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HITACHI

Relion 670 series

Busbar protection REB670
Version 2.1
Product guide



Hitachi Energy



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Section 1 Application

The IED is designed for the selective, reliable and fast differential protection of busbars, T-connections and meshed corners. It can be used for protection of single and double busbar with or without transfer bus, double circuit breaker or one-and-half circuit breaker stations. The IED is applicable for the protection of medium voltage (MV), high voltage (HV) and extra high voltage (EHV) installations at a power system frequency of 50Hz or 60Hz. It can detect all types of internal phase-to-phase and phase-to-earth faults in solidly earthed or low impedance earthed power systems, as well as all internal multi-phase faults in isolated or high-impedance earthed power systems.

Ordering of VT inputs inside of the busbar protection IED will allow integration of voltage related functionality like under-voltage release, residual over-voltage, power functions, metering and voltage recording during the faults. However attention shall be given to the fact that inclusion of VT inputs will reduce number of available CT inputs (in total 24 analogue inputs are the product limit). Consequently when VT inputs are ordered the busbar protection IED will be applicable for buses with a fewer number of bays. Practically the number of available CT inputs will limit the size of the station which can be protected.

The IED has very low requirements on the main current transformers (that is, CTs) and no interposing current transformers are necessary. For all applications, it is possible to include and mix main CTs with 1A and 5A rated secondary current within the same protection zone. Typically, CTs with up to 10:1 ratio difference can be used within the same differential protection zone. Adjustment for different main CT ratios is achieved numerically by a parameter setting.

The numerical, low-impedance differential protection function is designed for fast and selective protection for faults within protected zone. All connected CT inputs are provided with a restraint feature. The minimum pick-up value for the differential current is set to give a suitable sensitivity for all internal faults. The pick-up setting for the fault current must be less than 80% of the lowest fault current that can occur on the protected bus bars. If the minimum fault current is high enough, the set value should be set higher than the maximum load current.. This setting is made directly in primary amperes. The operating slope for the differential operating characteristic is fixed to 53% in the algorithm.

The fast tripping time (shortest trip time is 5ms) of the low-impedance differential protection function is especially advantageous for power system networks with high fault levels or where fast fault clearance is required for power system stability.

All CT inputs are provided with a restraint feature. The operation is based on the well-proven RADSS percentage restraint stabilization principle, with an extra stabilization feature to stabilize for very heavy CT saturation. Stability for external faults is guaranteed if a CT is not saturated for at least two milliseconds during each power system cycle.

The advanced open CT detection algorithm detects instantly the open CT secondary circuits and prevents differential protection operation without any need for additional check zone.

Differential protection zones in the IED include a sensitive operational level. This sensitive operational level is designed to be able to detect internal busbar earth faults in low impedance earthed power systems (that is, power systems where the earth-fault current is limited to a certain level, typically between 300A and 2000A primary by a neutral point reactor or resistor). Alternatively this sensitive level can be used when high sensitivity is required from busbar differential protection (that is, energizing of the bus via long line).

Overall operating characteristic of the differential function in the IED is shown in Figure 1.

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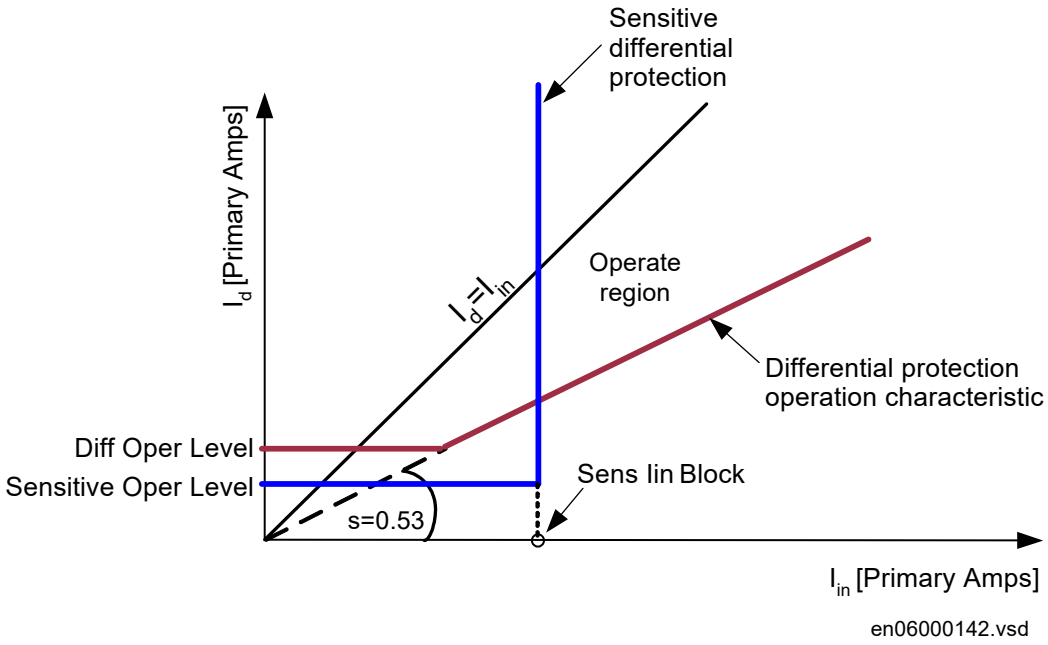


Figure 1: IED operating characteristic

Integrated overall check zone feature, independent from any disconnector position, is available. It can be used in double busbar stations to secure stability of the busbar differential protection in case of entirely wrong status indication of busbar disconnector in any of the feeder bays.

Flexible, software based dynamic Zone Selection enables easy and fast adaptation to the most common substation arrangements such as single busbar with or without transfer bus, double busbar with or without transfer bus, one-and-a-half breaker stations, double busbar-double breaker stations, ring busbars, and so on. The software based dynamic Zone Selections ensures:

- Dynamic linking of measured CT currents to the appropriate differential protection zone as required by substation topology
- Efficient merging of the two differential zones when required by substation topology (that is load-transfer)
- Selective operation of busbar differential protection ensures tripping only of circuit breakers connected to the faulty zone
- Correct marshaling of backup-trip commands from internally integrated or external circuit breaker failure protections to all surrounding circuit breakers
- Easy incorporation of bus-section and/or bus-coupler bays (that is, tie-breakers) with one or two sets of CTs into the protection scheme
- Disconnector and/or circuit breaker status supervision

Advanced Zone Selection logic accompanied by optionally available end-fault and/or circuit breaker failure protections ensure minimum possible tripping time and selectivity for faults within the blind spot or the end zone between bay CT and bay circuit breaker. Therefore the IED offers best possible coverage for such faults in feeder and bus-section/bus-coupler bays.

Optionally available circuit breaker failure protection, one for every CT input into the IED, offers secure local back-up protection for the circuit breakers in the station.

Optionally available four-stage, non-directional overcurrent protections, one for every CT input into the IED, provide remote backup functionality for connected feeders and remote-end stations.

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Optionally available voltage and frequency protection functions enable to include voltage release criterion for busbar protection or to integrate independent over-, under-voltage protection for the bus in the busbar protection IED.

Optionally available over-current, thermal overload and capacitor bank protection functions open possibilities to integrate protection of shunt reactors and shunt capacitor banks into the busbar protection IED.

It is normal practice to have just one busbar protection IED per busbar. Nevertheless some utilities do apply two independent busbar protection IEDs per zone of protection. This IED fits both solutions.

A simplified bus differential protection for multi-phase faults and earth faults can be obtained by using a single, one-phase IED with external auxiliary summation current transformers.

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, IOM & SOM) 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 61850 model of the IED. This customer model will be exposed in all IEC 61850 communication, 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

Optional apparatus control for up to 30 objects can provide a facility to draw simplified single line diagram (SLD) of the station on the local HMI.

1.1 Description of pre-configured packages

There are five pre-configured variants of REB670. They are describe in the following Table:

Table 1: REB670 pre-configured packages

	12 AI max 3*IO Cards 1/2 of 19" rack	**24 AI max 11*IO Cards full 19" rack**
3Ph, 4 bays, 2 zone BFP & OC protection optional!	Used for small, fixed zones like T protection, meshed corner, H-scheme, ring bus etc. **REB670-A20**	Not applicable
3Ph, 8 bays, 2 zone BFP & OC protection optional!	Not applicable	Used for substations/zones with up to 8 CT inputs. **REB670-A31**
1Ph, 12 bays, 2 zone (three IEDs required) BFP & OC protection optional!	Used for substation with up to 12 CT inputs. **Only three IO cards available** No extension possibilities to 24 CT inputs! Good solution for stations with fixed zones (i.e. one-and-half breaker station). **REB670-B20**	Used for substation with up to 12 CT inputs. Possible to extend up to 24 CT inputs. Optional LDCMs can be used to share binary IO. **REB670-B21**
Table continues on next page		

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	12 AI max 3*IO Cards 1/2 of 19" rack	24 AI max 11*IO Cards full 19" rack
1Ph, 24 bays, 2 zone (three IEDs required) BFP & OC protection optional!	Not applicable	Used for substation with up to 24 CT inputs. Optional LDCMs can be used to share binary IO. **REB670-B31**

1.2 Available ACT configurations for pre-configured REB670

Three configurations have been made available for pre-configured REB670 IED. It shall be noted that all three configurations include the following features:

- fully configured for the total available number of bays in each REB670 variant
- facility to take any bay out of service via the local HMI or externally via binary input
- facility to block any of the two zones via the local HMI or externally via binary input
- facility to block all bay trips via the local HMI or externally via binary input, but leaving all other function in service (that is BBP Zones, BFP and OCP where applicable)
- facility to externally initiate built-in disturbance recorder
- facility to connect external breaker failure backup trip signal from every bay
- facility to connect external bay trip signal

1.3 Configuration X01

This configuration includes only busbar protection for simple stations layouts (in other words, one-and-a-half breaker, double breaker or single breaker stations). Additionally it can be used for double busbar-single breaker stations where disconnector replica is done by using only b auxiliary contact from every disconnector and/or circuit breakers. As a consequence no disconnector/breaker supervision will be available. It is as well possible to adapt this configuration by the signal matrix tool to be used as direct replacement of RED521 terminals. This configuration is available for all five REB670 variants (that is A20, A31, B20, B21 & B31). It shall be noted that optional functions breaker failure protection CCRBRF, end fault protection and overcurrent protection PH4SPTOC can be ordered together with this configuration, but they will not be pre-configured. Thus these optional functions shall be configured by the end user.

1.4 Configuration X02

This configuration includes only busbar protection for double busbar-single breaker stations, where Zone Selection is done by using a and b auxiliary contacts from every disconnector and/or circuit breaker. Thus full disconnector/breaker supervision is available. This configuration is available for only three REB670 variants (that is A31, B21 and B31). It shall be noted that optional functions breaker failure protection CCRBRF, end fault protection and overcurrent protection PH4SPTOC can be ordered together with this configuration, but they will not be pre-configured. Thus these optional functions shall be configured by the end user.

1.5 Configuration X03

This configuration includes BBP with breaker failure protection CCRBRF, end fault protection and overcurrent protection PH4SPTOC for double busbar-single breaker stations, where Zone Selection is done by using a and b auxiliary contacts from every disconnectors and/or circuit

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breakers. Thus full disconnector/breaker supervision is available. This configuration is available for only three REB670 variants (that is A31, B21 and B31).

In order to use X03 configuration, optional breaker failure and overcurrent functions must be ordered.

