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Relion® 650 SERIES

Busbar protection REB650
Version 2.2
Product guide

Hitachi Energy

Disclaimer

Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by Hitachi Energy in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

Contents

1. Document revision history

Table 1. Document revision history

Document revision	Date	Product revision	History
-	2017–05	2.2.0	First release for product version 2.2
A	2017-10	2.2.1	Ethernet ports with RJ45 connector added. enhancements/updates made to GENPDIF, ZMFPDIS and ZMFCPDIS.
B	2018-03	2.2.1	Document enhancements and corrections
C	2019-05	2.2.1	PTP enhancements and corrections
D			Document not released
E	2020-09	2.2.4	Added new functions ALGOS, ALSVS and IEC61850SIM.
F	2021-06	2.2.5	Function HOLDMINMAX, INT_REAL, CONST_INT, INTSEL, LIMITER, ABS, POL_REC, RAD_DEG, CONST_REAL, REALSEL, STOREINT, STOREREAL, DEG_RAD and RSTP added. Support for COMTRADE2013 added. Updates/enhancements made to functions OC4PTOC, EF4PTOC, NS4PTOC, DRPRDRE and SXCBR. Pre-confuguration updated.
G	2021-06	2.2.5	Added note to Disturbance report and IEC 60870-5-103 protocol
H	2022-07	2.2.5.4	Introduced RIA600, which is a software implementation of the IED LHMI panel.

2. Application

The numerical high impedance differential busbar protection REB650 IED provides its users with a wide variety of application opportunities. Designed primarily for the protection of single busbar with or without sectionalizers in high impedance based applications, it also offers high impedance differential protection for generators, autotransformers, shunt reactors and capacitor banks.

Its I/O capability allows you to protect up to three 3-phase high impedance differential protection zones with a single IED. A number of additional protection functions are available for the protection of the bus coupler bay. The additional protection functions include different types of phase and earth fault overcurrent protection and over voltage/under voltage protection.

One pre-configured package has been defined for the following application:

- 2 zones/1 checkzone, 3 phase high impedance (A03)

For the high impedance differential protection, the differential current process is made in the analogue current transformer circuits where the differential current is connected to the IED via a high ohmic resistor. In REB650, a current input is used for each phase and protection zone. The package is configured and ready for direct use. Analog inputs and binary input/output circuits are pre-defined.

The IED can be used in applications with the IEC/UCA 61850-9-2LE process bus with up to four Merging Units (MU). Each MU has eight analogue channels, four current and four voltages. Conventional input transformer module and Merging Unit channels can be mixed freely in your application.

The pre-configured IED can be changed and adapted to suit specific applications with the application configuration tool.

IED supports COMTRADE1999 and COMTRADE2013 formats which can be selected in Parameter Setting Tool (PST) of PCM600 or via LHMI.

Forcing of binary inputs and outputs is a convenient way to test wiring in substations as well as testing configuration logic in the IEDs. Basically it means that all binary inputs and outputs on the IED I/O modules (BOM, BIM and IOM) can be forced to arbitrary values.

Central Account Management is an authentication infrastructure that offers a secure solution for enforcing access control to IEDs and other systems within a substation. This incorporates management of user accounts, roles and certificates and the distribution of such, a procedure completely transparent to the user.

The Flexible Product Naming allows the customer to use an IED-vendor independent IEC 61850 model of the IED. This customer model will be used as the IEC 61850 data model, but all other aspects of the IED will remain unchanged (e.g., names on the local HMI and names in the tools). This offers significant flexibility to adapt the IED to the customers' system and standard solution.

Description of A03

Complete busbar protection for two busbar sections (zone 1 and 2), with the possibility for check zone.

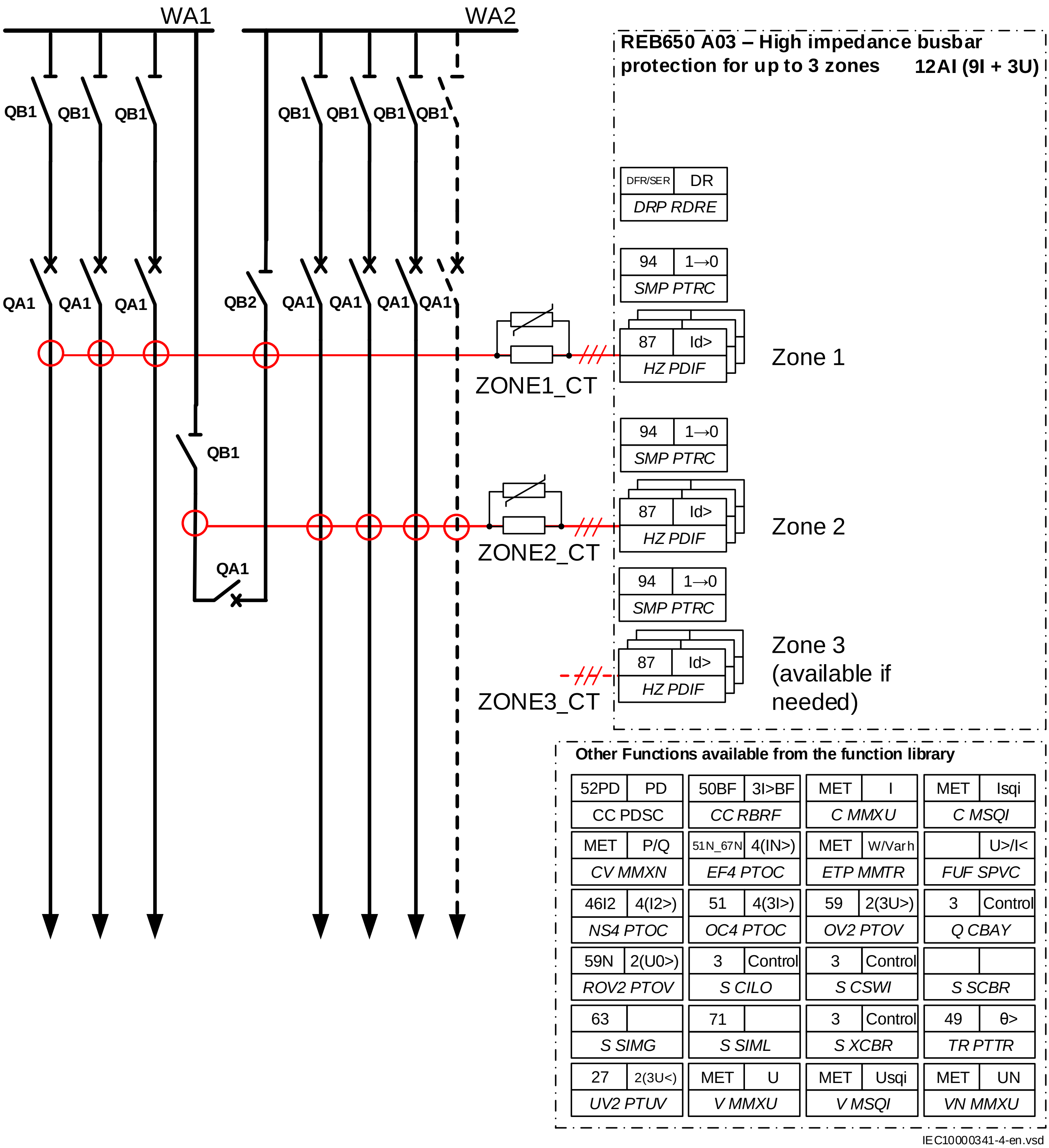

Figure 1. Block diagram for configuration A03

3. Available functions

The following tables list all the functions available in the IED. Those functions that are not exposed to the user or do not need to be configured are not described in this manual.

Main protection functions

Table 2. Example of quantities

2	= number of basic instances
0-3	= option quantities
3-A03	= optional function included in packages A03 (refer to ordering details)
C30	=1/2 CB application. For the pre-configured variants

IEC 61850 or function name	ANSI	Function description	Busbar
			REB650 (A03)
Differential protection			
HZPDIF	87	High impedance differential protection, single phase	9

Back-up protection functions

IEC 61850 or function name	ANSI	Function description	Busbar
			REB650 (A03)
Current protection			
OC4PTOC	51_67 1)	Directional phase overcurrent protection, four steps	1
EF4PTOC	51N_67N 2)	Directional residual overcurrent protection, four steps	1
NS4PTOC	46I2	Directional negative phase sequence overcurrent protection, four steps	1
TRPTTR	49	Thermal overload protection, two time constants	1
CCRBRF	50BF	Breaker failure protection	1
CCPDSC	52PD	Pole discordance protection	1
Voltage protection			
UV2PTUV	27	Two step undervoltage protection	1
OV2PTOV	59	Two step overvoltage protection	1
ROV2PTOV	59N	Residual overvoltage protection, two steps	2

1) 67 requires voltage
2) 67N requires voltage

Control and monitoring functions

IEC 61850 or function name	ANSI	Function description	Busbar
			REB650 (A03)
Control			
QCBAY		Bay control	1
LOCREM		Handling of LR-switch positions	1
LOCREMCTRL		LHMI control of PSTO	1
SXCBR		Circuit breaker	3
SCILO		Interlocking	3
SCSWI		Switch controller	3
XLNPROXY		Proxy for signals from switching device via GOOSE	9
SLGAPC		Logic rotating switch for function selection and LHMI presentation	15
VSGAPC		Selector mini switch	30
DPGAPC		Generic communication function for Double Point indication	16
SPC8GAPC		Single point generic control function, 8 signals	5
AUTOBITS		Automation bits, command function for DNP3.0	3
SINGLECMD		Single command, 16 signals	8
I103CMD		Function commands for IEC 60870-5-103	1
I103GENCMD		Function commands generic for IEC 60870-5-103	50
I103POSCMD		IED commands with position and select for IEC 60870-5-103	50
I103POSCMDV		IED direct commands with position for IEC 60870-5-103	50
I103IEDCMD		IED commands for IEC 60870-5-103	1
I103USRCMD		Function commands user defined for IEC 60870-5-103	4
Secondary system supervision			
FUFSPVC		Fuse failure supervision	1
Logic			
SMPPTRC	94	Tripping logic	6
SMAGAPC		General start matrix block	6
TMAGAPC		Trip matrix logic	12
ALMCALH		Logic for group alarm	5
WRNCALH		Logic for group warning	5
INDCALH		Logic for group indication	5
AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SRMEMORY, TIMERSET, XOR		Basic configurable logic blocks (see Table 3)	40-420
FXDSIGN		Fixed signal function block	1
B16I		Boolean to integer conversion, 16 bit	18
BTIGAPC		Boolean to integer conversion with logical node representation, 16 bit	16

IEC 61850 or function name	ANSI	Function description	Busbar
			REB650 (A03)
IB16		Integer to Boolean 16 conversion	24
ITBGAPC		Integer to Boolean 16 conversion with Logic Node representation	16
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision	12
INTCOMP		Comparator for integer inputs	30
REALCOMP		Comparator for real inputs	30
HOLDMINMAX		Hold minimum and maximum of input	20
INT_REAL		Converter integer to real	20
CONST_INT		Definable constant for logic functions	10
INTSEL		Analog input selector for integer values	5
LIMITER		Definable limiter	20
ABS		Absolute value	20
POL_REC		Polar to rectangular converter	20
RAD_DEG		Radians to degree angle converter	20
CONST_REAL		Definable constant for logic functions	10
REALSEL		Analog input selctor for real values	5
STOREINT		Store value for integer inputs	10
STOREREAL		Store value for real inputs	10
DEG_RAD		Degree to radians angle converter	20
Monitoring			
CVMMXN		Power system measurement	6
CMMXU		Current measurement	10
VMMXU		Voltage measurement phase-phase	6
CMSQI		Current sequence measurement	6
VMSQI		Voltage sequence measurement	6
VNMMXU		Voltage measurement phase-earth	6
AISVBAS		General service value presentation of analog inputs	1
SSIMG	63	Insulation supervision for gas medium	21
SSIML	71	Insulation supervision for liquid medium	3
SSCBR		Circuit breaker condition monitoring	3
EVENT		Event function	20
DRPRDRE, A1RADR-A4RADR, B1RBDR-B22RBDR		Disturbance report	1
SPGAPC		Generic communication function for single point indication	64
SP16GAPC		Generic communication function for single point indication, 16 inputs	16
MVGAPC		Generic communication function for measured values	24
BINSTATREP		Logical signal status report	3
RANGE_XP		Measured value expander block	28

IEC 61850 or function name	ANSI	Function description	Busbar
			REB650 (A03)
I103MEAS		Measurands for IEC 60870-5-103	1
I103MEASUSR		Measurands user defined signals for IEC 60870-5-103	3
I103AR		Function status auto-recloser for IEC 60870-5-103	1
I103EF		Function status earth-fault for IEC 60870-5-103	1
I103FLTPROT		Function status fault protection for IEC 60870-5-103	1
I103IED		IED status for IEC 60870-5-103	1
I103SUPERV		Supervision status for IEC 60870-5-103	1
I103USRDEF		Status for user defined signals for IEC 60870-5-103	20
L4UFCNT		Event counter with limit supervision	30
TEILGAPC		Running hour meter	6
Metering			
PCFCNT		Pulse-counter logic	16
ETPMMTR		Function for energy calculation and demand handling	6

Table 3. Total number of instances for basic configurable logic blocks

Basic configurable logic block	Total number of instances
AND	280
GATE	40
INV	420
LLD	40
OR	298
PULSETIMER	40
RSMEMORY	40
SRMEMORY	40
TIMERSET	60
XOR	40

Communication

IEC 61850 or function name	ANSI	Function description	Busbar
			REB650 (A03)
Station communication			
LONSPA, SPA		SPA communication protocol	1
ADE		LON communication protocol	1
HORZCOMM		Network variables via LON	1
PROTOCOL		Operation selection between SPA and IEC 60870-5-103 for SLM	1
RS485PROT		Operation selection for RS485	1
RS485GEN		RS485	1
DNPGEN		DNP3.0 communication general protocol	1
CHSERRS485		DNP3.0 for EIA-485 communication protocol	1
CH1TCP, CH2TCP, CH3TCP, CH4TCP		DNP3.0 for TCP/IP communication protocol	1
CHSEROPT		DNP3.0 for TCP/IP and EIA-485 communication protocol	1
MSTSER		DNP3.0 serial master	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for TCP/IP communication protocol	1
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1
IEC 61850-8-1		IEC 61850	1
IEC 61850SIM		IEC 61850 simulation mode	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59
GOOSEBINRCV		GOOSE binary receive	16
GOOSEDPRCV		GOOSE function block to receive a double point value	64
GOOSEINTRCV		GOOSE function block to receive an integer value	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	60
GOOSESPRCV		GOOSE function block to receive a single point value	64
GOOSEXLNRCV		GOOSE function block to receive a switching device	9
ALGOS		Supervision of GOOSE subscription	100
MULTICMDRCV/ MULTICMDSND		Multiple command and transmit	60/10
OPTICAL103		IEC 60870-5-103 Optical serial communication	1
RS485103		IEC 60870-5-103 serial communication for RS485	1
AGSAL		Generic security application component	1
LD0LLN0		IEC 61850 LD0 LLN0	1
SYSLLN0		IEC 61850 SYS LLN0	1
LPHD		Physical device information	1
PCMACCS		IED configuration protocol	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1
FSTACCSNA		Field service tool access via SPA protocol over Ethernet communication	1

