 80% AM (1 MHz); 150 Ω source impedance	IEC 60255-28 and IEC 61000-4-5, Level 3
Fast transient (EFT) (including functional earth port)	500 ns Tr/Fd; 5 MHz repetition frequency 4 kV (peak) for power supply input/output ports and 2 kV (peak) for communication port	IEC 60255-28 and IEC 61000-4-4
Damped oscillatory waves (RF) 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 60255-28 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) 2/50 µs voltage pulse	1.2/50 µs Tr/Fd (open circuit) 8/20 µs Tr/Fd (short circuit)	IEC 60255-28 and IEC 61000-4-5
• Auxiliary power supply and input/output ports ¹⁾	41 kVp (L-Gnd) 42 kVp (L-L)	
• Communication port	42 kVp (L-Gnd) while no L-L test is applicable	
Voltage dips, short interruptions and voltage variation immunity tests (AO 50 Hz and 60 Hz)	20% reduction for 2500 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 60255-28 and IEC 61000-4-11
Voltage dips, supply interruption and voltage variations on DC input power port (immunity tests)	50% reduction for 500 ms 65% reduction for 200 ms 100% reduction for 10, 20, 30 and 50 ms 100% reduction for 5 s	IEC 60255-28 and IEC 61000-4-29
Ripple voltage	15% U _n frequencies of ripple 100/120 Hz (for 50/60 Hz)	IEC 60255-1, IEC 61000-4-17 and IEC 60379-2005
Gradual shut-down/start-up test (for DC power supply)		IEC 60255-28
• Ramp towards shut-down	60 s	
• Wait at power of condition	5 minutes	
• Ramp towards start-up	60 s	

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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 60255-28 and IEC 61000-4-18
• Differential mode	150 V (RMS) 100 Ω coupling resistor 0.1 µF coupling capacitor	
• Common mode	300 V (RMS) 220 Ω coupling resistor 0.477 µF coupling capacitor	
Emission tests		IEC 60255-28
• 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...50 MHz	<78 dB (µV) quasi-peak <69 dB (µV) average	
0.5...30 MHz	<73 dB (µV) quasi-peak <60 dB (µV) average	

¹⁾ The SPD is considered as a series I/O, the test is applied at all pins 4-5/3 at 10 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 ±5 kV common mode/differential mode	IEEE C37.90.1-2002
Radio frequency interference tests	20 V/m (prior to modulation) f = 30...1000 MHz (AM) f = 500 kHz (FM)	IEEE C37.90.2-2004
Electrostatic discharge test	±15 kV 8/20 discharge	IEEE C37.90.1-2001

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Remote I/O	1MRS757487 F
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Table 24. Mechanical tests

Description	Type test value	Reference
Vibration tests (sinusoids)	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: 18 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	• 95 h at +75°C	IEC 60068-2-2 and IEEE C37.90-2005
Dry cold test	• 95 h at -25°C • 16 h at -40°C	IEC 60068-2-1 and IEEE C37.90-2005
Damp heat cyclic test	• 8 cycles (12 h + 12 h) at +25...+55°C, humidity +93%	IEC 60068-2-30
Damp heat steady state test	• Temperature 43°C • Humidity 93% • Duration 95 h	IEC 60068-2-78 and IEEE C37.90-2005
Change of temperature test	• 5 cycles (1 h + 3 h) at -25...+55°C	IEC 60068-2-14
Storage test	• 95 h at -45°C • 95 h at +15°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 50283 (2009) EN 60255-26 (2007)

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Remote I/O	1MRS757487 F
RIO600	
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Table 27. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

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RIO600	
Product version: 1.7	

Functions available in SIMSF

Table 28. Functions available in SIMSF

Function	IEC 61850		IEC 60817	IEC-ANSI
	Edition 1	Edition 2		
Measurement functions				
Three-phase current measurement	CUMXU	CVMXU	M	M
Three-phase voltage measurement	VUMXU	VMXU	U	U
Residual current measurement	RESUMXU	RESVMXU	Io	Io
Residual voltage measurement	RESVMXU	RESVMXU	Uo	Uo
Three-phase power and energy measurement	PEMXXU	PEMXXU	P	P
Three-phase power direction	PWRPDR	PWRPDR	-	-
Energy monitoring	EMATR	EMATR	E	E
Current, voltage and power average and peak measurement	CUMSTA	CVMXU CVMXU RCVMXU	-	-
	VUMSTA	VVMXU VVMXU	-	-
	PEMSTA	PEVMXU PEMXXU	-	-
Power quality measurement functions (harmonics)				
Current total demand distortion monitoring	CMTH	CMTH	POH1	POH1
Voltage total demand distortion monitoring	VUMTH	VUMTH	POH2	POH2
Detection and Indication functions				
Three-phase non-directional overcurrent fault detection	PHPTOC	PHPTOC	3P	51P
Three-phase directional overcurrent fault detection	DHPTOC	DHPTOC	3P>	67P
Non-directional earth-fault fault detection	EFPTOC	EFPTOC	1P	51N
Directional earth-fault fault detection	DEFTOC	DEFTOC	1P>	67N
Multi-frequency admittance-based earth-fault indication	MFAFSD	MFAFSD	1P>Y	67YN
Voltage presence indicator	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 60...4500 A ±10% in the range of 4500...20000 A			
Suppression of harmonics	RMS: No suppression			

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Table 30. VUMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f _n ±5% in the range of 480 V...9.6 kV ±5.5% 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. RESUMXU Technical data

Characteristic	Value
Operation accuracy	At frequency f = f _n ±5.0% (when all three phase currents in the range of 60...630 A)
Suppression of harmonics	RMS: No suppression

Table 32. RESVMXU 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. PEMXXU 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 60...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) ±3.0% for power factor
Suppression of harmonics	RMS: No suppression

Table 34. EMATR 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 60...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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Remote I/O RIO600 Product version: 1.7	1MRS757487 F
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Table 35. PRPT00 Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_0$, $\pm 1.5\%$ of the set value
Operate time accuracy (DMT)	$\pm 1.0\%$ of the set value or ± 20 ms

Table 36. DRHP100 Technical data

Characteristics	Value
Operation accuracy	Depending on the nominal frequency of the current measured: $f = f_0$, Current: $\pm 1.5\%$ of the set value Voltage: $\pm 1.5\%$ of the set value Phase angle: $\pm 2^\circ$
Operate time accuracy (DMT)	$\pm 1.0\%$ of the set value or ± 20 ms

Table 37. EPPT00 Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_0$, $\pm 10\%$ of the set value in range of 4...25 A $\pm 1.5\%$ of the set value in range of 25...1000 A (Current measurement based on internal calculation)
Operate time accuracy (DMT)	$\pm 1.0\%$ of the set value or ± 20 ms

Table 38. DEFP100 Technical data

Characteristics	Value
Operation accuracy	Depending on the frequency of the current measured: $f = f_0$, Current: $\pm 10\%$ of the set value in range of 4...25 A $\pm 1.5\%$ of the set value in range of 25...1000 A Voltage: $\pm 1.5\%$ of the set value Phase angle: $\pm 1^\circ$ (Current measurement based on internal calculation)
Operate time accuracy (DMT)	$\pm 1.0\%$ of the set value or ± 20 ms

