Relion® 615 series

Capacitor Bank Protection and Control
REV615
Product Guide

Contents

1. Description

REV615 is a dedicated capacitor bank relay designed for the protection, control, measurement and supervision of capacitor banks used for compensation of reactive power in utility substations and industrial power systems. REV615 can also be used for protection of harmonic filter circuits, if the highest significant harmonic component is the 11th. REV615 is a member of ABB's Relion® product family and part of its 615 protection and control product series. The 615 series relays are characterized by their compactness and withdrawable-unit design.

Re-engineered from the ground up, the 615 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices.

The relay provides main protection for single star, double star, and H-bridge connected capacitor banks and harmonic filters in distribution networks.

Depending on the chosen standard configuration, the relay is adapted for the protection of H-bridge connected or double star connected shunt capacitor banks. Once the standard configuration relay has been given the application-specific settings, it can directly be put into service.

The 615 series relays support a range of communication protocols including IEC 61850 with Edition 2 support, process bus according to IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Profibus DPV1 communication protocol is supported by using the protocol converter SPA-ZC 302.

2. Standard configurations

REV615 is available in two alternative standard configurations. The standard signal configuration can be altered by means of the signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Further, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions using various logical elements, including timers and flip-flops. By combining protection functions with logic function blocks, the relay configuration can be adapted to user-specific application requirements.

The relay is delivered from the factory with default connections described in the functional diagrams for binary inputs, binary outputs, function-to-function connections and alarm LEDs. Some of the supported functions in REV615 must be added with the Application Configuration tool to be available in the Signal Matrix tool and in the relay. The positive measuring direction of directional protection functions is towards the outgoing feeder.
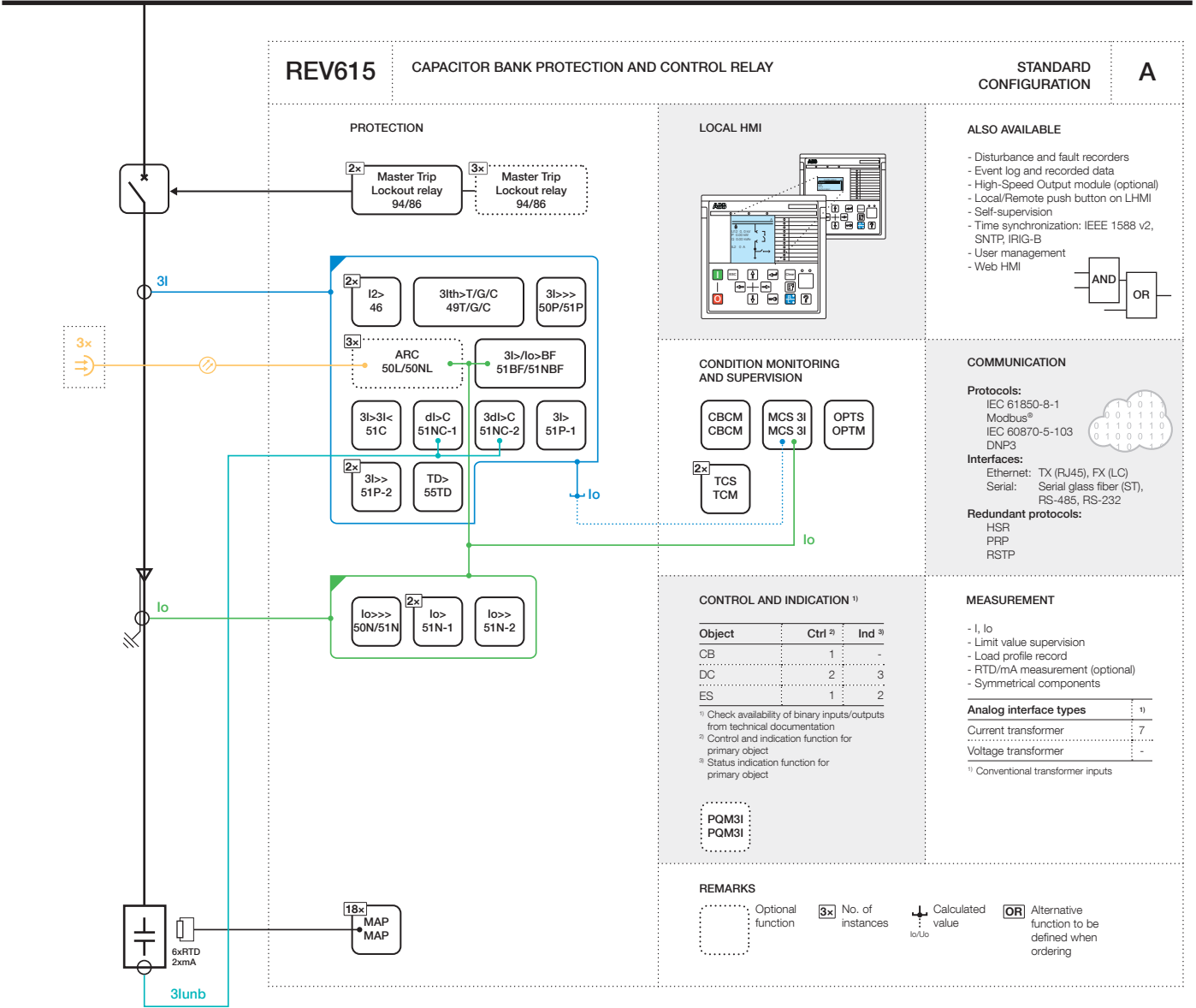
ABB   3

| REV615 | CAPACITOR BANK PROTECTION AND CONTROL RELAY | STANDARD CONFIGURATION | A |

PROTECTION

- 2× Master Trip Lockout relay 94/86
- 3× Master Trip Lockout relay 94/86

3I

- 2× I2> 46
- 3Ith>T/G/C 49T/G/C
- 3I>>> 50P/51P

3×

- 3× ARC 50L/50NL
- 3I>/Io>BF 51BF/51NBF

- 3I>3I< 51C
- dI>C 51NC-1
- 3dI>C 51NC-2
- 3I> 51P-1

- 2× 3I>> 51P-2
- TD> 55TD

Io

Io

- Io>>> 50N/51N
- 2× Io> 51N-1
- Io>> 51N-2

LOCAL HMI

CONDITION MONITORING AND SUPERVISION

- CBCM CBCM
- MCS 3I MCS 3I
- OPTS OPTM

- 2× TCS TCM

Io

CONTROL AND INDICATION [1]

Object	Ctrl [2]	Ind [3]
CB	1	-
DC	2	3
ES	1	2

[1] Check availability of binary inputs/outputs from technical documentation
[2] Control and indication function for primary object
[3] Status indication function for primary object

- PQM3I PQM3I

REMARKS

- Optional function
- 3× No. of instances
- Calculated value Io/Uo
- OR Alternative function to be defined when ordering

ALSO AVAILABLE

- Disturbance and fault recorders
- Event log and recorded data
- High-Speed Output module (optional)
- Local/Remote push button on LHMI
- Self-supervision
- Time synchronization: IEEE 1588 v2, SNTP, IRIG-B
- User management
- Web HMI

AND OR

COMMUNICATION

Protocols:
  IEC 61850-8-1
  Modbus®
  IEC 60870-5-103
  DNP3
Interfaces:
  Ethernet: TX (RJ45), FX (LC)
  Serial: Serial glass fiber (ST), RS-485, RS-232
Redundant protocols:
  HSR
  PRP
  RSTP

MEASUREMENT

- I, Io
- Limit value supervision
- Load profile record
- RTD/mA measurement (optional)
- Symmetrical components

