PRODUCT GUIDE

RET615

Transformer protection and control

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1. Description
RET615 is a dedicated transformer protection and control relay for power transformers, unit and step-up transformers including power generator-transformer blocks in utility and industry power distribution systems. RET615 is a member of ABB's Relion® product family and part of its 615 protection and control product series. The 615 series relays are characterized by their compactness and withdrawable-unit design.

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

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

2. Standard configurations
RET615 is available in two standard configurations. The standard signal configuration can be altered by means of the signal matrix or the graphical application functionality of the Protection and Control Relay Manager PCM600. Further, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions utilizing 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 RET615 must be added with the Application Configuration tool to be available in the Signal Matrix tool and in the relay. The positive measuring direction of directional protection functions is towards the outgoing feeder.

Figure 1. Functionality overview for standard configuration B

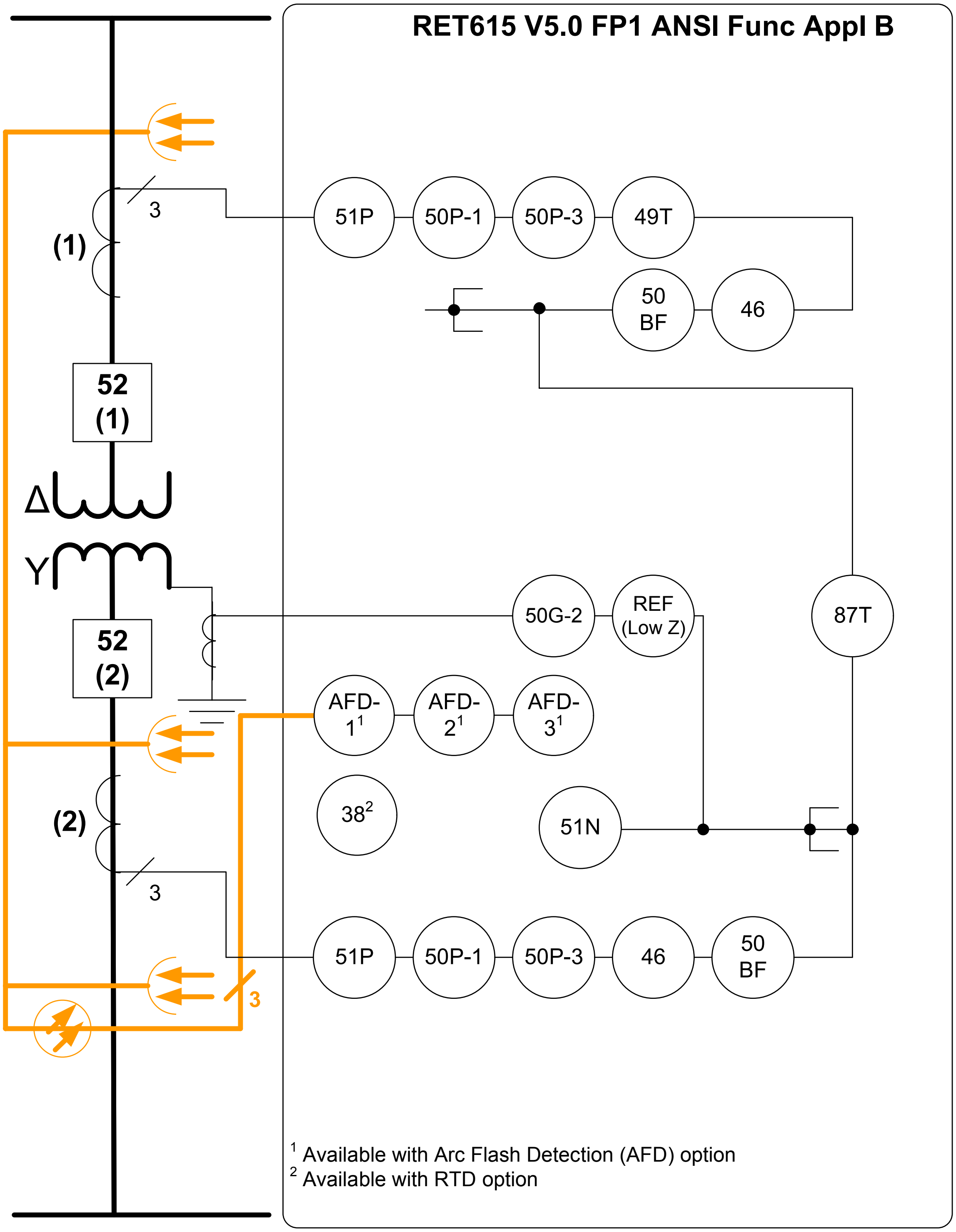

Figure 2. Functionality overview for standard configuration F

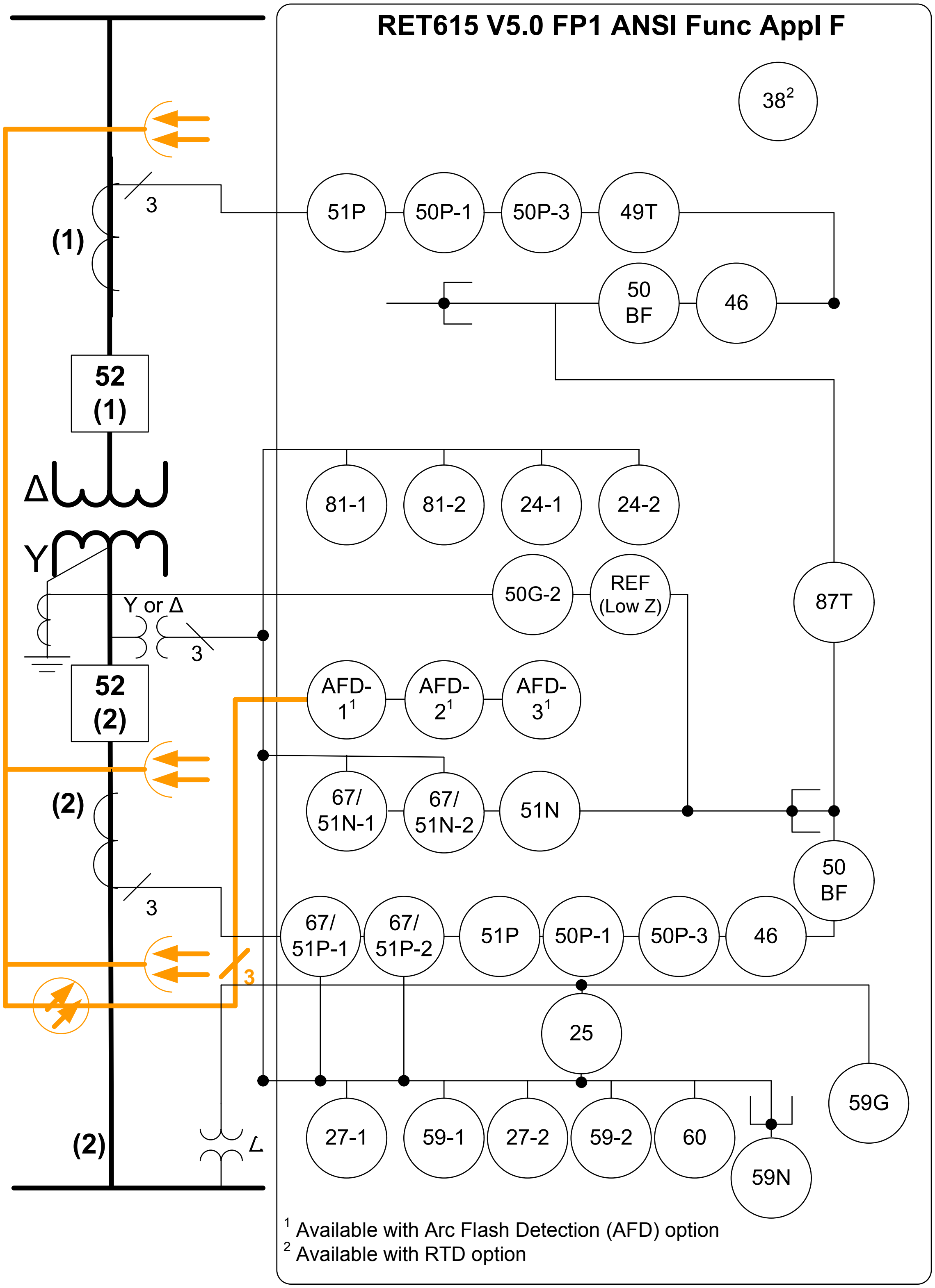

Table 1. Standard configurations

Description	Std. conf.
Transformer differential with low imp. restricted EF on MV side	B
Transformer differential with voltage protection & measurements and low imp. restricted EF on MV side, overexcitation, directional ground protection, and sync-check	F