1.6 Application examples of REB670

Examples of typical station layouts, which can be protected with REB670 are given below:

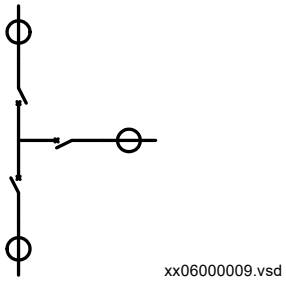


Figure 2: Example of T-connection

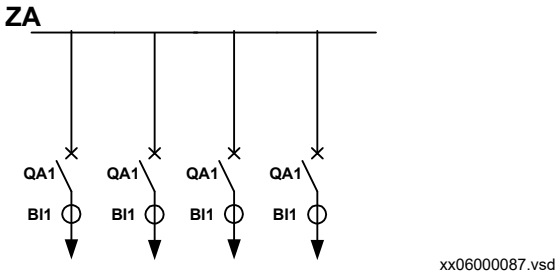


Figure 3: Example of single busbar section with feeder bays

Table 2: Typical solutions for single busbar arrangement

Version of REB670 pre-configured IED	Numbers of feeders per busbar	Number of REB670 IEDs required for the scheme
3PH; 2-zones, 4-bays BBP (A20)	4	1
3PH; 2-zones, 8-bays BBP (A31)	8	1
1Ph; 2-zones, 12-bays BBP (B20)	12	3
1Ph; 2-zones, 12-bays BBP (B21)	12	3
1Ph; 2-zones, 24-bays BBP (B31)	24	3

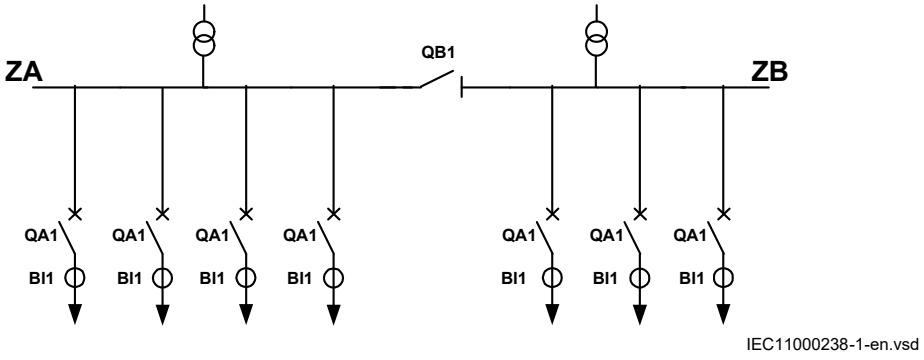


Figure 4: Example of two busbar sections connected with bus-sectionalizing disconnector

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Table 3: Typical solutions for stations with two busbar sections connected with bus-sectionalizing disconnector

Version of REB670 pre-configured IED	Total Number of feeders in both busbar sections	Number of REB670 IEDs required for the scheme
3PH; 2-zones, 4-bays BBP (A20)	4	1
3PH; 2-zones, 8-bays BBP (A31)	8	1
1Ph; 2-zones, 12-bays BBP (B20)	12	3
1Ph; 2-zones, 12-bays BBP (B21)	12	3
1Ph; 2-zones, 24-bays BBP (B31)	24	3

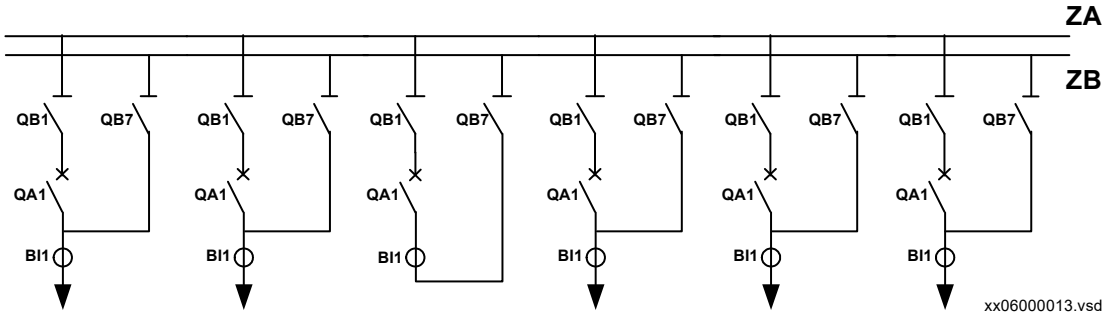


Figure 5: Example of single bus station with transfer bus

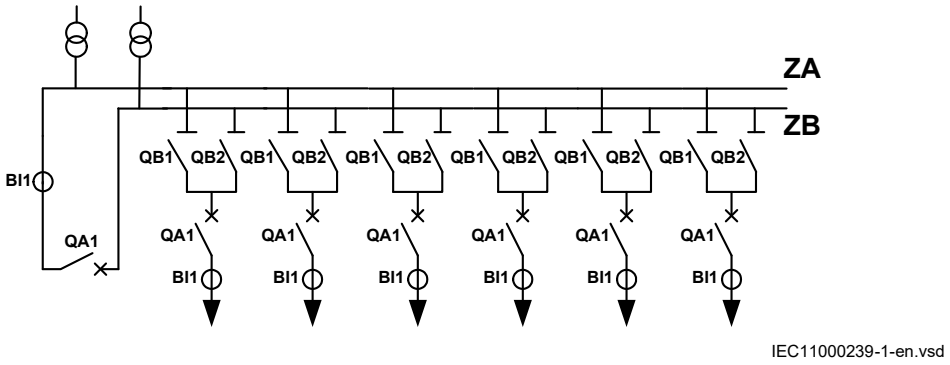


Figure 6: Example of double bus-single breaker station

Table 4: Typical solutions for double bus-single breaker stations

Version of REB670 pre-configured IED	Number of feeders in the station (excluding bus-coupler bay)	Number of REB670 IED required for the scheme
3PH; 2-zones, 4-bays BBP (A20)	3*)	1
3PH; 2-zones, 8-bays BBP (A31)	7*)	1
1Ph; 2-zones, 12-bays BBP (B20)	NA	NA
1Ph; 2-zones, 12-bays BBP (B21)	11*)	3
1Ph; 2-zones, 24-bays BBP (B31)	23*)	3
*) with just one CT input from bus-coupler bay		

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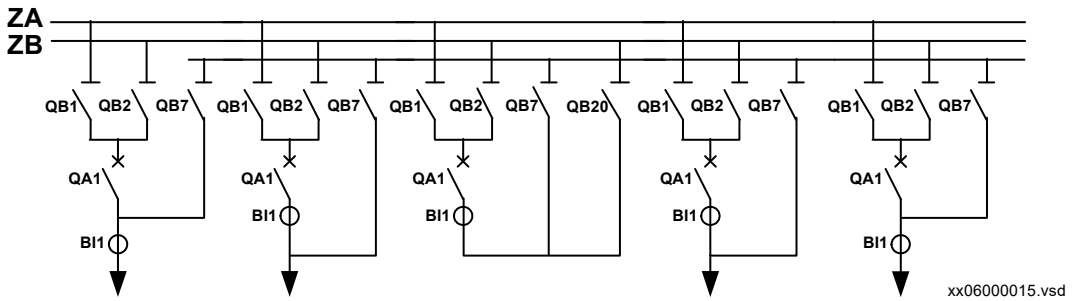


Figure 7: Example of double bus-single breaker station with transfer bus

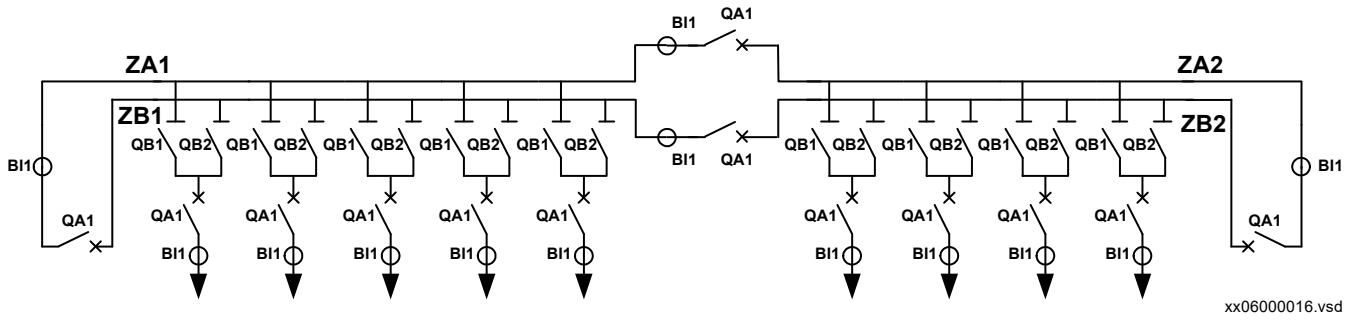


Figure 8: Example of double bus-single breaker station with two bus-section and two bus-coupler breakers (typical GIS station layout)

Table 5: Possible solutions for a typical GIS station

Version of REB670 pre-configured IED	Number of feeders on each side of the station (excluding bus-coupler & bus-section bays)	Number of REB670 IEDs required for the scheme
3PH; 2-zones, 4-bays BBP (A20)	NA	NA
3PH; 2-zones, 8-bays BBP (A31)	5*)	2
1Ph; 2-zones, 12-bays BBP (B20)	NA	NA
1Ph; 2-zones, 12-bays BBP (B21)	9*)	6
1Ph; 2-zones, 24-bays BBP (B31)	21*)	6
*) with just one CT input from bus-coupler bay		

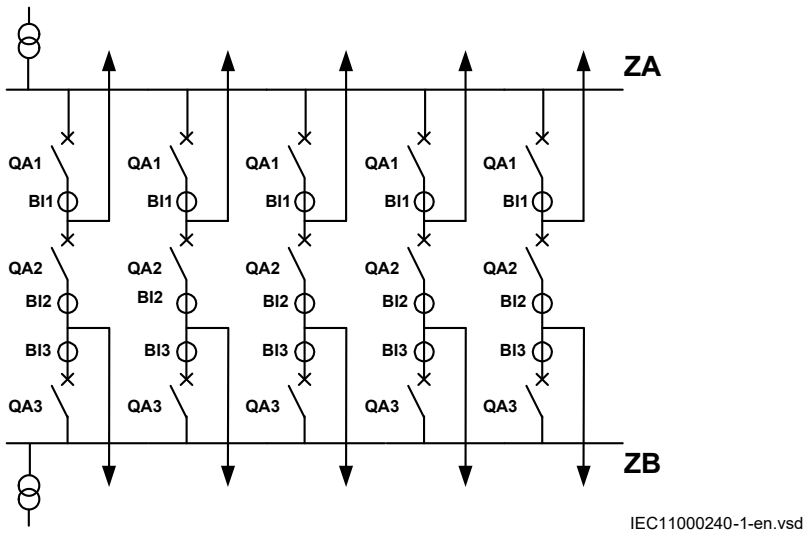


Figure 9: Example of one-and-a-half breaker station

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Table 6: Typical solutions for one-and-half circuit breaker stations when CBF for middle breaker is not required

Version of REB670 pre-configured IED	Number of diameters in the station	Number of REB670 IEDs required for the scheme
3PH; 2-zones, 4-bays BBP (A20)	2/4	1/2
3PH; 2-zones, 8-bays BBP (A31)	4/8	1/2
1Ph; 2-zones, 12-bays BBP (B20)	6/12	3/6
1Ph; 2-zones, 12-bays BBP (B21)	6/12	3/6
1Ph; 2-zones, 24-bays BBP (B31)	12/24	3/6