IEC 61850 or function name	ANSI	Function description	Busbar
			REB650 (A03)
FSTACCS		Field service tool access	1
		IEC 61850-9-2 Process bus communication, 4 merging units	1-P31
ACTIVLOG		Activity logging	1
ALTRK		Service tracking	1
PRP		IEC 62439-3 Parallel redundancy protocol	1-P23
HSR		IEC 62439-3 High-availability seamless redundancy	1-P24
RSTP		IEC 62439-3 Rapid spanning tree protocol	1-P25
AP_1-AP_4		AccessPoint_ABS1-AccessPoint_ABS4	1
AP_FRONT		Access point front	1
PTP		Precision time protocol	1
ROUTE_1-ROUTE_6		Route_ABS1-Route_ABS6	1
FRONTSTATUS		Access point diagnostic for front Ethernet port	1
SCHLCCH		Access point diagnostic for non-redundant Ethernet port	4
RCHLCCH		Access point diagnostic for redundant Ethernet ports	2
DHCP		DHCP configuration for front access point	1
QUALEXP		IEC 61850 quality expander	32

Basic IED functions

Table 4. Basic IED functions

IEC 61850 or function name	Description
INTERRSIG SELFSUPEVLST	Self supervision with internal event list
TIMESYNCHGEN	Time synchronization module
BININPUT, SYNCHCAN, SYNCHGPS, SYNCHCMPPS, SYNCHLON, SYNCHPPH, SYNCHPPS, SNTP, TIMEZONE	Time synchronization
DSTBEGIN	GPS time synchronization module
DSTENABLE	Enables or disables the use of daylight saving time
DSTEND	GPS time synchronization module
IRIG-B	Time synchronization
SETGRPS	Number of setting groups
ACTVGRP	Active parameter setting group
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
TERMINALID	IED identifiers
PRODINF	Product information
SYSTEMTIME	System time
LONGEN	LON communication
RUNTIME	IED Runtime component
SMBI	Signal matrix for binary inputs
SMBO	Signal matrix for binary outputs
SMAI1 - SMAI12	Signal matrix for analog inputs
3PHSUM	Summation block 3 phase
ATHSTAT	Authority status
ATHCHCK	Authority check
AUTHMAN	Authority management
FTPACCS	FTP access with password
SPACOMMMAP	SPA communication mapping
SPATD	Date and time via SPA protocol
BCSCONF	Basic communication system
GBASVAL	Global base values for settings
PRIMVAL	Primary system values
SAFEFILECOPY	Safe file copy function
ALTMS	Time master supervision

Table 4. Basic IED functions, continued

IEC 61850 or function name	Description
ALTIM	Time management
CAMCONFIG	Central account management configuration
CAMSTATUS	Central account management status
TOOLINF	Tools information
COMSTATUS	Protocol diagnostic

Table 5. Local HMI functions

IEC 61850 or function name	Description
LHMICTRL	Local HMI signals
LANGUAGE	Local human machine language
SCREEN	Local HMI Local human machine screen behavior
FNKEYTY1–FNKEYTY5 FNKEYMD1–FNKEYMD5	Parameter setting function for HMI in PCM600
LEDGEN	General LED indication part for LHMI
OPENCLOSE_LED	LHMI LEDs for open and close keys
GRP1_LED1–GRP1_LED15 GRP2_LED1–GRP2_LED15 GRP3_LED1–GRP3_LED15	Basic part for CP HW LED indication module

4. Differential protection

High impedance differential protection, single phase HZPDIF

High impedance differential protection, single phase (HZPDIF) functions can be used when the involved CT cores have the same turns ratio and similar magnetizing characteristics. It utilizes an external CT secondary current summation by wiring. Actually all CT secondary circuits which are involved in the differential scheme are connected in parallel. External series resistor, and a voltage dependent resistor which are both mounted externally to the IED, are also required.

The external resistor unit shall be ordered under IED accessories in the Product Guide.

5. Current protection

Directional phase overcurrent protection, four steps OC4PTOC

The four step phase overcurrent protection function (OC4PTOC) has an inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

Directional phase overcurrent protection, four steps (OC4PTOC) has an inverse or definite time delay for each step.

All IEC and ANSI inverse time characteristics are available together with an optional user defined time characteristic.

The directional function needs voltage as it is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

A second harmonic blocking level can be set for the function and can be used to block each step individually.

This function can be used as a backup bay protection (e.g. for transformers, reactors, shunt capacitors and tie-breakers). A special application is to use this phase overcurrent protection to detect short-circuits between the feeder circuit breaker and feeder CT in a feeder bay when the circuit breaker is open. This functionality is called end-fault protection. In such case unnecessarily operation of the busbar differential protection can be prevented and only fast overcurrent trip signal can be sent to the remote line end. In order to utilize this functionality the circuit breaker status and CB closing command must be connected to the IED. One of the overcurrent steps can be set and configured to act as end-fault protection in the IED.

The function is normally used as end fault protection to clear faults between current transformer and circuit breaker.

Directional residual overcurrent protection, four steps EF4PTOC

Directional residual overcurrent protection, four steps (EF4PTOC) can be used as main protection for phase-to-earth faults. It can also be used to provide a system back-up, for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

EF4PTOC has an inverse or definite time delay independent for each step.

All IEC and ANSI time-delayed characteristics are available together with an optional user-defined characteristic.

EF4PTOC can be set to be directional or non-directional independently for each step.

IDir, UPol and IPol can be independently selected to be either zero sequence or negative sequence.

A second harmonic blocking can be set individually for each step.

The residual current can be calculated by summing the three-phase currents or taking the input from the neutral CT.

EF4PTOC also provides very fast and reliable faulty phase identification for phase selective tripping and subsequent reclosing during earth fault.

Four step directional negative phase sequence overcurrent protection NS4PTOC

Four step directional negative phase sequence overcurrent protection (NS4PTOC) has an inverse or definite time delay independent for each step separately.

The directional function is voltage polarized.

NS4PTOC can be set directional or non-directional independently for each of the steps.

NS4PTOC can be used as main protection for unsymmetrical fault; phase-phase short circuits, phase-phase-earth short circuits and single phase earth faults.

NS4PTOC can also be used to provide a system backup for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

Thermal overload protection, two time constants TRPTTR

If a power transformer reaches very high temperatures the equipment might be damaged. The insulation within the transformer will experience forced ageing. As a consequence of this the risk of internal phase-to-phase or phase-to-earth faults will increase.

The thermal overload protection (TRPTTR) estimates the internal heat content of the transformer (temperature) continuously. This estimation is made by using a thermal model of the transformer with two time constants, which is based on current measurement.

Two warning levels are available. This enables actions in the power system to be done before dangerous temperatures are reached. If the temperature continues to increase to the trip value, the protection initiates a trip of the protected transformer.

The estimated time to trip before operation is presented.

Breaker failure protection CCRBRF, 3-phase activation and output

Breaker failure protection, 3-phase activation and output (CCRBRF) ensures fast backup tripping of surrounding breakers in case the own breaker fails to open. CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

A current based check with extremely short reset time is used as check criterion to achieve high security against inadvertent operation.

Breaker failure protection, 3-phase activation and output (CCRBRF) current criteria can be fulfilled by one or two phase currents the residual current, or one phase current plus residual current. When those currents exceed the user defined settings, the function is triggered. These conditions increase the security of the backup trip command.

CCRBRF function can be programmed to give a three-phase retrip of the own breaker to avoid inadvertent tripping of surrounding breakers.

Pole discordance protection CCPDSC

Circuit breakers and disconnectors can end up with the phases in different positions (close-open), due to electrical or mechanical failures. An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

Normally the own breaker is tripped to correct such a situation. If the situation persists the surrounding breakers should be tripped to clear the unsymmetrical load situation.

The pole discordance function operates based on information from the circuit breaker logic with additional criteria from phase selective current unsymmetry.

6. Voltage protection

Two-step undervoltage protection UV2PTUV

Undervoltages can occur in the power system during faults or abnormal conditions. The two-step undervoltage protection function (UV2PTUV) can be used to open circuit breakers to prepare for system restoration at power outages or as a long-time delayed back-up to the primary protection.

UV2PTUV has two voltage steps, each with inverse or definite time delay.

It has a high reset ratio to allow settings close to the system service voltage.

Two step overvoltage protection OV2PTOV

Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, and open line ends on long lines.

Two step overvoltage protection (OV2PTOV) function can be used to detect open line ends, normally then combined with a directional reactive over-power function to supervise the system voltage. When triggered, the function will cause an alarm, switch in reactors, or switch out capacitor banks.

OV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

OV2PTOV has a high reset ratio to allow settings close to system service voltage.

Residual overvoltage protection, two steps ROV2PTOV

Residual voltages may occur in the power system during earth faults.

Two step residual overvoltage protection (ROV2PTOV) function calculates the residual voltage from the three-phase voltage input transformers or measures it from a single voltage input transformer fed from an open delta or neutral point voltage transformer.

A reset delay ensures operation for intermittent earth faults.

ROV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

7. Secondary system supervision

Fuse failure supervision FUFSPVC

The aim of the fuse failure supervision function (FUFSPVC) is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid inadvertent operations that otherwise might occur.

The fuse failure supervision function basically has three different detection methods, negative sequence and zero sequence based detection and an additional delta voltage and delta current detection.

The negative sequence detection is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence measuring quantities, a high value of negative sequence voltage $3U_2$ without the presence of the negative-sequence current $3I_2$.

The zero sequence detection is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities, a high value of zero sequence voltage $3U_0$ without the presence of the zero sequence current $3I_0$.

For better adaptation to system requirements, an operation mode setting has been introduced which makes it possible to select the operating conditions for negative sequence and zero sequence based function. The selection of different operation modes makes it possible to choose different interaction possibilities between the negative sequence and zero sequence based detection.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

8. Control

Switch controller SCSWI

The Switch controller (SCSWI) initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one multi-phase device or up to three one-phase devices.

Circuit breaker SXCBR

The purpose of Circuit breaker (SXCBR) is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of circuit breakers via binary output boards and to supervise the switching operation and position.

Bay control QCBAY
The Bay control (QCBAY) function is used together with Local remote and local remote control functions to handle the selection of the operator place per bay. QCBAY also provides blocking functions that can be distributed to different apparatuses within the bay.

Proxy for signals from switching device via GOOSE XLNPROXY
The proxy for signals from switching device via GOOSE (XLNPROXY) gives an internal representation of the position status and control response for a switch modelled in a breaker IED. This representation is identical to that of an SXCBR function.

GOOSE function block to receive a switching device GOOSEXLNRCV
The GOOSE XLN Receive component is used to collect information from another device's XCBR/XSWI logical node sent over process bus via GOOSE. The GOOSE XLN Receive component includes 12 different outputs (and their respective channel valid bits) with defined names to ease the 61850 mapping of the GOOSE signals in the configuration process.

Local remote LOCREM/Local remote control LOCREMCTRL
The signals from the local HMI or from an external local/remote switch are connected via the function blocks local remote (LOCREM) and local remote control (LOCREMCTRL) to the Bay control (QCBAY) function block. The parameter *ControlMode* in function block LOCREM is set to choose if the switch signals are coming from the local HMI or from an external hardware switch connected via binary inputs.

Logic rotating switch for function selection and LHMI presentation SLGAPC
The logic rotating switch for function selection and LHMI presentation (SLGAPC) (or the selector switch function block) is used to get an enhanced selector switch functionality compared to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The selector switch function eliminates all these problems.

Selector mini switch VSGAPC
The Selector mini switch (VSGAPC) function block is a multipurpose function used for a variety of applications, as a general purpose switch.

VSGAPC can be controlled from the menu, from a symbol on the single line diagram (SLD) on the local HMI or from Binary inputs.

Generic communication function for Double Point indication DPGAPC
Generic communication function for Double Point indication (DPGAPC) function block is used to send double point position indications to other systems, equipment or functions in the substation through IEC 61850-8-1 or other communication protocols. It is especially intended to be used in the interlocking station-wide logics.

Single point generic control 8 signals SPC8GAPC
The Single point generic control 8 signals (SPC8GAPC) function block is a collection of 8 single point commands that can be used for direct commands for example reset of LEDs or putting IED in "ChangeLock" state from remote. In this way, simple commands can be sent directly to the IED outputs, without confirmation. The commands can be pulsed or steady with a settable pulse time.

AutomationBits AUTOBITS
The Automation bits function (AUTOBITS) is used to configure the DNP3 protocol command handling. Each of the 3 AUTOBITS available has 32 individual outputs available, each can be mapped as a binary output point in DNP3.

Single command, 16 inputs
The IEDs can receive commands either from a substation automation system or from the local HMI. The command function block has outputs that can be used, for example, to control high voltage apparatuses or for other user defined functionality.

9. Logic

Tripping logic common 3-phase output SMPPTRC
A function block for protection tripping and general start indication is always provided as a basic function for each circuit breaker. It provides a settable pulse prolongation time to ensure a three-phase trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block includes a settable latch function for the trip signal and circuit breaker lockout.

The trip function can collect start and directional signals from different application functions. The aggregated start and directional signals are mapped to the IEC 61850 logical node data model.

General start matrix block SMAGAPC

The Start Matrix (SMAGAPC) merges start and directional output signals from different application functions and creates a common start and directional output signal (*STDIR*) to be connected to the Trip function.

The purpose of this functionality is to provide general start and directional information for the IEC 61850 trip logic data model SMPPTRC.

Trip matrix logic TMAGAPC

The 12 Trip matrix logic (TMAGAPC) function each with 32 inputs are used to route trip signals and other logical output signals to the tripping logics SMPPTRC and SPTPTRC or to different output contacts on the IED.

The trip matrix logic function has 3 output signals and these outputs can be connected to physical tripping outputs according to the specific application needs for settable pulse or steady output.

Group alarm logic function ALMCALH

The group alarm logic function (ALMCALH) is used to route several alarm signals to a common indication, LED and/or contact, in the IED.

Group warning logic function WRNCALH

The group warning logic function (WRNCALH) is used to route several warning signals to a common indication, LED and/or contact, in the IED.