Table 39. MFAP50E Technical data

Characteristics	Value
Operation accuracy	At frequency $f = f_0$, $\pm 5\%$ in the range of 483 V...9.8 kV $\pm 5.5\%$ in the range of 9.8...28.4 kV
Operate time accuracy	$\pm 1.0\%$ of the set value or ± 50 ms

Table 40. PHSVPR Technical data

Characteristics	Value
Operation accuracy	At frequency $f = f_0$, $\pm 5\%$ in the range of 483 V...9.8 kV $\pm 5.5\%$ in the range of 9.8...28.4 kV

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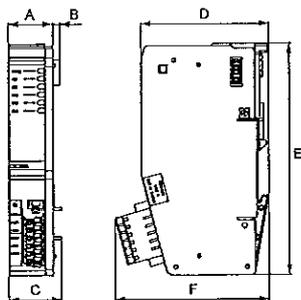


Figure 13. Dimension and mounting details of the digital output module DOM4

- A 27.5 mm
- B 4.5 mm
- C 33 mm
- D 81 mm
- E 148 mm
- F 93 mm

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Remote I/O RIO600 Product version: 1.7	1MRS757487 F
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7. Module dimensions

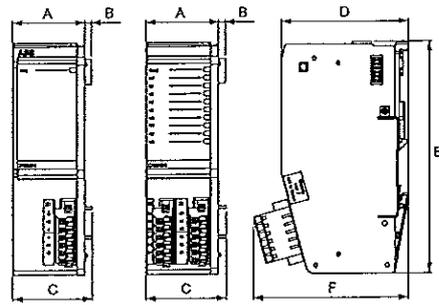


Figure 12. Dimension and mounting details of the PS24VPS160M/B/DEM5UR/ID4/AG/MA/SCM5/SCM3L modules

- A 45 mm
- B 4.5 mm
- C 51 mm
- D 81 mm
- E 148 mm
- F 93 mm

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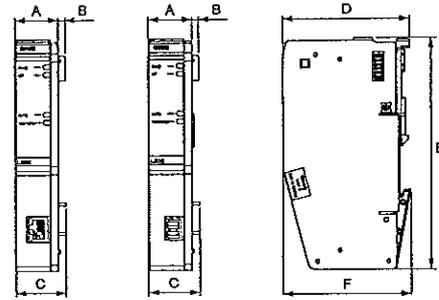


Figure 14. Dimension and mounting details of the communication module LCOM

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

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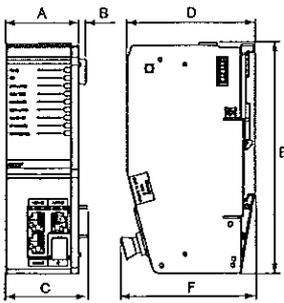


Figure 15. Dimension and mounting details of the 8MSF module

- A 49 mm
- B 4,25 mm
- C 51 mm
- D 31 mm
- E 149,5 mm
- F 85 mm

8. Assembly diagram

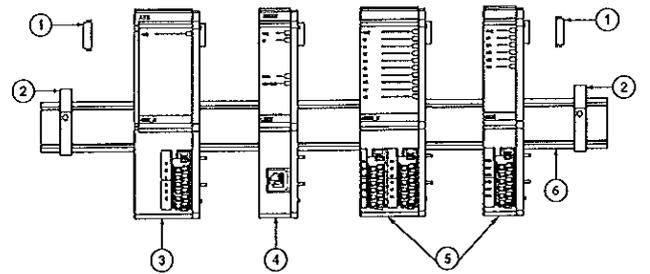


Figure 16. Assembly drawings of RIO600 modules

- 1 Rubber cap
- 2 End clamp
- 3 PSM module
- 4 LEDM module
- 5 Modules (8MAD04MRTD4/8M4S/8M5F/8M5H/8M5L)
- 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 Weldnutter 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	MO0650ADN5H
Digital input module with 8 inputs, low-voltage power supply	MO0650ADN5L
Digital output module with 4 outputs	MO0650AOD4R
RTD=AI input module with 4 inputs	MO0650ARTD4
Analog output module with 4 outputs	MO0650AOD4H
Sensor input module	MO0650AS5M5F
Smart control module with 4 inputs and 4 high-speed outputs, high-voltage power supply	MO0650ASC5H5H
Smart control module with 4 inputs and 4 high-speed outputs, low-voltage power supply	MO0650ASC5L5L
High-power supply module	MO0650APSMH07
Low-power supply module	MO0650APSML07
Communication module with RJ-45 port	MO0650FLECOMR
Communication module with multimode fiber optic LC port	MO0650FLECOMF

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 PCMS00 tool in combination with the RIO600-specific connectivity package.

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 package supports system integration and engineering and its minimizing device configuration and setup time.

The Protection and Control IED Manager PCMS00 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.

RIO600 parameters can be configured with Parameter Setting in PCMS00. Internal and station communication based logs are engineered in graphical Application Configuration and its Signal Matrix. IEC 61850 peer-to-peer communication can be configured in PCMS00 as well.

Table 42. Tools

Description	Version
PCMS00	2.7 Module 1 or later
Web browser	IE 8.0 or later
RIO600 Connectivity Package	1.7 or later

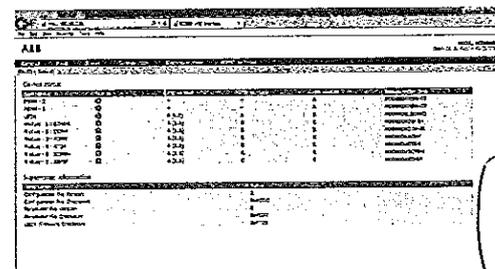


Figure 17. General view of RIO600 Web HMI

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11. Connection and terminal diagrams

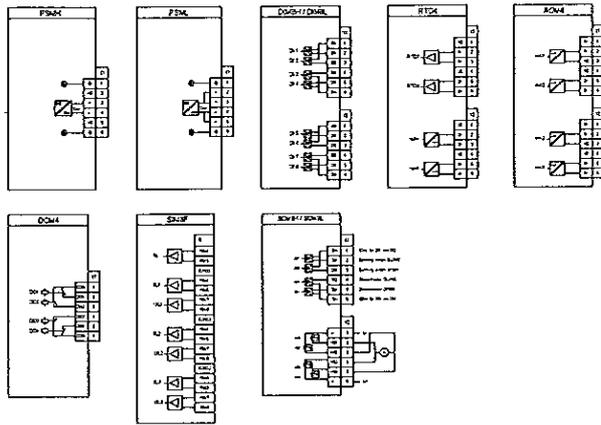


Figure 18. Connection and terminal diagrams of RIO600 modules

12. Document revision history

Document revision/date	Product version	History
A2011-12-23	1.0	First release
B2012-12-13	1.1	Content updated
C2013-03-20	1.2	Content updated
D2014-09-29	1.5	Content updated
E2015-04-31	1.6	Content updated
F2016-09-09	1.7	Content updated

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ВЯРНО С
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Power and productivity
for a better world™

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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.).