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Table 2. Supported functions

Function	IEC 61850	ANSI	B	F
Protection				
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	51P	1[HV)] 1[LV)]	1[HV)] 1[LV)]
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	50P	1[HV)] 1[LV)]	1[HV)] 1[LV)]
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	50P-3	1[HV)] 1[LV)]	1[HV)] 1[LV)]
Three-phase directional overcurrent protection, low stage	DPHLPDOC	67/51P		2[LV) 8)]
Non-directional ground-fault protection, low stage	EFLPTOC	51N	1[LV) 1)]	1[LV) 1)]
Non-directional ground-fault protection, high stage	EFHPTOC	50G	1[LV) 7)]	1[LV) 7)]
Directional ground-fault protection, low stage	DEFLPDEF	67/51N		2[LV) 8)]
Negative-sequence overcurrent protection	NSPTOC	46	1[HV)] 1[LV)]	1[HV)] 1[LV)]
Residual overvoltage protection	ROVPTOV	59G/59N		1[LV) 4) 8)] 1[LV) 5) 8)]
Three-phase undervoltage protection	PHPTUV	27		2[LV)]
Three-phase overvoltage protection	PHPTOV	59		2[LV)]
Frequency protection	FRPFRQ	81		2[LV) 8)]
Overexcitation protection	OEPVPH	24		2[LV) 8)]
Three-phase thermal protection for feeders, cables and distribution transformers	T2PTTR	49T	1[HV) 8)]	1[HV) 8)]
Stabilized and instantaneous differential protection for two-winding transformers	TR2PTDF	87T	1	1
Numerically stabilized low-impedance restricted ground-fault protection	LREFPNDF	87LOZREF	1[LV) 6)]	1[LV) 6)]
Circuit breaker failure protection	CCBRBRF	50BF	1[HV) 2)] 1[LV)]	1[HV) 2)] 1[LV)]
Master trip	TRPPTRC	86/94	2 (3)[9)]	2 (3)[9)]
Arc protection	ARCSARC	AFD	(3)[LV) 3)]	(3)[LV) 3)]
Multipurpose protection[2)]	MAPGAPC	MAP	18[8)]	18[8)]
Control				
Circuit breaker control	CBXCBR	52	1[HV)] 1[LV)]	1[HV)] 1[LV)]
Disconnector control	DCXSWI	29DS	2[8)]	2[8)]
Gorunding switch control	ESXSWI	29GS	1[8)]	1[8)]
Disconnector position indication	DCSXSWI	52-TOC, 29DS	1[8)] 2[8)]	1[8)] 2[8)]
Grounding switch indication	ESSXSWI	29GS	2[8)]	2[8)]
Tap changer position indication	TPOSYLTC	84T	1	1
Synchronism and energizing check	SECRSYN	25		1[LV)]
Conditioning monitoring and supervision				
Circuit breaker condition monitoring	SSCBR	52CM	1[HV)] 1[LV)]	1[HV)] 1[LV)]
Trip circuit supervision	TCSSCBR	TCM	2	2
Fuse failure supervision	SEQSPVC	60		1
Runtime counter for machines and devices	MDSOPT	OPTM	1	1
Measurement				
Load profile record	LDPRLRC	LOADPROF	1	1
Three-phase current measurement	CMMXU	IA, IB, IC	1[HV)] 1[LV)]	1[HV)] 1[LV)]
Sequence current measurement	CSMSQI	I1, I2, I0	1[HV)]	1[HV)]

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Table 2. Supported functions, continued

Function	IEC 61850	ANSI	C	D
Measurement				
Residual current measurement	RESCMMXU	IG	1 LV)	1 LV)
Three-phase voltage measurement	VMMXU	VA, VB, VC		1 LV)
Residual voltage measurement	RESVMMXU	VG		1 LV)
Sequence voltage measurement	VSMSQI	V1, V2, V0		1 LV)
Single-phase power and energy measurement	SPEMMXU	SP, SE		1 LV)
Three-phase power and energy measurement	PEMMXU	P, E		1 LV)
RTD/mA measurement	XRGGIO130	X130 (RTD)	(1)	(1)
Frequency measurement	FMMXU	f		1
IEC 61850-9-2 LE sampled value sending 10)11)	SMVSENDER	SMVSENDER		(1)
IEC 61850-9-2 LE sampled value receiving (voltage sharing) 10)11)	SMVRCV	SMVRECEIVER		(1)
Other				
"Minimum pulse timer (2 pcs)	TPGAPC	62TP	3 1 8)	3 1 8)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	62TPS	1 8)	1 8)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	62TPM	1 8)	1 8)
Pulse timer (8 pcs)	PTGAPC	62PT	2 8)	2 8)
Time delay off (8 pcs)	TOFGAPC	62TOF	2 2 8)	2 2 8)
Time delay on (8 pcs)	TONGAPC	62TON	2 2 8)	2 2 8)
Set-reset (8 pcs)	SRGAPC	SR	4 8)	4 8)
Move (8 pcs)	MVGAPC	MV	2 8)	2 8)
Generic control point (16 pcs)	SPCGAPC	SPC	2 8)	2 8)
Analog value scaling (4 pcs)	SCA4GAPC	SCA4	4 8)	4 8)
Integer value move (4 pcs)	MVI4GAPC	MVI4	1 8)	1 8)
Generic up-down counters	UDFCNT	CTR	4 8)	4 8)

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() = optional

1) Io selectable by parameter, Io calculated as default

2) Io calculated is always used

3) IoB calculated and 3IB are always used

4) Uo selectable by parameter, Uo measured as default

5) Uo measured is always used

6) IoB measured and 3IB are always used

7) IoB selectable by parameter, IoB measured as default

8) Must be added with ACT to be available in SMT and in Relay.

9) Master Trip included and connected to corresponding HSO in the configuration only when BIO0007 module is used. If additionally the ARC option is selected, then ARCSARC is connected in the configuration to the corresponding Master Trip input.

10) Only available with COM0031-0037

11) Only available with IEC 61850-9-2

LV) The function block is to be used on the low voltage side in the application

HV) The function block is to be used on the high voltage side in the application

3. Protection functions

The relay features three-phase, multi-slope stabilized (biased) stage transformer differential protection and an instantaneous stage to provide fast and selective protection for phase-to-phase short circuit, winding interturn fault and bushing flashover protection. Besides second harmonic restraint, an advanced waveform-based blocking algorithm ensures stability at transformer energization and a fifth harmonic restraint function ensures good protection stability at moderate overexcitation of power transformers. Sensitive restricted ground-fault protection completes the overall differential protection providing detection of even single phase-to-ground faults close to the neutral grounding point of the transformer. A numerical low-impedance scheme can be selected for protection of the transformer windings. When low-impedance restricted ground fault protection is used neither stabilizing resistors nor varistors are needed and as a further benefit the transforming ratio of the neutral grounding CTs can differ from those of the phase current transformers. Due to its unit protection character and absolute selectivity restricted ground fault does not need to be time-graded with other protection schemes, and therefore high speed fault clearance can be achieved.