Group indication logic function INDCALH

The group indication logic function (INDCALH) is used to route several indication signals to a common indication, LED and/or contact, in the IED.

Basic configurable logic blocks

The basic configurable logic blocks do not propagate the time stamp and quality of signals. The list below shows a summary of the function blocks and their features.

The logic blocks are available as a part of an extension logic package. The list below is a summary of the function blocks and their features.

- **AND** function block. The AND function is used to form general combinatory expressions with boolean variables. The AND function block has up to four inputs and two outputs.
- **GATE** function block is used for whether or not a signal should be able to pass from the input to the output.
- **INVERTER** function block that inverts the input signal to the output.
- **LLD** function block. Loop delay used to delay the output signal one execution cycle.
- **OR** function block. The OR function is used to form general combinatory expressions with boolean variables. The OR function block has up to six inputs and two outputs. One of the outputs is inverted.
- **PULSETIMER** function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- **RSMEMORY** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power interruption, the flip-flop resets or returns to the state it had before the power interruption. RESET input has priority.
- **SRMEMORY** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The SET input has priority if both SET and RESET inputs are operated simultaneously.
- **TIMERSET** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay and must be On for the input signal to activate the output with the appropriate time delay.
- **XOR** is used to generate combinatory expressions with boolean variables. XOR has two inputs and two outputs. One of the outputs is inverted. The output signal OUT is 1 if the input signals are different and 0 if they are the same.

Fixed signal function block FXDSIGN

The Fixed signals function (FXDSIGN) has nine pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating certain logic. Boolean, integer, floating point, string types of signals are available.

One FXDSIGN function block is included in all IEDs.

Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

The Elapsed time integrator function (TEIGAPC) is a function that accumulates the elapsed time when a given binary signal has been high.

The main features of TEIGAPC

- Applicable to long time integration (≤999 999.9 seconds).
- Supervision of limit transgression conditions and overflow.
- Possibility to define a warning or alarm with the resolution of 10 milliseconds.
- Retaining of the integration value.
- Possibilities for blocking and reset.
- Reporting of the integrated time.

Boolean to integer conversion, 16 bit B16I

Boolean to integer conversion, 16 bit (B16I) is used to transform a set of 16 boolean (logical) signals into an integer.

Boolean to integer conversion with logical node representation, 16 bit BTIGAPC
Boolean to integer conversion with logical node representation, 16 bit (BTIGAPC) is used to transform a set of 16 boolean (logical) signals into an integer. The block input will freeze the output at the last value.

Integer to Boolean 16 conversion IB16A
Integer to boolean 16 conversion function (IB16A) is used to transform an integer into a set of 16 boolean (logical) signals.

Integer to Boolean 16 conversion with logic node representation IB16FCVB
Integer to boolean conversion with logic node representation function (IB16FCVB) is used to transform an integer which is transmitted over IEC 61850 and received by the function to 16 boolean (logic) output signals.

Comparator for integer inputs INTCOMP
The function gives the possibility to monitor the level of integer values in the system relative to each other or to a fixed value. It is a basic arithmetic function that can be used for monitoring, supervision, interlocking and other logics.

Comparator for real inputs REALCOMP
The function gives the possibility to monitor the level of real value signals in the system relative to each other or to a fixed value. It is a basic arithmetic function that can be used for monitoring, supervision, interlocking and other logics.

Hold Maximum and Minimum of Input HOLDMINMAX
Hold minimum and maximum of input (HOLDMINMAX) function will acquire, compare and hold the minimum and maximum values of INPUT as soon as the START input goes to 1, the outputs are updated as long as the START is 1. After START goes to 0, the last updated value is stored. The outputs are reset when the RESET is 1.

Converter integer to real INT_REAL
The converter integer to real (INT_REAL) function can be used to convert integer to real values.

Definable constant for logic function CONST_INT
The definable constant for logic function CONST_INT can be used to provide a constant output in an integer format based on the set value in PST.

Analog input selector for integer values INTSEL
Analog input selector for integer values (INTSEL) selects one out of eight possible integer inputs. Each input (INPUTx) has its dedicated select input (SELx). The function provides the output for the value of the selected input, and its respective select number (INSEL).

If more than one input is selected, the output will be the lowest in order INPUT value. If inputs are not selected, the select value number shall be 0.

Definable limiter LIMITER
The definable limiter (LIMITER) function can be used to limit the output values within the minimum and maximum limits set in the PST. If the input is outside the set range then the value OUTLIMIT is set to 1 to indicate the output value is limited.

Absolute value ABS
The absolute value (ABS) function gives the absolute value of the input.

Polar to rectangular converter POL_REC
The polar to rectangular converter (POL_REC) function gives the possibility to convert an input values in polar form to a rectangular form.

Radians to degree angle converter RAD_DEG
The radians to degree angle converter (RAD_DEG) function gives the possibility to convert an input value from radian angles to degree angles.

Definable constant for logic function CONST_REAL
The definable constant for logic function (CONST_REAL) can be used to provide a constant output in an real format based on the set value in PST.

Analog input selctor for real values REALSEL
Analog input selector for real values (REALSEL) function selects one out of eight possible real inputs. Each input (INPUTx) has its dedicated select input (SELx).

The function provides the output for the value of the selected input and its respective select number (INSEL). If more than one input is selected, the output will be the lowest in order INPUT value. If inputs are not selected, the select value number shall be 0.

Store value for integer inputs STOREINT
The store value for integer inputs (STOREINT) function can be used to store the integer value upon the trigger, the minimum trigger duration for it to be stored is 100ms. The stored value is reset to 0 when the RESET input is set to 1.

Store value for real inputs STOREREAL
The store value for real inputs (STOREREAL) function can be used to store the real value upon the trigger, the minimum trigger duration for it to be stored is 100ms. The stored value is reset to 0 when the RESET input is set to 1.

Degree to radians angle converter DEG_RAD

The degree to radians angle converter (DEG_RAD) function gives the possibility to convert an input value from degree angles to radian angles.

10. Monitoring

Measurements CVMMXN, CMMXU, VNMMXU, VMMXU, CMSQI, VMSQI

The measurement functions are used to get on-line information from the IED. These service values make it possible to display on-line information on the local HMI and on the substation automation system about:

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- measured analog values from merging units
- measured currents
- primary phasors
- current sequence components
- voltage sequence components

Disturbance report DRPRDRE

Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.

Disturbance report (DRPRDRE), always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a maximum of 40 analog and 352 binary signals.

The Disturbance report functionality is a common name for several functions:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder
- Settings information

The Disturbance report function is characterized by great flexibility regarding configuration, starting conditions, recording times, and large storage capacity.

A disturbance is defined as an activation of an input to the AnRADR or BnRBDR function blocks, which are set to trigger the disturbance recorder. All connected signals from start of pre-fault time to the end of post-fault time will be included in the recording. Disturbance record will have visible settings from all function instances that are configured in the application configuration tool.

Every disturbance report recording is saved in the IED in the standard COMTRADE format. In the COMTRADE1999 format it is saved as a header file HDR, a configuration file CFG, and a data file DAT. In the COMTRADE2013 format, it is saved as CFF single file format. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files can be uploaded to PCM600 for further analysis using the disturbance handling tool.

IED must be configured with COMTRADE1999 format for disturbance recorder communication with IEC 60870-5-103 protocol.

Event list DRPRDRE

Continuous event-logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions.

The event list logs all binary input signals connected to the Disturbance recorder function. The list may contain up to 5000 time-tagged events stored in a ring-buffer.

Indications DRPRDRE

To get fast, condensed and reliable information about disturbances in the primary and/or in the secondary system it is important to know, for example binary signals that have changed status during a disturbance. This information is used in the short perspective to get information via the local HMI in a straightforward way.

There are three LEDs on the local HMI (green, yellow and red), which will display status information about the IED and the Disturbance recorder function (triggered).

The Indication list function shows all selected binary input signals connected to the Disturbance recorder function that have changed status during a disturbance.

Event recorder DRPRDRE

Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital, for example, time-tagged events logged during disturbances. This information is used for different purposes in the short term (for example corrective actions) and in the long term (for example functional analysis).

The event recorder logs all selected binary input signals connected to the Disturbance recorder function. Each recording can contain up to 1056 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

Trip value recorder DRPRDRE

Information about the pre-fault and fault values for currents and voltages are vital for the disturbance evaluation.

The Trip value recorder calculates the values of all selected analog input signals connected to the Disturbance recorder function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

Disturbance recorder DRPRDRE
The Disturbance recorder function supplies fast, complete and reliable information about disturbances in the power system. It facilitates understanding system behavior and related primary and secondary equipment during and after a disturbance. Recorded information is used for different purposes in the short perspective (for example corrective actions) and long perspective (for example functional analysis).

The Disturbance recorder acquires sampled data from selected analog and binary signals connected to the Disturbance recorder function (maximum 40 analog and 352 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependent on the operation of protection functions. It can record disturbances not detected by protection functions. Up to 9 seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 200 disturbances are saved in the IED and the local HMI is used to view the list of recordings .

Event function
When using a Substation Automation system with LON or SPA communication, time-tagged events can be sent at change or cyclically from the IED to the station level. These events are created from any available signal in the IED that is connected to the Event function (EVENT). The EVENT function block is used for LON and SPA communication.

Analog, integer and double indication values are also transferred through the EVENT function.

Generic communication function for Single Point indication SPGAPC
Generic communication function for Single Point indication (SPGAPC) is used to send one single logical signal to other systems or equipment in the substation.

Generic communication function for measured values MVGAPC
Generic communication function for measured values (MVGAPC) function is used to send the instantaneous value of an analog signal to other systems or equipment in the substation. It can also be used inside the same IED, to attach a RANGE aspect to an analog value and to permit measurement supervision on that value.

Measured value expander block MVEXP
The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGAPC) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block MVEXP has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

Insulation supervision for gas medium function SSIMG
Insulation supervision for gas medium (SSIMG) is used for monitoring the circuit breaker condition. Binary information based on the gas pressure in the circuit breaker can be used as input to the function. In addition, the function can be used with an analog value of gas pressure and temperature of the insulation medium and binary inputs. The SSIMG function generates alarms based on the received information.

Insulation supervision for liquid medium SSIML
Insulation supervision for liquid medium (SSIML) is used for monitoring the oil insulated device condition. For example, transformers, shunt reactors, and so on. Binary information based on the liquid level in the circuit breaker can be used as input to the function. In addition, the function can be used with an analog value of liquid level and temperature of the insulation medium and binary inputs. The function generates alarms based on the received information.

The circuit breaker condition monitoring function (SSCBR) is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of $I^y t$ values. Alarms are generated when the calculated values exceed the threshold settings. Each SCCBR function instance is made to be used with a 1-pole, 1-phase breaker.

The function contains a block alarm functionality.

The supervised and presented breaker functions include
- breaker open and close travel time
- spring charging time
- number of breaker operations
- accumulated $I^Y t$ per phase with alarm and lockout
- remaining breaker life per phase
- breaker inactivity

Event counter with limit supervison L4UFCNT

The Limit counter (L4UFCNT) provides a settable counter with four independent limits where the number of positive and/or negative flanks on the input signal are counted against the setting values for limits. The output for each limit is activated when the counted value reaches that limit.

Overflow indication is included for each up-counter.

Running hour-meter TEILGAPC

The Running hour-meter (TEILGAPC) function is a function that accumulates the elapsed time when a given binary signal has been high.

The main features of TEILGAPC are:

- Applicable to very long time accumulation (≤ 99999.9 hours)
- Supervision of limit transgression conditions and rollover/overflow
- Possibility to define a warning and alarm with the resolution of 0.1 hours
- Retain any saved accumulation value at a restart
- Possibilities for blocking and reset
- Possibility for manual addition of accumulated time
- Reporting of the accumulated time

11. Metering

Pulse-counter logic PCFCNT

Pulse-counter logic (PCFCNT) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the BIO (binary input/output) module and then read by the PCFCNT function. A scaled service value is available over the station bus.

Function for energy calculation and demand handling ETPMMTR

Power system measurement (CVMMXN) can be used to measure active as well as reactive power values. Function for energy calculation and demand handling (ETPMMTR) uses measured active and reactive power as input and calculates the accumulated active and reactive energy pulses, in forward and reverse direction. Energy values can be read or generated as pulses. Maximum demand power values are also calculated by the function. This function includes zero point clamping to remove noise from the input signal. As output of this function: periodic energy calculations, integration of energy values, calculation of energy pulses, alarm signals for limit violation of energy values and maximum power demand, can be found.

The values of active and reactive energies are calculated from the input power values by integrating them over a selected time *tEnergy*. The integration of active and reactive energy values will happen in both forward and reverse directions. These energy values are available as output signals and also as pulse outputs. Integration of energy values can be controlled by inputs (STARTACC and STOPACC) and *EnaAcc* setting and it can be reset to initial values with RSTACC input.

The maximum demand for active and reactive powers are calculated for the set time interval *tEnergy* and these values are updated every minute through output channels. The active and reactive maximum power demand values are calculated for both forward and reverse direction and these values can be reset with RSTDMD input.

12. Human machine interface

Local HMI

The LHMI of the IED contains the following elements

- Graphical display capable of showing a user defined single line diagram and provide an interface for controlling switchgear.
- Navigation buttons and five user defined command buttons to shortcuts in the HMI tree or simple commands.
- 15 user defined three-color LEDs.
- Communication port for PCM600.

The LHMI is used for setting, monitoring and controlling.

Remote IED access

Instead of the LHMI the Remote IED Access tool, RIA600, can be used and perform all of the actions that a physical LHMI can. The LHMI is then replaced by a blank front plate.

13. Basic IED functions

Time synchronization

The time synchronization function is used to select a common source of absolute time for the synchronization of the IED when it is a part of a protection system. This makes it possible to compare events and disturbance data between all IEDs within a station automation system and in between sub-stations. A common source shall be used for IED and merging unit when IEC/UCA 61850-9-2LE process bus communication is used.

The IED supports SNTPv4 (RFC2030).

Precision time protocol PTP

PTP according to IEEE 1588-2008 and specifically its profile IEC/IEEE 61850-9-3 for power utility automation is a synchronization method that can be used to maintain a common time within a station. This time can be synchronized to the global time using, for instance, a GPS receiver. If PTP is enabled on the IEDs and the switches that connect the station are compatible with IEEE 1588, the station will become synchronized to one common time with an accuracy of under 1us. Using an IED as a boundary clock between several networks will keep 1us accuracy on three levels or when using an HSR, 15 IEDs can be connected in a ring without losing a single microsecond in accuracy.

14. Ethernet

Access points

An access point is an Ethernet communication interface for single or redundant station communication. Each access point is allocated with one physical Ethernet port, two physical Ethernet ports (marked A and B) are allocated if redundant communication is activated for the access point.