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1MRS757890

EU Declaration of Conformity

Issued 26.04.2013
Version B/20.04.2016
Technical ref. Mika Kortensniemi
Checked by Asko Koironen


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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
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CE - marked	2013
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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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ВААСО С
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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
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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
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CE - marked	2013
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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:

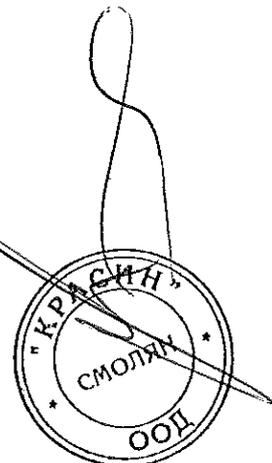
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ВЪРНО С
ОРИГИНАЛА



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. № PPC 17 – 169



Техническо предложение

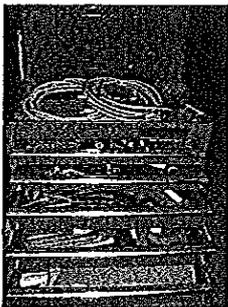
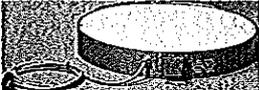
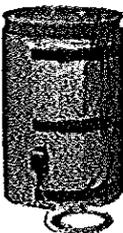
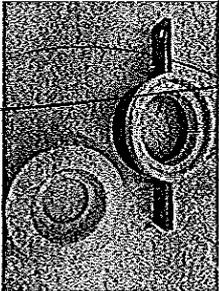
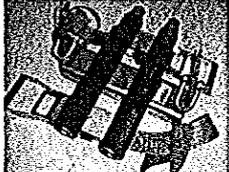


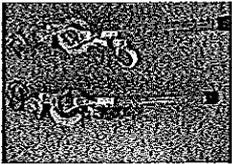
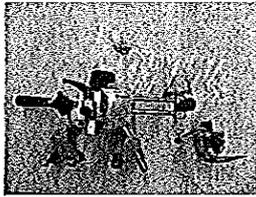
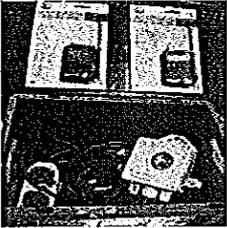
Техническа документация

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		<p>Набор монтажного инструмента Комплект 1010 (Монтажный инструмент включающий в себя необходимые позиции для разделки и монтажа кабеля высокого напряжения и кабельной арматуры)</p>
2		<p>Нагревательная плита (Предназначена для прогрева компаунда концевых муфт)</p>
3		<p>Нагревательная «рубашка» (Предназначена для прогрева компаунда концевых муфт)</p>
4		<p>Приспособление для натягивания силиконового изолятора (Приспособление состоит из прочных, мягких материалов, что не допускает повреждений на применяемой арматуре)</p>
5		<p>Устройство для крепления лебедок (Устройство фиксируется на кабель и имеет разъемы для крепления лебедок)</p>

№	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)

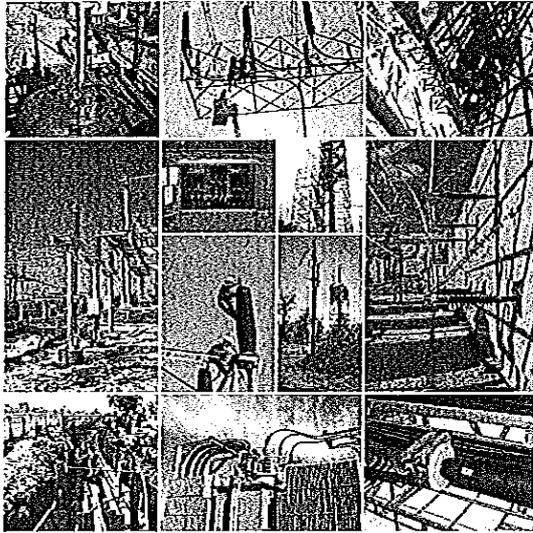


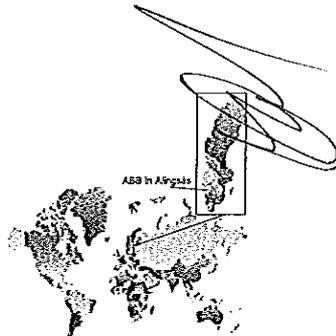
ABB ABB

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.



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".



Our factory is situated in Årågård about 50 kilometers 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 investment in quality and the environment are based on modern principles. They lead to the fulfillment of ambitious goals for competitiveness and profitability, with a view to maximizing 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



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 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 web site.

We reserve the right to alter the design and range of our products.

ABB AB
Kabeldon
Box 531, SE-411 15 Årågård, Sweden
Tel: +46 322 770 00
Fax: +46 322 770 01
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 *Some connector for joint* 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.

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 pre-moulded stress cones and splicing blocks. Resistive and refractive field control are achieved with special field-controlling materials integrated into prefabricated termination blocks.

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 swifly 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.

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.

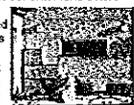
A separate product catalogue for low voltage switchgears is available on request.



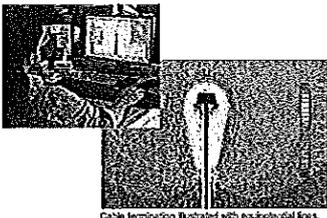
Flash-over during voltage withstand test of a cable termination.



Weather-O-Meter test of a cable termination.



Distribution board.



Cable termination illustrated with equipotential lines.

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 stocks.



Routine testing of high voltage cable joints.

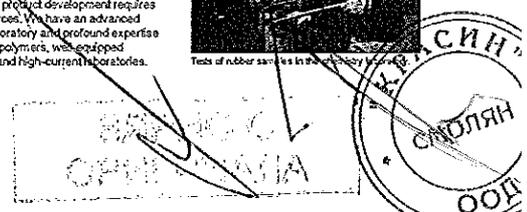


Testing in progress in the high voltage laboratory.



Tests of rubber samples in the laboratory.

Handwritten signatures and a stamp with the number 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-metallic test cables and accessories.

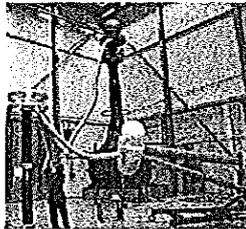
U_m = the maximum r.m.s. power-frequency voltage between two different conductors for which the cables and accessories are designed. It is the highest voltage that can be sustained under normal operating conditions at any time and at any point in a system. It excludes temporary voltage variations due 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 623.1 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_0 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_0 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_0 < 36 kV.

CENELEC: Current standards are HD 623.1 S1, which covers test methods, and HD 623.1 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 623.2 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_0 42 kV.

CENELEC voltage classes

U_0	U	U_m
3.6	6	7.2
3.8	6.8	7.2
6	10	12
6.35	11	12
6.7	15	17.5
12	20	24
12.7	22	24
18	30	36
18	33	36
20.6	35	42

IEEE: The currently applicable standards are Std. 43 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 52-420 kV
IEC standard 60240 covers cable systems with voltages above 38 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 60240 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 water tightness.

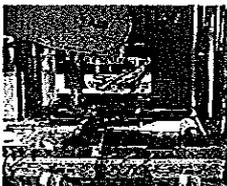
IEC voltage classes

U_0	U	U_m
28	45-47	52
35	60-62	72.5
54	110-115	135
72	130-131	160
87	150-161	190
127	220-230	265
180	315-337	380
190	335-344	392
270	380-400	470



We supply cable accessories for various types of cables.