Analog interface types	[1]
Current transformer	7
Voltage transformer	-

[1] Conventional transformer inputs

- 18× MAP MAP
- 6xRTD 2xmA

3Iunb

Figure 1.   Functionality overview for standard configuration A
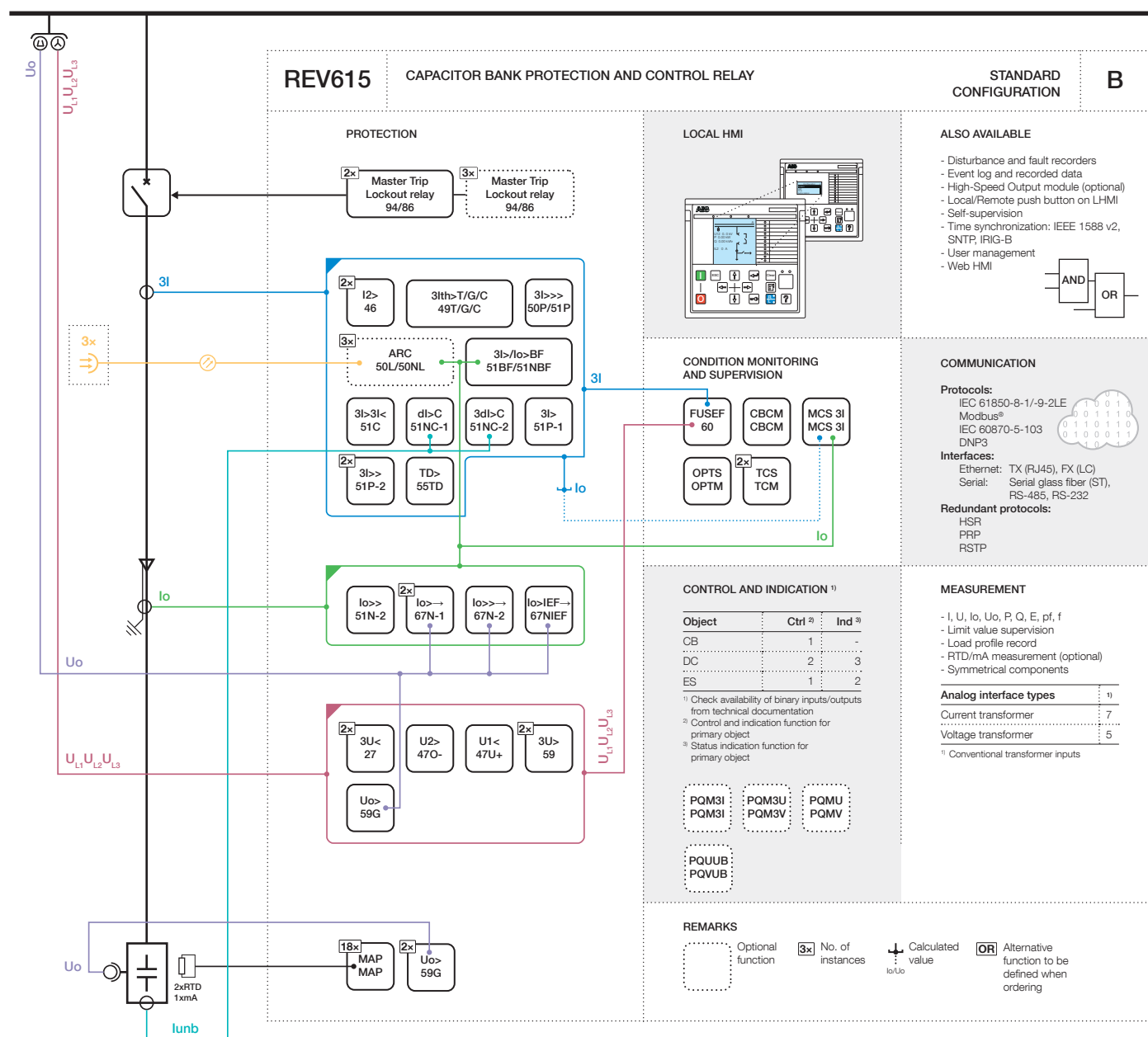
Figure 2.   Functionality overview for standard configuration B

Table 1. Standard configurations

Description	Std. conf.
Capacitor bank overload and unbalance protection, non-directional overcurrent and earth-fault protection and circuit-breaker condition monitoring	A
Capacitor bank overload and unbalance protection, non-directional overcurrent and directional earth-fault protection, voltage and frequency based protection and measurements, and circuit-breaker condition monitoring	B

ABB   5

Table 2. Supported functions

Function	IEC 61850	A	B
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	1	1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	1	1
Non-directional earth-fault protection, low stage	EFLPTOC	2	
Non-directional earth-fault protection, high stage	EFHPTOC	1	1
Non-directional earth-fault protection, instantaneous stage	EFIPTOC	1	
Directional earth-fault protection, low stage	DEFLPDEF		2
Directional earth-fault protection, high stage	DEFHPDEF		1
Transient/intermittent earth-fault protection	INTRPTEF		1 [1)]
Negative-sequence overcurrent protection	NSPTOC	2	2
Residual overvoltage protection	ROVPTOV		1 2 [2)]
Three-phase undervoltage protection	PHPTUV		2
Three-phase overvoltage protection	PHPTOV		2
Positive-sequence undervoltage protection	PSPTUV		1
Negative-sequence overvoltage protection	NSPTOV		1
Three-phase thermal overload protection, two time constants	T2PTTR	1	1
Circuit breaker failure protection	CCBRBRF	1	1
Master trip	TRPPTRC	2 (3) [3)]	2 (3) [3)]
Arc protection	ARCSARC	(3)	(3)
Multipurpose protection	MAPGAPC	18	18
Three-phase overload protection for shunt capacitor banks	COLPTOC	1	1
Current unbalance protection for shunt capacitor banks	CUBPTOC	1 [4)]	1 [4)]
Three-phase current unbalance protection for shunt capacitor banks	HCUBPTOC	1 [4)]	1 [4)]
Shunt capacitor bank switching resonance protection, current based	SRCPTOC	1	1
Power quality			
Current total demand distortion	CMHAI	(1) [5)]	(1) [6)]
Voltage total harmonic distortion	VMHAI		(1) [6)]
Voltage variation	PHQVVR		(1) [6)]
Voltage unbalance	VSQVUB		(1) [6)]
Control			
Circuit-breaker control	CBXCBR	1	1
Disconnector control	DCXSWI	2	2
Earthing switch control	ESXSWI	1	1
Disconnector position indication	DCSXSWI	3	3
Earthing switch indication	ESSXSWI	2	2
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR	1	1
Trip circuit supervision	TCSSCBR	2	2
Current circuit supervision	CCSPVC	1	1
Fuse failure supervision	SEQSPVC		1
Runtime counter for machines and devices	MDSOPT	1	1
Measurement			
Disturbance recorder	RDRE	1	1
Load profile record	LDPRLRC	1	1
Fault record	FLTRFRC	1	1
Three-phase current measurement	CMMXU	1	1
Sequence current measurement	CSMSQI	1	1
Residual current measurement	RESCMMXU	1	1
Three-phase voltage measurement	VMMXU		1
Residual voltage measurement	RESVMMXU		2
Sequence voltage measurement	VSMSQI		1
Three-phase power and energy measurement	PEMMXU		1

Table 2. Supported functions, continued

Function	IEC 61850	A	B
RTD/mA measurement	XRGGIO130	(1)	(1)
Frequency measurement	FMMXU		1
IEC 61850-9-2 LE sampled value sending [7][8]	SMVSENDER		(1)
IEC 61850-9-2 LE sampled value receiving (voltage sharing) [7][8]	SMVRCV		(1)
Other			
Minimum pulse timer (2 pcs)	TPGAPC	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	1	1
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	1	1
Pulse timer (8 pcs)	PTGAPC	2	2
Time delay off (8 pcs)	TOFGAPC	4	4
Time delay on (8 pcs)	TONGAPC	4	4
Set-reset (8 pcs)	SRGAPC	4	4
Move (8 pcs)	MVGAPC	2	2
Generic control point (16 pcs)	SPCGAPC	2	2
Analog value scaling (4 pcs)	SCA4GAPC	4	4
Integer value move (4 pcs)	MVI4GAPC	1	1

1, 2, ... = Number of included instances. The instances of a protection function represent the number of identical protection function blocks available in the standard configuration.
() = optional

1) "Io measured" is always used.
2) "Uob measured" is always used.
3) Master trip is included and connected to the corresponding HSO in the configuration only when the BIO0007 module is used. If additionally the ARC option is selected, ARCSARC is connected to the corresponding master trip input in the configuration.
4) The Iunb measurement values are taken from this block and put in the Measurent view.
5) Power quality option includes only current total demand distortion.
6) Power quality option includes current total demand distortion, voltage total harmonic distortion, voltage variation and voltage unbalance.
7) Available only with IEC 61850-9-2
8) Available only with COM0031-0037

3. Protection functions

The relay offers three-phase overload protection with undercurrent and reconnection inhibit functionality for capacitors, single or three-phase current-based unbalance protection for capacitors including compensation for natural unbalance and a current-based switching resonance protection.

The relay features non-directional overcurrent and thermal overload protection as well as non-directional earth-fault protection.

Additionally, the standard configuration B includes directional earth-fault protection, residual voltage protection, overvoltage protection and undervoltage protection functions.

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

The arc-fault protection sensor interface is available on the optional communication module. Fast tripping increases staff safety and security and limits material damage in an arc fault situation. A binary input and output module can be selected as an option - having three high speed binary outputs (HSO) it

further decreases the total operate time with typically 4...6 ms compared to the normal power outputs.

4. Application

REV615 is intended for the protection of capacitor banks used for reactive power compensation in utility substations and industrial power systems. REV615 offers protection functionality especially for H-bridge, double star and single star connected capacitor banks and the feeder cable.

The protection relay can also be used for the protection of harmonic filter circuits, if the highest significant harmonic component is the 11th.

Standard configurations A and B offer three-phase overload protection, unbalance protection with compensation for natural unbalance and switching resonance protection for capacitor banks. An integrated undercurrent function in the overload protection function block detects the disconnection of a capacitor bank and inhibits the closing of the circuit breaker as long as the capacitor bank is still partially discharged. A three-phase thermal overload protection can be used for the thermal protection of the reactors and resistors in the harmonic filter circuits. The relay features non-directional overcurrent and earth-fault protection for the feeder cable and the capacitor bank.

ABB   7

Standard configuration A is pre-configured for H-bridge connected capacitor banks. Three-phase current unbalance protection is used for unbalance.

Standard configuration B offers directional earth-fault protection, residual voltage protection, overvoltage protection and undervoltage protection functions. It is pre-configured for double star connected capacitor banks. Single current unbalance protection is used for unbalance.