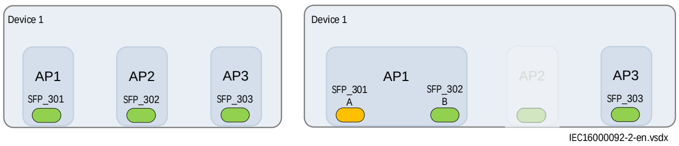

Figure 2. Access points, non redundant (left) and redundant communication (right)

Front port is not available in the IED's with blank front panel. By default, AP1 is available for engineering. DHCP is not available on AP1.

Access points diagnostics

The access point diagnostics function blocks (RCHLCCH, SCHLCCH and FRONTSTATUS) supervise communication. SCHLCCH is used for communication over the rear Ethernet ports, RCHLCCH is used for redundant communications over the rear Ethernet ports and FRONTSTATUS is used for communication over the front port. All access point function blocks include output signal for denial of service. To get this denial of service, that is reported on the communication, the DOSALARM output from these blocks must be connected to a communication function.

For RSTP, the frame error rate on an individual link cannot be extrapolated accurately to that of which is received by the IED. Hence, the frame error rate on link A (LCCH.FerCh) and the frame error rate on link B (LCCH.RedFerCh) cannot be calculated and are 0 always.

Redundant communication

PRP IEC 62439-3 redundant communication

Redundant communication according to IEC 62439-3 PRP-0 and IEC 62439-3 PRP-1 parallel redundancy protocol (PRP) is available as an option when ordering IEDs. PRP according to IEC 62439-3 uses two optical/Galvanic (RJ45) Ethernet ports.

HSR IEC 62439-3 High-availability seamless redundancy

Redundant station bus communication according to IEC 62439-3 Edition 2 High-availability seamless redundancy (HSR) is available as an option when ordering IEDs. Redundant station bus communication according to IEC 62439-3 uses two optical/Galvanic (RJ45) Ethernet ports.

The HSR ring 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.

RSTP Rapid spanning tree protocol

Rapid Spanning Tree Protocol (RSTP) is a network protocol built for loop-free network topology and redundancy/backup connections between switches.

- Support for RSTP is available on the Station level network communication.
- RSTP is only available on the Access Point (AP) 1 or Access Point (AP) 3. AP1 uses port 1 and port 2; AP3 uses port 3 and port 4.
- RSTP can be configured using Ethernet configuration Tool (ECT) and PST in PCM600.

Routes

A route is a specified path for data to travel between the source device in a subnetwork to the destination device in a different subnetwork. A route consists of a destination address and the address of the gateway to be used when sending data to the destination device, see Figure 3.

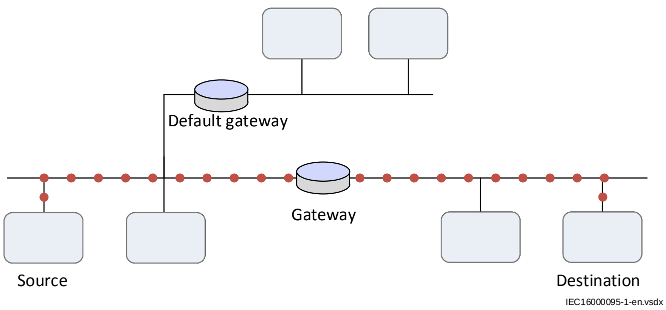

Figure 3. Route from source to destination through gateway

15. Station communication

Communication protocols

Each IED is provided with several communication interfaces enabling it to connect to one or many substation level systems or equipment, either on the Substation Automation (SA) bus or Substation Monitoring (SM) bus.

Available communication protocols are:

- IEC 61850-8-1 communication protocol
- IEC/UCA 61850-9-2LE communication protocol
- LON communication protocol
- SPA communication protocol
- IEC 60870-5-103 communication protocol

Several protocols can be combined in the same IED.

The LPHD.PhyHealth reflects the physical health of the IED. The status is set to Alarm when there is an internal failure in the IED or Warning if any active communication link fails.

IEC 61850-8-1 communication protocol

IEC 61850 Ed.1 or Ed.2 can be chosen by a setting in PCM600. The IED is equipped with four optical Ethernet rear ports for IEC 61850-8-1 station bus communication. The IEC 61850-8-1 communication is also possible from the electrical Ethernet front port. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. IED-to-IED communication using GOOSE and client-server communication over MMS are supported. Disturbance recording file (COMTRADE) uploading can be done over MMS or FTP.

The front port is only intended for PCM600 communication, maintenance, training and test purposes due to risk of interference during normal operation.

Front port is not available in the IED's with blank front panel. By default, AP1 is available for engineering and maintenance.

IEC 61850 quality expander QUALEXP

The quality expander component is used to display the detailed quality of an IEC/UCA 61850-9-2LE analog channel. The component expands the channel quality output of a Merging Unit analog channel received in the IED as per the IEC 61850-7-3 standard. This component can be used during the ACT monitoring to get the particular channel quality of the Merging Unit.

Supervision of GOOSE subscription (ALGOS)

ALGOS reports the status of GOOSE communication to a client according to IEC 61850.

There should be one instance of ALGOS in an IED for each data set that the IED receives from other IEDs. Each ALGOS reports the status of the receiving GOOSE communication.

All attributes, both mandatory and optional, according to IEC 61850-7-4 Ed. 2.0 are supported.

ALGOS is not defined in IEC 61850 Ed. 1 and is only supported in Ed. 2 mode.

Supervision of sampled value (IEC 61850-9-2LE) subscription (ALSVS)

ALSVS reports the status of sampled value communication to a client according to IEC 61850.

There should be one instance of ALSVS in an IED for each sampled value data stream that the IED receives. Each ALSVS reports the status of one receiving sampled value data stream.

The attributes *St* and *SimSt* are supported as well as the setting *SvCBRef*, according to IEC 61850-7-4 Ed. 2.0.

ALSVS is not defined in IEC 61850 Ed. 1 and is only supported in Ed. 2 mode.

IEC/UCA 61850-9-2LE communication protocol

Optical Ethernet port communication standard IEC/UCA 61850-9-2LE for process bus is supported. IEC/UCA 61850-9-2LE allows Non Conventional Instrument Transformers (NCIT) with Merging Units (MUs) or stand-alone MUs to exchange information with the IED, and simplifies SA engineering. IEC/UCA 61850-9-2LE uses the same port as IEC 61850-8-1.

LON communication protocol

Existing stations with Hitachi Power Grids station bus LON can be extended with use of the optical LON interface (glass or plastic). This allows full SA functionality including peer-to-peer messaging and cooperation between the IEDs.

SPA communication protocol

A single glass or plastic port is provided for the Hitachi Power Grids SPA protocol. This allows extensions of simple substation automation systems but the main use is for Substation Monitoring Systems SMS.

IEC 60870-5-103 communication protocol

A single glass or plastic port is provided for the IEC 60870-5-103 standard. This allows design of simple substation automation systems including equipment from different vendors. Disturbance files uploading is provided.

IED must be configured with COMTRADE1999 format for disturbance recorder communication with IEC 60870-5-103 protocol.

Measurands for IEC 60870-5-103 I103MEAS
103MEAS is a function block that reports all valid measuring types depending on the connected signals. The set of connected inputs will control which ASDUs (Application Service Data Units) are generated.

Measurands user-defined signals for IEC 60870-5-103 I103MEASUSR
I103MEASUSR is a function block with user-defined input measurands in monitor direction. These function blocks include the *FunctionType* parameter for each block in the private range, and the *Information number* parameter for each block.

Function status auto-recloser for IEC 60870-5-103 I103AR
I103AR is a function block with defined functions for autorecloser indications in monitor direction. This block includes the *FunctionType* parameter, and the *information number* parameter is defined for each output signal.

Function status earth-fault for IEC 60870-5-103 I103EF
I103EF is a function block with defined functions for earth fault indications in monitor direction. This block includes the *FunctionType* parameter; the *information number* parameter is defined for each output signal.

Function status fault protection for IEC 60870-5-103 I103FLTPROT
I103FLTPROT is used for fault indications in monitor direction. Each input on the function block is specific for a certain fault type and therefore must be connected to a correspondent signal present in the configuration. For example: 68_TRGEN represents the General Trip of the device and must be connected to the general trip signal SMPPTRC_TRIP or equivalent.

IED status for IEC 60870-5-103 I103IED
I103IED is a function block with defined IED functions in monitor direction. This block uses the parameter *FunctionType*; the *information number* parameter is defined for each input signal.

Supervison status for IEC 60870-5-103 I103SUPERV
I103SUPERV is a function block with defined functions for supervision indications in monitor direction. This block includes the *FunctionType* parameter; the *information number* parameter is defined for each output signal.

Status for user-defined signals for IEC 60870-5-103 I103USRDEF
I103USRDEF comprises function blocks with user-defined input signals in monitor direction. These function blocks include the *FunctionType* parameter for each block in the private range, and the *information number* parameter for each input signal.

Function commands for IEC 60870-5-103 I103CMD
I103CMD is a command function block in control direction with pre-defined output signals. The signals are in steady state, not pulsed, and stored in the IED in case of restart.

IED commands for IEC 60870-5-103 I103IEDCMD
I103IEDCMD is a command block in control direction with defined IED functions. All outputs are pulsed and they are NOT stored. *Pulse-time* is a hidden parameter.

Function commands user-defined for IEC 60870-5-103 I103USRCMD
I103USRCMD is a command block in control direction with user-defined output signals. These function blocks include the *FunctionType* parameter for each block in the private range, and the *Information number* parameter for each output signal.

Function commands generic for IEC 60870-5-103 I103GENCMD
I103GENCMD is used for transmitting generic commands over IEC 60870-5-103. The function has two output signals, CMD_OFF and CMD_ON, that can be used to implement double-point command schemes.

The I103GENCMD component can be configured as either 2 pulsed ON/OFF or 2 steady ON/OFF outputs. The ON output is pulsed with a command with value 2, while the OFF output is pulsed with a command with value 1. If in steady mode is ON asserted and OFF deasserted with command 2 and vice versa with command 1.

IED commands with position and select for IEC 60870-5-103 I103POSCMD
I103POSCMD has double-point position indicators that are getting the position value as an integer (for example, from the POSITION output of the SCSWI function block) and sending it over IEC 60870-5-103 (1=OPEN; 2=CLOSE). The standard does not define the use of values 0 and 3. However, when connected to a switching device, these values are transmitted.

The BLOCK input will block only the signals in monitoring direction (the position information), not the commands via IEC 60870-5-103. The SELECT input is used to indicate that the monitored apparatus has been selected (in a select-before-operate type of control).

DNP3.0 communication protocol
An electrical RS485 serial port, optical serial ports on the serial communication module (SLM), optical Ethernet ports

are available for DNP3.0 communication. DNP3.0 Level 2 communication with unsolicited events, time synchronization and disturbance reporting is provided for communication to RTUs, Gateways or HMI systems.

Multiple command and transmit

When IEDs are used in Substation Automation systems with LON, SPA or IEC 60870-5-103 communication protocols, the Event and Multiple Command function blocks are used as the communication interface for vertical communication to station HMI and gateway, and as interface for horizontal peer-to-peer communication (over LON only).

16. Hardware description

Hardware modules

Numeric processing module NUM

The numeric processing module (NUM) is a CPU module that handles all protection functions and logic.

NUM provides up to 4 optical (type LC) or galvanic (type RJ45) Ethernet ports (one basic and three optional).

Ethernet ports can be configured as four separate or in redundant mode PRP, HSR, or RSTP. The combination supports two PRP, two HSR networks, or one RSTP network.

Power supply module PSM

The power supply module is used to provide the correct internal voltages and full isolation between the IED and the battery system. An internal fail alarm output is available.

Alternative connectors of Ring lug or Compression type can be ordered.

Binary input module BIM

The binary input module has 16 optically isolated inputs and is available in two versions, one standard and one with enhanced pulse counting capabilities on the inputs to be used with the pulse counter function. The binary inputs are freely programmable and can be used for the input of logical signals to any of the functions. They can also be included in the disturbance recording and event-recording functions. This enables extensive monitoring and evaluation of operation of the IED and for all associated electrical circuits.

Binary output module BOM

The binary output module has 24 independent output relays and is used for trip output or any signaling purpose.

Binary input/output module IOM

The binary input/output module is used when only a few input and output channels are needed. The ten standard output channels are used for trip output or any signaling purpose. The two high speed signal output channels are used for applications where short operating time is essential. Eight optically isolated binary inputs cater for required binary input information.

Serial and LON communication module (SLM) for SPA/IEC 60870-5-103, LON and DNP 3.0

The Serial and LON communication module (SLM) is used for SPA, IEC 60870-5-103, DNP3 and LON communication. SLM has two optical communication ports for plastic/plastic, plastic/glass or glass/glass fiber cables. One port is used for serial communication (SPA, IEC 60870-5-103 or DNP3 port) and the other port is used for LON communication.

Galvanic RS485 serial communication module

The Galvanic RS485 communication module (RS485) is used for DNP3.0 and IEC 60870-5-103 communication. The module has one RS485 communication port. The RS485 is a balanced serial communication that can be used either in 2-wire or 4-wire connections. A 2-wire connection uses the same signal for RX and TX and is a multidrop communication with no dedicated Master or slave. This variant requires however a control of the output. The 4-wire connection has separated signals for RX and TX multidrop communication with a dedicated Master and the rest are slaves. No special control signal is needed in this case.

IRIG-B Time synchronizing module

The IRIG-B time synchronizing module is used for accurate time synchronizing of the IED from a station clock.

The Pulse Per Second (PPS) input is supported.

Electrical (BNC) and optical connection (ST) for 0XX and 12X IRIG-B support.

Transformer input module TRM

The transformer input module is used to galvanically separate and adapt the secondary currents and voltages generated by the measuring transformers. The module has twelve inputs in different combinations of currents and voltage inputs.

Ring lug or compression type connectors can be ordered.

High impedance resistor unit

The high impedance resistor unit, with resistors for pick-up value setting and a voltage dependent resistor, is available in a single phase unit and a three phase unit. Both are mounted on a 1/1 19 inch apparatus plate with compression type terminals.