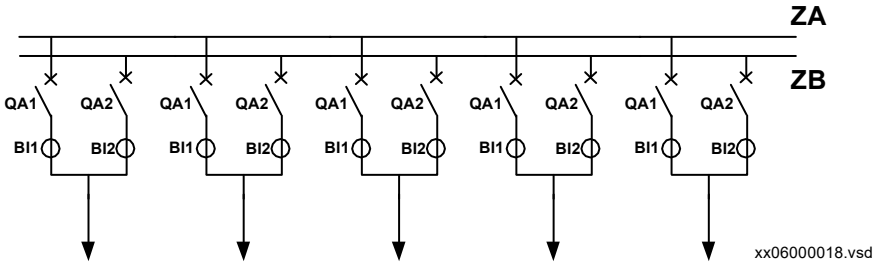


Figure 10: Example of double bus-double breaker station

Table 7: Typical solutions for double circuit breaker busbar arrangement

Version of REB670 pre-configured IED	Numbers of feeders per station	Number of REB670 IEDs required for the scheme
3PH; 2-zones, 4-bays BBP (A20)	4	2
3PH; 2-zones, 8-bays BBP (A31)	4/8	1/2
1Ph; 2-zones, 12-bays BBP (B20)	6/12	3/6
1Ph; 2-zones, 12-bays BBP (B21)	6/12	3/6
1Ph; 2-zones, 24-bays BBP (B31)	12/24	3/6

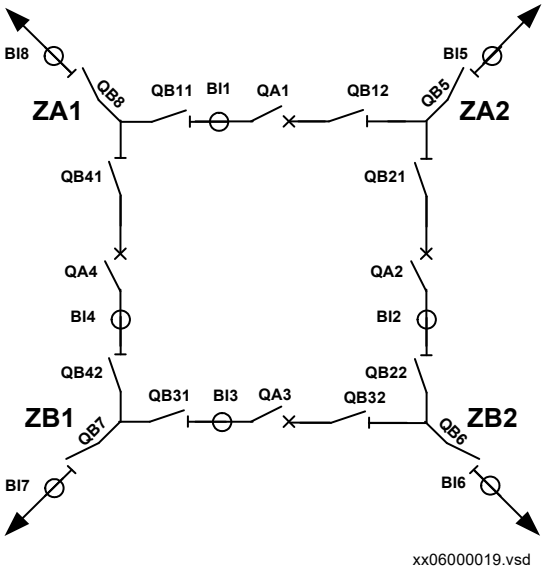


Figure 11: Example of mesh or ring bus station

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Note that customized REB670 is delivered without any configuration. Thus the complete IED engineering shall be done by the customer or its system integrator. In order to secure proper operation of the busbar protection it is strictly recommended to always start engineering work from the PCM600 project for the pre-configured REB670 which is the closest to the actual application. Then, necessary modifications shall be applied in order to adopt the customized IED configuration to suite the actual station layout. The PCM600 project for the pre-configured REB670 IEDs is available in the Connectivity Package DVD.

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Section 2 Available functions

2.1 Main protection functions

Table 8: Example of quantities

2	= number of basic instances
0-3	= option quantities
3-A03	= optional function included in packages A03 (refer to ordering details)

IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
Differential protection								
BUTPTRC, BCZTPDIF, BZNTPDIF, BZITGGIO, BUTSM4	87B	Busbar differential protection, 2 zones, three phase/4 bays		1				
BUTPTRC, BCZTPDIF, BZNTPDIF, BZITGGIO, BUTSM8	87B	Busbar differential protection, 2 zones, three phase/8 bays	1		1			
BUSPTRC, BCZSPDIF, BZNSPDIF, BZISGGIO, BUSSM12	87B	Busbar differential protection, 2 zones, single phase/12 bays				1	1	
BUSPTRC, BCZSPDIF, BZNSPDIF, BZISGGIO, BUSSM24	87B	Busbar differential protection, 2 zones, single phase/24 bays	1					1
BDCGAPC		Status of primary switching object for busbar protection zone selection	96	20	40	60	60	96

2.2 Back-up protection functions

IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
Current protection								
OC4PTOC	51_67 [1]	Four step phase overcurrent protection	0-8	4-C06	8-C07			
PH4SPTOC	51	Four step single phase overcurrent protection	0-24			12-C08	12-C08	24-C09

Table continues on next page

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IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
EF4PTOC	51N_67N [2]	Four step residual overcurrent protection	0-8					
NS4PTOC	46I2	Four step directional negative phase sequence overcurrent protection	0-8					
TRPTTR	49	Thermal overload protection, two time constant	0-2					
CCRBRF	50BF	Breaker failure protection	0-8	4-C10	8-C11			
CCSRBRF	50BF	Breaker failure protection, single phase version	0-24			12-C12	12-C12	24-C13
GUPPDUP	37	Directional underpower protection	0-4					
GOPPDOP	32	Directional overpower protection	0-4					
CBPGAPC		Capacitor bank protection	0-2					
Voltage protection								
UV2PTUV	27	Two step undervoltage protection	0-2					
OV2PTOV	59	Two step overvoltage protection	0-2					
ROV2PTOV	59N	Two step residual overvoltage protection	0-2					
VDCPTOV	60	Voltage differential protection	0-2					
LOVPTUV	27	Loss of voltage check	0-2					
Frequency protection								
SAPTUF	81	Underfrequency protection	0-6					
SAPTOF	81	Overfrequency protection	0-6					
SAPFRC	81	Rate-of-change frequency protection	0-6					
Multipurpose protection								
CVGAPC		General current and voltage protection	0-6					

Table Note:
[1] 67 requires voltage
[2] 67N requires voltage

2.3 Control and monitoring functions

IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
Control								

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IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
SESRSYN	25	Synchrocheck, energizing check and synchronizing	0-3					
SMBRREC	79	Autorecloser	0-2	2-H05	2-H05	2-H05	2-H05	2-H05
APC30	3	Apparatus control for up to 6 bays, max 30 apparatuses (6CBs) incl. interlocking	0-1					
QCBAY		Apparatus control	1+5/APC30	1	1	1	1	1
LOCREM		Handling of LRswitch positions	1+5/APC30	1	1	1	1	1
LOCREMCTRL		LHMI control of PSTO	1+5/APC30	1	1	1	1	1
SLGAPC		Logic rotating switch for function selection and LHMI presentation	15	15	15	15	15	15
VSGAPC		Selector mini switch	20	20	20	20	20	20
DPGAPC		Generic communication function for Double Point indication	16	16	16	16	16	16
SPC8GAPC		Single point generic control 8 signals	5	5	5	5	5	5
AUTOBITS		Automation bits, command function for DNP3.0	3	3	3	3	3	3
SINGLECMD		Single command, 16 signals	4	4	4	4	4	4
I103CMD		Function commands for IEC 60870-5-103	1	1	1	1	1	1
I103GENCMD		Function commands generic for IEC 60870-5-103	50	50	50	50	50	50
I103POSCMD		IED commands with position and select for IEC 60870-5-103	50	50	50	50	50	50
I103POSCMDV		IED direct commands with position for IEC 60870-5-103	50	50	50		50	50
I103IEDCMD		IED commands for IEC 60870-5-103	1	1	1	1	1	1
I103USRCMD		Function commands user defined for IEC 60870-5-103	4	4	4	4	4	4
Secondary system supervision								
FUFSPVC		Fuse failure supervision	0-2					
VDSPVC	60	Fuse failure supervision based on voltage difference	0-2					
Logic								
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, SRMEMORY, TIMERSET, XOR		Basic configurable logic blocks (see Table 9)	40-420	40-280	40-280	40-280	40-280	40-280

Table continues on next page

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IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
ANDQT, INDCOMBSPQT, INDEXTSPQT, INVALIDQT, INVERTERQT, ORQT, PULSETIMERQT, RSMEMORYQT, SRMEMORYQT, TIMERSETQT, XORQT		Configurable logic blocks Q/T (see Table 10)	0-1					
AND, GATE, INV, LLD, OR, PULSETIMER, SLGAPC, SRMEMORY, TIMERSET, VSGAPC, XOR		Extension logic package (see Table 11)	0-1					
FXDSIGN		Fixed signal function block	1	1	1	1	1	1
B16I		Boolean 16 to Integer conversion	18	18	18	18	18	18
BTIGAPC		Boolean 16 to Integer conversion with Logic Node representation	16	16	16	16	16	16
IB16		Integer to Boolean 16 conversion	18	18	18	18	18	18
ITBGAPC		Integer to boolean conversion with logical node representation, 16 bit	16	16	16	16	16	16
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12	12	12
INTCOMP		Comparator for integer inputs	12	12	12	12	12	12
REALCOMP		Comparator for real inputs	12	12	12	12	12	12
Monitoring								
CVMMXN, VMMXU, CMSQI, VMSQI, VNMMXU		Measurements	6	6	6	6	6	6
CMMXU		Measurements	10	10	10	10	10	10
AISVBAS		Function block for service value presentation of secondary analog inputs	1	1	1	1	1	1
EVENT		Event function	20	20	20	20	20	20
DRPRDRE, A1RADR-A4RADR, B1RBDR-B22RBDR		Disturbance report	1	1	1	1	1	1
SPGAPC		Generic communication function for Single point indication	64	64	64	64	64	64
SP16GAPC		Generic communication function for Single point indication 16 inputs	16	16	16	16	16	16

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IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
MVGAPC		Generic communication function for Measured value	24	24	24	24	24	24
BINSTATREP		Logical signal status report	3	3	3	3	3	3
RANGE_XP		Measured value expander block	28	28	28	28	28	28
SSIMG	63	Gas medium supervision	21					
SSIML	71	Liquid medium supervision	3	3	3	3	3	3
SSCBR		Circuit breaker condition monitoring	3	12-M12	24-M14	12-M12	12-M12	24-M14
I103MEAS		Measurands for IEC 60870-5-103	1	1	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC 60870-5-103	3	3	3	3	3	3
I103AR		Function status auto-recloser for IEC 60870-5-103	1	1	1	1	1	1
I103EF		Function status earth-fault for IEC 60870-5-103	1	1	1	1	1	1
I103FLTPROT		Function status fault protection for IEC 60870-5-103	1	1	1	1	1	1
I103IED		IED status for IEC 60870-5-103	1	1	1	1	1	1
I103SUPERV		Supervision status for IEC 60870-5-103	1	1	1	1	1	1
I103USRDEF		Status for user defined signals for IEC 60870-5-103	20	20	20	20	20	20
L4UFCNT		Event counter with limit supervision	30	30	30	30	30	30
TEILGAPC		Running hour meter	6	6	6		6	6
Metering								
PCFCNT		Pulse-counter logic	16					
ETPMMTR		Function for energy calculation and demand handling	6					

Table 9: Total number of instances for basic configurable logic blocks

Basic configurable logic block	Total number of instances
AND	328
GATE	64
INV	468
LLD	40
OR	481
PULSETIMER	40
RSMEMORY	40
SRMEMORY	40
TIMERSET	84
XOR	40

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Table 10: Total number of instances for configurable logic blocks Q/T

Configurable logic blocks Q/T	Total number of instances
ANDQT	120
INDCOMBSPQT	20
INDEXTSPQT	20
INVALIDQT	22
INVERTERQT	120
ORQT	120
PULSETIMERQT	40
RSMEMORYQT	40
SRMEMORYQT	40
TIMERSETQT	40
XORQT	40

Table 11: Total number of instances for extended logic package

Extended configurable logic block	Total number of instances
AND	180
GATE	49
INV	180
LLD	49
OR	180
PULSETIMER	59
SLGAPC	74
SRMEMORY	110
TIMERSET	49
VSGAPC	130
XOR	49

2.4 Communication

IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
Station communication								
LONSPA, SPA		SPA communication protocol	1	1	1	1	1	1
ADE		LON communication protocol	1	1	1	1	1	1
HORZCOMM		Network variables via LON	1	1	1	1	1	1
PROTOCOL		Operation selection between SPA and IEC 60870-5-103 for SLM	1	1	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1	1	1
RS485GEN		RS485	1	1	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1	1	1