The second and third stage of the residual voltage protection in the standard configuration B can be used as voltage-based unbalance protection mainly for single star connected capacitor banks, with unearthed star point. Dedicated voltage input Uob is used for this purpose. This functionality is available in standard configuration B and needs to be configured before it is taken into use.
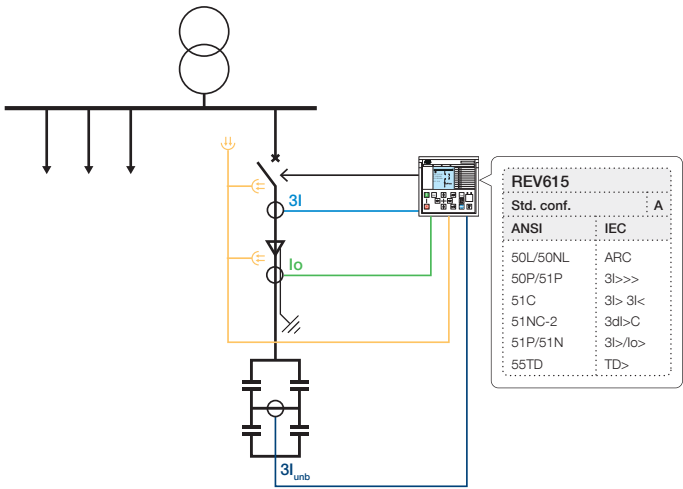
Figure 3.   Protection of a H-bridge connected capacitor bank

Figure 3 illustrates the protection of an H-bridge connected capacitor bank. Standard configuration A is used with overload, three-phase connected current unbalance and undercurrent protection for the capacitor bank. Overcurrent and earth-fault protection functions are used for protecting the feeder cable and capacitor bank combination.
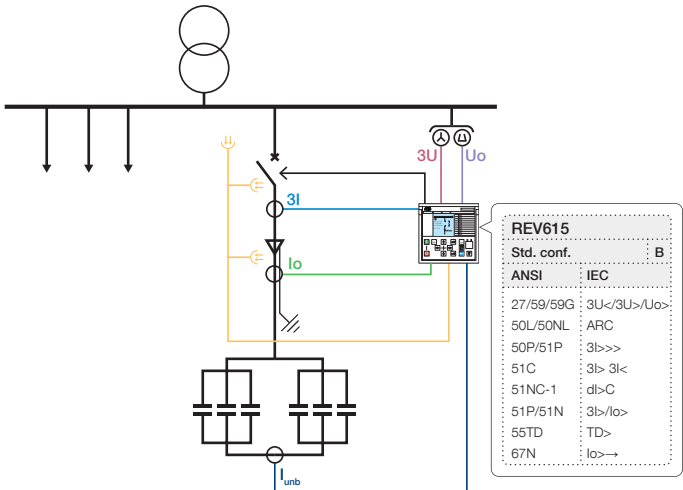

Figure 4.   Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral

Protection of a double star connected capacitor bank in a distribution network with a compensated or isolated neutral is shown in Figure 4. Standard configuration B is used with overload, single phase connected current unbalance and undercurrent protection for the capacitor bank. Overcurrent and directional earth-fault protection functions are used for protecting the feeder cable and capacitor bank combination.
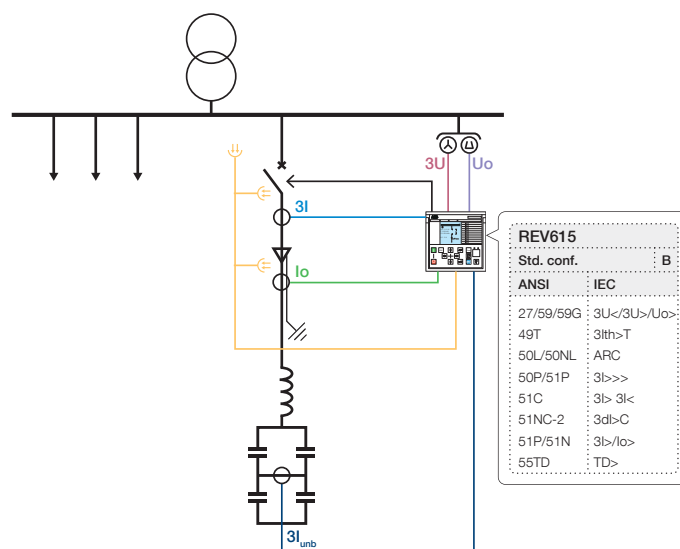
Figure 5. Protection of a harmonic filter circuit in an industrial network

Figure 5 illustrates the protection of a harmonic filter circuit in an industrial network. Standard configuration B is used with overload, three-phase connected current unbalance and undercurrent protection for the harmonic filter and with an additional thermal protection mainly for the coil. Overcurrent and earth-fault protection functions are used for protecting the feeder cable and harmonic filter circuit combination.
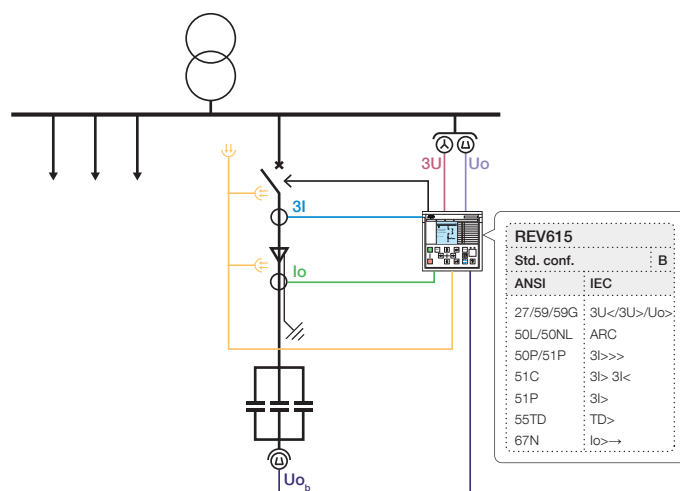

Figure 6. Protection of a single star connected capacitor bank

The protection of a single star connected capacitor bank is shown in Figure 6. Standard configuration B is used with overload, voltage-based unbalance (Uob) and undercurrent protection for the capacitor bank. Overcurrent and earth-fault protection functions are used for protecting the feeder cable and the capacitor bank combination.

ABB 9

5. Supported ABB solutions

ABB's 615 series protection and control relays together with the Substation Automation Unit COM600 constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate and streamline the system engineering, ABB's relays are supplied with connectivity packages. The connectivity packages include a compilation of software and relay-specific information, including single-line diagram templates and a full relay data model. The data model also includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with the Substation Automation Unit COM600 or the network control and management system MicroSCADA Pro.

The 615 series relays offer native support for IEC 61850 Edition 2 also including binary and analog horizontal GOOSE messaging. In addition, process bus with the sending of sampled values of analog currents and voltages and the receiving of sampled values of voltages is supported. Compared to traditional hard-wired, inter-device signaling, peer-to-peer communication over a switched Ethernet LAN offers an advanced and versatile platform for power system protection. Among the distinctive features of the protection system approach, enabled by the full implementation of the IEC 61850 substation automation standard, are fast communication capability, continuous supervision of the 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 SLD feature is especially useful when 615 series relays without the optional single-line diagram feature are used. 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.

GOOSE Analyzer interface in COM600 enables the following and analyzing the horizontal IEC 61850 application during commissioning and operation at station level. It logs all GOOSE events during substation operation to enable improved system supervision.

Table 3. Supported ABB solutions

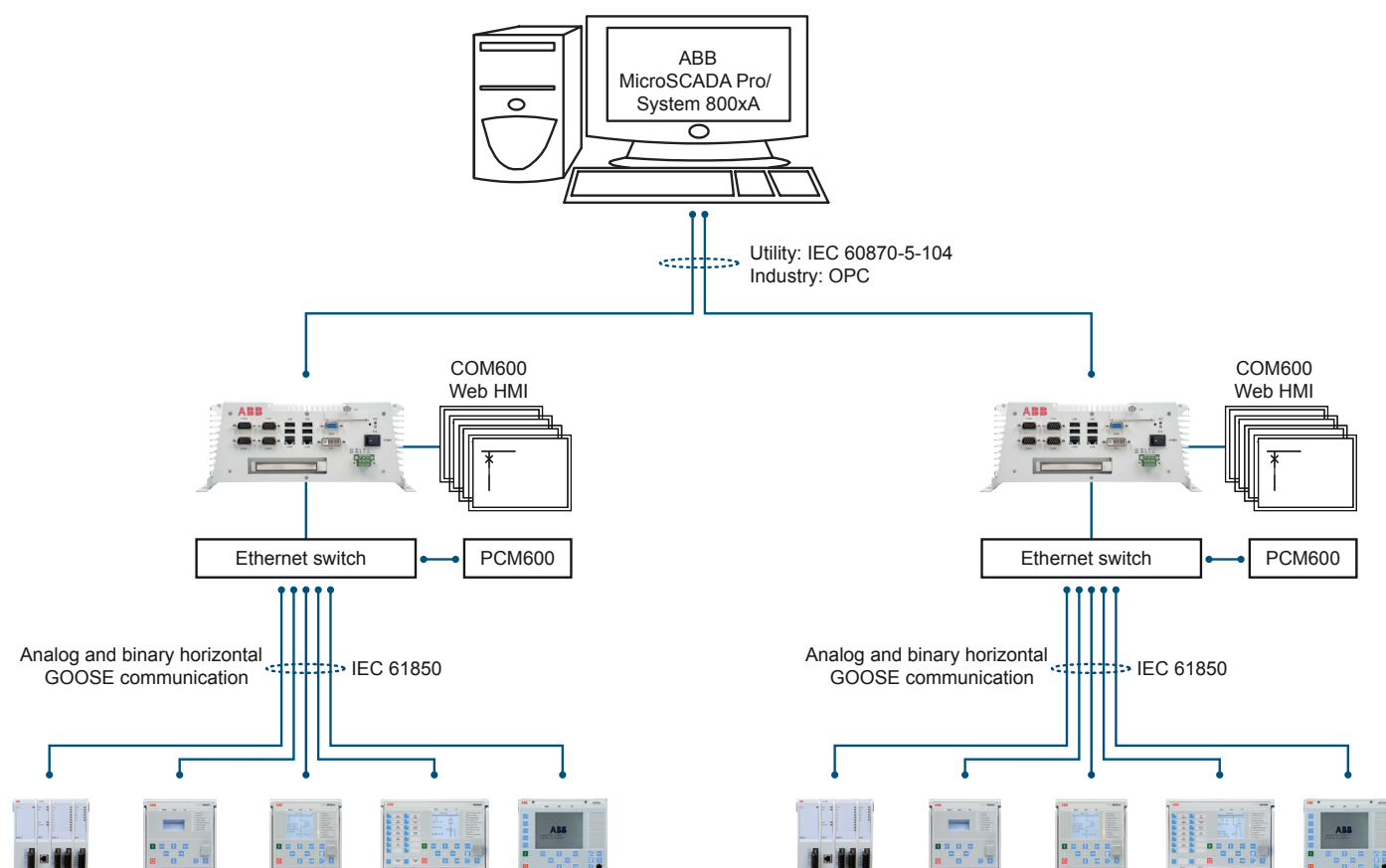| Product	Version
Substation Automation Unit COM600	4.0 SP1 or later
	4.1 or later (Edition 2)
MicroSCADA Pro SYS 600	9.3 FP2 or later
	9.4 or later (Edition 2)
System 800xA	5.1 or later

Figure 7.   ABB power system example using Relion relays, Substation Automation Unit COM600 and MicroSCADA Pro/System 800xA

6. Control

REV615 integrates functionality for the control of a circuit breaker via the front panel HMI or by means of remote controls. In addition to the circuit breaker control the relay features two control blocks intended for motor-operated control of disconnectors or circuit breaker truck and their position indications.