Layout and dimensions

Dimensions

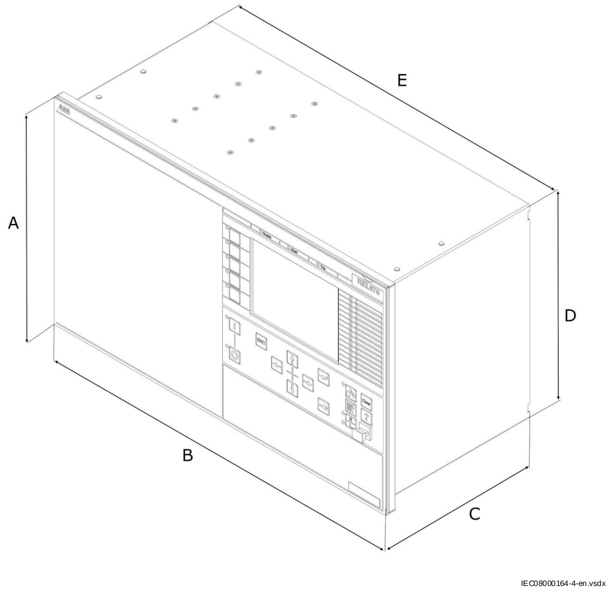

Figure 4. Case without protective cover

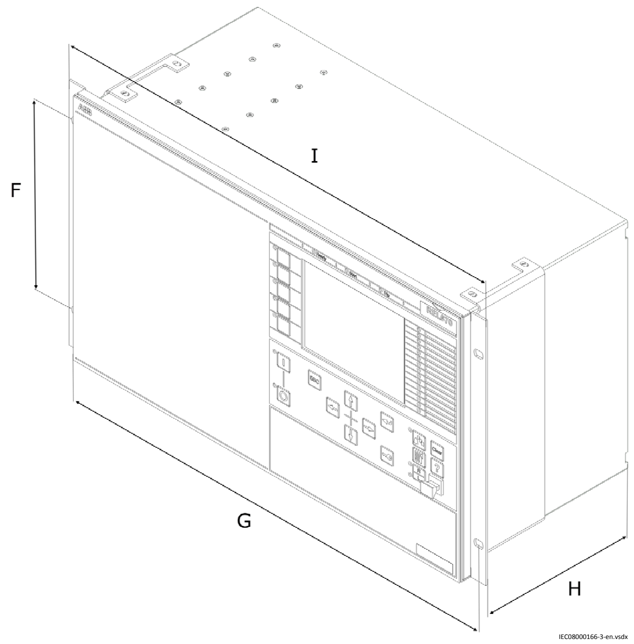

Figure 5. Case without protective cover with 19” rack mounting kit

Table 6. Case dimensions

Case size (mm)/ (inches)	A	B	C	D	E	F	G	H	I
6U, 1/2 x 19”	265.9/ 10.47	223.7/ 8.81	247.5/ 9.74	255.0/ 10.04	205.8/ 8.10	190.5/ 7.50	466.5/ 18.36	232.5/ 9.15	482.6/ 19
The G and H dimensions are defined by the 19” rack mounting kit.									

Mounting alternatives

- 19” rack mounting kit
- Flush mounting kit with cut-out dimensions:
  - 1/2 case size (h) 254.3 mm/10.01” (w) 210.1 mm/8.27”
- Wall mounting kit

See ordering for details about available mounting alternatives.

17. Connection diagrams

The connection diagrams are delivered in the IED Connectivity package as part of the product delivery.

The latest versions of the connection diagrams can be downloaded from http://www.hitachiabb-powergrids.com/protection-control.

Connection diagrams for Configured products

Connection diagram, REB650 2.2, A03X00 1MRK006507-BA

Connection diagrams for Customized products

Connection diagram, 650 series 2.2 IEC 1MRK006501-AG

Connection diagram, 650 series 2.2 ANSI 1MRK006502-AG

18. Certification

The following are the list of certification for Relion® 650 series.

UL certification* for Relion® 650 series	E502400
IEC 60255-1 Environmental & functional issued by DNV GL	1418-18 1446-18
G3 Compliance Certificate Sulphur dioxide test for contacts and connections Hydrogen sulphide test for contacts and connections Flowing mixed gas corrosion test	IEC 60068-2-42: 2003 IEC 60068-2-43: 2003 IEC 60068-2-60: 2015
IEC 61850 Ed2 level A1 certificate issued by DNV GL	10289889-INC-21-2985
IEC 61850 Ed1 level B1 certificate issued by Hitachi ABB Power Grids, SVC Baden	1KHL050134
IEC 62439-3 Ed3 certificate issued by DNV GL	10257149-INC 21-2619rev1
IEC 60870-5-103 certificate issued by DNV GL	10021419-OPE/INC 16-2490
DNP 3.0 certificate issued by DNV GL	10021419-OPE/INC 16-2532
* Valid for IEDs produced at factory in Sweden.	

19. Technical data

General

Definitions	
Reference value	The specified value of an influencing factor to which are referred the characteristics of the equipment
Nominal range	The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements
Operative range	The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements

- Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.
- The stated operate time for functions include the operating time for the binary inputs and outputs.
- Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation. BOM/IOM/SOM should be activated continuously due to power dissipation.
- Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation. The stated operate time for functions include the operating time for the binary inputs and outputs.

Presumptions for Technical Data

The technical data stated in this document are only valid under the following circumstances:

1. Main current transformers with 1 A or 2 A secondary rating are wired to the IED 1 A rated CT inputs.
2. Main current transformer with 5 A secondary rating are wired to the IED 5 A rated CT inputs.
3. CT and VT ratios in the IED are set in accordance with the associated main instrument transformers. Note that for functions which measure an analogue signal which do not have corresponding primary quantity the 1:1 ratio shall be set for the used analogue inputs on the IED. Example of such functions are: HZPDIF, ROTIPHIZ and STTIPHIZ.
4. Parameter *IBase* used by the tested function is set equal to the rated CT primary current.
5. Parameter *UBase* used by the tested function is set equal to the rated primary phase-to-phase voltage.
6. Parameter *SBase* used by the tested function is set equal to:
   – $\sqrt{3}$ × *IBase* × *UBase*
7. The rated secondary quantities have the following values:
   – Rated secondary phase current I_r is either 1 A or 5 A depending on selected TRM.
   – Rated secondary phase-to-phase voltage U_r is within the range from 100 V to 120 V.
   – Rated secondary power for three-phase system $S_r = \sqrt{3} \times U_r \times I_r$
8. For operate and reset time testing, the default setting values of the function and BOM module are used if not explicitly stated otherwise.

   All reset times are measured using BOM output contacts if not explicitly stated otherwise. The operate/reset times are determined by characteristics of the output module used.
9. During testing, signals with rated frequency have been injected if not explicitly stated otherwise.

Energizing quantities, rated values and limits

Analog inputs

Table 7. TRM - Energizing quantities, rated values and limits for protection transformer

Description	Value
Frequency	
Rated frequency f_r	50/60 Hz
Operating range	f_r ± 10%
Current inputs	
Rated current I_r	1 or 5 A
Operating range	(0-100) x I_r
Thermal withstand	100 × I_r for 1 s *) 30 × I_r for 10 s 10 × I_r for 1 min 4 × I_r continuously
Dynamic withstand	250 × I_r one half wave
Burden	< 20 mVA at I_r = 1 A < 150 mVA at I_r = 5 A
*) max. 350 A for 1 s when COMBITEST test switch is included.	
Voltage inputs **)	
Rated voltage U_r	110 or 220 V
Operating range	0 - 340 V
Thermal withstand	450 V for 10 s 420 V continuously
Burden	< 20 mVA at 110 V < 80 mVA at 220 V
**) all values for individual voltage inputs	
Note! All current and voltage data are specified as RMS values at rated frequency	

Auxiliary AC and DC voltage

Table 8. PSM - Power supply module

Quantity	Rated value	Nominal range
Auxiliary DC voltage, EL (input)	EL = (24-60) V EL = (90-250) V	EL ±20% EL ±20%
Power consumption	32 W typically	-
Auxiliary DC power in-rush	< 10 A during 0.1 s	-
Supply interruption bridging time	< 50 ms	-

Binary inputs and outputs

Table 9. BIM - Binary input module

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V, 50 mA 48/60 V, 50 mA 110/125 V, 50 mA 220/250 V, 50 mA 220/250 V, 110 mA	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.5 W/input	-
Counter input frequency	10 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	
*Debounce filter	Settable 1–20 ms	
Binary input operate time (Debounce filter set to 0 ms)	3 ms	-
* Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.		

Table 10. BIM - Binary input module with enhanced pulse counting capabilities

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V 48/60 V 110/125 V 220/250 V	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input	-
Counter input frequency	10 pulses/s max	-
Balanced counter input frequency	40 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	
*Debounce filter	Settable 1-20 ms	
Binary input operate time (Debounce filter set to 0 ms)	3 ms	-
* Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.		

Table 11. IOM - Binary input/output module

Quantity	Rated value	Nominal range
Binary inputs	8	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V, 50 mA 48/60 V, 50 mA 110/125 V, 50 mA 220/250 V, 50 mA 220/250 V, 110 mA	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.5 W/input	-
Counter input frequency	10 pulses/s max	
Oscillating signal discriminator	Blocking settable 1-40 Hz Release settable 1-30 Hz	
*Debounce filter	Settable 1-20 ms	
Binary input operate time (Debounce filter set to 0 ms)	3 ms	-
* Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.		

Table 12. IOM - Binary input/output module contact data (reference standard: IEC 61810-1)

Function or quantity	Trip and signal relays	Fast signal relays (parallel reed relay)
Binary outputs	10	2[1)]
Max system voltage	250 V AC/DC	250 V DC
Min load voltage	24 V DC	—
Test voltage across open contact, 1 min	1000 V rms	800 V DC
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A	 8 A 10 A 12 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	 220–250 V/0.4 A 110–125 V/0.4 A 48–60 V/0.2 A 24–30 V/0.1 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms (According to IEC 61810-1)	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A	110 V / 0.3 A
Breaking capacity for DC with resistive load	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A
Maximum capacitive load	-	10 nF
Max operations with inductive load L/R ≤ 40 ms	1000	
Max operations with resistive load	2000	
Max operations with no load	10000	
Operating time	< 6 ms	<= 1 ms

1) These reed relays have been excluded from UL evaluation.

Table 13. IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-1)

Function or quantity	**Trip and Signal relays**	**Fast signal relays (parallel reed relay)**
Binary outputs	IOM: 10	IOM: 2
Max system voltage	250 V AC/ DC	250 V DC
Min load voltage	24 V DC	-
Test voltage across open contact, 1 min	250 V rms	250 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A	 8 A 10 A 12 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	 220–250 V/0.4 A 110–125 V/0.4 A 48–60 V/0.2 A 24–30 V/0.1 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms (According to IEC 61810-1)	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A	110 V / 0.3 A
Breaking capacity for DC with resistive load	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A
Maximum capacitive load	-	10 nF
Max operations with inductive load L/R ≤ 40 ms	1000	-
Max operations with resistive load	2000	
Max operations with no load	10000	-
Operating time	< 6 ms	<= 1 ms

Table 14. BOM - Binary output module contact data (reference standard: IEC 61810-1)

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC/DC
Min load voltage	24 V DC
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A
Max operations with inductive load L/R ≤ 40 ms	1000
Max operations with resistive load	2000
Max operations with load	1000
Max operations with no load	10000
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 10 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A
Breaking capacity for DC with resistive load	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A
Operating time	< 6 ms

The stated operate time for functions include the operating time for the binary inputs and outputs.

Table 15. IRF - Internal Fail relay output

Quantity	Rated value
Max. system voltage	250 V DC
Min. load voltage	24 V DC
Number of outputs	1
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 4 A 8 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	20 A 8 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 20 A 8 A
Making capacity at resistive load 0.2 s 1.0 s	 20 A 8 A
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1)	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Breaking capacity for DC with L/R=100 ms	110 V/0.3 A
Breaking capacity for DC with resistive load	48 V/2 A 110 V/0.5 A 125 V/0.45 A 220 V/0.35 A 250 V/0.3 A
Max. operations with inductive load L/R ≤ 40 ms	1000
Max. operations with resistive load	2000
Max. operations with no load	10000

Influencing factors

Table 16. Temperature and humidity influence

Parameter	Reference value	Nominal range	Influence
Ambient temperature, operate value	+20±5°C	-25°C to +55°C	0.02%/°C
Relative humidity Operative range	45-75% 0-95%	10-90%	-

Table 17. Auxiliary DC supply voltage influence on functionality during operation

Dependence on	Reference value	Within nominal range	Influence
Ripple, in DC auxiliary voltage Operative range	max. 2% Full wave rectified	15% of EL	0.01%/%
Auxiliary voltage dependence, operate value		±20% of EL	0.01%/%
Interrupted auxiliary DC voltage		24-60 V DC ± 20% 90-250 V DC ± 20%	
Interruption interval 0–50 ms			No restart
0–∞ s			Correct behaviour at power down
Restart time			< 300 s

Table 18. Frequency influence (reference standard: IEC 60255–1)

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±1.0%/Hz
Harmonic frequency dependence (20% content)	2nd, 3rd and 5th harmonic of f_r	±1.0%
Harmonic frequency dependence for high impedance differential protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±10.0%
Harmonic frequency dependence for overcurrent protection	2nd, 3rd and 5th harmonic of f_r	±3.0%

Table 19. Frequency influence (reference standard: IEC 60255–1)

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±1.0%/Hz
Harmonic frequency dependence (20% content)	2nd, 3rd and 5th harmonic of f_r	±1.0%
Harmonic frequency dependence for high impedance differential protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±5.0%

Type tests according to standards

Table 20. Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-26
100 kHz slow damped oscillatory wave immunity test	2.5 kV	IEC 61000-4-18, Level 3
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Level 4
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-26 IEC 61000-4-2, Level 4
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.3
Fast transient disturbance	4 kV 2 kV, SFP galvanic RJ45 2 kV, MIM mA-inputs	IEC 60255-26, Zone A IEC 60255-26, Zone B
Surge immunity test	2-4 kV, 1.2/50μs high energy 1-2 kV, BOM and IRF outputs	IEC 60255-26, Zone A IEC 60255-26, Zone B
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-26, Zone A
Conducted common mode immunity test	30-3 V, 15-150 Hz	IEC 61000-4-16, Level 4
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8, Level 5
Pulse magnetic field immunity test	1000 A/m	IEC 61000–4–9, Level 5
Damped oscillatory magnetic field test	100 A/m	IEC 61000-4-10, Level 5
Radiated electromagnetic field disturbance	20 V/m 80-1000 MHz 1.4-2.7 GHz 10 V/m, 2.7-6.0 GHz	IEC 60255-26 IEEE/ANSI C37.90.2 EN 50121-5
Radiated emission	30-6000 MHz	IEC 60255-26
	30-8500 MHz	IEEE/ANSI C63.4, FCC
Conducted emission	0.15-30 MHz	IEC 60255-26