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IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
DNPGENTCP		DNP3.0 communication general TCP protocol	1	1	1	1	1	1
CHSERRS485		DNP3.0 for EIA-485 communication protocol	1	1	1	1	1	1
CH1TCP, CH2TCP, CH3TCP, CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1	1	1
CHSEROPT		DNP3.0 for TCP/IP and EIA-485 communication protocol	1	1	1	1	1	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for serial communication protocol	1	1	1	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1	1	1	1	1	1
IEC 61850-8-1		Parameter setting function for IEC 61850	1	1	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59	59	59
GOOSEBINRCV		GOOSE binary receive	16	16	16	16	16	16
GOOSEDPRCV		GOOSE function block to receive a double point value	64	64	64	64	64	64
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	60	60	60	60	60	60
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64	64	64
MULTICMDRCV, MULTICMDSND		Multiple command and transmit	60/10	60/10	60/10	60/10	60/10	60/10
FRONT, LANABI, LANAB, LANCDI, LANCD		Ethernet configuration of links	1	1	1	1	1	1
GATEWAY		Ethernet configuration of link one	1	1	1	1	1	1
OPTICAL103		IEC 60870-5-103 Optical serial communication	1	1	1	1	1	1
RS485103		IEC 60870-5-103 serial communication for RS485	1	1	1	1	1	1
AGSAL		Generic security application component	1	1	1	1	1	1
LD0LLN0		IEC 61850 LD0 LLN0	1	1	1	1	1	1
SYSLLN0		IEC 61850 SYS LLN0	1	1	1	1	1	1
LPHD		Physical device information	1	1	1	1	1	1
PCMACCS		IED configuration protocol	1	1	1	1	1	1

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IEC 61850	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1	1	1
FSTACCS FSTACCSNA		Field service tool access via SPA protocol over ethernet communication	1	1	1	1	1	1
ACTIVLOG		Activity logging parameters	1	1	1	1	1	1
ALTRK		Service tracking	1	1	1	1	1	1
SINGLELCCH		Single ethernet port link status	1	1	1	1	1	1
PRPSTATUS		Dual ethernet port link status	1	1	1	1	1	1
PRP		IEC 62439-3 parallel redundancy protocol	0-1	1-P03	1-P03	1-P03	1-P03	1-P03
Remote communication								
		Binary signal transfer receive/transmit	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6
		Transmission of analog data from LDCM	1	1	1	1	1	1
		Receive binary status from remote LDCM	6/3/3	6/3/3	6/3/3	6/3/3	6/3/3	6/3/3

2.5 Basic IED functions

Table 12: 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, SYNCHSPA	Time synchronization
TIMEZONE	Time synchronization
DSTBEGIN, DSTENABLE, DSTEND	GPS time synchronization module
IRIG-B	Time synchronization
SETGRPS	Number of setting groups
ACTVGRP	Parameter setting groups
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
SMBI	Signal matrix for binary inputs

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IEC 61850 or function name	Description
SMBO	Signal matrix for binary outputs
SMMI	Signal matrix for mA inputs
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
DOSFRNT	Denial of service, frame rate control for front port
DOSLANAB	Denial of service, frame rate control for OEM port AB
DOSLANCD	Denial of service, frame rate control for OEM port CD
DOSSCKT	Denial of service, socket flow control
GBASVAL	Global base values for settings
PRIMVAL	Primary system values
ALTMS	Time master supervision
ALTIM	Time management
MSTSER	DNP3.0 for serial communication protocol
PRODINF	Product information
RUNTIME	IED Runtime Comp
CAMCONFIG	Central account management configuration
CAMSTATUS	Central account management status
TOOLINF	Tools Information component
SAFEFILECOPY	Safe file copy function

Table 13: Local HMI functions

IEC 61850 or function name	ANSI	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

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Section 3 Differential protection

The function consists of differential protection algorithm, sensitive differential protection algorithm, check zone algorithm, open CT algorithm and two supervision algorithms.

3.1 Busbar differential protection

This protection function is intended for fast and selective tripping of faults within protected zone. For each current input, the CT ratio can be set from the front HMI or via the parameter-setting tool, PCM600. In this way adaptation to different CT ratios is provided in the simplest way. The minimum pick-up value for the differential current is then set to give a suitable sensitivity for all internal faults. This setting is made directly in primary amperes. For busbar protection applications typical setting value for the minimum differential operating current is from 50% to 150% of the biggest CT. The settings can be changed from the front HMI or via the parameter-setting tool, PCM600.

All current inputs are indirectly provided with a restraint feature. The operation is based on the well-proven RADSS percentage restraint stabilization principle, with an extra stabilization feature to stabilize for very heavy CT saturation. Stability for external faults is guaranteed if a CT is not saturated for at least two milliseconds during each power system cycle. It is also possible to add external tripping criteria by binary signal.

The trip command from the differential protection including sensitive differential protection and circuit breaker failure backup-trip commands can be set either as self-resetting or latched. In second case the manual reset is needed in order to reset the individual bay trip output contacts.

3.2 Sensitive differential level

Differential protection zones in REB670 include a sensitive operational level. This sensitive operational level is designed to be able to detect internal busbar earth faults in low impedance earthed power systems (i.e. power systems where the earth-fault current is limited to a certain level, typically between 300A and 2000A primary by a neutral point reactor or resistor).
For increased security, the sensitive differential protection must be externally enabled by a binary signal (e.g. from external open delta VT overvoltage relay or external power transformer neutral point overcurrent relay). Finally it is as well possible to set a time delay before the trip signal from the sensitive differential protection is given. This sensitive level can be alternatively used in special applications when high sensitivity is required from busbar differential protection (i.e. energizing of dead bus via a long line).

Operation and operating characteristic of the sensitive differential protection can be set independently from the operating characteristic of the main differential protection. However, the sensitive differential level is blocked as soon as the total incoming current exceeds the pre-set level or when differential current exceed the set minimum pickup current for the usual differential protection. Therefore, by appropriate settings it can be ensured that this sensitive level is blocked for all external multi-phase faults, which can cause CT saturation. Operating characteristic of sensitive differential characteristics is shown in Figure 1.

3.3 Check zone

For busbar protection in double busbar stations when dynamic zone selection is needed, it is sometimes required to include the overall differential zone (that is, check zone). Hence, the built-in, overall check zone is available in the IED. Because the built-in check zone current measurement is not dependent on the disconnector status, this feature ensures stability of Busbar differential protection even for completely wrong status indication from the busbar

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disconnectors. It is to be noted that the overall check zone, only supervise the usual differential protection operation. The external trip commands, breaker failure backup-trip commands and sensitive differential protection operation are not supervised by the overall check zone.

The overall check zone has simple current operating algorithm, which ensures check zone operation for all internal faults regardless the fault current distribution. To achieve this, the outgoing current from the overall check zone is used as restraint quantity. If required, the check zone operation can be activated externally by a binary signal.

3.4 Open CT detection

The innovative measuring algorithm provides stability for open or short-circuited main CT secondary circuits, which means that no separate check zone is actually necessary. Start current level for open CT detection can usually be set to detect the open circuit condition for the smallest CT. This built-in feature allows the protection terminal to be set very sensitive, even to a lower value than the maximum CT primary rating in the station. At detection of problems in CT secondary circuits, the differential protection can be instantly blocked and an alarm is given. Alternatively, the differential protection can be automatically desensitized in order to ensure busbar differential protection stability during normal through-load condition. When problems in CT secondary circuits have been found and associated error has been corrected a manual reset must be given to the IED. This can be done locally from the local HMI, or remotely via binary input or communication link.

However, it is to be noted that this feature can only be partly utilized when the summation principle is in use.

3.5 Differential protection supervision

Dual monitoring of differential protection status is available. The first monitoring feature operates after settable time delay when differential current is higher than the user settable level. This feature can be, for example, used to design automatic reset logic for previously described open CT detection feature. The second monitoring feature operates immediately when the busbar through-going current is bigger than the user settable level. Both of these monitoring features are phase segregated and they give out binary signals, which can be either used to trigger disturbance recorder or for alarming purposes.

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Section 4 Zone selection

Typically CT secondary circuits from every bay in the station are connected to the busbar protection. The built-in software feature called “Zone Selection” gives a simple but efficient control over the connected CTs to busbar protection IED in order to provide fully operational differential protection scheme for multi-zone applications on both small and large buses.

The function consists of dedicated disconnector/circuit breaker status monitoring algorithm, bay dedicated CT-connection control algorithm and zone interconnection algorithm.

4.1 Switch status monitoring

For stations with complex primary layout (that is, double busbar single breaker station with or without transfer bus) the information about busbar disconnector position in every bay is crucial information for busbar protection. The positions of these disconnectors then actually determine which CT input (that is, bay) is connected to which differential protection zone. For some more advanced features like end-fault or blind-spot protection the actual status of the circuit breaker in some or even all bays can be vital information for busbar protection as well. The switch function block is used to take the status of two auxiliary contacts from the primary device, evaluate them and then to deliver the device primary contact position to the rest of the zone selection logic.

For such applications typically two auxiliary contacts (that is, normally open and normally closed auxiliary contacts) from each relevant primary switching object shall be connected to the IED. Then the status for every individual primary switching object will be determined. The dedicated function block for each primary switching object is available in order to determine the status of the object primary contacts. By a parameter setting one of the following two logical schemes can be selected for each primary object individually by the end user:

- If not open then closed (that is, as in RADSS schemes)
- Open or closed only when clearly indicated by aux contact status (that is, as in INX schemes)

Table 14 gives quick overview about both schemes.

Note that the first scheme only requires fast breaking normally closed auxiliary contact (that is, b contact) for proper operation. The timing of normally open auxiliary contact is not critical because it is only used for supervision of the primary object status. The second scheme in addition requires properly timed-adjusted, early-making normally open auxiliary contact (that is, early making a contact) for proper operation.

Regardless which scheme is used the time-delayed disconnector/circuit breaker status supervision alarm is available (that is, 00 or 11 auxiliary contact status). How two integrated differential protection zones behave when disconnector alarm appears is freely configurable by the end user.

It is possible by a parameter setting to override the primary object status as either permanently open or permanently closed. This feature can be useful during testing, installation and commissioning of the busbar protection scheme. At the same time, separate alarm is given to indicate that the actual object status is overwritten by a setting parameter.

It is to be noted that it is as well possible to use only normally closed auxiliary contacts for Zone Selection logic. In that case the Switch function blocks are not used.

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Table 14: Treatment of primary object auxiliary contact status

Primary equipment		Status in busbar protection		Alarm facility	
Normally Open auxiliary contact status (that is, "closed" or "a" contact)	**Normally Closed auxiliary contact status (that is, "open" or "b" contact)**	**when "Scheme 1 RADSS" is selected**	**when "Scheme 2 INX" is selected**	**Alarm after settable time delay**	**Information visible on local HMI**
open	open	closed	Last position saved	yes	intermediate_00
open	closed	open	open	no	open
closed	open	closed	closed	no	closed
closed	closed	closed	closed	yes	badState_11

4.2 Bay

Each CT input is allocated to one dedicated bay function block. This function block is used to provide complete user interface for all signals from and towards this bay. It is also used to influence bay measured current.