The relay has one control block intended for motor-operated control of one earthing switch control and its position indication. Two physical binary inputs and two physical binary outputs are needed in the relay for each controllable primary device taken into use. The number of unused binary inputs and binary outputs varies, depending on the chosen standard configuration of the relay. Further, some standard configurations offer optional hardware modules that increase the number of available binary inputs and outputs.

If the amount of available binary inputs or outputs of the chosen standard configuration is not sufficient, the standard configuration can be modified to release some binary inputs or outputs which have originally been configured for other

purposes, when applicable, or an external input or output module, for example, RIO600 can be integrated to the relay. The binary inputs and outputs of the external I/O module can be used for the less time critical binary signals of the application. The integration enables releasing of some initially reserved binary inputs and outputs of the relay in the standard configuration.

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

The optional large graphical LCD of the relay's HMI includes a single-line diagram (SLD) with position indication for the relevant primary devices. Interlocking schemes required by the application are configured using the signal matrix or the application configuration functionality of PCM600.

ABB   11

7. Measurements

The relay continuously measures the phase currents, the single or three-phase unbalance currents (with the natural unbalance current compensated), the symmetrical components of the phase currents and the residual current.

The standard configuration B includes voltage measurements. It measures the residual voltage, the phase voltages, the voltage sequence components and frequency. It also measures the capacitor bank unbalance voltage if the Uob is connected and the relay is configured accordingly. This voltage measurement is called residual voltage measurement, instance 2. The relay offers three-phase power and energy measurement including power factor.

In addition, the relay calculates the demand value of current over a user-selectable preset time frames, the thermal overload of the protected object, and the phase unbalance value based on the ratio between the negative-sequence and positive-sequence current.

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

The protection relay has the following power quality monitoring functions.

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

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

The voltage and current harmonics functions provide a method for monitoring the power quality by means of the current waveform distortion and voltage waveform distortion. The functions provides a short-term 3-second average and a long-term demand for total demand distortion TDD and total harmonic distortion THD.

9. Disturbance recorder

The relay is provided with a disturbance recorder 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.

10. Event log

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

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

11. 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.

12. Condition monitoring

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

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

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

13. Trip-circuit supervision

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

14. Self-supervision

The relay's built-in self-supervision system continuously monitors the state of the relay hardware and the operation of the relay software. Any fault or malfunction detected is used for alerting the operator.

A permanent relay fault blocks the protection functions to prevent incorrect operation.

15. Fuse failure supervision

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

16. Current circuit supervision

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

17. Access control

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

18. Inputs and outputs

The relay is equipped with three phase-current inputs, three unbalance-current inputs and one residual-current input for non-directional earth-fault protection.

In the standard configuration B, the relay is additionally equipped with three phase-voltage inputs, one residual voltage input for directional earth-fault protection and one voltage input (Uob) that can be used for voltage based unbalance protection.

The rated level of the current inputs is 1/5 A and selectable in the relay software. The three phase-voltage inputs and the residual-voltage inputs cover the rated voltages 60-210 V. Both phase-to-phase voltages and phase-to-earth voltages can be connected. The binary input thresholds 16…176 V DC are selected by adjusting the relay's parameter settings.

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

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

Optionally, a binary input and output module can be selected. It has three high speed binary outputs (HSO) and it decreases the total operate time with typically 4...6 ms compared to the normal power outputs.

ABB   13

Table 4. Input/output overview

Std. conf.	Order code digit		Analog channels		Binary channels			
	5-6	7-8	CT	VT	BI	BO	RTD	mA
A	BA	BA	7	-	8	4 PO + 6 SO	-	-
		BB	7	-	14	4 PO + 9 SO	-	-
		FD	7	-	8	4 PO + 2 SO + 3 HSO	-	-
		FF	7	-	14	4 PO + 5 SO + 3 HSO	-	-
	BG	BA	7	-	8	4 PO + 6 SO	6	2
		FD	7	-	8	4 PO + 2 SO + 3 HSO	6	2
B	BC	AD	7	5	12	4 PO + 6 SO	-	-
		FE	7	5	12	4 PO + 2 SO + 3 HSO	-	-
	BE	BA	7	5	8	4 PO + 6 SO	2	1
		FD	7	5	8	4 PO + 2 SO + 3 HSO	2	1

As an option for standard configuration B, the relay has two RTD inputs and 1 mA input. The relay measures signals such as temperature via the two RTD inputs and mA inputs using a transducer. The values can, apart from measuring and monitoring purposes, be used for tripping and alarm purposes using the multipurpose protection functions. The temperature signal can also be used for ambient temperature information for the thermal protection function.

19. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Profibus DPV1 communication protocol is supported with using the protocol converter SPA-ZC 302. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the relays, is only enabled by the IEC 61850 communication protocol.

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

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

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

The relay also supports IEC 61850 process bus by sending sampled values of analog currents and voltages and by receiving sampled values of voltages. With this functionality the galvanic interpanel wiring can be replaced with Ethernet communication. The measured values are transferred as sampled values using IEC 61850-9-2 LE protocol. The intended

application for sampled values shares the voltages to other 615 series relays, having voltage based functions and 9-2 support. 615 relays with process bus based applications use IEEE 1588 for high accuracy time synchronization.

For redundant Ethernet communication, the relay offers either two optical or two galvanic Ethernet network interfaces. A third port with galvanic Ethernet network interface is also available. The third Ethernet interface provides connectivity for any other Ethernet device to an IEC 61850 station bus inside a switchgear bay, for example connection of a Remote I/O. Ethernet network redundancy can be achieved using the high-availability seamless redundancy (HSR) protocol or the parallel redundancy protocol (PRP) or a with self-healing ring using RSTP in managed switches. Ethernet redundancy can be applied to Ethernet-based IEC 61850, Modbus and DNP3 protocols.

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

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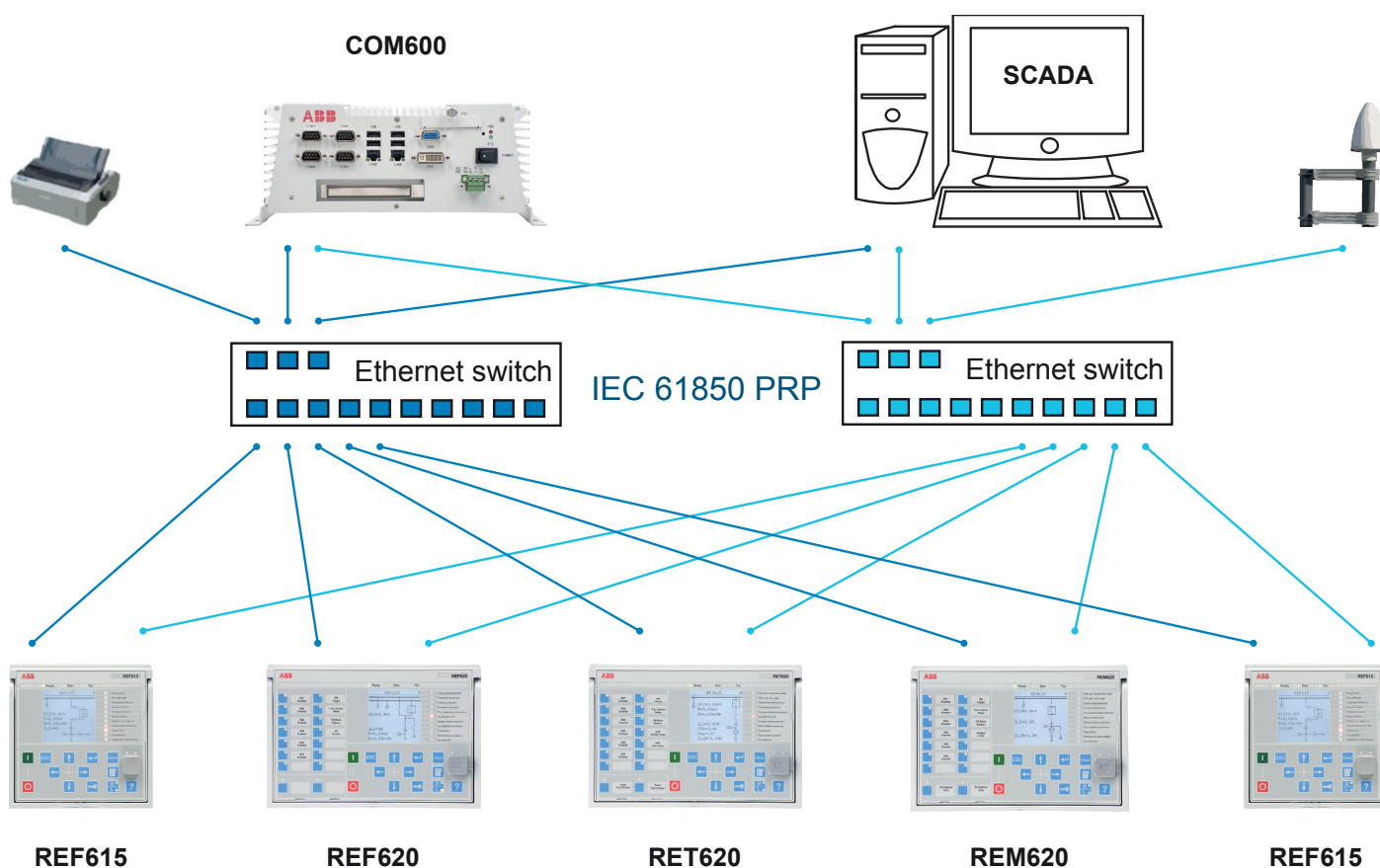