The relay also incorporates a thermal overload protection function, which supervises the thermal stress of the transformer windings to prevent premature aging of the insulation of the windings. Multiple stages of short circuit, phase overcurrent, negative-sequence and ground-fault backup protection are separately available for both sides of the power transformer. Ground-fault protection based on the measured or calculated residual voltage is also available. Depending on the chosen standard configuration the relay also features three-phase overvoltage protection, three-phase undervoltage protection and residual overvoltage protection. Further, the relay also offers circuit breaker failure protection.

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

RET615 provides main protection for two-winding power transformers and power generator-transformer blocks. The standard configurations offer comprehensive protection functions for detection and elimination of operational disturbance conditions and power transformer faults.

The B and F configurations fit transformers with solidly grounded LV side neutral or the LV side with a neutral grounding resistor. The B, and F configurations also fit applications including a separate grounding transformer located within the area of protection. The B and F configurations also suit applications, where the turns ratio of the CT of the neutral grounding circuit differs from the turns ratio of the line CTs.

Standard configuration F includes phase-voltage protection and measurement functions which provide two-stage power transformer overvoltage and undervoltage protection and/or supervision.

Two optional RTD/mA modules are available. The optional RTD/mA module offered for the standard configuration B allows up to eight analog signals to be measured via the six RTD inputs and the two mA inputs using transducers. The RTD and mA inputs can be used for measuring the oil temperature at the bottom and top of the transformer.

Furthermore, the RTD/mA inputs can be used for measuring the ambient air temperature. The RTD inputs also offer thermal protection of dry-type power transformers fitted with Pt-100 temperature sensors. Temperature measurement over the RTD/mA inputs extends the function of the three-phase thermal overload protection of the relay. Further, one of the RTD inputs can also be used as a direct resistance measuring input for position information of the on-load tap changer. Alternatively, the tap changer position indication can be obtained via a mA-transducer.

The optional RTD/mA module offered for the standard configuration F allows up to three analog signals to be measured via the two RTD inputs and the one mA input using transducers. The RTD inputs can be used for measuring the oil temperature and the ambient air temperature. Temperature measurement over the RTD inputs extends the function of the three-phase thermal overload protection of the relay. For on-load tap changer, the tap changer position indication can be obtained via a mA transducer. If required, the analog temperature or tap changer position values can be sent to other devices using analog horizontal GOOSE messaging. Analog values can also be received from other devices over the station bus, thus improving the extent of relevant information.

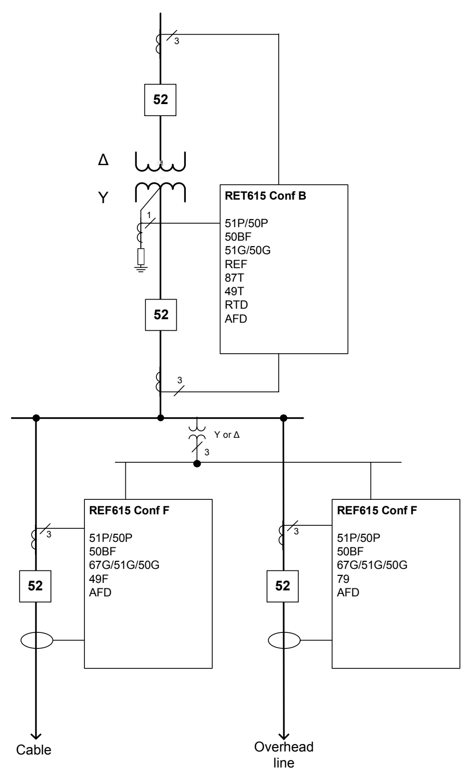


Figure 3. Protection of a two-winding power transformer with RET615 standard configuration B

Figure 3. Illustrates the protection of a two winding power transformer with configuration B. The main protection used in this application example is transformer differential protection. Additionally, restricted ground fault protection with numerical low impedance principal is applied on the transformer's LV side.

Figure 4. Protection of two-winding power transformers feeding a single busbar switch-gear arranged into two bus sections separated with bus coupler.

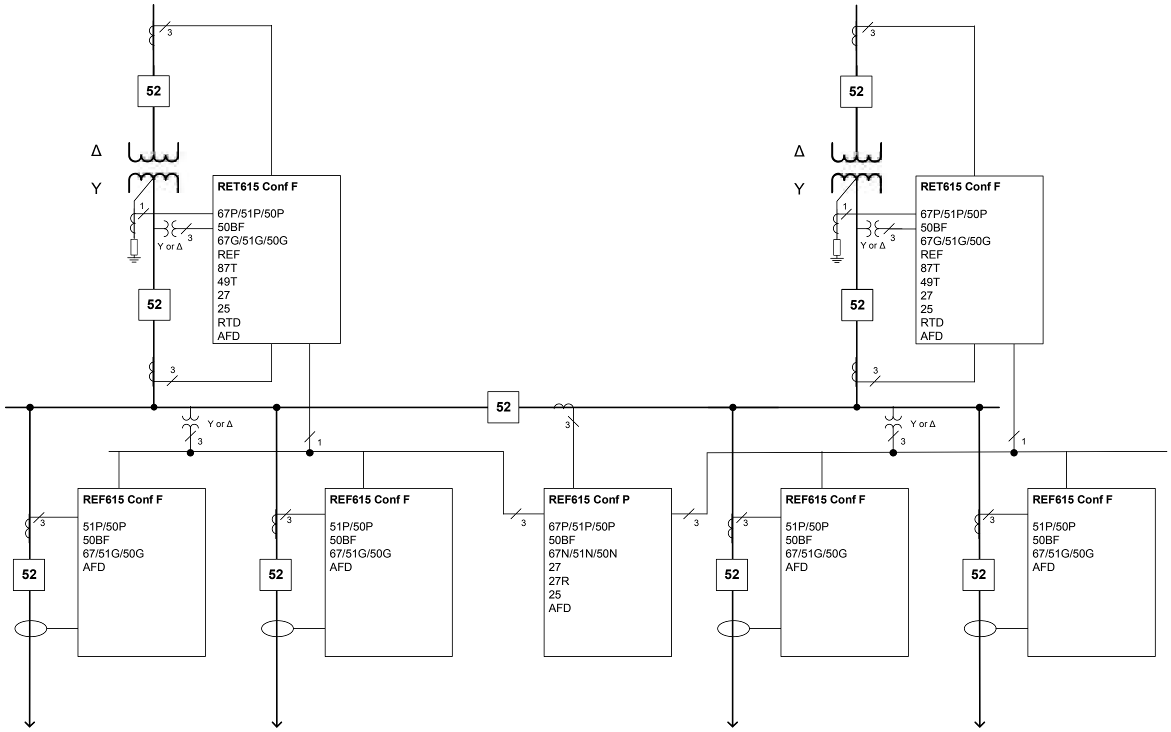


Figure 4 Illustrates the protection of the two winding power transformers feeding a double ended substation. In this case configuration F provides the main protection for the transformers: differential protection and low impedance restricted ground fault protection. In addition configuration F provides the main protection for the incoming feeders also, and it includes synch-check control and directional overcurrent protection in case incoming feeders will be momentarily paralleled.

5. Supported solutions

The 615 series protection relays together with the Substation Management Unit COM600F constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate the system engineering, ABB's relays are supplied with connectivity packages. The connectivity packages include a compilation of software and relay-specific information, including single-line diagram templates and a full relay data model. The data model includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with COM600F or the network control and management system MicroSCADA Pro.

The 615 series relays offer native support for IEC 61850 Edition 2 also including binary and analog horizontal GOOSE messaging. In addition, process bus with the sending of sampled values of analog currents and voltages and the receiving of sampled values of voltages is supported. Compared to traditional hard-wired, inter-device signaling, peer-to-peer communication over a switched Ethernet LAN offers an advanced and versatile platform for power system protection. Among the distinctive features of the protection system approach, enabled by the full implementation of the IEC 61850 substation automation standard, are fast communication capability, continuous supervision of the protection and communication system's integrity, and an inherent flexibility regarding reconfiguration and upgrades. This protection relay series is able to optimally utilize interoperability provided by the IEC 61850 Edition 2 features.