It is possible by a parameter setting *CTConnection* to connect or disconnect the CT input to the bay function block. Once the CT input is connected to the bay function block this associated current input can be included to or excluded from the two internally available differential functions in software. This can be done by a parameter setting for simple station layouts (that is, one-and-a-half breaker stations) or alternatively via dedicated logical scheme (that is, double busbar stations). For each bay the end user have to select one of the following five alternatives:

- Permanently connect this bay current to zone A (that is, ZA)
- Permanently connect this bay current to zone B (that is, ZB)
- Permanently connect this bay current to zone A and inverted bay current to ZB (that is, ZA and -ZB)
- Connect this bay current to ZA or ZB depending on the logical status of the two input binary signals available on this bay function block. These two input signals will include measured current to the respective zone when their logical value is one (that is, *CntrlIncludes*). This option is used together with above described Switch function blocks in order to provide complete Zone Selection logic
- Connect the bay current to ZA or ZB depending on the logical status of the two input binary signals available on this bay function block. These two signals will include measured current to the respective zone when their logical value is zero (that is, *CntrlExcludes*). This option is typically used when only normally closed auxiliary contacts from the busbar disconnector are available to the Zone Selection logic

At the same time, an additional feature for instantaneous or time delayed disconnection or even inversion of the connected bay current via separate logical signals is also available. This feature is provided in order to facilitate for bus-section or bus-coupler CT disconnection for tie-breakers with a CT only on one side of the circuit breaker. This ensures correct and fast fault clearance of faults between the CT and the circuit breaker within these bays. The same feature can be individually used in any feeder bay to optimize Busbar differential protection performance, when feeder circuit breaker is open. Thus, the end-fault protection for faults between circuit breaker and the CT is available. However, to use this feature circuit breaker auxiliary contacts and closing command to the circuit breaker shall be wired to the binary inputs of the IED. Therefore, he IED offers best possible coverage for these special faults between CT and circuit breaker in feeder and bus-section/bus-coupler bays.

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Within the Bay function block it is decided by a parameter setting how this bay should behave during zone interconnection (that is, load transfer). For each bay individually one of the following three options can be selected:

- Bay current is forced out from both zones during zone interconnection (used for bus-coupler bays)
- Bay current is unconditionally forced into both zones during zone interconnection (used in special applications)
- Bay current is connected to both zones during zone interconnection if the bay was previously connected to one of the two zones (typically used for feeder bays)

The third option ensures that the feeder, which is out of service, is not connected to any of the two zones during zone interconnection.

Within the Bay function block it is decided by a parameter setting whether this bay should be connected to the check zone or not. In this way the end user has simple control over the bays, which shall be connected to the overall check zone.

By appropriate configuration logic it is possible to take any bay (that is, CT input) out of service. This can be done from the local HMI or externally via binary signal. In that case all internal current measuring functions (that is, differential protection, sensitive differential protection, check zone, breaker failure protection and overcurrent protection) are disabled. At the same time, any trip command to this bay circuit breaker can be inhibited.

Via two dedicated binary input signals it is possible to:

- Trip only the bay circuit breaker (used for integrated OC protection tripping)
- Trip the whole differential zone to which this bay is presently connected (used for backup-trip command from either integrated or external bay circuit breaker failure protection)

Finally dedicated trip binary output from the Bay function block is available in order to provide common trip signal to the bay circuit breaker from busbar differential protection, breaker failure protection, backup overcurrent protection and so on.

In this way the interface to the user is kept as simple as possible and IED engineering work is quite straight forward.

4.3 Zone interconnection (Load transfer)

When this feature is activated the two integrated differential protection zones are merged into one common, overall differential zone. This feature is required in double busbar stations when in any of the feeder bays both busbar disconnectors are closed at the same time (that is, load transfer). As explained in above section Bay each CT input will then behave in the pre-set way in order to ensure proper current balancing during this special condition. This feature can be started automatically (when Zone Selection logic determines that both busbar disconnectors in one feeder bay are closed at the same time) or externally via dedicated binary signal. If this feature is active for longer time than the pre-set vale the alarm signal is given.

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Section 5 Current protection

5.1 Four-step phase overcurrent protection OC4PTOC

The four step three-phase overcurrent protection function OC4PTOC has an inverse or definite time delay independent for step 1 to 4 separately .

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.

5.2 Four step single phase overcurrent protection PH4SPTOC

Four step single phase, non-directional overcurrent protection (PH4SPTOC) has an inverse or definite time delay independent for each step separately.

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

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

5.3 Four step residual overcurrent protection, zero sequence and negative sequence direction EF4PTOC

The four step residual overcurrent protection 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 directional or non-directional independently for each of the steps.

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

Second harmonic blocking can be set individually for each step.

EF4PTOC can be used as main protection for phase-to-earth faults.

EF4PTOC 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.

Residual current can be calculated by summing the three phase currents or taking the input from neutral CT

5.4 Four step negative sequence overcurrent protection NS4PTOC

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

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

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.

5.5 Thermal overload protection, two time constant 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 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.

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5.6 Breaker failure protection CCRBRF

Breaker failure protection (CCRBRF) ensures a fast backup tripping of the 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 check with extremely short reset time is used as check criterion to achieve high security against inadvertent operation.

Contact check criteria can be used where the fault current through the breaker is small.

CCRBRF can be single- or three-phase initiated to allow use with single phase tripping applications. For the three-phase version of CCRBRF the current criteria can be set to operate only if two out of four for example, two phases or one phase plus the residual current start. This gives a higher security to the back-up trip command.

CCRBRF function can be programmed to give a single- or three-phase re-trip of its own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect initiation due to mistakes during testing.

5.7 Breaker failure protection, single phase version CCSRBRF

Breaker failure protection, single phase version (CCSRBRF) function ensures fast back-up tripping of surrounding breakers.

A current check with extremely short reset time is used as check criteria to achieve a high security against unnecessary operation.

CCSRBRF can be programmed to give a re-trip of the own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect starting due to mistakes during testing.

5.8 Directional over/underpower protection GOPPDOP/ GUPPDUP

The directional over-/under-power protection GOPPDOP/GUPPDUP can be used wherever a high/low active, reactive or apparent power protection or alarming is required. The functions can alternatively be used to check the direction of active or reactive power flow in the power system. There are a number of applications where such functionality is needed. Some of them are:

- detection of reversed active power flow
- detection of high reactive power flow

Each function has two steps with definite time delay.

5.9 Capacitor bank protection (CBPGAPC)

Shunt Capacitor Banks (SCB) are used in a power system to provide reactive power compensation and power factor correction. They are as well used as integral parts of Static Var Compensators (SVC) or Harmonic Filters installations. Capacitor bank protection (CBPGAPC) function is specially designed to provide protection and supervision features for SCBs.

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Section 6 Voltage protection

6.1 Two step undervoltage protection UV2PTUV

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

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

UV2PTUV has a high reset ratio to allow settings close to system service voltage.

6.2 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, each of them with inverse or definite time delayed.

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

6.3 Two step residual overvoltage protection 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.

ROV2PTOV has two voltage steps, each with inverse or definite time delay.

Reset delay ensures operation for intermittent earth faults.

6.4 Voltage differential protection VDCPTOV

A voltage differential monitoring function is available. It compares the voltages from two three phase sets of voltage transformers and has one sensitive alarm step and one trip step.

6.5 Loss of voltage check LOVPTUV

Loss of voltage check LOVPTUV is suitable for use in networks with an automatic system restoration function. LOVPTUV issues a three-pole trip command to the circuit breaker, if all three phase voltages fall below the set value for a time longer than the set time and the circuit breaker remains closed.

The operation of LOVPTUV is supervised by the fuse failure supervision FUFSPVC.

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Section 7 Frequency protection

7.1 Underfrequency protection SAPTUF

Underfrequency occurs as a result of a lack of generation in the network.

Underfrequency protection SAPTUF measures frequency with high accuracy, and is used for load shedding systems, remedial action schemes, gas turbine startup and so on. Separate definite time delays are provided for operate and restore.

SAPTUF is provided with undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how to connect analog inputs, refer to **Application manual** > **IED application** > **Analog inputs** > **Setting guidelines**

7.2 Overfrequency protection SAPTOF

Overfrequency protection function SAPTOF is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Overfrequency occurs because of sudden load drops or shunt faults in the power network. Close to the generating plant, generator governor problems can also cause over frequency.

SAPTOF measures frequency with high accuracy, and is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring. A definite time delay is provided for operate.

SAPTOF is provided with an undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how to connect analog inputs, refer to **Application manual** > **IED application** > **Analog inputs** > **Setting guidelines**

7.3 Rate-of-change frequency protection SAPFRC

The rate-of-change frequency protection function SAPFRC gives an early indication of a main disturbance in the system. SAPFRC measures frequency with high accuracy, and can be used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between a positive or negative change of frequency. A definite time delay is provided for operate.

SAPFRC is provided with an undervoltage blocking. The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected. For information about how to connect analog inputs, refer to **Application manual** > **IED application** > **Analog inputs** > **Setting guidelines**.

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Section 8 Multipurpose protection

8.1 General current and voltage protection CVGAPC

The General current and voltage protection (CVGAPC) can be utilized as a negative or zero sequence current and/or voltage protection detecting unsymmetrical conditions such as open phase or unsymmetrical faults.

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Section 9 Secondary system supervision

9.1 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 algorithm is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence quantities.

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.

The selection of different operation modes is possible by a setting parameter in order to take into account the particular earthing of the network.

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.

9.2 Fuse failure supervision VDSPVC

Different protection functions within the protection IED operates on the basis of measured voltage at the relay point. Some example of protection functions are:

- Distance protection function.
- Undervoltage function.
- Energisation function and voltage check for the weak infeed logic.

These functions can operate unintentionally, if a fault occurs in the secondary circuits between voltage instrument transformers and the IED. These unintentional operations can be prevented by VDSPVC.

VDSPVC is designed to detect fuse failures or faults in voltage measurement circuit, based on phase wise comparison of voltages of main and pilot fused circuits. VDSPVC blocking output can be configured to block functions that need to be blocked in case of faults in the voltage circuit.

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Section 10 Control

10.1 Synchrocheck, energizing check, and synchronizing SESRSYN

The Synchronizing function allows closing of asynchronous networks at the correct moment including the breaker closing time, which improves the network stability.

Synchrocheck, energizing check, and synchronizing SESRSYN function checks that the voltages on both sides of the circuit breaker are in synchronism, or with at least one side dead to ensure that closing can be done safely.

SESRSYN function includes a built-in voltage selection scheme for double bus and 1½ breaker or ring busbar arrangements.

Manual closing as well as automatic reclosing can be checked by the function and can have different settings.

For systems, which are running asynchronous, a synchronizing function is provided. The main purpose of the synchronizing function is to provide controlled closing of circuit breakers when two asynchronous systems are going to be connected. The synchronizing function evaluates voltage difference, phase angle difference, slip frequency and frequency rate of change before issuing a controlled closing of the circuit breaker. Breaker closing time is a parameter setting.

10.2 Autorecloser SMBRREC

The autorecloser SMBRREC function provides high-speed and/or delayed auto-reclosing for single or multi-breaker applications.

Up to five three-phase reclosing attempts can be included by parameter setting. The first attempt can be single-, two and/or three phase for single phase or multi-phase faults respectively.

Multiple autoreclosing functions are provided for multi-breaker arrangements. A priority circuit allows one circuit breaker to close first and the second will only close if the fault proved to be transient.

Each autoreclosing function is configured to co-operate with the synchrocheck function.

The autoreclosing function provides high-speed and/or delayed three pole autoreclosing. The autoreclosing can be used for delayed busbar restoration. Two Autoreclosers (SMBRREC) one for each busbar can be provided.

10.3 Apparatus control APC

The apparatus control functions are used for control and supervision of circuit breakers, disconnectors and earthing switches within a bay. Permission to operate is given after evaluation of conditions from other functions such as interlocking, synchrocheck, operator place selection and external or internal blockings.

Apparatus control features:

- Select-Execute principle to give high reliability

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- Selection function to prevent simultaneous operation
- Selection and supervision of operator place
- Command supervision
- Block/deblock of operation
- Block/deblock of updating of position indications
- Substitution of position and quality indications
- Overriding of interlocking functions
- Overriding of synchrocheck
- Operation counter
- Suppression of mid position

Two types of command models can be used:

- Direct with normal security
- SBO (Select-Before-Operate) with enhanced security

Normal security means that only the command is evaluated and the resulting position is not supervised. Enhanced security means that the command is evaluated with an additional supervision of the status value of the control object. The command sequence with enhanced security is always terminated by a CommandTermination service primitive and an AddCause telling if the command was successful or if something went wrong.