Figure 8.   Parallel redundancy protocol (PRP) solution

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

ABB   15
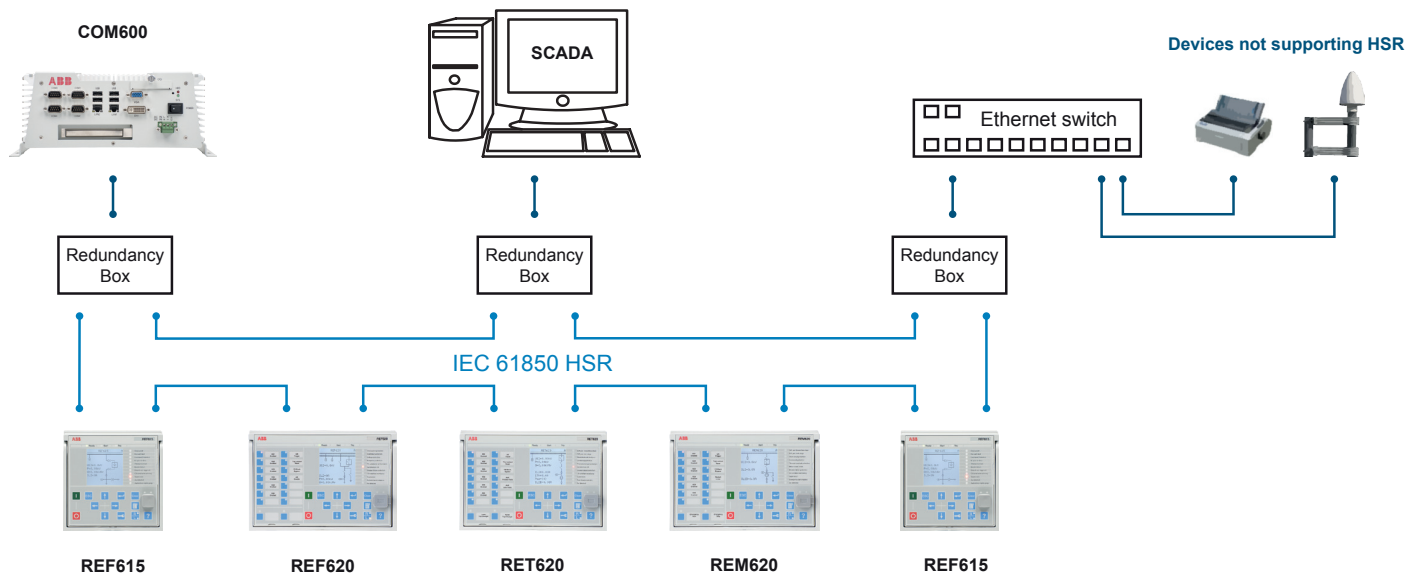
Figure 9.   High availability seamless redundancy (HSR) solution

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

The self-healing Ethernet ring solution enables a cost-efficient communication ring controlled by a managed switch with standard Rapid Spanning Tree Protocol (RSTP) support. The managed switch controls the consistency of the loop, routes the data and corrects the data flow in case of a communication switch-over. The relays in the ring topology act as unmanaged switches forwarding unrelated data traffic. The Ethernet ring solution supports the connection of up to 30 615 series relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings. The self-healing Ethernet ring solution avoids single point of failure concerns and improves the reliability of the communication.
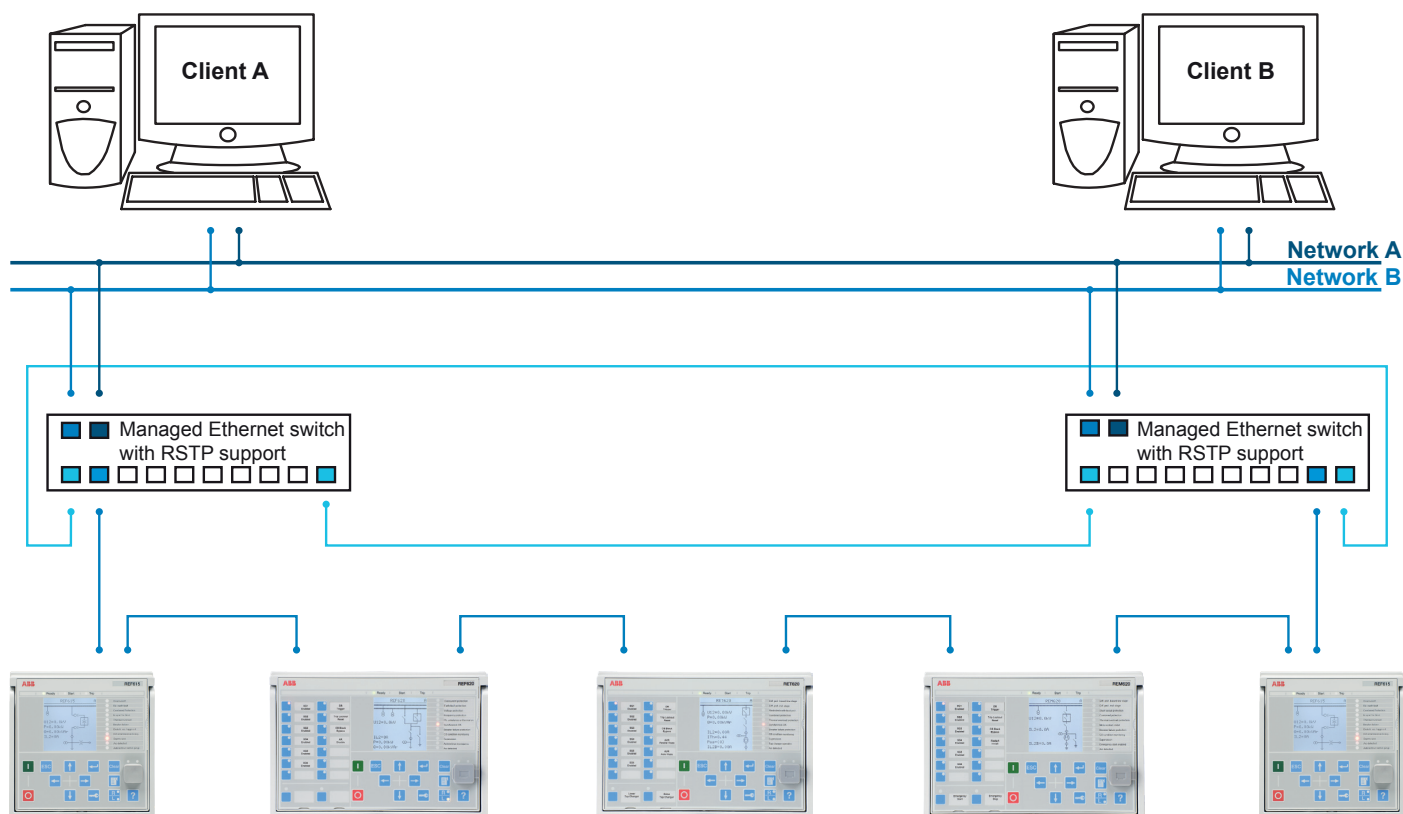
Figure 10. Self-healing Ethernet ring solution

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

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

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

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

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

When the relay uses the RS-485 bus for the serial communication, both two- and four wire connections are supported. Termination and pull-up/down resistors can be configured with jumpers on the communication card so external resistors are not needed.

The relay supports the following time synchronization methods with a time-stamping resolution of 1 ms.