At substation level, COM600F uses the data content of the bay level devices to enhance substation level functionality. COM600F features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The SLD feature is especially useful when 615 series relays without the optional single-line diagram feature are used. The Web HMI of COM600F also provides an overview of the whole substation, including relay-specific single-line diagrams, which makes information easily accessible. Substation devices and processes can also be remotely accessed through the Web HMI, which improves personnel safety.

In addition, COM600F can be used as a local data warehouse for the substation's technical documentation and for the network data collected by the devices. The collected network data facilitates extensive reporting and analyzing of network fault situations by using the data historian and event handling features of COM600F. The historical data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and historical values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

COM600F can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems, such as MicroSCADA Pro and System 800xA.

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

Table 3. Supported ABB solutions

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

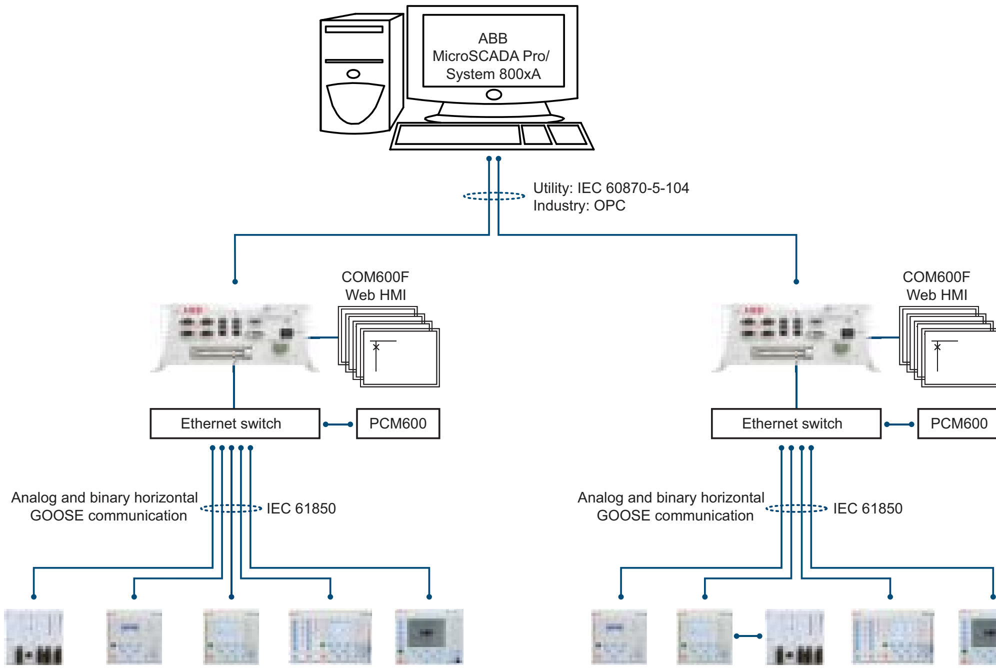


Figure 5. ABB power system example using Relion relays, COM600F and MicroSCADA Pro/ System 800xA

6. Control

RET615 integrates functionality for the control of a circuit breaker via the front panel HMI or by means of remote controls. In addition to the circuit-breaker control the relay features two control blocks which are intended for motor-operated control of disconnectors or circuit breaker truck and for their position indications. Further, the relay offers one control block which is intended for motor-operated control of one grounding switch control and its position indication.

Two physical binary inputs and two physical binary outputs are needed in the relay for each controllable primary device taken into use. Depending on the chosen standard configuration of the relay the number of unused binary inputs and binary outputs varies. Further, some standard configurations also offer optional hardware modules that increase the number of available binary inputs and outputs.

If the amount of available binary inputs or outputs of the chosen standard configuration is not sufficient, the standard configuration can be modified to release some binary inputs or outputs which have originally been configured for other purposes, when applicable, or an external input or output module, for example, RIO600 can be integrated to the relay. The binary inputs and outputs of the external I/O module can be used for the less time critical binary signals of the application. The integration enables releasing of some initially reserved binary inputs and outputs of the relay in the standard configuration.

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

The large graphical LCD of the relay's 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.

7. Measurements

The relay continuously measures the high voltage (HV) side and the low voltage (LV) side phase currents and the neutral current of the protected transformer. In addition, the relay calculates the symmetrical components of the currents and voltages, maximum current demand value over a user-selectable pre-set time frame, the active and reactive power, the power factor, and the active and reactive energy values. Calculated values are also obtained from the protection and condition monitoring functions of the relay. Depending on the standard configuration, the relay also measures the phase voltages, the residual voltage and the voltage sequence components.

For standard configuration B, RTD/mA inputs are offered as an option. By means of the optional RTD/mA module the relay can measure up to eight analog signals such as temperature, pressure and tap changer position values via the six RTD inputs or the two mA inputs using transducers.

For standard configuration F, RTD/mA inputs are offered as an option. By means of these inputs the relay can measure up to three analog signals such as temperature, pressure and tap changer position values via the two RTD inputs or the one mA inputs using transducers.

The measured values can be accessed via the local HMI or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the Web HMI.

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

8. Disturbance recorder

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

The analog channels can be set to trigger the recording function when the measured value falls below or exceeds the set values.

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

9. Event log

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

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

10. Recorded data

The relay has the capacity to store the records of the 128 latest fault events. The records can be used to analyze the power system events. Each record includes, for example, current, voltage and angle values and a time stamp. The fault recording can be triggered by the start or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. Fault records store relay measurement values at the moment when any protection function starts. In addition, the maximum demand current with time stamp is separately recorded. The records are stored in the non-volatile memory.

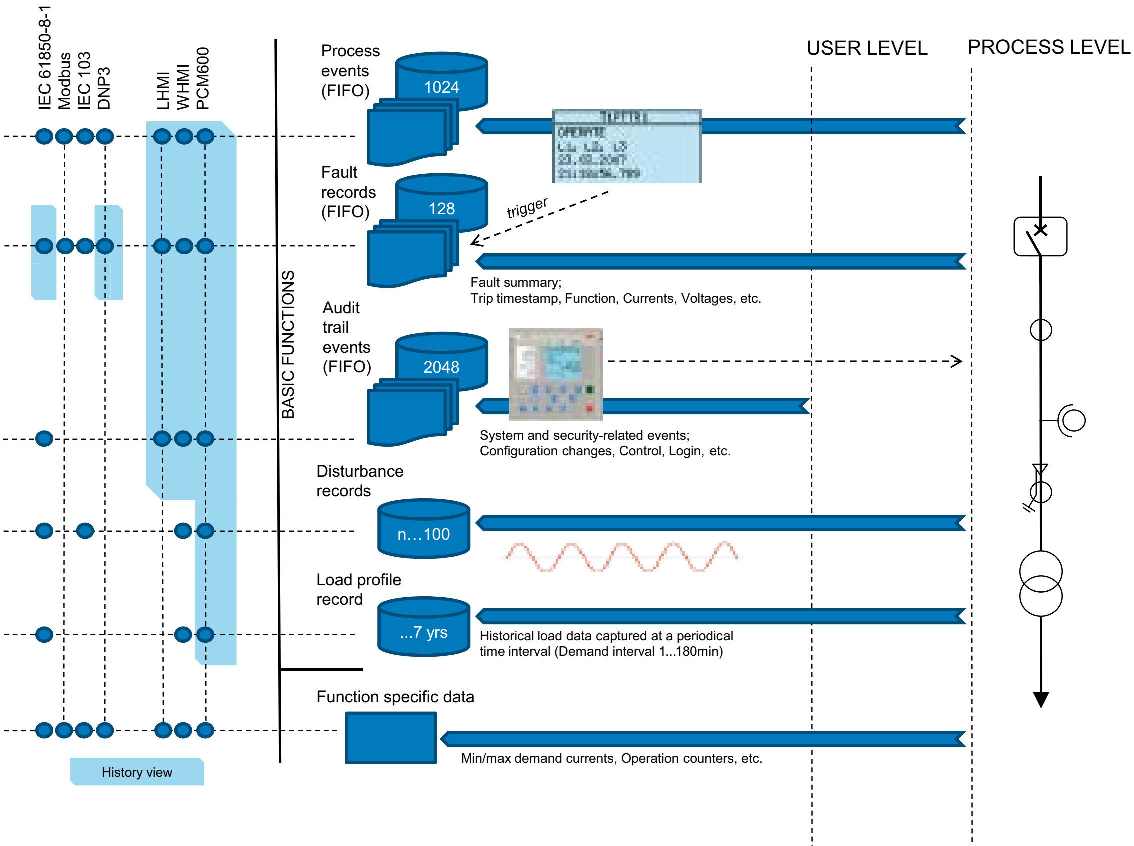


Figure 6. Recording and event capabilities overview 12.