Control operation can be performed from the local HMI with authority control if so defined.

10.4 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 three-phase device or up to three one-phase devices.

10.5 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.

10.6 Circuit switch SXSWI

The purpose of Circuit switch (SXSWI) function 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 disconnectors or earthing switches via binary output boards and to supervise the switching operation and position.

10.7 Reservation function QCRSV

The purpose of the reservation function is primarily to transfer interlocking information between IEDs in a safe way and to prevent double operation in a bay, switchyard part, or complete substation.

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10.8 Reservation input RESIN

The Reservation input (RESIN) function receives the reservation information from other bays. The number of instances is the same as the number of involved bays (up to 60 instances are available).

10.9 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.

10.10 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 LOCREM and 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.

10.11 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.

10.12 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 or from a symbol on the single line diagram (SLD) on the local HMI.

10.13 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.

10.14 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, designed to bring in commands from REMOTE (SCADA) to those

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parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. Confirmation (status) of the result of the commands is supposed to be achieved by other means, such as binary inputs and SPGAPC function blocks. The commands can be pulsed or steady with a settable pulse time.

10.15 AutomationBits, command function for DNP3.0 AUTOBITS

AutomationBits function for DNP3 (AUTOBITS) is used within PCM600 to get into the configuration of the commands coming through the DNP3 protocol. The AUTOBITS function plays the same role as functions GOOSEBINRCV (for IEC 61850) and MULTICMDRCV (for LON).

10.16 Single command, 16 signals

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.

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Section 11 Logic

11.1 Trip matrix logic TMAGAPC

The trip matrix logic TMAGAPC function is used to route trip signals and other logical output signals 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.

11.2 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.

11.3 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.

11.4 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.

11.5 Basic configurable logic blocks

The basic configurable logic blocks do not propagate the time stamp and quality of signals (have no suffix QT at the end of their function name). A number of logic blocks and timers are always available as basic for the user to adapt the configuration to the specific application needs. The list below shows a summary of the function blocks and their features.

These logic blocks are also available as part of an extension logic package with the same number of instances.

- **AND** function block. Each block has four inputs and two outputs where one is inverted.
- **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 one input signal to the output.
- **LLD** function block. Loop delay used to delay the output signal one execution cycle.
- **OR** function block. Each block has up to six inputs and two outputs where one 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

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controls if, after a power interruption, the flip-flop resets or returns to the state it had before the power interruption. The SET input has priority.

- **TIMERSET** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay.
- **XOR** function block. Each block has two outputs where one is inverted.

11.6 Extension logic package

The logic extension block package includes additional trip matrix logic and configurable logic blocks.

11.6.1 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.

11.6.2 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 or from a symbol on the single line diagram (SLD) on the local HMI.

11.7 Fixed signal function block

The Fixed signals function FXDSIGN generates 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.

11.8 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.

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- Reporting of the integrated time.

11.9 Boolean 16 to Integer conversion B16I

Boolean 16 to integer conversion function B16I is used to transform a set of 16 binary (logical) signals into an integer.

11.10 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.

11.11 Integer to Boolean 16 conversion IB16

Integer to boolean 16 conversion function IB16 is used to transform an integer into a set of 16 binary (logical) signals.

11.12 Integer to Boolean 16 conversion with logic node representation ITBGAPC

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

ITBGAPC function can only receive remote values over IEC 61850 when the R/L (Remote/Local) push button on the front HMI, indicates that the control mode for the operator is in position R (Remote i.e. the LED adjacent to R is lit), and the corresponding signal is connected to the input PSTO ITBGAPC function block. The input BLOCK will freeze the output at the last received value and blocks new integer values to be received and converted to binary coded outputs.

11.13 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.

11.14 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.

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Section 12 Monitoring

12.1 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 currents
- primary phasors
- positive, negative and zero sequence currents and voltages
- mA, input currents
- pulse counters

Voltage and power can be measured only when VT inputs into the REB670 are available.

12.2 Supervision of mA input signals

The main purpose of the function is to measure and process signals from different measuring transducers. Many devices used in process control represent various parameters such as frequency, temperature and DC battery voltage as low current values, usually in the range 4-20 mA or 0-20 mA.

Alarm limits can be set and used as triggers, e.g. to generate trip or alarm signals.

The function requires that the IED is equipped with the mA input module.

12.3 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

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

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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.

Every disturbance report recording is saved in the IED in the standard Comtrade format as a reader file HDR, a configuration file CFG, and a data file DAT. 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 may be uploaded to PCM600 for further analysis using the disturbance handling tool.

12.4 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 1000 time-tagged events stored in a ring-buffer.

12.5 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.

12.6 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 150 time-tagged events.

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

The event recording information is an integrated part of the disturbance record (Comtrade file).

12.7 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.

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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).

12.8 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 ten seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

12.9 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 and double indication values are also transferred through EVENT function.

12.10 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.

12.11 Generic communication function for Measured Value MVGAPC

Generic communication function for Measured Value 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.

12.12 Measured value expander block RANGE_XP

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

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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 (RANGE_XP) 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.

12.13 Gas medium supervision SSIMG

Gas medium supervision SSIMG is used for monitoring the circuit breaker condition. Binary information based on the gas pressure in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

12.14 Liquid medium supervision SSIML

Liquid medium supervision SSIML is used for monitoring the circuit breaker condition. Binary information based on the oil level in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

12.15 Breaker monitoring SSCBR

The breaker monitoring function SSCBR is used to monitor different parameters of the breaker condition. The breaker requires maintenance when the number of operations reaches a predefined value. For a proper functioning of the circuit breaker, it is essential to monitor the circuit breaker operation, spring charge indication or breaker wear, travel time, number of operation cycles and estimate the accumulated energy during arcing periods.

12.16 Event counter with limit supervison L4UFCNT

The 30 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.

12.17 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

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Section 13 Metering

13.1 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 binary input module and then read by the PCFCNT function. A scaled service value is available over the station bus. The special Binary input module with enhanced pulse counting capabilities must be ordered to achieve this functionality.

13.2 Function for energy calculation and demand handling (ETPMMTR)

Measurements function block (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.

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Section 14 Human machine interface

14.1 Local HMI

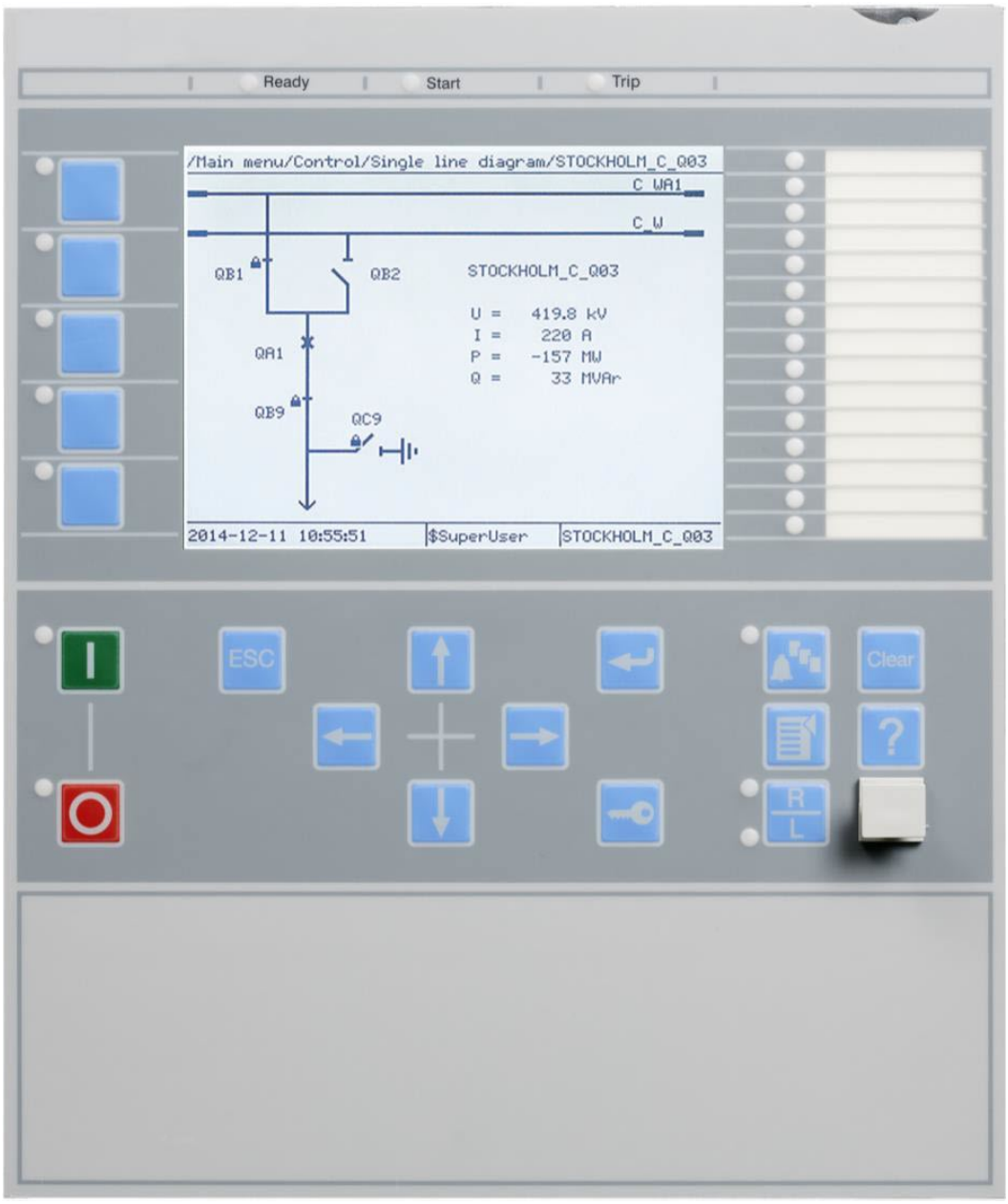


Figure 12: Local human-machine interface

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.

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Section 15 Basic IED functions

15.1 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.

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Section 16 Station communication

16.1 Communication protocols

Each IED is provided with a communication interface, 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
- LON communication protocol
- SPA or IEC 60870-5-103 communication protocol
- DNP3.0 communication protocol

Several protocols can be combined in the same IED.

16.2 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 single or double optical Ethernet rear ports (order dependent) 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.

16.3 LON communication protocol

Existing stations with Hitachi Energy station bus LON can be extended with use of the optical LON interface. This allows full SA functionality including peer-to-peer messaging and cooperation between the IEDs.

16.4 SPA communication protocol

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

16.5 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.

16.6 DNP3.0 communication protocol

An electrical RS485 and an optical Ethernet port is available for the DNP3.0 communication. DNP3.0 Level 2 communication with unsolicited events, time synchronizing and disturbance reporting is provided for communication to RTUs, Gateways or HMI systems.

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16.7 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).

16.8 IEC 62439-3 Parallel Redundancy Protocol

Redundant station bus communication according to IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2 parallel redundancy protocol (PRP) are available as options when ordering IEDs. Redundant station bus communication according to IEC 62439-3 uses both port AB and port CD on the OEM module.

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Section 17 Remote communication

17.1 Analog and binary signal transfer to remote end

Three analog and eight binary signals can be exchanged between two IEDs. This functionality is mainly used for the line differential protection. However it can be used in other products as well. An IED can communicate with up to 4 remote IEDs.

17.2 Binary signal transfer to remote end, 192 signals

If the communication channel is used for transfer of binary signals only, up to 192 binary signals can be exchanged between two IEDs. For example, this functionality can be used to send information such as status of primary switchgear apparatus or intertripping signals to the remote IED. An IED can communicate with up to 4 remote IEDs.

For REB670 primary apparatus position indication can be exchanged between the single phase IEDs.