Table 21. Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min. 1.0 kV AC, 1 min.: -SFP galvanic RJ45 - X.21-LDCM	IEC 60255-27 ANSI C37.90 IEEE 802.3-2015, Environment A
Impulse voltage test	5 kV, 1.2/50μs, 0.5 J 1 kV, 1.2/50 μs 0.5 J: -SFP galvanic RJ45 - X.21-LDCM	
Insulation resistance	> 100 MΩ at 500 VDC	

Table 22. Environmental conditions

Description	Value
Operating temperature range	-25°C to +55°C (continuous)
Short-time service temperature range	-40°C to +70°C (<16h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25°C to +55°C
Relative humidity	<93%, non-condensing
Atmospheric pressure	86 kPa to 106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40°C to +85°C

Table 23. Environmental tests

Test	Type test value	Reference standard
Cold operation test	Test Ad for 16 h at -25°C	IEC 60068-2-1
Cold storage test	Test Ab for 16 h at -40°C	IEC 60068-2-1
Dry heat operation test	Test Bd for 16 h at +70°C	IEC 60068-2-2
Dry heat storage test	Test Bb for 16 h at +85°C	IEC 60068-2-2
Change of temperature test	Test Nb for 5 cycles at -25°C to +70°C	IEC 60068-2-14
Damp heat test, steady state	Test Ca for 56 days at +40°C and humidity 93%	IEC 60068-2-78
Damp heat test, cyclic	Test Db for 6 cycles at +25 to +55°C and humidity 93 to 95% (1 cycle = 24 hours)	IEC 60068-2-30

Table 24. CE compliance

Test	According to
Electromagnetic compatibility (EMC)	EN 60255–26
Low voltage (LVD)	EN 60255–27

Table 25. Mechanical tests

Test	Type test values	Reference standards
Vibration response test	Class II: Rack mount Class I: Flush and wall mount	IEC 60255-21-1
Vibration endurance test	Class I: Rack, flush and wall mount	IEC 60255-21-1
Shock response test	Class I: Rack, flush and wall mount	IEC 60255-21-2
Shock withstand test	Class I: Rack, flush and wall mount	IEC 60255-21-2
Bump test	Class I: Rack, flush and wall mount	IEC 60255-21-2
Seismic test	Class II: Rack mount Class I: Flush and wall mount	IEC 60255-21-3

Differential protection

Table 26. High impedance differential protection, single phase HZPDIF

Function	Range or value	Accuracy
Operate voltage	(10-900) V I=U/R	±1.0% of I_r
Reset ratio	>95%	-
Maximum continuous power	See[1)]	-
Operate time at 0 to 10 x U_d	Min. = 5 ms Max. = 15 ms	
Reset time at 10 x U_d to 0	Min. = 75 ms Max. = 95 ms	
Critical impulse time	2 ms typically at 0 to 10 x U_d	-

1) The value U^2Trip/ R should always be lower than Stabilizing resistor thermal rating to allow continuous activation during testing. If this value is exceeded, testing should be done with a transient faults. Typical value for the thermal rating of the resistor is 100W.

Current protection

Table 27. Four step phase overcurrent protection, 3-phase output OC4PTOC

Function	Range or value	Accuracy
Operate current, step 1-4	(1-2500)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Minimum operate current, step 1-4	(5-10000)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(-70.0– -50.0) degrees	±2.0 degrees
Maximum forward angle	(40.0–70.0) degrees	
Minimum forward angle	(75.0–90.0) degrees	±2.0 degrees
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Independent time delay at 0 to 2 x I_{set}, step 1-4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves , step 1-4	(0.000-60.000) s	±0.5% ±25 ms
Inverse time characteristics, see table 119, table 120 and table 121	15 curve types	[1] ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 x I_{set} to 0	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 ms typically at 2 x I_{set} to 0	-
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Operate frequency, directional overcurrent	38-83 Hz	-
Operate frequency, non-directional overcurrent	10-90 Hz	-

[1] **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off

Table 28. Four step residual overcurrent protection EF4PTOC technical data

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	±1.0% of I_r at $I < I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison, Zero sequence	(1–100)% of IBase	±2.0% of I_r
Operate current for directional comparison, Negative sequence	(1–100)% of IBase	±2.0% of I_r
Minimum operating current	(1-10000)% of IBase	±1.0% of I_r at $I < I_r$ ±1.0% of I at $I > I_r$
Minimum operate time for inverse characteristics	(0.000-60.000) s	±0.5% ±25 ms
Timers	(0.000-60.000) s	±0.5% ±25 ms
Inverse characteristics, see Table 119, Table 120 and Table 121	15 curve types	1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Minimum polarizing voltage, Zero sequence	(1–100)% of UBase	±0.5% of U_r
Minimum polarizing voltage, Negative sequence	(1–100)% of UBase	±0.5% of U_r
Minimum polarizing current, Zero sequence	(2–100)% of IBase	±1.0% of I_r
Minimum polarizing current, Negative sequence	(2–100)% of IBase	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-
2)Operate time, non-directional start function	30 ms typically at 0.5 x I_{set} to 2 x I_{set}	-
2)Reset time, non-directional start function	30 ms typically at 2 x I_{set} to 0.5 x I_{set}	-
30 ms typically at 0.5 x I_N to 2 x I_N	-	-
2)Reset time, directional start function	30 ms typically at 2 x I_N to 0.5 x I_N	

1) **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off.
2) **Note:** Operate time and reset time are only valid if harmonic blocking is turned off for a step.

Table 29. Four step directional negative phase sequence overcurrent protection NS4PTOC

Function	Range or value	Accuracy
Operate current, step 1 - 4	(1-2500)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1 - 4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see table 119, table 120 and table 121	16 curve types	See table 119, table 120 and table 121
Minimum operate current, step 1 - 4	(1.00 - 10000.00)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Relay characteristic angle (RCA)	(-180 to 180) degrees	±2.0 degrees
Operate current for directional release	(1–100)% of *IBase*	For RCA ±60 degrees: ±2.5% of I_r at I ≤ I_r ±2.5% of I at I > I_r
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 30. Thermal overload protection, two time constants TRPTTR

Function	Range or value	Accuracy
Base current 1 and 2	(30–250)% of *IBase*	±1.0% of I_r
Operate time: $$t = \tau \cdot ln\left(\frac{I^2 - I_p^{\,2}}{I^2 - I_{Trip}^{\,2}}\right)$$ (Equation 1) I = actual measured current Ip = load current before overload occurs ITrip = steady state operate current level in % of *IBasex*	Time constant τ = (0.10–500.00) minutes	±5.0% or ±200 ms whichever is greater
Alarm level 1 and 2	(50–99)% of heat content operate value	±2.0% of heat content trip
Operate current	(50–250)% of *IBase*	±1.0% of I_r
Reset level temperature	(10–95)% of heat content trip	±2.0% of heat content trip

Table 31. Breaker failure protection, 3-phase activation and output CCRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time for current detection	10 ms typically	-
Reset time for current detection	10 ms maximum *	-
Time delay for retrip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Time delay for backup trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Time delay for backup trip at multi-phase start at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Additional time delay for a second backup trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Time delay for alarm for faulty circuit breaker	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Minimum trip pulse duration	(0.010-60.000) s	±0.2% or ±5 ms whichever is greater
* Valid for product version 2.2.3 or later		

Table 32. Pole discordance protection CCPDSC

Function	Range or value	Accuracy
Operate value, current asymmetry level	(0-100) %	±1.0% of I_r
Reset ratio	>95%	-
Independent time delay between trip condition and trip signal	(0.000-60.000) s	±0.5% ± 25 ms

Voltage protection

Table 33. Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1.0–100.0)% of *UBase*	±0.5% of U_r
Reset ratio	<102%	-
Inverse time characteristics for low and high step, see table 126	-	See table 126
Definite time delay, step 1 at 1.2 x U_{set} to 0	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 x U_{set} to 0	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000–60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 1.2 x U_{set} to 0.5 x U_{set}	-
Reset time, start function	40 ms typically at 0.5 x U_{set} to 1.2 x U_{set}	-
Operate time, start at 2 x U_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 1.2 x U_{set} to 0	Min. = 5 ms Max. = 25 ms	-
Reset time, start at 0 to 1.2 x U_{set}	Min. = 15 ms Max. = 35 ms	-
Critical impulse time	5 ms typically at 1.2 x U_{set} to 0	-
Impulse margin time	15 ms typically	-

Table 34. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1.0-200.0)% of *UBase*	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio	>98%	-
Inverse time characteristics for steps 1 and 2, see table 125	-	See table 125
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	±0.5% ±25
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	±0.5% ±25 ms
Minimum operate time, Inverse characteristics	(0.000-60.000) s	±0.5% ±25 ms
Operate time, start function	25 ms typically at 0 to 2 x U_{set} 30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	25 ms typically at 0 to 2 x U_{set} 40 ms typically at 2 x U_{set} to 0	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 35. Residual overvoltage protection, two steps ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1	(1.0-200.0)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Operate voltage, step 2	(1–100)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Reset ratio 125	> 98%	-
Inverse time characteristics for low and high step, see table	-	See table 125
Definite time setting, step 1	(0.00–6000.00) s	± 0.5% ± 25 ms
Definite time setting, step 2	(0.000–60.000) s	± 0.5% ± 25 ms
Minimum operate time for step 1 inverse characteristic	(0.000-60.000) s	± 0.2% ± 25 ms
Critical impulse time	10 ms typically at 0 to 1.2 x U_{set}	-
Impulse margin time	15 ms typically	-

Secondary system supervision

Table 36. Fuse failure supervision FUFSPVC

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, zero sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage, negative sequence	(1–100)% of UBase	±0.5% of U_r
Operate current, negative sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage change level	(1–100)% of UBase	±10.0% of U_r
Operate current change level	(1–100)% of IBase	±10.0% of I_r
Operate phase voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase current	(1–100)% of IBase	±0.5% of I_r
Operate phase dead line voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase dead line current	(1–100)% of IBase	±1.0% of I_r

Logic

Table 37. Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action, *Program*	3 phase	-
Timers	(0.000-60.000) s	±0.5% ±15 ms
3-pole trip delay, *tWaitForPHS*	(0.020-0.500) s	±0.2% or ±15 ms whichever is greater
Evolving fault delay , *tEvolvingFault*	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 38. Number of SMAGAPC instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
SMAGAPC	6	-	-

Table 39. Number of TMAGAPC instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
TMAGAPC	6	6	-

Table 40. Number of ALMCALH instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
ALMCALH	-	-	5

Table 41. Number of WRNCALH instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
WRNCALH	-	-	5

Table 42. Number of INDCALH instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
INDCALH	-	5	-

Table 43. Number of AND instances

Logic block	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
AND	60	60	160

Table 44. Number of GATE instances

Logic block	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
GATE	10	10	20

Table 45. Number of INV instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INV	90	90	240

Table 46. Number of LLD instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
LLD	10	10	20

Table 47. Number of OR instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
OR	78	60	160

Table 48. Number of PULSETIMER instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
PULSETIMER	10	10	20	(0.000–90000.000) s	±0.5% ±10 ms

Table 49. Number of RSMEMORY instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
RSMEMORY	10	10	20

Table 50. Number of SRMEMORY instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
SRMEMORY	10	10	20

Table 51. Number of TIMERSET instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
TIMERSET	15	15	30	(0.000–90000.000) s	±0.5% ±10 ms

Table 52. Number of XOR instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
XOR	10	10	20

Table 53. Number of B16I instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
B16I	6	4	8

Table 54. Number of BTIGAPC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
BTIGAPC	4	4	8

Table 55. Number of IB16 instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
IB16	12	4	8

Table 56. Number of ITBGAPC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
ITBGAPC	4	4	8

Table 57. Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	3	0 ~ 999999.9 s	±0.2% or ±20 ms whichever is greater
	8	0 ~ 999999.9 s	±0.2% or ±100 ms whichever is greater
	100	0 ~ 999999.9 s	±0.2% or ±250 ms whichever is greater

Table 58. Number of TEIGAPC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
TEIGAPC	4	4	4

Table 59. Number of INTCOMP instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
INTCOMP	10	10	10

Table 60. Number of REALCOMP instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
REALCOMP	10	10	10

Table 61. Number of HOLDMINMAX instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
HOLDMINMAX	-	-	20

Table 62. Number of INT_REAL instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
INT_REAL	-	-	20

Table 63. Number of CONST_INT instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
CONST_INT	-	-	10

Table 64. Number of INTSEL instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
INTSEL	-	-	5

Table 65. Number of LIMITER instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
LIMITER	-	-	20

Table 66. Number of ABS instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
ABS	-	-	20

Table 67. Number of POL_REC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
POL_REC	-	-	20

Table 68. Number of RAD_DEG instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
RAD_DEG	-	-	20

Table 69. Number of CONST_REAL instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
CONST_REAL	-	-	10

Table 70. Number of REALSEL instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
REALSEL	-	-	5

Table 71. Number of STOREINT instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
STOREINT	-	-	10

Table 72. Number of STOREREAL instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
STOREREAL	-	-	10

Table 73. Number of DEG_RAD instances

Function	Quantity with cycle time		
	3 ms	**8 ms**	**100 ms**
DEG_RAD	-	-	20

Monitoring

Table 74. Power system measurement CVMMXN

Function	Range or value	Accuracy
Frequency	(0.8-1.2) x f_r	±5.0 mHz for U at 0.2 × U_r ≤ U < 0.5 × U_r ±3.0 mHz for U at 0.5 × U_r ≤ U < 1.0 × U_r ±2.0 mHz for U at U ≥ U_r
Voltage	(10 to 300) V	±0.3% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Current	(0.1-4.0) x I_r	±0.8% of I at 0.1 x I_r < I < 0.2 x I_r ± 0.5% of I at 0.2 x I_r < I < 0.5 x I_r ±0.2% of I at 0.5 x I_r < I < 4.0 x I_r
Active power, P	(10 to 300) V (0.1-4.0) x I_r	±0.5% of S_r at S ≤0.5 x S_r ±0.5% of S at S > 0.5 x S_r
	(100 to 220) V (0.5-2.0) x I_r cos φ > 0.7	±0.2% of P
Reactive power, Q	(10 to 300) V (0.1-4.0) x I_r	±0.5% of S_r at S ≤0.5 x S_r ±0.5% of S at S > 0.5 x S_r
	(100 to 220) V (0.5-2.0) x I_r cos φ < 0.7	±0.2% of Q
Apparent power, S	(10 to 300) V (0.1-4.0) x I_r	±0.5% of S_r at S ≤0.5 x S_r ±0.5% of S at S >0.5 x S_r
	(100 to 220) V (0.5-2.0) x I_r	±0.2% of S
Power factor, cos (φ)	(10 to 300) V (0.1-4.0) x I_r	<0.02
	(100 to 220) V (0.5-2.0) x I_r	<0.01