11. Condition monitoring

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

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

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

12. Trip-circuit supervision

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

13. Self-supervision

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

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

14. Fuse failure supervision

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

15. Access control

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

16. Inputs and outputs

The relay is equipped with six phase-current inputs and one neutral-current input or six phase-current inputs, one neutral current input, three phase-voltage inputs and one residual voltage input. 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 input covers the rated voltages 60... 210 V. Both phase-to-phase voltages and phase-to-ground voltages can be connected. In addition, the binary input thresholds 16…176 V DC are selected by adjusting the relay's parameter settings.

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

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

As an option for standard configuration F, the relay offers two RTD inputs and one mA input.

As an option a binary input and output module can be selected, having three high speed binary outputs (HSO), decreasing further the total operate time with typically 4...6 ms compared to the normal power outputs.

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

Table 4. Input/output overview

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

17. Station communication

The relay supports a range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, Modbus®, and DNP3. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the relays, is only enabled by the IEC 61850 communication protocol.

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

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

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

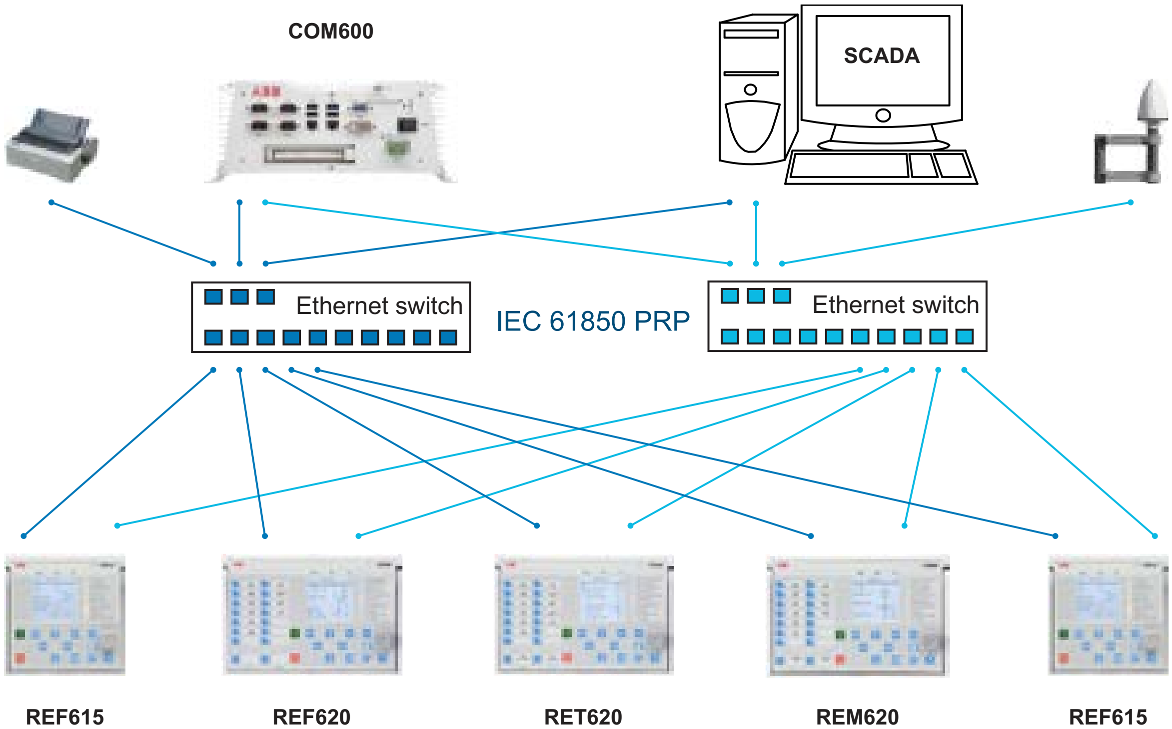
The relay also supports IEC 61850 process bus by sending sampled values of analog currents and voltages and by receiving sampled values of voltages. With this functionality the galvanic interpanel wiring can be replaced with Ethernet communication. The measured values are transferred as sampled values using IEC 61850-9-2 LE protocol. The intended application for sampled values shares the voltages to other 615 series relays, having voltage based functions and 9-2 support. 615 relays with process bus based applications use IEEE 1588 for high accuracy time synchronization.

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

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

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

Figure 7. Parallel redundancy protocol (PRP) solution



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

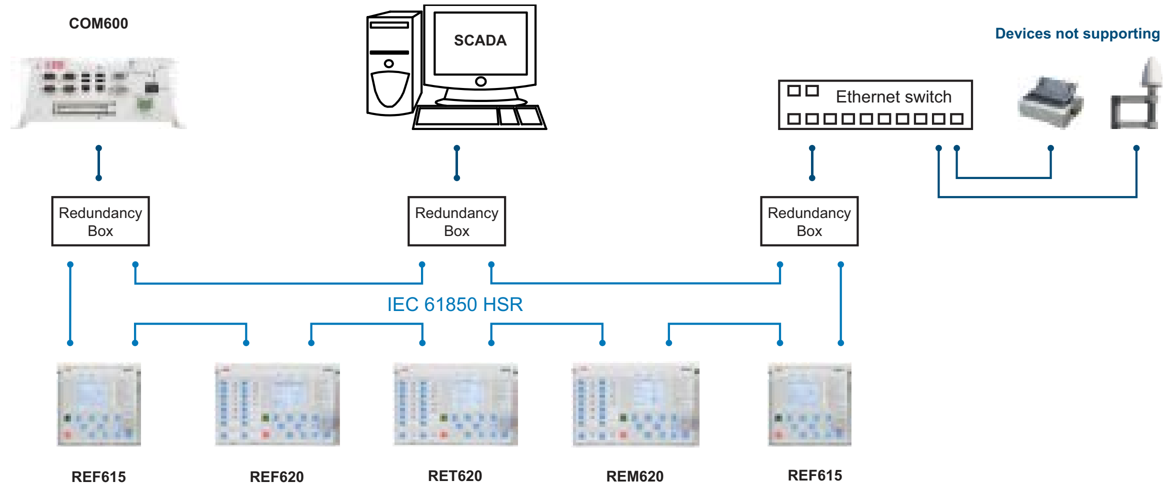


Figure 8. High availability seamless redundancy (HSR) solution

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.