17.3 Line data communication module, short range LDCM

The line data communication module (LDCM) is used for communication between the IEDs situated at distances <110 km/68 miles or from the IED to optical to electrical converter with G.703 or G.703E1 interface located on a distances < 3 km/1.9 miles away. The LDCM module sends and receives data, to and from another LDCM module. The IEEE/ANSI C37.94 standard format is used.

17.4 Galvanic X.21 line data communication module X.21-LDCM

A module with built-in galvanic X.21 converter which e.g. can be connected to modems for pilot wires is also available.

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Section 18 Hardware description

18.1 Hardware modules

18.1.1 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.

18.1.2 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.

18.1.3 Binary output module BOM

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

18.1.4 Static binary output module SOM

The static binary output module has six fast static outputs and six change over output relays for use in applications with high speed requirements.

18.1.5 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.

18.1.6 mA input module MIM

The milli-ampere input module is used to interface transducer signals in the –20 to +20 mA range from for example OLTC position, temperature or pressure transducers. The module has six independent, galvanically separated channels.

18.1.7 Optical ethernet module OEM

The optical fast-ethernet module is used for fast and interference-free communication of synchrophasor data over IEEE C37.118 and/or IEEE 1344 protocols. It is also used to connect an IED to the communication buses (like the station bus) that use the IEC 61850-8-1 protocol (port A, B). The module has one or two optical ports with ST connectors.

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

18.1.9 Line data communication module LDCM

Each module has one optical port, one for each remote end to which the IED communicates.

Alternative cards for Long range (1550 nm single mode), Medium range (1310 nm single mode) and Short range (850 nm multi mode) are available.

18.1.10 Galvanic X.21 line data communication module X.21-LDCM

The galvanic X.21 line data communication module is used for connection to telecommunication equipment, for example leased telephone lines. The module supports 64 kbit/s data communication between IEDs.

Examples of applications:

- Line differential protection
- Binary signal transfer

18.1.11 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.

18.1.12 GPS time synchronization module GTM

This module includes a GPS receiver used for time synchronization. The GTM has one SMA contact for connection to an antenna. It also includes an optical PPS ST-connector output.

18.1.13 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 shall be used for synchronizing when IEC 61850-9-2LE is used.

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

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18.1.14 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.

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

18.2 Layout and dimensions

18.2.1 Dimensions

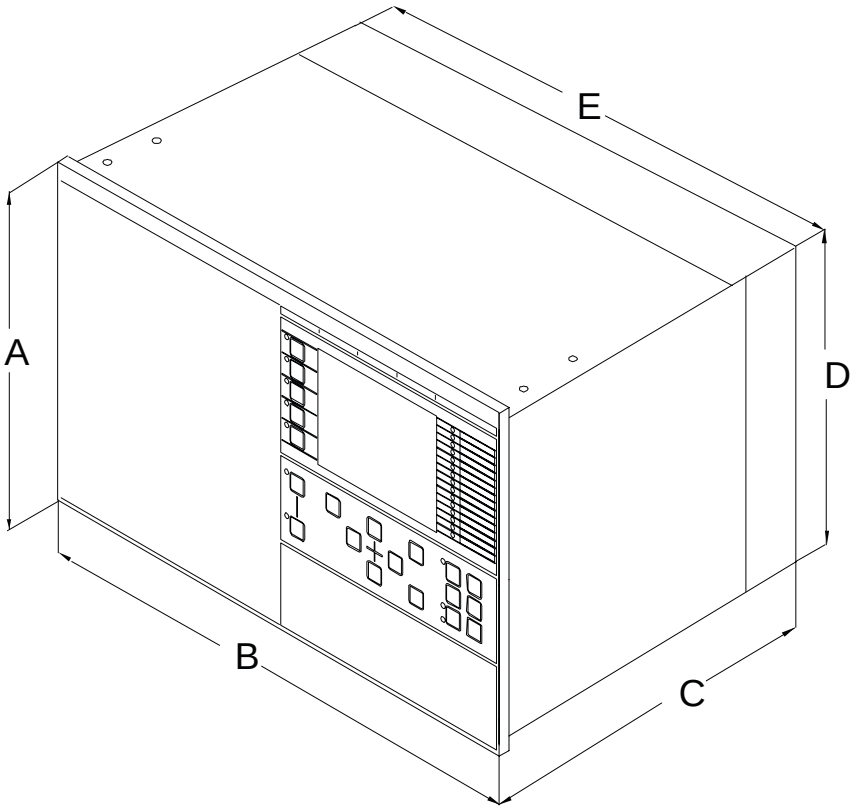


Figure 13: Case with rear cover

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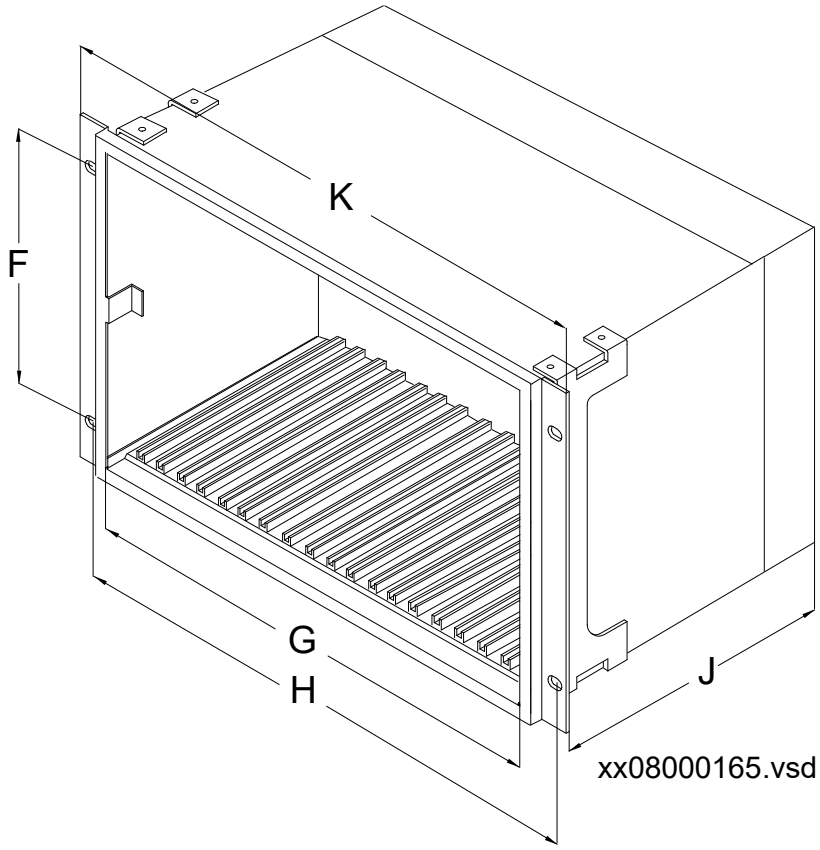


Figure 14: Case with rear cover and 19” rack mounting kit

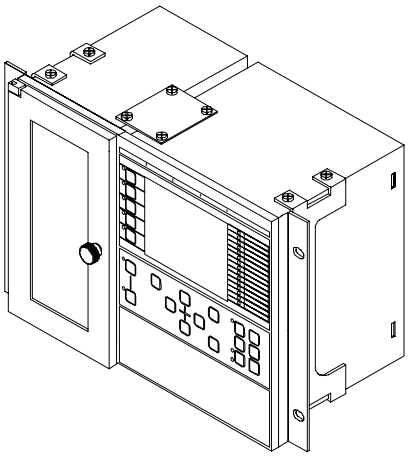


Figure 15: A 1/2 x 19” size IED side-by-side with RHGS6.

Case size (mm)/ (inches)	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”	265.9/10.47	223.7/8.81	242.1/9.53	255.8/10.07	205.7/8.10	190.5/7.50	203.7/8.02	-	228.6/9.00	-
6U, 3/4 x 19”	265.9/10.47	336.0/13.23	242.1/9.53	255.8/10.07	318.0/12.52	190.5/7.50	316.0/12.4	-	228.6/9.00	-

Table continues on next page

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Case size (mm)/ (inches)	A	B	C	D	E	F	G	H	J	K
6U, 1/1 x 19”	265.9/10.47	448.3/17.65	242.1/9.53	255.8/10.07	430.3/16.86	190.5/7.50	428.3/16.86	465.1/18.31	228.6/9.00	482.6/19.00
The H and K dimensions are defined by the 19” rack mounting kit.										

18.2.2 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”
  - 1/1 case size (h) 254.3 mm/10.01” (w) 434.7 mm/17.11”
- Wall mounting kit

See ordering for details about available mounting alternatives.

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Section 19 Connection diagrams

19.1 Connection diagrams

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

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

Connection diagrams for Customized products

Connection diagram, 670 series 2.1 1MRK002801-AF

Connection diagrams for Configured products

Connection diagram, REB670 2.1, A20 1MRK002803-EH

Connection diagram, REB670 2.1, A31X01 1MRK002803-EK

Connection diagram, REB670 2.1, A31X02 1MRK002803-EL

Connection diagram, REB670 2.1, A31X03 1MRK002803-EM

Connection diagram, REB670 2.1, B20 1MRK002803-EA

Connection diagram, REB670 2.1, B21X01 1MRK002803-EB

Connection diagram, REB670 2.1, B21X02 1MRK002803-EC

Connection diagram, REB670 2.1, B21X03 1MRK002803-ED

Connection diagram, REB670 2.1, B31X01 1MRK002803-EE

Connection diagram, REB670 2.1, B31X02 1MRK002803-EF

Connection diagram, REB670 2.1, B31X03 1MRK002803-EG

Connection diagrams for Customized products

Connection diagram, 670 series 2.1 1MRK002802-AF

Connection diagrams for Configured products

Connection diagram, REB670 2.1, A31A 1MRK002804-EK

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Section 20 Technical data

20.1 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

20.1.1 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:
   - $\sqrt{3} \times IBase \times UBase$
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 are used if not explicitly stated otherwise.
9. During testing, signals with rated frequency have been injected if not explicitly stated otherwise.

20.2 Energizing quantities, rated values and limits

20.2.1 Analog inputs

Table 15: TRM - Energizing quantities, rated values and limits for protection transformer

Description	Value
Frequency	
Rated frequency f_r	50/60 Hz
Table continues on next page	

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Description	Value
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	

Table 16: TRM - Energizing quantities, rated values and limits for measuring transformer

Description	Value	
Frequency		
Rated frequency f_r	50/60 Hz	
Operating range	f_r ± 10%	
Current inputs		
Rated current I_r	1A	5 A
Operating range	(0-1.8) × I_r	(0-1.6) × I_r
Thermal withstand	80 × I_r for 1 s 25 × I_r for 10 s 10 × I_r for 1 min 1.8 × I_r for 30 min 1.1 × I_r continuously	65 × I_r for 1 s 20 × I_r for 10 s 8 × I_r for 1 min 1.6 × I_r for 30 min 1.1 × I_r continuously
Burden	< 200 mVA at I_r	< 350 mVA at I_r
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		

Table 17: MIM - mA input module

Quantity:	Rated value:	Nominal range:
Input resistance	R_{in} = 194 Ohm	-
Input range	±5, ±10, ±20mA 0-5, 0-10, 0-20, 4-20mA	-
Table continues on next page		

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Quantity:	Rated value:	Nominal range:
Power consumption each mA-board each mA input	 £ 2 W £ 0.1 W	-

Table 18: OEM - Optical ethernet module

Quantity	Rated value
Number of channels	1 or 2
Standard	IEEE 802.3u 100BASE-FX
Type of fiber	62.5/125 mm multimode fiber
Wave length	1300 nm
Optical connector	Type ST
Communication speed	Fast Ethernet 100 Mbit/s

20.2.2 Auxiliary DC voltage

Table 19: 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	50 W typically	-
Auxiliary DC power in-rush	< 10 A during 0.1 s	-

20.2.3 Binary inputs and outputs

Table 20: 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	-

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.