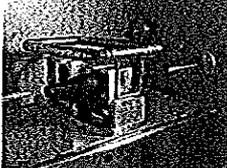
Manufacturing and testing



Manufacturing of premoiled 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 premoiled cable joints are routine tested after manufacturing.



A snapshot of cable termination manufacture.

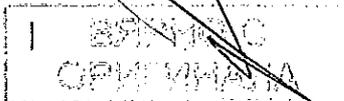


We have also developed electrical connections with reliable green technique.



Research and development are the key for manufacturing of our products.

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Reference pictures
Cable terminations
APED, APSEA

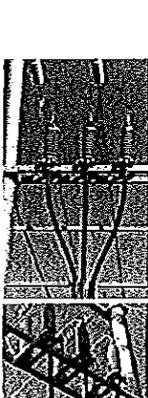
Reference pictures



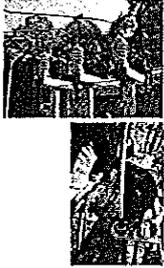
APED 72 kV, India.



APED 72 kV, Sri Lanka.



APED 72 kV, Port Hedland, the west Australia.



APSEA, Australia.



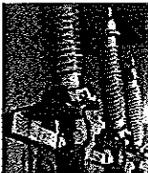
APED 38 kV, Australia



APSEA installed on the wallwashings, USA.

Reference pictures
Cable termination
APECB

Reference pictures



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 & into place, Greece.



APECB, Greece.



APECB-P 145 kV with composite insulator, Sweden.

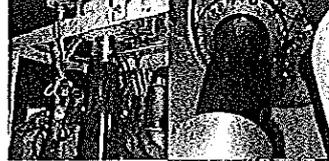


APECB-P 145 kV with composite insulator, Sweden.

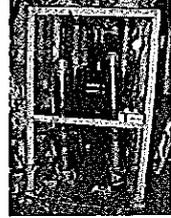


APECB assembled horizontally on the ground before lifted & into place, Australia.

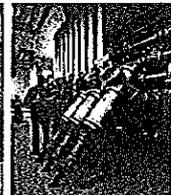
Reference pictures
Cable termination
APEGA GIS



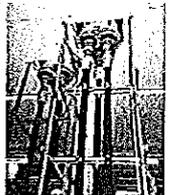
APEGA 170 kV at GIS (gas-insulated switchgear), Taiwan.



APEGA 170, Malaysia.



APEGA 110 kV at GIS, Finland.



APEGA 170 kV at GIS, Australia.

Reference pictures
Cable termination
APECB 84-420 kV



APECB Baltimore, USA.



Base part and cable clamp.



Stress cone.



Cover, clamp, and base.

1000731

ВЕРНО
ОРИГИНАЛ

«КРАСИН»
СМОЛЕНС

Reference pictures
Premoulded cable joints
JS 52-123 kV

Reference pictures



Reference pictures
Tape joint
SMX

Reference pictures



Reference pictures
Prefabricated cable joint
SMPGB

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Reference pictures
Cable distribution cabinets
for 12-24 kV
HDC 250 and HDC 630

Reference pictures



Installation of HDC 630 at Farsund, Norway.



Tereboda Energi, Malmöstad, Sweden.

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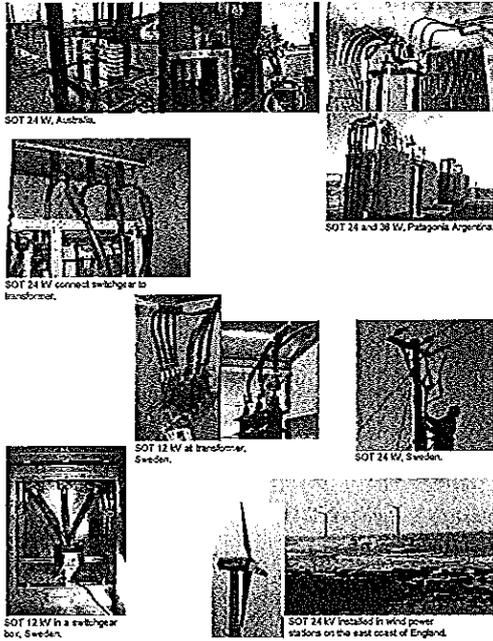
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ВЕРНО С
ОРИГИНАЛА

ИРАСИН
СМОЛ
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Reference pictures
Prefabricated cable termination
SOT

Reference pictures



SOT 24 W, Australia.

SOT 24 W connect switchgear to transformer.

SOT 24 and 36 W, Patagonia, Argentina.

SOT 12 W at transformer, Sweden.

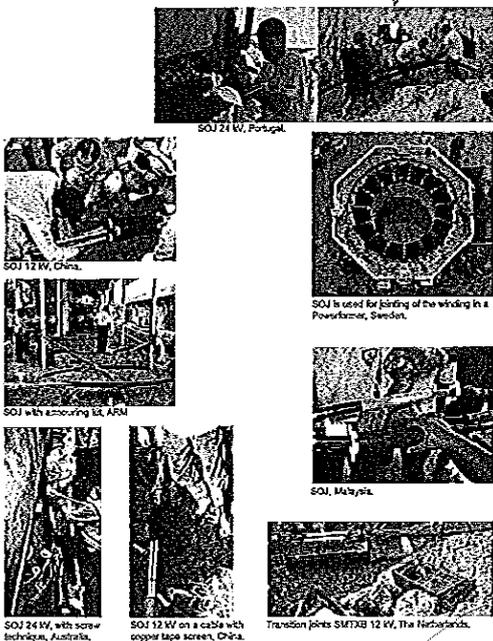
SOT 24 W, Sweden.

SOT 12 W in a switchgear box, Sweden.

SOT 24 W installed in wind power stations on the east coast of England.

Reference pictures
Prefabricated cable joint SOJ
Transition joint SMTXB

Reference pictures



SOJ 24 W, Portugal.

SOJ 12 W, China.

SOJ is used for joining of the winding in a Powerformer, Sweden.

SOJ with accessory kit, ARN.

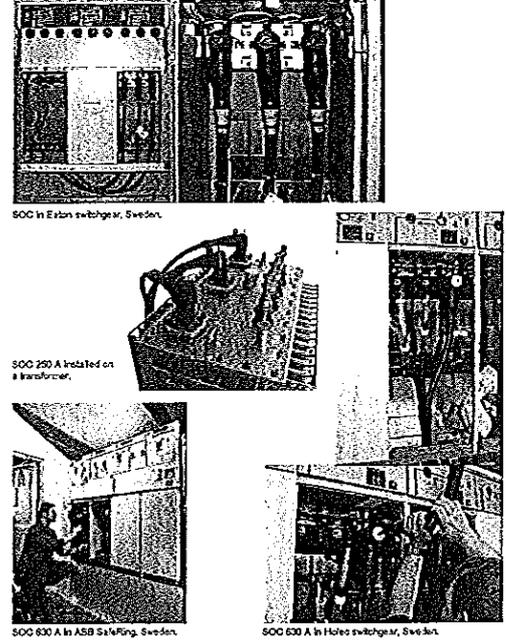
SOJ, Malaysia.