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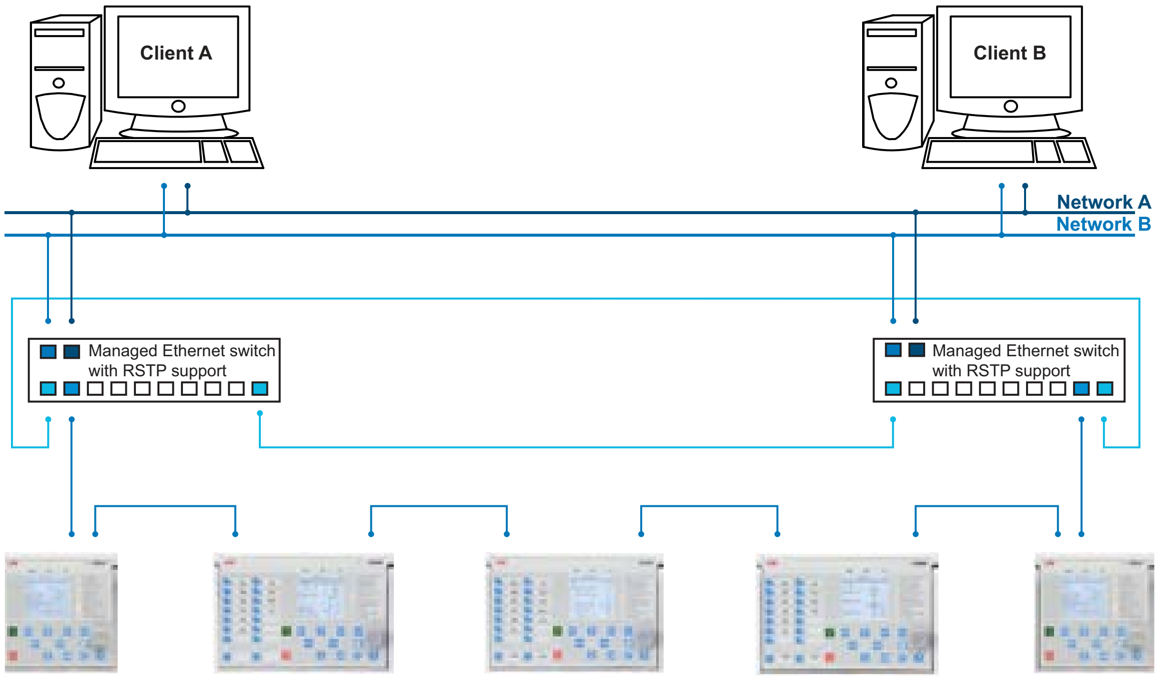
Figure 9. Self-healing Ethernet ring solution



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

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

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

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

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

Ethernet-based
• SNTP (Simple Network Time Protocol)

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

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

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, and DNP3 serial communication protocols.

Table 5. Supported station communication interfaces and protocols

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

• = Supported

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

Table 8. Energizing inputs

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

1) Residual current and/or phase current

Table 9. Binary inputs

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

Table 10. RTD/mA measurement (XRGGIO130)

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

Table 11. Signal output X100: SO1

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

Table 12. Signal outputs and IRF output

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

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

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

Table 14. Single-pole power output relays

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

Table 15. High-speed output HSO with BIO0007

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

Table 16. Front port Ethernet interfaces

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

Table 17. Station communication link, fiber optic

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

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

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

3) Maximum allowed attenuation caused by connectors and cable together

Table 18. IRIG-B

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

1) According to the 200-04 IRIG standard

Table 19. Lens sensor and optical fiber for arc protection

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

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

Description	Value
Front side	IP 54
Rear side, connection terminals	IP 10
Left and right side	IP 20
Top and bottom	IP 20

Table 21. 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 22. Electromagnetic compatibility tests

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

Table 22. Electromagnetic compatibility tests, continued

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

Table 23. Insulation tests

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

Table 24. Mechanical tests

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

Table 25. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55ºC • 16 h at +85ºC[1)]	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

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

Table 26. Product safety

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

Table 27. EMC compliance

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

Table 28. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

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

Description	Type test value	Reference		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	DPHLPDOC	±1.5% of the set value or ±0.002 × I_n		
	DPHLPDOC	±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
	I_{Fault} = 2.0 × set Start value	39 ms	43 ms	47 ms
	I_{Fault} = 10 × set Start value	11 ms	12 ms	14 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 × set Start value	23 ms	26 ms	29 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Measurement mode and Pol quantity = default, current before fault = 0.0 x In, voltage before fault = 1.0 x U_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected fromrandom 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 x I_n, Start value multiples in range of 1.5...20

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

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

1) For further reference, see the Operation characteristics table

Table 31. Three-phase non-directional overcurrent protection (PHxPTOC)

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

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

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

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

1) For further reference, see the Operation characteristics table

Table 33. Directional ground-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	DEFLPDEF	±1.5% of the set value or ±0.002 × I_n		
	DEFHPDEF	±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
	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) Measurement mode and Pol quantity = default, current before fault = 0.0 × In, voltage before fault = 1.0 × U_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = 2.5 × In, Start value multiples in range of 1.5...20

Table 34. Directional ground-fault protection (DEFxPDEF) main settings

	Function	Value (Range)	Step
Start value	DEFLPDEF	0.010...5.000 × I_n	0.005
	DEFLPDEF	0.10...40.00 × I_n	0.01
Directional mode	DEFLPDEF and DEFHPDEF	1 = Non-directional	
		2 = Forward	
		3 = Reverse	0.01
Time multiplier	DEFLPDEF	0.05...15.00	10
	DEFHPDEF	0.05...15.00	10
Operate delay time	DEFLPDEF	50...200000 ms	
	DEFHPDEF	40...200000 ms	
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, 9, 10, 12, 15, 17	
		1 = Phase angle	
		2 = IoSin	
		3 = IoCos	
		4 = Phase angle 80	
Operation mode	DEFxPDEF	**5 = Phase angle 88**	

1) For further reference, see the Operating characteristics table

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

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

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

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

	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 × I_n	0.005
	EFHPTOC	0.10...40.00 × I_n	0.01
Time multiplier	EFLPTOC and EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC and EFHPTOC	40...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	

1) For further reference, see the Operating characteristics table

Table 37. Negative-sequence overcurrent protection (NSPTOC)

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

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

—

Table 38. Negative-sequence overcurrent protection (NSPTOC) main settings

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

1) For further reference, see the Operation characteristics table

—

Table 39. 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
	UFault = 2 × set Start value	48 ms	51 ms	54 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

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

—

Table 40. Residual overvoltage protection (ROVPTOV) main settings

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

—

Table 41. Three-phase undervoltage protection (PHPTUV)

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

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

—

Table 42. Three-phase undervoltage protection (PHPTUV) main settings

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

1) For further reference, see the Operation characteristics table

—

Table 43. Three-phase overvoltage protection (PHPTOV)

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

1) Start value = 1.0 × U_n, Voltage before fault = 0.9 × U_n, f_n = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

3) Maximum Start value = 1.20 × U_n, Start value multiples in range of 1.10...2.00

—

Table 44. Three-phase overvoltage protection (PHPTOV) main settings

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

1) For further reference, see the Operation characteristics table

—

Table 45. Frequency protection (FRPFRQ)

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

Table 46. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1 = Freq< 2 = Freq> 3 = df/dt 4 = Freq< + df/ft 5 = Freq> + df/dt 6 = Freq < OR df/dt 7 = Freq> OR df/dt	-
Start value Freq>	FRPFRQ	0.9000...1.2000 x f_n	0.0001
Start value Freq<	FRPFRQ	0.8000...1.1000 x f_n	0.001
Start value df/dt	FRPFRQ	-0.2000...0.2000 x f_n/s	0.005
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 47. Overexcitation protection (OEPVPH)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±3.0% of the set value
Start time[1)2)]	Frequency change: Typically 200 ms
	Voltage change: Typically 40 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96 ms
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 ±0.50 ms

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

Table 48. Overexcitation protection (OEPVPH) main settings

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

Table 49. Three-phase thermal overload protection, two time constants (T2PTTR)

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

1) Overload current > 1.2 x Operate level temperature

—

Table 50. Three-phase thermal overload protection, two time constants (T2PTTR) main settings

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

—

Table 51. Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz		
		±3.0% of the set value or ±0.002 × I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	Low stage	36 ms	41 ms	46 ms
	High stage	21 ms	22 ms	24 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Current before fault = 0.0, fn = 50 Hz, results based on statistical distribution of 1000 measurements

2) Includes the delay of the output contact. When differential current = 2 × set operate value and fn = 50 Hz.