Ethernet-based
• SNTP (Simple Network Time Protocol)

With special time synchronization wiring
• IRIG-B (Inter-Range Instrumentation Group - Time Code Format B)

ABB   17

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 5. Supported station communication interfaces and protocols

Interfaces/Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/RS-485	Fiber optic ST
IEC 61850-8-1	●	●	-	-
IEC 61850-9-2 LE	●	●	-	-
MODBUS RTU/ASCII	-	-	●	●
MODBUS TCP/IP	●	●	-	-
DNP3 (serial)	-	-	●	●
DNP3 TCP/IP	●	●	-	-
IEC 60870-5-103	-	-	●	●

● = Supported

20. Technical data

Table 6. Dimensions

Description	Value	
Width	Frame	177 mm
	Case	164 mm
Height	Frame	177 mm (4U)
	Case	160 mm
Depth		201 mm (153 + 48 mm)
Weight	Complete protection relay	4.1 kg
	Plug-in unit only	2.1 kg

Table 7. Power supply

Description	Type 1	Type 2
Nominal auxiliary voltage U_n	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U_n	
Auxiliary voltage variation	38...110% of U_n (38...264 V AC)	50...120% of U_n (12...72 V DC)
	80...120% of U_n (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC × 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	DC <12.0 W (nominal)/<18.0 W (max) AC <16.0 W (nominal)/<21.0 W (max)	DC <12.0 W (nominal)/<18.0 W (max)
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

Table 8. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Current inputs	Rated current, I_n	0.2/1 A[1]	1/5 A[2]
	Thermal withstand capability:		
	• Continuously	4 A	20 A
	• For 1 s	100 A	500 A
	Dynamic current withstand:		
	• Half-wave value	250 A	1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	60...210 V AC	
	Voltage withstand:		
	• Continuous	240 V AC	
	• For 10 s	360 V AC	
	Burden at rated voltage	<0.05 VA	

1) Ordering option for residual current input
2) Residual current and/or phase current

Table 9. Binary inputs

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

Table 10. Signal output X100: SO1

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

Table 11. Signal outputs and IRF output

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

Table 12. Double-pole power output relays with TCS function

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

ABB

Table 13. Single-pole power output relays

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

Table 14. High-speed output HSO with BIO0007

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

Table 15. Front port Ethernet interfaces

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

Table 16. IRIG-B

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

1) According to the 200-04 IRIG standard

Table 17. Degree of protection of flush-mounted protection relay

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

ABB

21

Table 18. Environmental conditions

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

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

Table 19. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III IEEE C37.90.1-2002
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test		
	10 V (rms) f = 150 kHz...80 MHz	IEC 61000-4-6 IEC 60255-26, class III
	10 V/m (rms) f = 80...2700 MHz	IEC 61000-4-3 IEC 60255-26, class III
	10 V/m f = 900 MHz	ENV 50204 IEC 60255-26, class III
	20 V/m (rms) f = 80...1000 MHz	IEEE C37.90.2-2004
Fast transient disturbance test		IEC 61000-4-4 IEC 60255-26 IEEE C37.90.1-2002
• All ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-26
• Communication	1 kV, line-to-earth	
• Other ports	4 kV, line-to-earth 2 kV, line-to-line	
Power frequency (50 Hz) magnetic field immunity test		IEC 61000-4-8
• Continuous	300 A/m	
• 1...3 s	1000 A/m	
Pulse magnetic field immunity test	1000 A/m 6.4/16 µs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11

ABB | 23

Table 19. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Power frequency immunity test	Binary inputs only	IEC 61000-4-16 IEC 60255-26, class A
• Common mode	300 V rms	
• Differential mode	150 V rms	
Conducted common mode disturbances	15 Hz...150 kHz Test level 3 (10/1/10 V rms)	IEC 61000-4-16
Emission tests		EN 55011, class A IEC 60255-26 CISPR 11 CISPR 12
• Conducted		
0.15...0.50 MHz	<79 dB (µV) quasi peak <66 dB (µV) average	
0.5...30 MHz	<73 dB (µV) quasi peak <60 dB (µV) average	
• Radiated		
30...230 MHz	<40 dB (µV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	<47 dB (µV/m) quasi peak, measured at 10 m distance	
1…3 GHz	< 76 dB (µV/m) peak < 56 dB (µV/m) average, measured at 3 m distance	
3…6 GHz	< 80 dB (µV/m) peak < 60 dB (µV/m) average, measured at 3 m distance	

Table 20. 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 21. Mechanical tests

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

Table 22. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55ºC	IEC 60068-2-2
Dry cold test	• 96 h at -25ºC • 16 h at -40ºC	IEC 60068-2-1
Damp heat test	• 6 cycles (12 h + 12 h) at +25°C…+55°C, humidity >93%	IEC 60068-2-30
Change of temperature test	• 5 cycles (3 h + 3 h) at -25°C...+55°C	IEC60068-2-14
Storage test	• 96 h at -40ºC • 96 h at +85ºC	IEC 60068-2-1 IEC 60068-2-2

Table 23. Product safety

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

Table 24. EMC compliance

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

Table 25. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

ABB | 25

Protection functions

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

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

1) Set *Operate delay time* = 0,02 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × In, fn = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

ABB

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

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

1) For further reference, see Operation characteristics table

Table 28. Non-directional earth-fault protection (EFxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: $f_n \pm 2$ Hz		
	EFLPTOC	$\pm 1.5\%$ of the set value or $\pm 0.002 \times I_n$		
	EFHPTOC and EFIPTOC	$\pm 1.5\%$ 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
	EFIPTOC: $I_{Fault} = 2 \times$ set *Start value* $I_{Fault} = 10 \times$ set *Start value*	16 ms 11 ms	19 ms 12 ms	23 ms 14 ms
	EFHPTOC and EFLPTOC: $I_{Fault} = 2 \times$ set *Start value*	23 ms	26 ms	29 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		$\pm 1.0\%$ 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 mode* = default (depends on stage), current before fault = $0.0 \times I_n$, f_n = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = $2.5 \times I_n$, *Start value* multiples in range of 1.5...20

ABB | 27

Table 29. Non-directional earth-fault protection (EFxPTOC) main settings

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

1) For further reference, see Operation characteristics table

Table 30. Directional earth-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	DEFLPDEF	Current: ±1.5% of the set value or ±0.002 × I_n Voltage ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time [1][2]		Minimum	Typical	Maximum
	DEFHPDEF I_{Fault} = 2 × set *Start value*	42 ms	46 ms	49 ms
	DEFLPDEF I_{Fault} = 2 × set *Start value*	58 ms	62 ms	66 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

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

2) Includes the delay of the signal output contact

3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

ABB
29

Table 31. Directional earth-fault protection (DEFxPDEF) main settings

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

[1] For further reference, refer to the Operating characteristics table

Table 32. Transient/intermittent earth-fault protection (INTRPTEF)

Characteristic	Value
Operation accuracy (Uo criteria with transient protection)	Depending on the frequency of the measured current: f_n ±2 Hz
	±1.5% of the set value or $±0.002 \times Uo$
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 33. 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 (voltage start value for transient EF)	INTRPTEF	$0.01...0.50 \times Un$	0.01
Operation mode	INTRPTEF	1=Intermittent EF 2=Transient EF	-
Peak counter limit (Min requirement for peak counter before start in IEF mode)	INTRPTEF	2...20	-
Min operate current	INTRPTEF	$0.01...1.00 \times In$	0.01

Table 34. Negative-sequence overcurrent protection (NSPTOC)

Characteristic	Value		
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz		
	±1.5% of the set value or ±0.002 × I_n		
Start time [1][2]		Minimum	Typical	Maximum
I_{Fault} = 2 × set *Start value*		23 ms	26 ms	28 ms
I_{Fault} = 10 × set *Start value*		15 ms	18 ms	20ms
Reset time	Typically 40 ms		
Reset ratio	Typically 0.96		
Retardation time	<35 ms		
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode	±5.0% of the theoretical value or ±20 ms [3]		
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

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

Table 35. Negative-sequence overcurrent protection (NSPTOC) main settings

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

1)   For further reference, see Operation characteristics table

Table 36. Residual overvoltage protection (ROVPTOV)

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

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

ABB   31

Table 37. Residual overvoltage protection (ROVPTOV) main settings

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

Table 38. Three-phase undervoltage protection (PHPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz		
		$\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$		
Start time[1][2]		Minimum	Typical	Maximum
	$U_{Fault} = 0.9 \times$ set *Start value*	62 ms	66 ms	70 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		$\pm 1.0\%$ 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,…		

1) *Start value* = $1.0 \times U_n$, Voltage before fault = $1.1 \times U_n$, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

Table 39. 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	60...300000 ms	10
Operating curve type[1]	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference, see Operation characteristics table

Table 40. Three-phase overvoltage protection (PHPTOV)

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

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

Table 41. Three-phase overvoltage protection (PHPTOV) main settings

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

1) For further reference, see Operation characteristics table

Table 42. Positive-sequence undervoltage protection (PSPTUV)

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

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

ABB   33

Table 43. 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	$0.01...1.0 \times U_n$	0.01

Table 44. Negative-sequence overvoltage protection (NSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: $f_n \pm 2$ Hz		
		$\pm 1.5\%$ of the set value or $\pm 0.002 \times U_n$		
Start time[1][2]		Minimum	Typical	Maximum
	$U_{Fault} = 1.1 \times$ set *Start value*	33 ms	35 ms	37 ms
	$U_{Fault} = 2.0 \times$ set *Start value*	24 ms	26 ms	28 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		$\pm 1.0\%$ 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,…		

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

Table 45. Negative-sequence overvoltage protection (NSPTOV) main settings

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

Table 46. Three-phase thermal overload protection, two time constants (T2PTTR)

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

1) Overload current > 1.2 x Operate level temperature

Table 47. Three-phase thermal overload protection, two time constants (T2PTTR) main settings

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

Table 48. Circuit breaker failure protection (CCBRBRF)

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

1)   Trip pulse time defines the minimum pulse length

Table 49. Circuit breaker failure protection (CCBRBRF) main settings

Parameter	Function	Value (Range)	Step
Current value (Operating phase current)	CCBRBRF	$0.05...1.00 \times I_n$	0.05
Current value Res (Operating residual current)	CCBRBRF	$0.05...1.00 \times I_n$	0.05
CB failure mode (Operating mode of function)	CCBRBRF	1 = Current 2 = Breaker status 3 = Both	-
CB fail trip mode	CCBRBRF	1 = Off 2 = Without check 3 = Current check	-
Retrip time	CCBRBRF	0...60000 ms	10
CB failure delay	CCBRBRF	0...60000 ms	10
CB fault delay	CCBRBRF	0...60000 ms	10

ABB

35

Table 50. Arc protection (ARCSARC)

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

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

Table 51. Arc protection (ARCSARC) main settings

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

Table 52. Multipurpose protection (MAPGAPC)

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

Table 53. 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	Over Under	-

Table 54. Three-phase overload protection for shunt capacitor banks (COLPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz, and no harmonics
	5% of the set value or 0.002 × I_n
Start time for overload stage[1][2]	Typically 75 ms
Start time for under current stage[2][3]	Typically 26 ms
Reset time for overload and alarm stage	Typically 60 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the set value or ±20 ms
Operate time accuracy in inverse time mode	10% of the theoretical value or ±20 ms
Suppression of harmonics for under current stage	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,..