SOJ 24 W, with screw technique, Australia.

SOJ 12 W on a cable with copper tape screen, China.

Transition joints SMTXB 12 W, The Netherlands.

Reference pictures
Prefabricated cable connector
SOC



SOC in Eaton switchgear, Sweden.

SOC 250 A installed on a transformer.

SOC 630 A in ASB S4/Ring, Sweden.

SOC 630 A in Holes switchgear, Sweden.

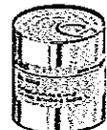
General accessories for
paper-insulated cable joints
and transition joints



GC
The kit contains one sealing ring, screws and two conical 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 ALPE side of the transition joints SMTXB 1502/1522/1532 when installing 1-core cables with an outer diameter greater than 40 mm.

IA 2112 - 2113
Impregnated paper for filling, for example in cable clamps.

R204 432
Funnel for oil filling.



IA 1003
Stress controlling tape.



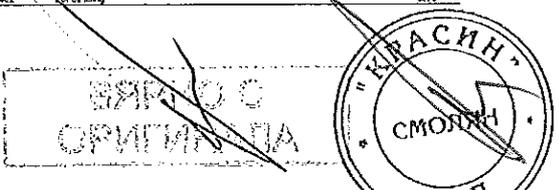
IA 2112 - 2113
Impregnated crepe paper tape.



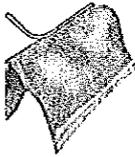
R204 432
Impregnated carbon crepe paper (conductivity).

Designation	Use	Length m	Width mm	Thickness mm	Weight kg/roll
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	8	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	203	0.5	1.60
IA 2512	For filling cable clamps	10	83	0.5	0.50
IA 2513	For filling cable clamps	14	100	0.5	0.75
R204	-	-	-	-	0.30
R204 432	For oil filling	-	-	-	0.10

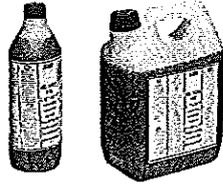
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Accessories for paper-insulated cable joints and transition joints



IG 1201 Cold insulating bitumen compound for cable clamps.



IG 1011, IG 1034 Insulating oil for joints and terminations for paper-insulated cables 12-52 kV. Need not be heated at temperatures exceeding 117°C.



IG 1117, IG 1118 Insulating film made of transparent polyester for transition joints and for paper-insulated cables 12-24 kV, type SM730 and SM70.



IK 1002 Ethen yarn.



IK 1003 Polyester tape.

Designation	Length m	Width mm	Voltage kV	Weight kg/10m
IG 1201	-	-	-	1.3
IG 1011	-	-	5.0	1.0
IG 1034	-	-	4.0	4.1
IG 1117	1.7	457	-	0.3
IG 1118	1.5	711	-	0.2
IK 1002	5	-	-	0.2
IK 1003	41.5	2.5	-	0.1

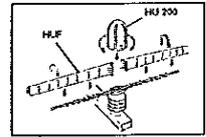
Bird protection for pole-mounted transformers, support insulators, etc

- Protects bird life
- Prevents short-circuit caused by birds
- UV-resistant material



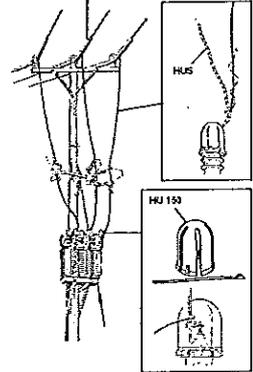
Use:
Used for bird protection on the high-voltage bushings for pole-mounted transformers. To prevent short-circuits caused by larger birds, HU is also placed on the surge arresters, but for total protection HU should be combined with an insulated down-conductor. This is done with insulation spiral HUS.

On post insulators, HU is used in combination with two wings HUF, which protect the overhead line closest to the insulator from short-circuiting.



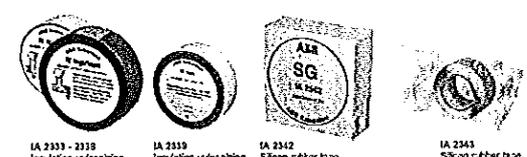
Standards:
HU is designed for bushings with a diameter of 120-220 mm according to DIN 42531 standard.

Design:
All components are made of UV-resistant plastic.

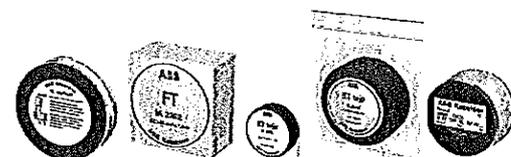


Designation	Bushing diameter A		Pieces/kit	Length m	Weight kg/10m
	min	max			
HU 150	120	180	3	-	0.6
HU 200	160	220	3	-	0.8
HUF	-	-	6	0.6	1.1
HUS	-	-	1	30	1.8

Tapes

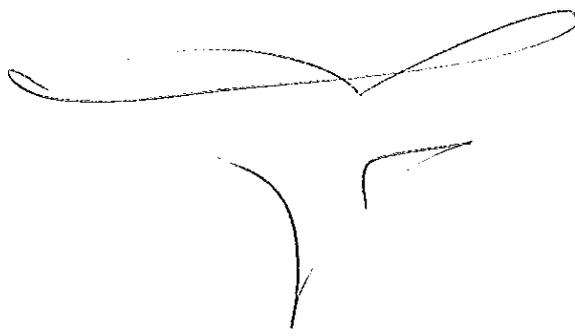


IA 2333 - 2339 Insulating vulcanizing tape. IA 2342 Silicon rubber tape. IA 2343 Silicon rubber tape.

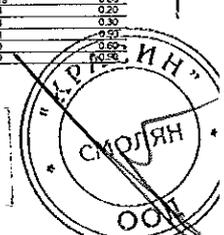
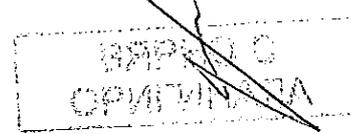


IA 2355 Semiconducting tape. IA 2402 Firing tape. IA 2421 Electrical tape. IA 2441 - 2444 Protective tape. RULLE Two-layer insulating tape made of EPDM and butyl rubber.

Designation	Length m	Width mm	Thickness mm	Weight kg/10m
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	0.16	0.10
IA 2342	9	25	0.5	0.18
IA 2343	7.5	25	0.5	0.30
IA 2352	4.5	19	3.8	0.30
IA 2353	1.5	38	3.8	0.30
IA 2421	10	19	0.18	0.08
IA 2441	19	25	0.4	0.20
IA 2443	19	50	0.4	0.30
IA 2444	30.5	80	0.4	0.50
RULLE 1	3.5	80	2.0	0.60
RULLE 2	5.5	80	2.0	0.80



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Other accessories



KC 1105, 1103
Abrasive cloth.



KC 1405, KC 1406
Lashing wire (plated copper wire).



KC 1421, KC 1407
Lashing wire (plated copper wire).



KC 1602
Lashing wire (galvanized steel wire).



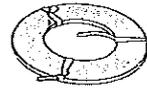
KC 2221
Silica grass, 25 g.



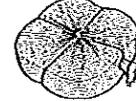
KC 2233
Grass, type AP paste, 10 g.