Table 52. Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF) main settings

Parameter	Function	Value (Range)	Step
High operate value	TR2PTDF	500...3000 %I_r	10
Low operate value	TR2PTDF	5...50 %I_r	1
Slope section 2	TR2PTDF	10...50%	1
End section 2	TR2PTDF	100...500 %I_r	1
Restraint mode	TR2PTDF	5 = Waveform 6 = 2.h + waveform 8 = 5.h + waveform 9 = 2.h + 5.h + wav	-
Start value 2.H	TR2PTDF	7...20%	1
Start value 5.H	TR2PTDF	10...50%	1
Operation	TR2PTDF	1 = on 5 = off	-
Winding 1 type	TR2PTDF	1 = Y 2 = YN 3 = D 4 = Z 5 = ZN	-
Winding 2 type	TR2PTDF	1 = y 2 = yn 3 = d 4 = z 5 = zn	-
Zro A elimination	TR2PTDF	1 = Not eliminated 2 = Winding 1 3 = Winding 2 4 = Winding 1 and 2	-

Table 53. Numerically stabilized low-impedance restricted ground-fault protection (LREFPNDF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz		
		±2.5% of the set value or ±0.002 x I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set Operate value	37 ms	41 ms	45 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) Current before fault = 0.0, fn = 50 Hz, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

Table 54. Stabilized restricted ground-fault protection (LREFPNDF) main settings

Parameter	Function	Value (Range)	Step
Operate value	LREFPNDF	5...50 %I_n	1
Minimum operate time	LREFPNDF	40...300000 ms	1
Restraint mode		1 = None 2 = Harmonic2	-
Start value 2.H	LREFPNDF	10...50%	1
Operation	LREFPNDF	1 = on 5 = off	-

Table 55. Circuit breaker failure protection (CCBRBRF)

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

Table 56. Circuit breaker failure protection (CCBRBRF) main settings

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

Table 57. Arc protection (ARCSARC)

Characteristic		Value		
Operation accuracy		±3% of the set value or ±0.01 × I_n		
Start time 1)2)		Minimum	Typical	Maximum
	Operation mode = "Light +current"1)2)	9 ms3) 4 ms4)	12 ms3) 6 ms4)	15 ms 3) 9 ms4)
	Operation mode = "Light only"2)	9 ms3) 4 ms4)	10 ms3) 6 ms4)	12 ms3) 7 ms4)
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 58. Arc protection (ARCSARC) main settings

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

Table 59. Multipurpose protection (MAPGAPC)

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

Table 60. Multipurpose protection (MAPGAPC) main settings

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

Table 61. 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 23 = Programmable

Control functions

Table 61. Tap changer position indication (TPOSYLTC)

Description	Value
Response time for binary inputs	Typical 100 ms

Table 62.Synchronism and energizing check (SECRSYN)

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

Table 63. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	1 = Off 2 = Both Dead 3 = Dead L, Live B 4 = Dead Bus, L Any 5 = Dead L, Bus Any 6 = Onle Live, Dead 7 = Not Both Live	
Difference voltage	SECRSYN	0.01...0.550 x U_n	
Difference frequency	SECRSYN	0.001...0.100 x f_n	
Difference angle	SECRSYN	5...90°	
Synchrocheck mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchornous	
Dead line value	SECRSYN	0.1...0.8 x U_n	
Live line value	SECRSYN	0.2...1.0 x Un	
Max energeizing V	SECRSYN	1 = Continuos	
Control mode	SECRSYN	2 = Command	
Close pulse	SECRSYN	200...60000 ms	
Phase shift	SECRSYN	-180...180°	
Minimum Syn time	SECRSYN	0...60000 ms	
Maximum Syn time	SECRSYN	100...6000000 ms	
Energizing time	SECRSYN	100...60000 ms	
Closing time of CB	SECRSYN	40...250 ms	

Condition and supervision functions

Table 64. Circuit-breaker condition monitoring (SSCBR)

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

Table 65. Fuse failure supervision (SEQSPVC)

Parameter	Function	Value (Range)	Step
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 66. Runtime counter for machines and devices (MDSOPT)

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

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

Measurement functions

Table 67. Three-phase current measurement (CMMXU)

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

Table 68. Sequence current measurement (CSMSQI)

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

Table 69. Residual current measurement (RESCMMXU)

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

Table 70. Three-phase voltage measurement (VMMXU)

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

Table 71. Residual voltage measurement (RESVMMXU)

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

—

Table 72. 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 73. Three-phase power and energy measurement (SPEMMXU/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 74. RTD/mA measurement (XRGGIO130)

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

—

Table 75. Frequency measurement (FMMXU)

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

Other functions

—
Table 76. Pulse timer (PTGAPC)

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

—
Table 77. Time delay off (8 pcs) (TOFPAGC)

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

—
Table 78. Time delay on (8 pcs) (TONGAPC)

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

19. Local HMI

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

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

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

Figure 10. Large display

Table 79. Large display

Character size[1]	Rows in the view	Characters per row
Small, mono-spaced (6 × 12 pixels)	10	20
Large, variable width (13 × 14 pixels)	7	8 or more

1) Depending on the selected language

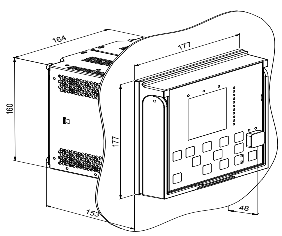
20. Mounting methods

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

Further, the relays can be mounted in any standard 19” instrument cabinet by means of 19” mounting panels available with cut-outs for one or two relays.

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

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



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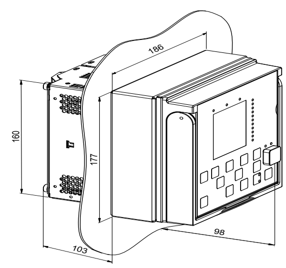
11



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12

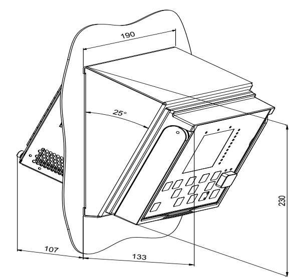

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Figure 11. Flush mounting

Figure 12. Semi-flush mounting

Figure 13. Semi-flush mounting in a 25º tilt

21. Relay case and plug-in unit

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

22. Selection and ordering data

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

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

23. Accessories and ordering data

Table 80. Cables

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

Table 81. Mounting accessories

Item	Order number
Semi-flush mounting kit	1MRS050696
Wall mounting kit	1MRS050697
Inclined semi-flush mounting kit	1MRS050831
19” rack mounting kit with cut-out for one relay	1MRS050694
19” rack mounting kit with cut-out for two relays	1MRS050695
Functional grounding flange for RTD modules[1)]	2RCA036978A0001

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

24. Tools

The protection relay is delivered as a preconfigured unit. The default parameter setting values can be changed from the front panel user interface (local HMI), the Web browser-based user interface (Web HMI) or Protection and Control Relay Manager PCM600 in combination with the relay-specific connectivity package.

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

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

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

Table 82. Tools

Description	Version
PCM600	2.8 or later
Web browser	IE 11.0
RET615 Connectivity Package	5.1 or later

Table 83. Supported functions

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

• = Supported

25. Cyber security

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

26. Terminal diagrams

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Figure 14. Terminal diagram of standard configurations B