1) Harmonics current before fault = 0.5 × I_n, harmonics fault current 1.5 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Harmonics current before fault = 1.2 × I_n, harmonics fault current 0.8 × *Start value*, results based on statistical distribution of 1000 measurements

Table 55. Three-phase overload protection for shunt capacitor banks (COLPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value overload	COLPTOC	0.30...1.50 × I_n	0.01
Alarm start value	COLPTOC	80...120%	1
Start value Un Cur	COLPTOC	0.10...0.70 × I_n	0.01
Time multiplier	COLPTOC	0.05...2.00	0.01
Alarm delay time	COLPTOC	500...6000000	100
Un Cur delay time	COLPTOC	100...120000	100

Table 56. Current unbalance protection for shunt capacitor banks (CUBPTOC)

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

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

ABB   37

Table 57. Current unbalance protection for shunt capacitor banks (CUBPTOC) main settings

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

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

Table 58. Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC)

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

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

Table 59. Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	HCUBPTOC	0.01...1.00 × I_n	0.01
Alarm start value	HCUBPTOC	0.01...1.00 × I_n	0.01
Time multiplier	HCUBPTOC	0.05...15.00	0.01
Operating curve type [1]	HCUBPTOC	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	HCUBPTOC	40...200000 ms	10
Alarm delay time	HCUBPTOC	40...200000 ms	10

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

Table 60. Shunt capacitor bank switching resonance protection, current based (SRCPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: fn ±2 Hz
	Operate value accuracy: ±3% of the set value or ±0.002 × I_n (for 2nd order Harmonics) ±1.5% of the set value or ±0.002 × I_n (for 3rd order < Harmonics < 10th order) ±6% of the set value or ±0.004 × I_n (for Harmonics >= 10th order)
Reset time	Typically 45 ms or maximum 50 ms
Retardation time	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = f_n

Table 61. Shunt capacitor bank switching resonance protection, current based (SRCPTOC) main settings

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

ABB

39

Table 62. Operation characteristics

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

Power quality functions

Table 63. Voltage variation (PHQVVR)

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

Table 64. Voltage unbalance (VSQVUB)

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

ABB   41

Condition and supervision functions

Table 65. Circuit-breaker condition monitoring (SSCBR)

Characteristic	Value
Current measuring accuracy	$\pm1.5\%$ or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) $\pm5.0\%$ (at currents in the range of 10…40 x I_n)
Operate time accuracy	$\pm1.0\%$ of the set value or ±20 ms
Travelling time measurement	+10 ms / -0 ms

Table 66. Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time [1]	<30 ms

1)   Including the delay of the output contact

Table 67. Current circuit supervision (CCSPVC) main settings

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

Table 68. Fuse failure supervision (SEQSPVC)

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

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

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

Description	Value
Motor runtime measurement accuracy[1]	$\pm0.5\%$

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

Measurement functions

Table 70. Three-phase current measurement (CMMXU)

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

Table 71. Sequence current measurement (CSMSQI)

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

Table 72. Residual current measurement (RESCMMXU)

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

Table 73. Three-phase voltage measurement (VMMXU)

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

Table 74. Residual voltage measurement (RESVMMXU)

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

ABB   43

Table 75. Sequence voltage measurement (VSMSQI)

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

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

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

1) |PF| >0.5 which equals |cosφ| >0.5
2) |PF| <0.86 which equals |sinφ| >0.5

Table 77. Frequency measurement (FMMXU)

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

Other functions

Table 78. Pulse timer function block (PTGAPC)

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

Table 79. Time delay off (8 pcs) (TOFPAGC)

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

Table 80. Time delay on (8 pcs) (TONGAPC)

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

ABB   45

21. Local HMI

The relay is available with two optional displays, a large one and a small one. The large display is suited for relay installations where the front panel user interface is frequently used and a single line diagram is required. The small display is suited for remotely controlled substations where the relay is only occasionally accessed locally via the front panel user interface.

Both LCD displays offer front-panel user interface functionality with menu navigation and menu views. However, the large display offers increased front-panel usability with less menu scrolling and improved information overview. In addition, the large display includes a user-configurable single line diagram (SLD) with position indication for the associated primary equipment. Depending on the chosen standard configuration, the relay displays the related measuring values, apart from the default single line diagram. The SLD view can also be accessed using the Web browser-based user interface. The default SLD can be modified according to user requirements by using the Graphical Display Editor in PCM600. The user can create up to 10 SLD pages.

The local HMI includes a push button (L/R) for local/remote operation of the relay. When the relay is in the local mode, it can be operated only by using the local front panel user interface. When the relay is in the remote mode, it can execute commands sent from a remote location. The relay supports the remote selection of local/remote mode via a binary input. This feature facilitates, for example, the use of an external switch at the substation to ensure that all relays are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.
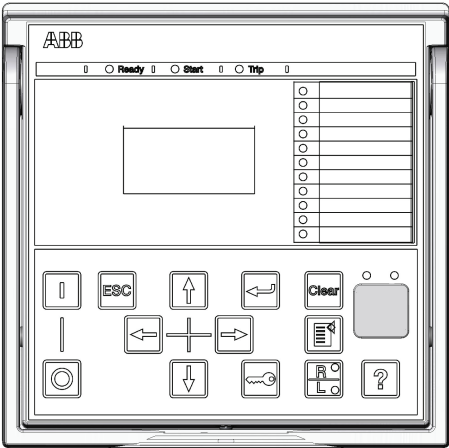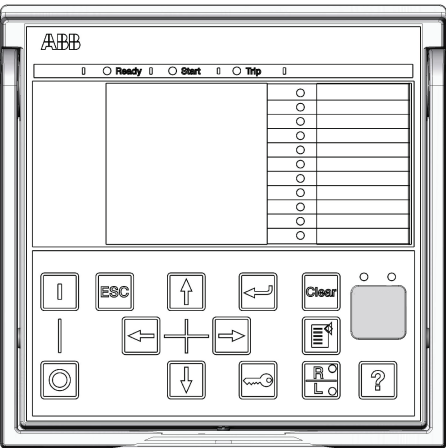

Figure 11.   Small display

Figure 12.   Large display

Table 81. Small display

Character size[1]	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	5	20
Large, variable width (13x14 pixels)	3	8 or more

1)   Depending on the selected language

Table 82. Large display

Character size[1]	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	10	20
Large, variable width (13x14 pixels)	7	8 or more

1)   Depending on the selected language

22. Mounting methods

By means of appropriate mounting accessories the standard relay case for the 615 series relay can be flush mounted, semi-flush mounted or wall mounted. The flush mounted and wall mounted relay cases can also be mounted in a tilted position (25°) using special accessories.

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

For the routine testing purposes, the relay cases can be equipped with test switches, type RTXP 18, which can be mounted side by side with the relay cases.

Mounting methods:

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

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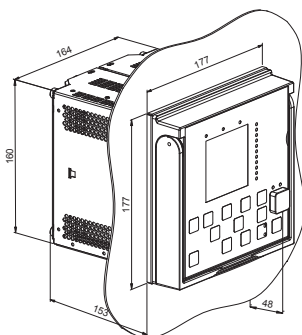- Height: 161.5 ±1 mm
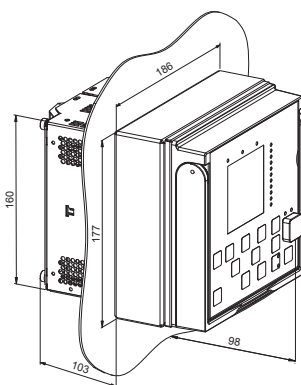- Width: 165.5 ±1 mm

Figure 13.   Flush mounting

Figure 14.   Semi-flush mounting
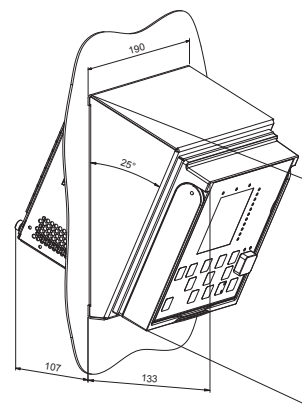

Figure 15.   Semi-flush with a 25° tilt

23. 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.