Designation	Length m	Diameter mm	Coarseness	Weight kg/roll
KC 1105	1	-	120	0.1
KC 1103	1	-	220	0.1
KC 1401	2	1.4	-	0.1
KC 1402	5	1.4	-	0.1
KC 1405	3.5	1.4	-	0.2
KC 1407	6	1.0	-	0.2
KC 1602	4	1.5	-	0.1
KC 2221	-	-	-	0.03
KC 2233	-	-	-	0.02

Other accessories



IA 1701
Earthing braid, sold by the
meter, 10 mm.



IA 1705
Copper net for e.g. SMOS, sold
by the meter, approx. 10 mm.



IA 1719
Earthing braid with
lining, 10 mm.



KC 2259
Washing cloth, 3 alcohol-treated
paper cloths 200 x 300 mm.



MSR 250
Stainless marking
tape, 100 units/roll.



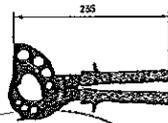
SKALUS
Peeling string for
XLPE insulation.

Designation	Length m	Width mm	Thickness mm	Weight
IA 1701	-	15	1.0	0.10 kg/m
IA 1705	-	60	1.5	0.05 kg/m
IA 1719	0.4	27	0.1	0.08 kg/m
KC 2259	-	-	-	0.03 kg/roll
MSR 250	0.25	-	1.0	0.50 kg/roll
SKALUS	2	-	1.0	0.02 kg/roll

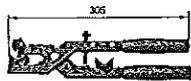
Tools



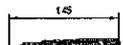
730 R
Torque wrench for screw connectors,
screw cable legs, overhead line clamps,
etc. Supplied with 7 mm socket head,
extension and 8 mm internal hexagon
head.
Torque range 6-50 Nm.



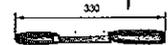
Inter cable No. RGS 1607 654
Cable shears for cutting cable
Ø max 64 mm.



RGM 1055
Splitting tool for longitudinal splitting
of XLPE insulation
with Ø 10-55 mm.



RGM 679
Cable knife, 30 mm blade.



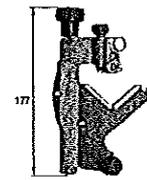
RGM 672
Sheath removing knife with
two handles for plastic
sheathed cable.

Designation	Description
730 R	Torque wrench
RGS 1607 654	Cable shears
RGM 1055	Splitting tool
RGM 679	Cable knife
RGM 672	Sheath removing knife

Tools



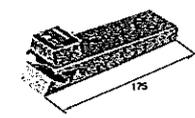
Inter cable No. AV 6220
Sheath removing tool for
PE-sheathed cable Ø > 20 mm.



Inter cable 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 4020
Cutting tool for cable sheath
and XLPE insulation.
Diameter Ø 15-50 mm
Cutting depth: ≤ 8 mm.



Model 1700 Series
Peeling tool for stripable outer
conductive layer on XLPE
insulated cable Ø 13-51 mm.

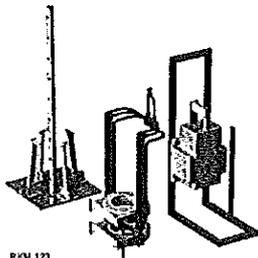
Designation	Description
AV 6220	Sheath removing tool
FBS-1722 1	Stripping tool
GB-4020	XLPE stripping tool
Model 1700 Series	Peeling tool

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ВЕРИТЕ С
ОРИГИНАЛ



Equipment for installation of cable joints and terminations



RUM 123
Installation tool for JB and JK cable joints.



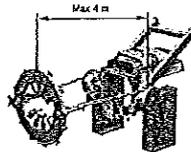
RUM 850
Saving tool to split an installation tube.



Installation kit
The kit consists of an installation cone, extraction sleeve halves and assembly ring halves. It is available in seven sizes that must be selected according to the cable cross-section.

Designation	Description	Net weight kg/lot
RUM 123	Installation tool	55.0
RUM 850	Saver to split an installation tube	0.8
Installation kit	Installation kit	9.8

Tool and accessories



RUM 170
Installation tool for SMP08 joint 145-170 kV.



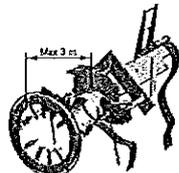
Installation cone
For installing adapter.

Designation	Description	Weight kg/lot
RUM 170	Installation tool	42

Installation cone	Installation cone	
-------------------	-------------------	--



Installation cone
For installing adapter.



RUM 352
Installation tool for SMP08 joint 302 kV.

To be ordered separately:

Designation	Description	Net weight kg/lot
RUM 352	Installation tool for SMP08 302 kV	74

Earthing kits for cable terminations

Note that the earthing kit increases the cable outer diameter by 20 mm!

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.

- For corrugated screens made of:
 - Aluminum (JSA 1 Al)
 - Copper (JSA 1 Pb)
 - Steel (not tested)



Cable with copper wire screen only.

No earthing kit is needed.



Cable with copper wire screen and metal-PE laminate.

Use earthing kit SKC 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	Outer diam. over sheath mm	No. of plates	Total Cu equivalent cross section in earthing kit mm ²	No. of Cu braids	For cables with
JSA 1 Al	—	—	130	6	Corrugated aluminum
JSA 1 Pb	43-120*	—	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
SKC 2-1	13-26	1	—	—	Metal-PE laminated as radial water-tightness
SKC 2-2	26-28	2	—	—	Metal-PE laminated as radial water-tightness
SKC 2-3	28-30	3	—	—	Metal-PE laminated as radial water-tightness
SKC 2-4	30-32	4	—	—	Metal-PE laminated as radial water-tightness
SKC 2-5	32-34	5	—	—	Metal-PE laminated as radial water-tightness
SKC 2-6	34-36	6	—	—	Metal-PE laminated as radial water-tightness
SKC 2-7	36-38	7	—	—	Metal-PE laminated as radial water-tightness
SKC 2-8	38-40	8	—	—	Metal-PE laminated as radial water-tightness
SKC 2-9	40-42	9	—	—	Metal-PE laminated as radial water-tightness
SKC 2-10	42-44	10	—	—	Metal-PE laminated as radial water-tightness

* Applicable for cable sheath $\ge 10\text{ mm}$. For thicker sheath contact us.

Handwritten signatures and scribbles.