Table 75. Technical data covering measurement functions: CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU

Function	Range or value	Accuracy
Voltage	(0.1-1.5) ×U_r	±0.5% of U_r at U≤U_r ±0.5% of U at U > U_r
Connected current	(0.2-4.0) × I_r	±0.5% of I_r at I ≤ I_r ±0.5% of I at I > I_r
Active power, P	0.1 x U_r< U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	±1.0% of S_r at S ≤ S_r ±1.0% of S at S > S_r
Reactive power, Q	0.1 x U_r< U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	±1.0% of S_r at S ≤ S_r ±1.0% of S at S > S_r
Apparent power, S	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r< I < 4.0 x I_r	±1.0% of S_r at S ≤ S_r ±1.0% of S at S > S_r
Apparent power, S Three phase settings	cos phi = 1	±0.5% of S at S > S_r ±0.5% of S_r at S ≤ S_r
Power factor, cos (φ)	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r< I < 4.0 x I_r	< 0.02

Table 76. Current measurement CMMXU

Function	Range or value	Accuracy
Current at symmetrical load	(0.1-4.0) × I_r	±0.3% of I_r at I ≤ 0.5 × I_r ±0.3% of I at I > 0.5 × I_r
Phase angle at symmetrical load	(0.1-4.0) × I_r	±1.0 degrees at 0.1 × I_r < I ≤ 0.5 × I_r ±0.5 degrees at 0.5 × I_r < I ≤ 4.0 × I_r

Table 77. Voltage measurement phase-phase VMMXU

Function	Range or value	Accuracy
Voltage	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Phase angle	(10 to 300) V	±0.5 degrees at U ≤ 50 V ±0.2 degrees at U > 50 V

Table 78. Voltage measurement phase-earth VNMMXU

Function	Range or value	Accuracy
Voltage	(5 to 175) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Phase angle	(5 to 175) V	±0.5 degrees at U ≤ 50 V ±0.2 degrees at U > 50 V

Table 79. Current sequence measurement CMSQI

Function	Range or value	Accuracy
Current positive sequence, I1 Three phase settings	(0.1–4.0) × I_r	±0.3% of I_r at I ≤ 0.5 × I_r ±0.3% of I at I > 0.5 × I_r
Current zero sequence, 3I0 Three phase settings	(0.1–1.0) × I_r	±0.3% of I_r at I ≤ 0.5 × I_r ±0.3% of I at I > 0.5 × I_r
Current negative sequence, I2 Three phase settings	(0.1–1.0) × I_r	±0.3% of I_r at I ≤ 0.5 × I_r ±0.3% of I at I > 0.5 × I_r
Phase angle	(0.1–4.0) × I_r	±1.0 degrees at 0.1 × I_r < I ≤ 0.5 × I_r ±0.5 degrees at 0.5 × I_r < I ≤ 4.0 × I_r

Table 80. Voltage sequence measurement VMSQI

Function	Range or value	Accuracy
Voltage positive sequence, U1	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Voltage zero sequence, 3U0	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Voltage negative sequence, U2	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Phase angle	(10 to 300) V	±0.5 degrees at U ≤ 50 V ±0.2 degrees at U > 50 V

Table 81. Supervision of mA input signals

Function	Range or value	Accuracy
mA measuring function	±5, ±10, ±20 mA 0-5, 0-10, 0-20, 4-20 mA	±0.1 % of set value ±0.005 mA
Max current of transducer to input	(-20.00 to +20.00) mA	
Min current of transducer to input	(-20.00 to +20.00) mA	
Alarm level for input	(-20.00 to +20.00) mA	
Warning level for input	(-20.00 to +20.00) mA	
Alarm hysteresis for input	(0.0-20.0) mA	

Table 82. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Current recording	-	± 1,0% of I_r at $I \leq I_r$ ± 1,0% of I at I > Ir
Voltage recording	-	± 1,0% of U_r at $U \leq U_r$ ± 1,0% of U at $U > U_r$
Pre-fault time	(0.05–9.903.00) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–10.08.0) s	-
Maximum number of recordings	200, first in - first out	-
Time tagging resolution	1 ms	See table 116 See time synchronization technical data
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	352	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	352	-
Maximum number of events in the Event recording per recording	1056	-
Maximum number of events in the Event list	5000, first in - first out	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 83. Insulation supervision for gas medium function SSIMG

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms
Time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Reset time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Time delay for pressure lockout	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Reset time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Time delay for temperature lockout	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater

Table 84. Insulation supervision for liquid medium function SSIML

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms
Time delay for oil alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for oil alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for oil lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for temperature lockout	(0.000-60.000) s	±0.2% or ±250ms whichever is greater

Table 85. Circuit breaker condition monitoring SSCBR

Function	Range or value	Accuracy
Alarm levels for open and close travel time	(0-200) ms	±0.5% ±25 ms
Alarm levels for number of operations	(0 - 9999)	-
Setting of alarm for spring charging time	(0.00-60.00) s	±0.5% ±25 ms
Time delay for gas pressure alarm	(0.00-60.00) s	±0.5% ±25 ms
Time delay for gas pressure lockout	(0.00-60.00) s	±0.5% ±25 ms

Table 86. Circuit breaker condition monitoring SSCBR

Function	Range or value	Accuracy
Alarm level for open and close travel time	(0 – 200) ms	±3 ms
Alarm level for number of operations	(0 – 9999)	-
Independent time delay for spring charging time alarm	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay for gas pressure alarm	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay for gas pressure lockout	(0.00 – 60.00) s	±0.2% or ±30 ms whichever is greater
CB Contact Travel Time, opening and closing		±3 ms
Remaining Life of CB		±2 operations
Accumulated Energy		±1.0% or ±0.5 whichever is greater

Table 87. Event list DRPRDRE

Function		Value
Buffer capacity	Maximum number of events in the list	5000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 88. Indications DRPRDRE

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	352
	Maximum number of recorded disturbances	200

Table 89. Event recorder DRPRDRE

Function		Value
Buffer capacity	Maximum number of events in disturbance report	1056
	Maximum number of disturbance reports	200
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 90. Trip value recorder DRPRDRE

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	200

Table 91. Disturbance recorder DRPRDRE

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	352
	Maximum number of disturbance reports	200
Format Types	COMTRADE Format	1999 (Int16) 2013 (Int16) 2013 (Float32)

Relion® 650 series can store up to 10240 security events.

Table 92. Event counter with limit supervision L4UFCNT

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	30 pulses/s (50% duty cycle)	-

Table 93. Running hour-meter TEILGAPC

Function	Range or value	Accuracy
Time limit for alarm supervision, tAlarm	(0 - 99999.9) hours	±0.1% of set value
Time limit for warning supervision, tWarning	(0 - 99999.9) hours	±0.1% of set value
Time limit for overflow supervision	Fixed to 99999.9 hours	±0.1%

Metering

Table 94. Pulse-counter logic PCFCNT

Function	Setting range	Accuracy
Cycle time for report of counter value	(1–3600) s	-

Table 95. Function for energy calculation and demand handling ETPMMTR

Function	Range or value	Accuracy
Energy metering	MWh Export/Import, MVArh Export/Import	Input from CVMMXN. No extra error at steady load

Station communication

Table 96. Communication protocols

Function	Value
Protocol Communication speed for the IEDs	IEC 61850-8-1 100BASE-FX
Protocol Communication speed for the IEDs	IEC 60870–5–103 9600 or 19200 Bd
Protocol Communication speed for the IEDs	DNP3.0 300–115200 Bd
Protocol Communication speed for the IEDs	TCP/IP, Ethernet 100 Mbit/s
Protocol Communication speed for the IEDs	LON 1.25 Mbit/s
Protocol Communication speed for the IEDs	SPA 300–38400 Bd

Table 97. Communication protocols

Function	Value
Protocol TCP/IP Communication speed for the IEDs	Ethernet 100 Mbit/s
Protocol Communication speed for the IEDs	IEC 61850–8–1 100BASE-FX
Protocol Communication speed for the IEDs	DNP3.0/TCP 100BASE-FX
Protocol, serial Communication speed for the IEDs	IEC 60870–5–103 9600 or 19200 Bd
Protocol, serial Communication speed for the IEDs	DNP3.0 300–115200 Bd

Table 98. IEC 61850-9-2 communication protocol

Function	Value
Protocol	IEC 61850-9-2
Communication speed for the IEDs	100BASE-FX

Table 99. LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 100. SPA communication protocol

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800, 9600, 19200 or 38400 Bd
Slave number	1 to 899

Table 101. IEC 60870-5-103 communication protocol

Function	Value
Protocol	IEC 60870-5-103
Communication speed	9600, 19200 Bd

Table 102. SLM – LON port

Quantity	Range or value
Optical connector	Glass fiber: type ST Plastic fiber: type HFBR snap-in
Fiber, optical budget	Glass fiber: 11 dB (1000m/3000 ft typically *) Plastic fiber: 7 dB (10m/35 ft typically *)
Fiber diameter	Glass fiber: 62.5/125 µm Plastic fiber: 1 mm
*) depending on optical budget calculation	

Table 103. SLM – SPA/IEC 60870-5-103/DNP3 port

Quantity	Range or value
Optical connector	Glass fiber: type ST Plastic fiber: type HFBR snap-in
Fiber, optical budget	Glass fiber: 11 dB (1000m/3000 ft typically *) Plastic fiber: 7 dB (25m/80 ft typically *)
Fiber diameter	Glass fiber: 62.5/125 µm Plastic fiber: 1 mm
*) depending on optical budget calculation	

Table 104. Galvanic RS485 communication module

Quantity	Range or value
Communication speed	2400–19200 bauds
External connectors	RS-485 6-pole connector Soft ground 2-pole connector

Table 105. Ethernet redundancy protocols, IEC 62439-3

Function	Value
Protocol	IEC 62439-3 Ed.1 Parallel Redundancy Protocol (PRP-0)
Communication speed	100Base-FX
Protocol	IEC 62439-3 Ed.3 Parallel Redundancy Protocol (PRP-1)
Communication speed	100Base-FX
Protocol	IEC 62439-3 Ed.3 High-availability Seamless Redundancy (HSR)
Communication speed	100Base-FX
Connectors	Optical, type LC or Galvanic, type RJ45

Table 106. Rapid spanning tree protocol (RSTP)

Function	Value
Protocol	IEEE 802.1D Rapid spanning tree protocol (RSTP)
Communication speed	100Base-FX
Connectors	Optical, type LC or Galvanic, type RJ45
Supported topologies	Star, Ring, Ring and star
Maximum number of nodes in a ring	39 IEDs
Performance measurements	Recovery time from single link failure for 9 IEDs + 1 switch is < 45 ms and for 39 IEDs + 1 switch is < 185 ms in ring topology

The recovery time of a link failure on RSTP with the IEDs that are using Galvanic ports is higher than the IEDs with the Optical ports.

Hardware

IED

Table 107. Case

Material	Steel sheet
Front plate	Stainless steel with cut-out for HMI
Surface treatment	Aluzink preplated steel
Finish	Light grey (RAL 7035)

Table 108. Water and dust protection level according to IEC 60529

Front	IP40 (IP54 with sealing strip)
Sides, top and bottom	IP40
Rear side	IP20 with screw compression type IP10 with ring lug terminals

Table 109. Weight

Case size	Weight
6U, 1/2 x 19”	≤ 7.5 kg/16 lb

Electrical safety

Table 110. Electrical safety according to IEC 60255-27

Equipment class	I (protective earthed)
Overvoltage category	III
Pollution degree	2 (normally only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected)

Connection system

Table 111. CT and VT circuit connectors

Connector type	Rated voltage and current	Maximum conductor area
Screw compression type	250 V AC, 20 A	4 mm^2 (AWG12)
Terminal blocks suitable for ring lug terminals	250 V AC, 20 A	4 mm^2 (AWG12)

Table 112. Auxiliary power supply connectors

Connector type	Rated voltage	Maximum conductor area
Screw compression type	250 V AC	2.5 mm^2 (AWG14) 2 × 1 mm^2 (2 x AWG18)
Terminal blocks suitable for ring lug terminals	300 V AC	3 mm^2 (AWG14)

Table 113. Binary I/O connectors

Connector type	Rated voltage	Maximum conductor area
Screw compression type	250 V AC	2.5 mm^2 (AWG14) 2 × 1 mm^2 (2 x AWG18)

Table 114. NUM: Communication ports

NUM	4 Ethernet ports 1 Basic, 3 Optional
Ethernet connection type	SFP Optical LC or Galvanic RJ45

Basic IED functions

Table 115. Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first in-first out

Table 116. Time synchronization, time tagging

Function	Value
Time tagging resolution, events and sampled measurement values	1 ms
Time tagging error with synchronization once/min (minute pulse synchronization), events and sampled measurement values	± 1.0 ms typically
Time tagging error with SNTP synchronization, sampled measurement values	± 1.0 ms typically

Table 117. Time synchronization PTP: IEC/IEEE 61850-9-3

Supported types of clock Accuracy	Boundary Clock (BC), Ordinary Clock (OC), Transparent Clock (TC) According to standard IEC/IEEE 61850-9-3
Number of nodes Ports supported	According to standard IEC/IEEE 61850-9-3 All rear Ethernet ports

Table 118. IRIG-B

Quantity	Rated value
Number of channels IRIG-B	1
Number of optical channels	1
Electrical connector:	
Electrical connector IRIG-B	BNC
Optical connector IRIG-B	Type ST
Type of fiber	62.5/125 μm multimode fiber
Supported formats	IRIG-B 00x
Accuracy	+/- 1μs

Inverse characteristic

Table 119. ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1 \right)} + B \right) \cdot k$$ I = $I_{measured}/I_{set}$	$0.05 \le k \le 999.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0	
ANSI Very inverse	A=19.61, B=0.491, P=2.0	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02	
Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0	
Long Time Very Inverse	A=28.55, B=0.712, P=2.0	
Long Time Inverse	A=0.086, B=0.185, P=0.02	

Table 120. IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$$ I = $I_{measured}/I_{set}$	$0.05 \le k \le 999.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	

The parameter setting *Characteristn = Reserved* (where, n = 1 - 4) shall not be used, since this parameter setting is for future use and not implemented yet.

The parameter setting *Characterist1 and 4/ Reserved* shall not be used, since this parameter setting is for future use and not implemented yet.