24. Selection and ordering data

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

ABB

47

25. Accessories and ordering data

Table 83. Mounting accessories

Item	Order number
Semi-flush mounting kit	1MRS050696
Wall mounting kit	1MRS050697
Inclined semi-flush mounting kit	1MRS050831
19" rack mounting kit with cut-out for one relay	1MRS050694
19" rack mounting kit with cut-out for two relays	1MRS050695
Mounting bracket for one relay with test switch RTXP in 4U Combiflex (RHGT 19" variant C)	2RCA022642P0001
Mounting bracket for one relay in 4U Combiflex (RHGT 19" variant C)	2RCA022643P0001
19" rack mounting kit for one relay and one RTXP18 test switch (the test switch is not included in the delivery)	2RCA021952A0003
19" rack mounting kit for one relay and one RTXP24 test switch (the test switch is not included in the delivery)	2RCA022561A0003
Replacement kit for a Strömberg SP_J40 series relay (cut-out in the center of the installation plate)	2RCA027871A0001
Replacement kit for a Strömberg SP_J40 series relay (cut-out on the left or the right of the installation plate)	2RCA027874A0001
Replacement kit for two Strömberg SP_J3 series relays	2RCA027880A0001
19" rack replacement kit for Strömberg SP_J3/J6 series relays (one cut-out)	2RCA027894A0001
19" rack replacement kit for Strömberg SP_J3/J6 series relays (two cut-outs)	2RCA027897A0001
Replacement kit for a Strömberg SP_J6 series relay	2RCA027881A0001
Replacement kit for three BBC S_ series relays	2RCA027882A0001
Replacement kit for a SPA 300 series relay	2RCA027885A0001

26. Tools

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

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

When the Web browser-based user interface is used, the protection relay can be accessed either locally or remotely using a Web browser (Internet Explorer). For security reasons, the Web browser-based user interface is disabled by default but it can be enabled via the front-panel user interface. The Web HMI functionality can be limited to read-only access.

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

Table 84. Tools

Configuration and setting tools	Version
PCM600	2.6 (Rollup 20150626) or later
Web browser-based user interface	IE 8.0, IE 9.0, IE 10.0 or IE 11.0
REV615 Connectivity Package	5.1 or later

ABB   49

Table 85. Supported functions

Function	Web HMI	PCM600
Relay parameter setting	●	●
Saving of relay parameter settings in the relay	●	●
Signal monitoring	●	●
Disturbance recorder handling	●	●
Alarm LED viewing	●	●
Access control management	●	●
Relay signal configuration (Signal Matrix)	-	●
Modbus® communication configuration (communication management)	-	●
DNP3 communication configuration (communication management)	-	●
IEC 60870-5-103 communication configuration (communication management)	-	●
Saving of relay parameter settings in the tool	-	●
Disturbance record analysis	-	●
XRIO parameter export/import	-	●
Graphical display configuration	-	●
Application configuration	-	●
IEC 61850 communication configuration, GOOSE (communication configuration)	-	●
Phasor diagram viewing	●	-
Event viewing	●	●
Saving of event data on the user's PC	●	●
Online monitoring	-	●

● = Supported

27. 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 desired system setup.
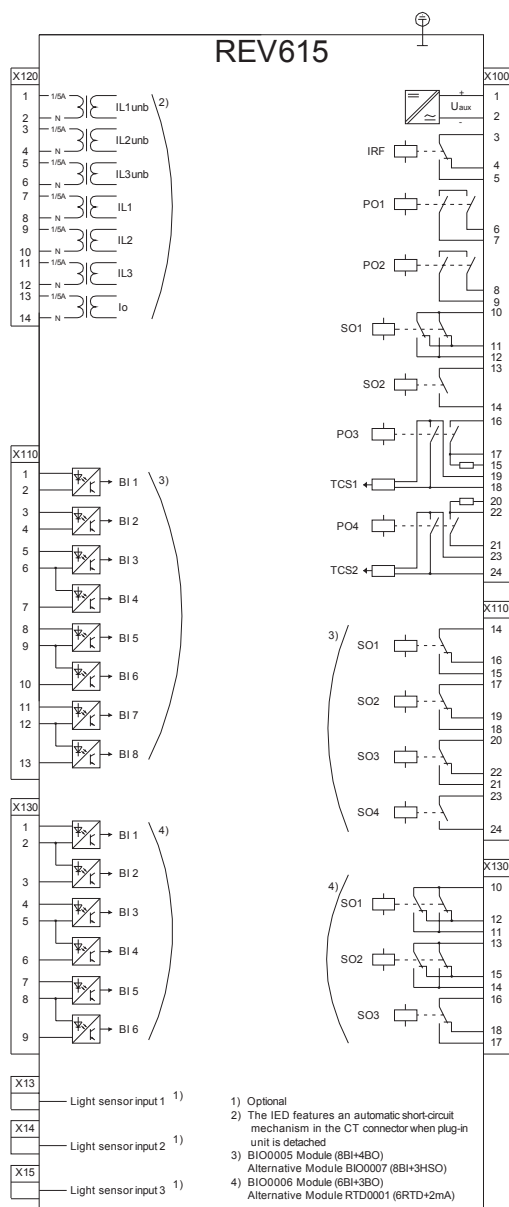
28. Terminal diagrams

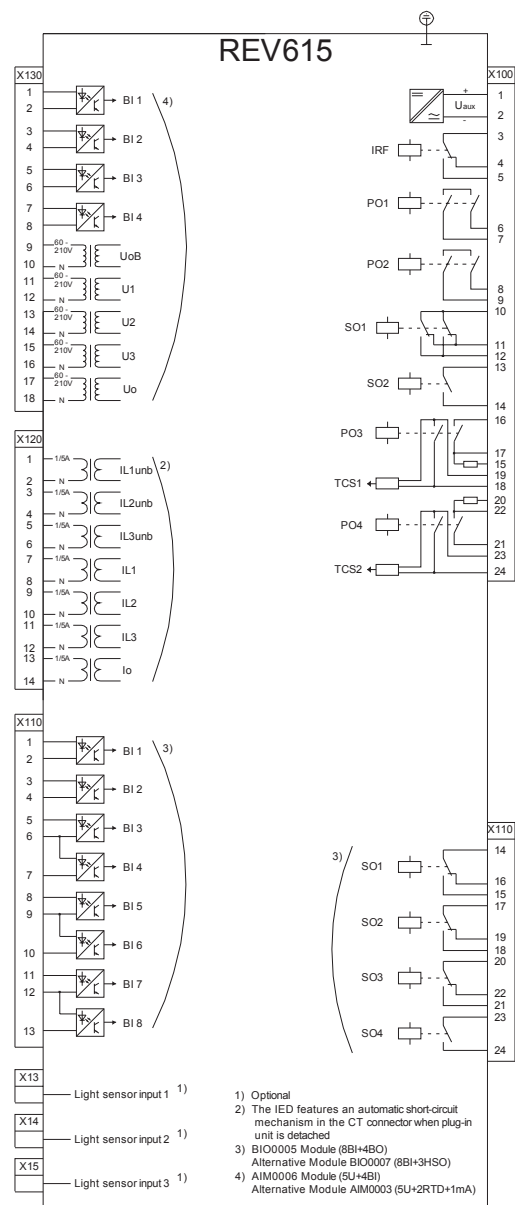
Figure 16. Terminal diagram for standard configuration A

ABB

51

Figure 17.   Terminal diagram for standard configuration B

29. Certificates

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

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

Additional certificates can be found on the product page.

30. References

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

You will find the latest relevant information on the REV615 protection and control relay on the product page. Scroll down the page to find and download the related documentation.

ABB   53

31. Functions, codes and symbols

Table 86. Functions included in the relay

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I>> (1)	51P-2 (1)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Transient/intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Residual overvoltage protection	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
Three-phase thermal overload protection, two time constants	T2PTTR1	3Ith>T/G/C (1)	49T/G/C (1)
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)
	TRPPTRC2	Master Trip (2)	94/86 (2)
	TRPPTRC3	Master Trip (3)	94/86 (3)
	TRPPTRC4	Master Trip (4)	94/86 (4)
	TRPPTRC5	Master Trip (5)	94/86 (5)
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)

Table 86. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
Three-phase overload protection for shunt capacitor banks	COLPTOC1	3I> 3I< (1)	51C/37 (1)
Current unbalance protection for shunt capacitor banks	CUBPTOC1	dI>C (1)	51NC-1 (1)
Three-phase current unbalance protection for shunt capacitor banks	HCUBPTOC1	3dI>C (1)	51NC-2 (1)
Shunt capacitor bank switching resonance protection, current based	SRCPTOC1	TD> (1)	55TD (1)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (1)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)

ABB | 55

Table 86. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTS (1)	OPTM (1)
Measurement			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Load profile record	LDPRLRC1	LOADPROF (1)	LOADPROF (1)
Fault record	FLTRFRC1	FAULTREC (1)	FAULTREC (1)
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
	RESVMMXU2	Uo (2)	Vn (2)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
RTD/mA measurement	XRGGIO130	X130 (RTD) (1)	X130 (RTD) (1)
Frequency measurement	FMMXU1	f (1)	f (1)
IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER	SMVSENDER
IEC 61850-9-2 LE sampled value receiving (voltage sharing)	SMVRECEIVER	SMVRECEIVER	SMVRECEIVER
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)

Table 86. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Time delay off (8 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
Analog value scaling	SCA4GAPC1	SCA4 (1)	SCA4 (1)
	SCA4GAPC2	SCA4 (2)	SCA4 (2)
	SCA4GAPC3	SCA4 (3)	SCA4 (3)
	SCA4GAPC4	SCA4 (4)	SCA4 (4)
Integer value move	MVI4GAPC1	MVI4 (1)	MVI4 (1)

32. Document revision history

Document revision/date	Product version	History
A/2014-01-24	5.0	First release
B/2015-10-30	5.0 FP1	Content updated to correspond to the product version

ABB | 57

Contact us

ABB Oy
Medium Voltage Products,
Distribution Automation
P.O. Box 699
FI-65101 VAASA, Finland
Phone   +358 10 22 11
Fax   +358 10 22 41094

www.abb.com/mediumvoltage

www.abb.com/substationautomation

ABB India Limited,
Distribution Automation
Maneja Works
Vadodara-390013, India
Phone   +91 265 6724402
Fax   +91 265 6724423

www.abb.com/mediumvoltage

www.abb.com/substationautomation

Power and productivity
for a better world™

ABB