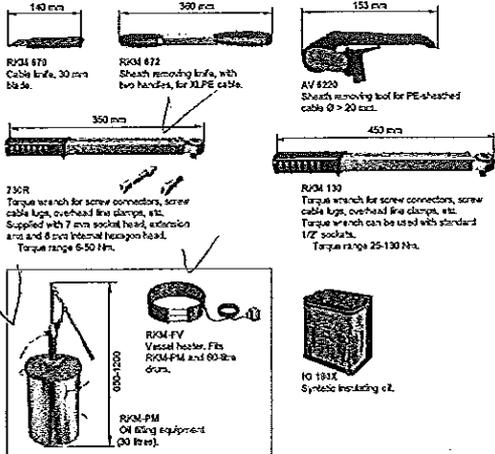
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ВЯРНИ ОРИГИНАЛ



Tools and oil

All dimensions in mm

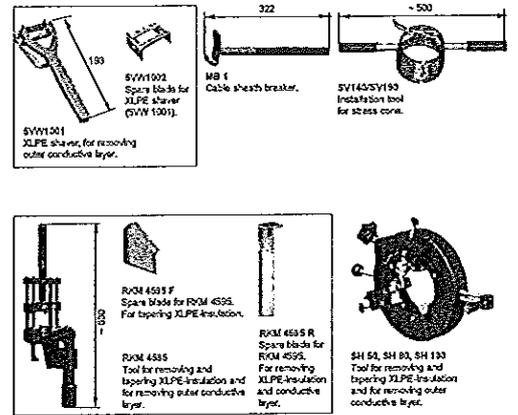


Designation	Description	Designation	Description
RJM 670	Cable knife	RJM 130	Torque wrench 25-130 Nm
RJM 672	Sheath removing knife	RJM PM	Manual oil filling equipment
AV 6220	Sheath removing tool	RJM FV	Vessel heater
730 R	Torque wrench 8-50 Nm		

Designation	Description	Content	Vessel
IO 1801	Synthetic insulating oil	4	Tin
IO 1803	Synthetic insulating oil	2	Tin
IO 1805	Synthetic insulating oil	60	Drum
IO 1807	Synthetic insulating oil	130	Drum

Tools

All dimensions in mm



Designation	Description	Diagonal access XLPE-insulation Ø mm
SVW1001	XLPE shaver	
SVW1002	Spare blade	
RJM 4555	Tool for removing and opening	45-50
RJM 4555 F	Spare blade for opening the insulation	
RJM 4555 R	Spare blade for removing the insulation	
MB 6	Cable sheath breaker (jack of bar)	
SH 5A	XLPE shaver	15-50
SH 80	XLPE shaver	40-80
SH 130	XLPE shaver	70-130
SV145	Installation tool for stress cone, SSG	
SV193	Installation tool for stress cone, SSG	

Kabeldon general accessories

- Non-magnetic
- With stands 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.

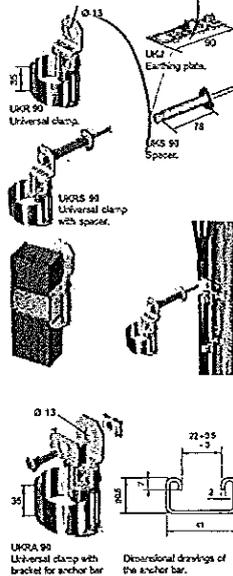
Typical applications:



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.



Designation	Weight kg/10m
UKR 90	0.17
UKRA 90	0.23
UKR 90	0.28
UKR 90	0.45
UKR 90	0.14

Kabeldon general accessories

- Non-magnetic
- With stands 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.

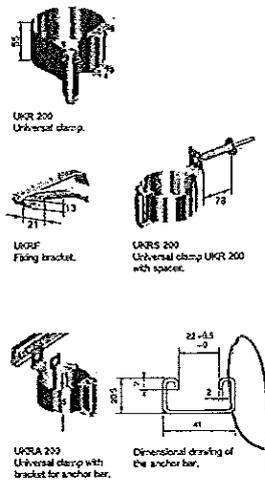
UKRF
Application:
For fixing cables, etc., to cable ladders. For use together with UKR 200. The height of the ladder profile is approx. 16 mm and will fit within the specified dimensions.

Design:
The bracket is made from hot-dip galvanized steel.

UKRA 200
Application:
For fixing cables with diameters of 50-275 mm to the anchor bars.

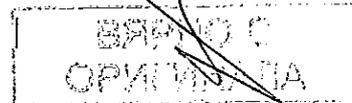
Design:
The bracket is made of hot-dip galvanized steel. The band is stainless steel SS 2333-02 with rounded edges and a thickness of 0.2 mm. The locking bolt is made of die-cast zinc alloy and can be tightened and locked in one operation.

A spring-loaded shaped nut with a reversible locking washer offers a choice of fixed or flexible position and direction.



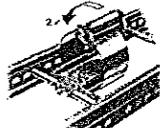
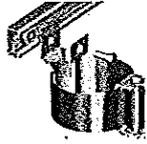
Designation	Weight kg/10m
UKR 200	0.22
UKRA 200	0.45
UKRF	0.21
UKRS 200	0.21

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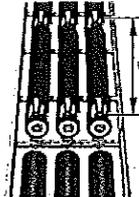
Typical applications
UKR 200, UKRA 200

Flat configuration
(Results of testing with 2 turns of steel band).

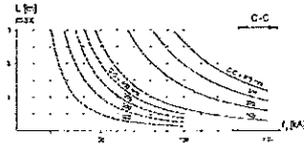


UKR 200 with fixing brackets UKRF.

Max Ø 275

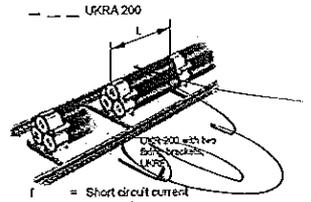
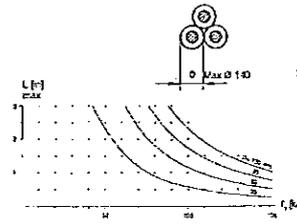


UKR 200 with one fixing bracket UKRF.



I_s = Short circuit current (peak value)
C-C = Distance between cable centres
 L_{max} = Distance between clamps
UKR 200 with fixing bracket UKRF

Trefoil configuration



UKRA 200 with two fixing brackets UKRF.
 I_s = Short circuit current (peak value)
D = Outer diameter of cable
 L_{max} = Distance between clamps
UKR 200 with fixing bracket UKRF

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ВАРШО С
ОРИГИНАЛ



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.

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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:

Стандарт:

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

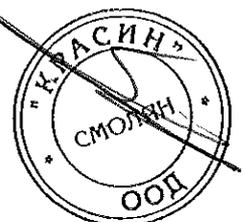
Номер на удостоверението: SE004225-1 / SE004224-1 / SE004226-1

Само електронно копие



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ВЕРИТАС
ОРИГИНАЛ



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

Согр
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, Нюшюпинг
Продажби M&D, Лулеа
Продажби M&D, Йоншюпинг
Продажби M&D, Стокхолм
Продажби M&D, Йорншюлдсвик

Продукти ниско напрежение

Cewe-ontrol, Вастерас
Cewe-ontrol, Нюшюпинг
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,
Сертификационно Бюро „ВЕРИТАС Швеция АБ“

000741

ВЕРНО С
ОРИГИНАЛА



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, Карлсруна
Високо постоянно напрежение, Лудвика
FACTS, Вастерас
Офшърни Вятърни вризки, Вастерас
Подстанции, Вастерас
Вентикс, Вастерас
АП Продукти, Вастерас
АП Системи, Вастерас
Производство на електроенергия, Вастерас

Услуги

Вастерас
Данемора
Фигехолм
Финспонг
Гьотеборг
Хускварна
Карлсруна
Карлстад
Кируна
Галивар
Лудвика
Лулеа
Малмьо
Мьолндал
Норщюпинг
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



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

ВЕРНО С
ОРИГИНАЛА

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

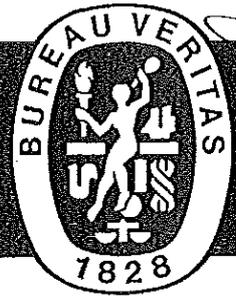
Date: 19 May 2015

Mikael Lindström
Technical Manager,
Bureau Veritas Certification Sverige AB

000744

ВЯРНО С
ОРИГИНАЛ

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 the applicability of the management system requirements may