Table 121. RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $t = \dfrac{1}{0.339 - \dfrac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 999.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot \ln \dfrac{I}{k}\right)$ $I = I_{measured}/I_{set}$		

Table 122. ANSI Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\dfrac{A}{\left(I^{P} - 1\right)} + B\right) \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 2.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0	
ANSI Very inverse	A=19.61, B=0.491, P=2.0	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02	
Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0	
Long Time Very Inverse	A=28.55, B=0.712, P=2.0	
Long Time Inverse	A=0.086, B=0.185, P=0.02	

Table 123. IEC Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\dfrac{A}{\left(I^{P} - 1\right)}\right) \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 2.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	

Table 124. RI and RD type inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	**Range or value**	**Accuracy**
RI type inverse characteristic $t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 2.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot ln \frac{I}{k}\right)$ $I = I_{measured}/I_{set}$		

Table 125. Inverse time characteristics for overvoltage protection

Function	**Range or value**	**Accuracy**
Type A curve: $t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$ $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5% +60 ms
Type B curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U_n>}{U_n>} - 0.5\right)^{2.0}} + 0.035$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U_n>}{U>} - 0.5\right)^{3.0}} + 0.035$	k = (0.05-1.10) in steps of 0.01	

Table 126. Inverse time characteristics for undervoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U< -U}{U<}\right)}$$ U< = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5% +60 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< -U}{U<} - 0.5\right)^{2.0}} + 0.055$$ U< = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	

Table 127. Inverse time characteristics for residual overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ U> = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5% +70 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	

20. Ordering for pre-configured IED

Guidelines
Carefully read and follow the set of rules to ensure problem-free order management.
Please refer to the available functions table for included application functions.
PCM600 can be used to make changes and/or additions to the delivered factory configuration of the pre-configured.

To obtain the complete ordering code, please combine code from the tables, as given in the example below.

Example code: REB650*2.2-A03X00-P23-B1A12-AA-CA-B-A3-CD1AX-KXXXXXLXGX. Using the code of each position #1-11 specified as REB650*1-2 2-3-4 4-5 6-7 7-8-9 9-10 10-10-11 11 11

	Product version		Configuration alternatives			Software options			Language		
#	1	-	2		-	3		-	4		-
REB650*	2.2	-			-			-			-

Casing and Mounting			Power supply			HMI		Analog system		
5	6	-	7		-	8	-	9		-
		-			-		-			-

Binary input/output modules					Station communication and time synchronization									
10				-	11									
				-										X

	Position	
Product version	#1	Notes and rules
Version no.	2.2	
Selection for position #1	2.2	

Configuration alternatives	Ordering no	#2		Notes and rules
Busbar protection, 2 zones/1 checkzone, 3 phase high impedance	1MRK008006-AG	A03		
ACT configuration				
Hitachi Power Grids standard configuration			X00	
	Selection for position #2			

Software options	Ordering no	#3	Notes and rules
No option		X00	1)
IEC 62439-3 Parallel redundancy protocol	1MRK004001-PP	P23	2)
IEC 62439-3 High-availability seamless redundancy	1MRK004001-PR	P24	
Rapid spanning tree protocol	1MRK004001-PY	P25	
IEC 61850-9-2 Process Bus communication, 4 merging units	1MRK004001-PU	P31	
	Selection for position #3		

1) All fields in the ordering form do not need to be filled in.
2) Options P23, 24 and P25 require two SFPs placed in pairs.

Language	Ordering no	#4		Notes and rules
First local HMI user dialogue language				
HMI language, English IEC	1MRK002930-AA	B1		
Additional local HMI user dialogue language				
No additional HMI language			X0	
HMI language, English US	1MRK002920-UB		A12	
	Selection for position #4	B1		

Casing	Ordering no	#5	Notes and rules
1/2 x 19" rack casing, 1 TRM	1MRK000151-VA	A	
	Selection for position #5	A	

Mounting details with IP40 of protection from the front	Ordering no	#6	Notes and rules
No mounting kit included		X	
19" rack mounting kit for 1/2 x 19" case or 2xRHGS6 or RHGS12	1MRK002420-BB	A	
19" rack mounting kit for 3/4 x 19" case or 3xRHGS6	1MRK002420-BA	B	
19" rack mounting kit for 1/1 x 19" case	1MRK002420-CA	C	
Wall mounting kit	1MRK002420-DA	D	1)
Flush mounting kit	1MRK002420-PA	E	
Flush mounting kit + IP54 mounting seal	1MRK002420-NA	F	
	Selection for position #6		

1) Wall mounting not recommended with communication modules with fiber connection

Power supply modules	Ordering no	#7		Notes and rules
Compression terminals	1MRK002960-GA	C		
Ringlug terminals	1MRK002960-HA	R		
Power supply module, 24-60 VDC	1MRK002239-AB		A	
Power supply module, 90-250 VDC	1MRK002239-BB		B	
	Selection for position #7			

Human machine hardware interface	Ordering no	#8	Notes and rules
Medium size - graphic display, IEC keypad symbols	1MRK000028-AA	B	
Medium size - graphic display, ANSI keypad symbols	1MRK000028-AB	C	
Blank front, IEC symbols	1MRK000030-AA	D	
Blank front, ANSI symbols	1MRK000030-AB	E	
	Selection for position #8		

Analog system	Ordering no	#9	Notes and rules
Slot position (front view/rear view)		P40/X401	
No Transformer input module included		X0	1)
TRM 9I 1A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BG	A3	
TRM 9I 5A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BH	A4	
TRM 9I 1A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BC	B3	
TRM 9I 5A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BD	B4	
	Selection for position #9		

1) Only valid if IEC 61850-9-2 Process bus communication is selected.

Binary input/output modules	Ordering no	#10				Notes and rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1 BIM required in position P3 and 1 BOM always included in position P4.						
Slot position (front view/rear view)			P3/X31	P4/X41	P5/X51	1)
1/2 case with 1 TRM			■	■	■	
Compression terminals	1MRK002960-KA	C				
No board in slot					X	
Binary output module 24 output relays (BOM)	1MRK000614-AB			A	A	
BIM 16 inputs, RL24, 24-30VDC, 50mA	1MRK000508-DD		B1		B1	
BIM 16 inputs, RL48, 48-60VDC, 50mA	1MRK000508-AD		C1		C1	
BIM 16 inputs, RL110, 110-125VDC, 50mA	1MRK000508-BD		D1		D1	
BIM 16 inputs, RL220, 220-250VDC, 50mA	1MRK000508-CD		E1		E1	
BIM 16 inputs, RL220, 220-250VDC, 120mA	1MRK000508-CE		E2		E2	
BIM, with enhanced pulse counting, 16 inputs, RL24, 24-30VDC, 50mA	1MRK000508-HA				F	
BIM, with enhanced pulse counting, 16 inputs, RL48, 48-60VDC, 50mA	1MRK000508-EA				G	
BIM, with enhanced pulse counting, 16 inputs, RL110, 110-125VDC, 50mA	1MRK000508-FA				H	
BIM, with enhanced pulse counting, 16 inputs, RL220, 220-250VDC, 50mA	1MRK000508-GA				K	
IOM, 8 inputs, RL 24-30 VDC, 50mA, + 10 + 2 output relays	1MRK000173-GD				L1	
IOM, 8 inputs, RL 48-60 VDC, 50mA, + 10 + 2 output relays	1MRK000173-AE				M1	
IOM, 8 inputs, RL 110-125 VDC, 50mA, + 10 + 2 output relays	1MRK000173-BE				N1	
IOM, 8 inputs, RL 220-250 VDC, 50mA, + 10 + 2 output relays	1MRK000173-CE				P1	
IOM, 8 inputs, RL 220-250 VDC, 110mA, + 10 + 2 output relays	1MRK000173-CF				P2	
IOM, with MOV 8 inputs, RL 24-30 VDC, 50mA, + 10 + 2 output relays	1MRK000173-GC				U	
IOM, with MOV 8 inputs, RL 48-60 VDC, 50mA, + 10 + 2 output relays	1MRK000173-AD				V	
IOM, with MOV 8 inputs, RL 110-125 VDC, 50mA, + 10 + 2 output relays	1MRK000173-BD				W	
IOM, with MOV 8 inputs, RL 220-250 VDC, 50mA, + 10 + 2 output relays	1MRK000173-CD				Y	
	Selection for position #10	C				

1) Max 3 positions in 1/2 rack

Station communication and time synchronization	Ordering no	#11										Notes and rules
Slot position (front view/rear view)		P30:1/X301	P30:2/X302	P30:3/X303	P30:4/X304	P30:6:1/X3061	P30:6:2/X3062	P31:1/X311	P31:2/X312	P31:3/X313	LDCM mode	
Available slots in 1/2 case with 1 TRM		■	■	■	■	■	■	■	■	■		
No communication board included			X	X	X	X	X	X	X	X	X	
Ethernet SFP, optical LC connector	1MRK005500-AA	K	K	K	K							1)
Ethernet SFP, RJ45 connector	1MRK005500-BA	P	P	P	P							
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	1MRK001608-AB							L				
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/ glass interface	1MRK001608-BB							M				
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	1MRK001608-CB							N				
Galvanic RS485 communication module	1MRK002309-AA									G		
Line data communication, default 64kbps mode	—										X	2)
IRIG-B time synchronization module, with PPS	1MRK002305-AA								F	F		
	Selection for position #11										X	

1) Ethernet SFP is basic in P30:1.
2) LDCM is not applicable.

21. Ordering for Accessories

Accessories

Test switch

The test system COMBITEST intended for use with the IEDs is described in 1MRK 512 001-BEN and 1MRK 001024-CA. Please refer to the website: www.hitachiabb-powergrids.com/protection-control for detailed information.

Due to the high flexibility of our product and the wide variety of applications possible the test switches needs to be selected for each specific application.

Select your suitable test switch based on the available contacts arrangements shown in the reference documentation.

However our proposals for suitable variants are:

RK926 315-AV is provided with one three-phase CT input with current shorting and with sixteen trip output blocking contacts. It is suitable when external CT grounding is required both for the three-phase version and single-phase versions. One such switch is then used per bay. With such arrangement the best possible test facilities for BBP & integrated BFP are available

Test switches type RTXP 24 is ordered separately. Please refer to Section Related documents for references to corresponding documents.

RHGS 6 Case or RHGS 12 Case with mounted RTXP 24 and the on/off switch for DC-supply are ordered separately. Please refer to Section Related documents for references to corresponding documents.

Protection cover

Protective cover for rear side of RHGS6, 6U, 1/4 x 19”	Quantity:	☐	1MRK 002 420-AE
Protective cover for rear side of terminal, 6U, 1/2 x 19”	Quantity:	☐	1MRK 002 420-AC

External resistor unit

High impedance resistor unit with resistor and voltage dependent resistor 20-100V, 1ph	Quantity:	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐	RK 795 101-MA
High impedance resistor unit with resistor and voltage dependent resistor 20-100V, 3ph	Quantity:	1 ☐ 2 ☐	RK 795 101-MB
High impedance resistor unit with resistor and voltage dependent resistor 100-400V, 1ph	Quantity:	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐	RK 795 101-CB
High impedance resistor unit with resistor and voltage dependent resistor 100-400V, 3ph	Quantity:	1 ☐ 2 ☐	RK 795 101-DC

Combiflex

Key switch for settings

Key switch for lock-out of settings via LHMI	Quantity:	☐	1MRK 000 611-A

Note: To connect the key switch, leads with 10 A Combiflex socket on one end must be used.

Mounting kit

Side-by-side mounting kit	Quantity:	☐	1MRK 002 420-Z

Configuration and monitoring tools

Front connection cable between LHMI and PC	Quantity:	☐	1MRK 001 665-CA
LED Label special paper A4, 1 pc	Quantity:	☐	1MRK 002 038-CA
LED Label special paper Letter, 1 pc	Quantity:	☐	1MRK 002 038-DA

Manuals

Note: One (1) IED Connect USB flash drive containing user documentation (Operation manual, Technical manual, Installation manual, Commissioning manual, Application manual and Getting started guide), Connectivity packages and LED label template is always included for each IED.

Specify additional quantity of IED Connect USB flash drive requested.	Quantity:	☐	1MRK 003 500-AB

User documentation

Specify the number of printed manuals requested

Application manual	IEC	Quantity:	☐	1MRK 505 388-UEN
Technical manual	IEC	Quantity:	☐	1MRK 505 389-UEN
Commissioning manual	IEC	Quantity:	☐	1MRK 505 390-UEN
Communication protocol manual, IEC 61850 Edition 1	IEC	Quantity:	☐	1MRK 511 414-UEN
Communication protocol manual, IEC 61850 Edition 2	IEC	Quantity:	☐	1MRK 511 415-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity:	☐	1MRK 511 416-UEN
Communication protocol manual, LON	IEC	Quantity:	☐	1MRK 511 417-UEN
Communication protocol manual, SPA	IEC	Quantity:	☐	1MRK 511 418-UEN
Communication protocol manual, DNP	ANSI	Quantity:	☐	1MRK 511 413-UUS
Point list manual, DNP	ANSI	Quantity:	☐	1MRK 511 419-UUS
Operation manual	IEC	Quantity:	☐	1MRK 500 128-UEN
Installation manual	IEC	Quantity:	☐	1MRK 514 027-UEN
Engineering manual	IEC	Quantity:	☐	1MRK 511 420-UEN
Cyber security deployment guideline	IEC	Quantity:	☐	1MRK 511 421-UEN
Application guide, Communication set-up	IEC	Quantity:	☐	1MRK 505 382-UEN

Reference information

For our reference and statistics we would be pleased to be provided with the following application data:

Country:		End user:	
Station name:		Voltage level:	kV

Related documents

Documents related to REB650	Document numbers
Application manual	1MRK 505 388-UEN
Commissioning manual	1MRK 505 390-UEN
Product guide	1MRK 505 391-BEN
Technical manual	1MRK 505 389-UEN
Type test certificate	1MRK 505 391-TEN

650 series manuals	Document numbers
Operation manual	1MRK 500 128-UEN
Engineering manual	1MRK 511 420-UEN
Installation manual	1MRK 514 027-UEN
Communication protocol manual, DNP3	1MRK 511 413-UUS
Communication protocol manual, IEC 60870-5-103	1MRK 511 416-UEN
Communication protocol manual, IEC 61850 Edition 1	1MRK 511 414-UEN
Communication protocol manual, IEC 61850 Edition 2	1MRK 511 415-UEN
Communication protocol manual, LON	1MRK 511 417-UEN
Communication protocol manual, SPA	1MRK 511 418-UEN
Point list manual, DNP3	1MRK 511 419-UUS
Accessories guide	IEC: 1MRK 514 012-UEN ANSI: 1MRK 514 012-UUS
Cyber security deployment guideline	1MRK 511 421-UEN
Connection and Installation components	1MRK 513 003-BEN
Test system, COMBITEST	1MRK 512 001-BEN
Application guide, Communication set-up	1MRK 505 382-UEN
User guide, RIA600	1MRK 511 619-UEN

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