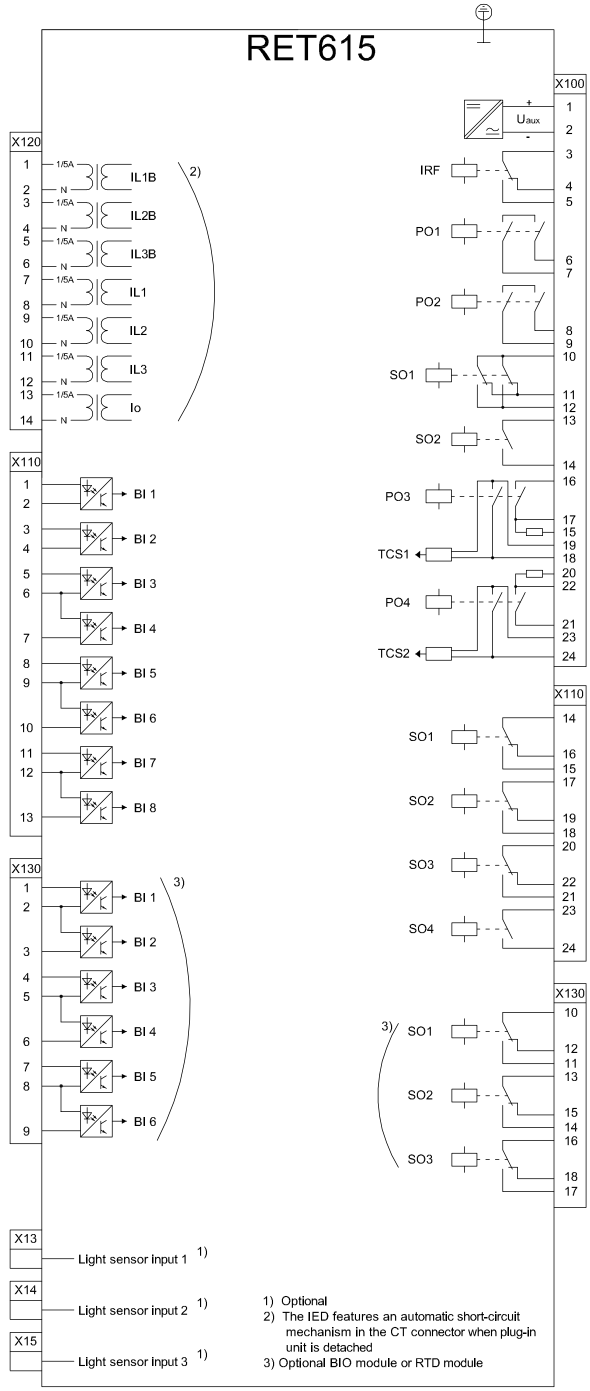

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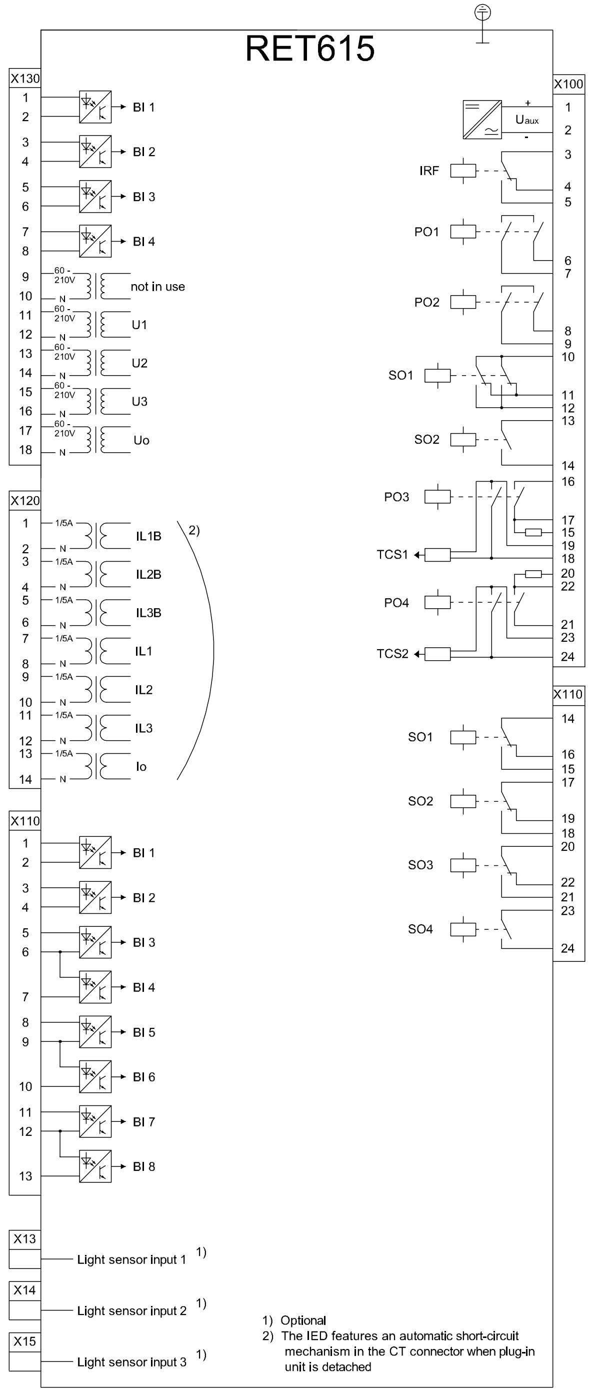
Figure 15. Terminal diagram of standard configuration F



27. 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**.

28. References

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

The latest relevant information on the RET615 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

29. Functions, codes, and symbols

Table 84. Functions included in the relay

Function	IEC 61850	ANSI
Protection		
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	51P
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	50P
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	50P-3
Three-phase directional overcurrent protection, low stage	DPHLPDOC	67/51P
Non-directional ground-fault protection, low stage	EFLPTOC	51N
Non-directional ground-fault protection, high stage	EFHPTOC	50G
Directional ground-fault protection, low stage	DEFLPDEF	67/51N
Negative-sequence overcurrent protection	NSPTOC	46
Residual overvoltage protection	ROVPTOV	59G/59N
Three-phase undervoltage protection	PHPTUV	27
Three-phase overvoltage protection	PHPTOV	59
Frequency protection	FRPFRQ	81
Overexcitation protection	OEPVPH	24
Three-phase thermal protection for feeders, cables and distribution transformers	T2PTTR	49T
Stabilized and instantaneous differential protection for two-winding transformers	TR2PTDF	87T
Numerically stabilized low-impedance restricted ground-fault protection	LREFPNDF	87LOZREF
Circuit breaker failure protection	CCBRBRF	50BF
Master trip	TRPPTRC	86/94
Arc protection	ARCSARC	AFD
Multipurpose protection	MAPGAPC	MAP
Control		
Circuit breaker control	CBXCBR	52
Disconnector control	DCXSWI	29DS
Grounding switch control	ESXSWI	29GS
Disconnector position indication	DCSXSWI	52-TOC, 29DS
Grounding switch indication	ESSXSWI	29GS
Tap changer position indication	TPOSYLTC	84T
Synchronism and energizing check	SECRSYN	25
Conditioning monitoring and supervision		
Circuit breaker condition monitoring	SSCBR	52CM
Trip circuit supervision	TCSSCBR	TCM
Fuse failure supervision	SEQSPVC	60
Runtime counter for machines and devices	MDSOPT	OPTM
Measurement		
Disturbance recorder	RDRE	DFR
Load profile record	LDPRLRC	LOADPROF
Fault record	FLTRFRC	FAULTREC
Three-phase current measurement	CMMXU	IA, IB, IC
Sequence current measurement	CSMSQI	I1, I2, I0
Residual current measurement	RESCMMXU	IG
Three-phase voltage measurement	VMMXU	VA, VB, VC
Residual voltage measurement	RESVMMXU	VG
Sequence voltage measurement	VSMSQI	V1, V2, V0
Single-phase power and energy measurement	SPEMMXU	SP, SE
Three-phase power and energy measurement	PEMMXU	P, E
RTD/mA measurement	XRGGIO130	X130 (RTD)
Frequency measurement	FMMXU	f
"IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER

Table 84. Functions included in the relay, continued

Function	IEC 61850	ANSI
Measurement		
"IEC 61850-9-2 LE sampled value receiving (voltage sharing)	SMVRCV	SMVRECEIVER
Other		
"Minimum pulse timer (2 pcs)	TPGAPC	62TP
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	62TPS
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	62TPM
Pulse timer (8 pcs)	PTGAPC	62PT
Time delay off (8 pcs)	TOFGAPC	62TOF
Time delay on (8 pcs)	TONGAPC	62TON
Set-reset (8 pcs)	SRGAPC	SR
Move (8 pcs)	MVGAPC	MV
"Generic control point (16 pcs)"	SPCGAPC	SPC
"Analog value scaling (4 pcs)"	SCA4GAPC	SCA4
"Integer value move (4 pcs)"	MVI4GAPC	MVI4
Generic up-down counters	UDFCNT	CTR

30. Document revision history

Table 85. Document revision history

Document revision/date	Product version	History
A/2016-05-20	5.0 FP1	First release

Notes

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