Further clarification be obtained

applicability of the management system requirements may

Mikael Lindström, Technical Manager, Bureau Veritas Certification Sverige AB

Date: 23 April 2015

Certificate Number: SE004225-1 / SE004224-1 / SE004226-1

Bureau Veritas Certification Sverige AB, Fabriksgatan 13, 412 50 GÖTEBORG, Sverige



000745



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

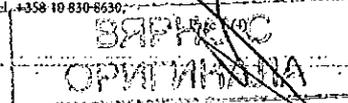


0008

Certification body address: Bureau Veritas Certification Holding SAS – UK Branch, 66 Prescott Street, London E2 8JG, 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



BUREAU VERITAS
Certification

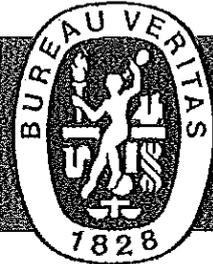


ABB Oy

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
Strömbergintie 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

Hölmantie 13, FI-00380 Helsinki, Finland
Strömbergintie 1 Aa, FI-00380 Helsinki, Finland
Valimopolku 4 A, FI-00380 Helsinki, Finland
Kiitoradantie 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: FIHSK8968319.AB

Version 1, Revision date: 7 March 2017

на основание чл. 2 от ЗЗЛД

Signed on behalf of BVCH SAS UK Branch

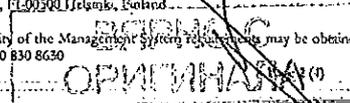


0000

Certification body address: Bureau Veritas Certification Holding SAS – UK Branch, 66 Prescott Street, London E1 8 1G, United Kingdom
Certification office: Bureau Veritas Certification Finland, Sörnästen rantatie 29, FI-00380 Helsinki, Finland

For further clarifications regarding the scope of this certificate and the applicability of the Management System Requirements, you may be obtained by consulting our contact centre. To check the validity of this certificate, please call us, +358 10 830 8630

000747



BUREAU VERITAS
Certification

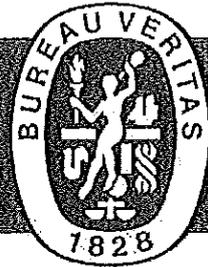


ABB Oy

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

Merenkulukijankatu 1, FI-00980 Helsinki, Finland
Komentosilta 1, FI-00980 Helsinki, Finland
Rydöntie 7, FI-20360 Turku, Finland
Ilaliharantie 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

Muotitie 2 A, FI-65320 Vaasa, Finland
Dynamotie 4 N, FI-65320 Vaasa, Finland
Hennankatu 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 основании чл. 2 от ЗЗЛД

Signed on behalf of BVGH SAS UK Branch



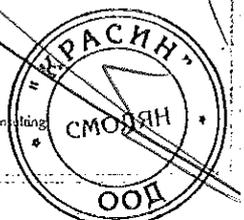
0088

Certification body address: Bureau Veritas Certification Holding SAS - UK Branch, 66 Prescott Street, London E1 8JG, United Kingdom
Certification office: Bureau Veritas Certification Finland, Sörnäisten rantatie 29, FI-00500 Helsinki, Finland

For other clarifications regarding the scope of this certificate and the applicability of the Management System requirements, may be obtained by consulting the issuing organisation. To check the validity of this certificate please call, tel. +358 10 830 8230

000748

ОРГИНИАЛ



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

Virtaväva 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 E, FI-87100 Kajaani, Finland

ABB Oy, Protection and Connection
Marketing, sales, development, design, manufacturing and delivery of low voltage switch products

Muotitie 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 основании чл. 2 от 33ЛД

Signed on behalf of BVCH SAS UK Branch



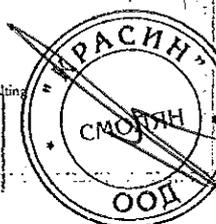
0008

Certification body address: Bureau Veritas Certification Holding SAS - UK Branch, 66 Prescot Street, London E1 8JG, 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

ВЯРЛОС
ОРВИЕНА



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 основании чл. 2 от 33ЛД

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

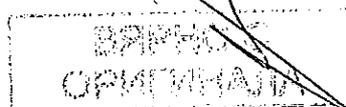
Langemarckstraße 20

45141 Essen

www.tuev-nord-cert.com



000750



[ЛОГО на ТЮФ НОРД]

СЕРТИФИКАТ

Система за управление съгласно
ISO 9001 : 2008

В съответствие с процедурите на ТЮФ НОРД CERT, 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 CERT ГмбХ

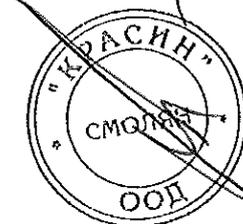
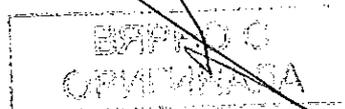
Есен, 2015-10-16

Настоящата сертификация е проведена в съответствие с одитните и сертифициращи процедури на ТЮФ НОРД CERT и е предмет на периодични контролни одити.

ТЮФ НОРД CERT Лангемаркщрасе 20 45141 Есен www.tuev-nord-cert.com

[лога, не се чете]

000751



CERTIFICATE

Management system as per
ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that

ARKASIL
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

Kbaas

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

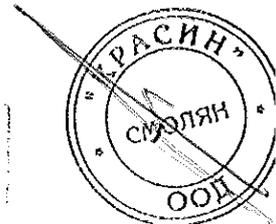
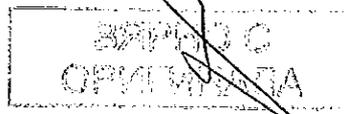
Langemarckstraße 20

45141 Essen

www.tuev-nord-cert.com



000752



СЕРТИФИКАТ

Системы менеджмента в соответствии с
ISO 9001 : 2008

В соответствии с процедурами TÜV NORD CERT настоящим подтверждается, что

AKKASIL
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

Kbaas
Сертификационный орган
в TÜV NORD CERT GmbH

г. Эссен, 2015-05-20

Процесс сертификации проведён в соответствии с процедурами аудиторирования и сертификации TÜV NORD CERT и подлежит регулярным надзорным аудитам.

TÜV NORD CERT GmbH

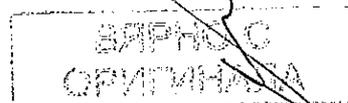
Langemarckstraße 20

45141 Essen

www.tuev-nord-cert.com



000753



[ЛОГО на ТЮФ НОРД]

СЕРТИФИКАТ

Система за управление съгласно **ISO 9001 : 2008**

В съответствие с процедурите на ТЮФ НОРД CERT, 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

Итен 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 CERT ГмбХ

Есен, 2015-05-20

Настоящата сертификация е проведена в съответствие с одитните и сертифициращи процедури на ТЮФ НОРД CERT и е предмет на периодични контролни одити.

ТЮФ НОРД CERT

Лангемаркштрассе 2045141 Есен

www.tuev-nord-cert.com

[лого, не се чете]

000754

ВЯРНО
ОРИГИНАЛ