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Table 21: 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.		

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.

Table 22: 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	-

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.

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Table 23: IOM - Binary input/output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and signal relays	Fast signal relays (parallel reed relay)
Binary outputs	10	2
Max system voltage	250 V AC, DC	250 V DC
Min load voltage	24VDC	—
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 at inductive load 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	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
Maximum capacitive load	-	10 nF
Max operations with load	1000	
Max operations with no load	10000	
Operating time	< 6 ms	<= 1 ms

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.

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

Table 24: IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-2)

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	24VDC	-
Test voltage across open contact, 1 min	250 V rms	250 V rms
Table continues on next page		

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Function or quantity	Trip and Signal relays	Fast signal relays (parallel reed relay)
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 at inductive loadwith 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 j > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	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
Maximum capacitive load	-	10 nF
Max operations with load	1000	-
Max operations with no load	10000	-
Operating time	< 6 ms	<= 1 ms

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.

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

Table 25: SOM - Static Output Module (reference standard: IEC 61810-2): Static binary outputs

Function of quantity	Static binary output trip	
Rated voltage	48-60 VDC	110-250 VDC
Number of outputs	6	6
Impedance open state	~300 kΩ	~810 kΩ
Test voltage across open contact, 1 min	No galvanic separation	No galvanic separation
Current carrying capacity: Continuous 1.0 s	 5 A 10 A	 5 A 10 A
Making capacity at capacitive load with the maximum capacitance of 0.2 µF : 0.2 s 1.0 s	 30 A 10 A	 30 A 10 A
Breaking capacity for DC with L/R ≤ 40 ms	48 V/1 A 60 V/0.75 A	110 V/0.4 A 125 V/0.35 A

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Function of quantity	Static binary output trip	
		220 V/0.2 A 250 V/0.15 A
Operating time	< 1 ms	< 1 ms

Table 26: SOM - Static Output module data (reference standard: IEC 61810-2): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250 V AC/DC
Min load voltage	24VDC
Number of outputs	6
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 8 A 10 A
Max operations with load	1000
Max operations with no load	10000
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 30 A 10 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
Operating time	< 6 ms

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

Table 27: BOM - Binary output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC, DC
Min load voltage	24VDC
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 load	1000
Max operations with no load	10000
Making capacity at inductive load with L/R > 10 ms 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos j > 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
Operating time	< 6 ms

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

20.2.4 Influencing factors

Table 28: Temperature and humidity influence

Parameter	Reference value	Nominal range	Influence
Ambient temperature, operate value	+20°C	-25°C to +55°C	0.02%/°C
Relative humidity Operative range	10-90% 0-95%	10-90%	-
Storage temperature	-	-40°C to +70°C	-

Table 29: 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 Interruption interval 0–50 ms 0–∞ s Restart time		24-60 V DC ± 20% 100-250 V DC ±20%	 No restart Correct behaviour at power down < 300 s

Table 30: 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
Frequency dependence for differential protection	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±2.0%/Hz
Harmonic frequency dependence (20% content)	2^{nd}, 3^{rd} and 5^{th} harmonic of f_r	±2.0%
Harmonic frequency dependence for differential protection (10% content)	2^{nd}, 3^{rd} and 5^{th} harmonic of f_r	±6.0%

20.3 Type tests according to standards

Table 31: 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
Table continues on next page		

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Test	Type test values	Reference standards
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Level 4
Surge withstand capability test	2.5 kV, oscillatory	IEEE/ANSI C37.90.1
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-26
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.1
Fast transient disturbance	4 kV 2 kV, MIM mA-inputs	IEC 60255-26, Zone A IEC 60255-26, Zone B
Surge immunity test	2-4 kV, 1.2/50ms 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	15 Hz-150 kHz	IEC 61000-4-16, Level 4
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 60255-26
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	IEC 60255-26
Radiated electromagnetic field disturbance	20 V/m 80-1000 MHz 10 V/m, 5.1-6.0 GHz	IEEE/ANSI C37.90.2 EN 50121-5
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEEE/ANSI C63.4, FCC
Conducted emission	0.15-30 MHz	IEC 60255-26

Table 32: Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min. 1.0 kVrms, 1 min.)	IEC 60255-27 ANSI C37.90 IEEE 802.3-2015, Environment A
Impulse voltage test	5 kV, 1.2/50ms, 0.5 J 1 kV, 1.2/50 ms 0.5 J	
Insulation resistance	> 100 MW at 500 VDC	

Table 33: Environmental tests

Test	Type test value	Reference standard
Cold operation test	Test Ad for 16 h at -25°C	IEC 60255-1
Cold storage test	Test Ab for 16 h at -40°C	IEC 60255-1
Dry heat operation test	Test Bd for 16 h at +70°C	IEC 60255-1
Dry heat storage test	Test Bb for 16 h at +85°C	IEC 60255-1
Change of temperature test	Test Nb for 5 cycles at -25°C to +70°C	IEC 60255-1
Damp heat test, steady state	Test Ca for 10 days at +40°C and humidity 93%	IEC 60255-1
Damp heat test, cyclic	Test Db for 6 cycles at +25 to +55°C and humidity 93 to 95% (1 cycle = 24 hours)	IEC 60255-1

Table 34: CE compliance

Directive	According to
Low voltage directive	2014/35/EU
EMC directive	2014/30/EU

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Table 35: Mechanical tests

Test	Type test values	Reference standards
Vibration response test	Class 2	IEC 60255-1
Vibration endurance test	Class 1	IEC 60255-1
Shock response test	Class 1	IEC 60255-1
Shock withstand test	Class 1	IEC 60255-1
Bump test	Class 1	IEC 60255-1
Seismic test	Class 2	IEC 60255-1

20.4 Differential protection

Table 36: Busbar differential protection

Function	Range or value	Accuracy
Operating characteristic	S=0.53 fixed	± 2.0% of I_r for I ≤ I_r ± 2.0% of I for I > I_r
Reset ratio	> 95%	-
Differential current operating level	(10-99999) A	± 2.0% of I_r for I ≤ I_r ± 2.0% of I for I > I_r
Sensitive differential operation level	(10-99999) A	± 2.0% of I_r for I ≤ I_r ± 2.0% of I for I < I_r
Check zone operation level	(10-99999) A	± 2.0% of I_r for I ≤ I_r ± 2.0% of I for I > I_r
Check zone slope	(0.0-0.9)	-
Operate time at 0 to 2 x Id	Min = 10 ms Max = 20 ms	-
Reset time at 2 to 0 x Id	Min = 10 ms Max = 20 ms	-
Operate time at 0 to 10 x Id	Min = 5 ms Max = 15 ms	-
Reset time at 10 to 0 x Id	Min = 15 ms Max = 30 ms	-
Critical impulse time	8 ms typically at 0 to 2 x I_d	-
Independent time delay for alarm for too long Load Transfer	(0.00-6000.00) s	± 0.2% or ± 20 ms whichever is greater
Independent time delay for differential current alarm level at 0 to 2 x IdAlarm	(0.00-6000.00) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay for slow open CT alarm at 2 to 0 x OCTLev	(1.00-6000.00) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay to force current to zero via binary signal	(0.000-60.000) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay for differential trip drop-off at 2 to 0 x IdLev	(0.000-60.000) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay for sensitive differential function operation at 0 to 2 x IdSens	(0.000-60.000) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay to invert current via binary signal	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater

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20.5 Current protection

Table 37: Directional phase overcurrent protection, four steps OC4PTOC

Function	Range or value	Accuracy
Operate current, step 1-4	(5-2500)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Minimum operate current, step 1-4	(1-10000) % of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Relay characteristic angle (RCA)	(40.0–65.0) degrees	±2.0 degrees
Relay operating angle (ROA)	(40.0–89.0) 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	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see Table 133, Table 134 and Table 135	16 curve types	See Table 133, Table 134 and Table 135
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	-

Table 38: Four step single phase overcurrent protection PH4SPTOC

Function	Setting range	Accuracy
Operate current, step 1 - 4	(5-2500)% of IBase	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I > I_r
Reset ratio	> 95% at (50-2500)% of IBase	-
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	± 0.2% or ± 35 ms whichever is greater
Inverse time characteristics, see Table 133, Table 134, and Table 135	16 curve types	See Table 133, Table 134, and Table 135
Operate time, start at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	-
Reset time, start at 2 to 0 x I_{set}	Min = 15 ms Max = 30 ms	-
Table continues on next page		

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Function	Setting range	Accuracy
Operate time, start at 0 to 10 x I_{set}	Min = 5 ms Max = 20 ms	-
Reset time, start at 10 to 0 x I_{set}	Min = 20 ms Max = 35 ms	-
Critical impulse time	15 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	10 ms typically	-

Table 39: Directional residual overcurrent protection, four steps EF4PTOC

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	-
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
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 133, Table 134 and Table 135	16 curve types	See Table 133, Table 134 and Table 135
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Minimum polarizing voltage	(1–100)% of UBase	±0.5% of U_r
Minimum polarizing current	(2-100)% of IBase	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) W/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) W/phase	-
*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	-
*Note: Operate time and reset time are only valid if harmonic blocking is turned off for a step.		

Table 40: Four step negative 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
Table continues on next page		

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Function	Range or value	Accuracy
Inverse time characteristics, see Table 133, Table 134 and Table 135	16 curve types	See Table 133, Table 134 and Table 135
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
Minimum polarizing current	(2-100)% of *IBase*	±1.0% of I_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) W/phase	-
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) W/phase	-
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 to 0 x I_{set}	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 to 0 x I_{set}	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 41: 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 42: Breaker failure protection, REB670 3–phase, CCRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at I £ I_r ± 1.0% of I at I > I_r
Reset ratio, phase current	> 95%	-
Table continues on next page		

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Function	Range or value	Accuracy
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at I £ 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 £ I_r ± 1.0% of I at I > I_r
Reset ratio	> 95%	-
Operate time for current detection	15 ms typically	-
Reset time for current detection	20 ms maximum	-
Time delay for re-trip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater
Time delay for back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater
Time delay for back-up trip at multi-phase start at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Additional time delay for a second back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 35 ms whichever is greater
Time delay for alarm for faulty circuit breaker	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater

Table 43: Breaker failure protection, single phase version CCSRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at I £ I_r ± 1.0% of I at I > I_r
Reset ratio, phase current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	± 1.0% of I_r at I £ I_r ± 1.0% of I at I > I_r
Reset ratio	> 95%	-
Operate time for current detection	15 ms typically	-
Reset time for current detection	20 ms maximum	-
Time delay for retrip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater
Time delay for backup trip at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2% or ± 30 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 ± 35 ms whichever is greater
Time delay for alarm for faulty circuit breaker	(0.000-60.000) s	± 0.2% or ± 30 ms whichever is greater
Minimum trip pulse duration	(0.010-60.000) s	± 0.2% or ± 10 ms whichever is greater

Table 44: Directional underpower protection GUPPDUP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of *SBase*	±1.0% of S_r at S ≤ S_r ±1.0% of S at S > S_r where $S_r = 1.732 \cdot U_r \cdot I_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	±2.0 degrees
Independent time delay to operate for Step 1 and Step 2 at 2 to 0.5 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

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Table 45: Directional overpower protection GOPPDOP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of SBase	±1.0% of S_r at $S \leq S_r$ ±1.0% of S at $S > S_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	±2.0 degrees
Operate time, start at 0.5 to 2 x S_r and *k=0.000*	Min. =10 ms	
	Max. = 25 ms	
Reset time, start at 2 to 0.5 x S_r and *k=0.000*	Min. = 35 ms	
	Max. = 55 ms	
Independent time delay to operate for Step 1 and Step 2 at 0.5 to 2 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 46: Capacitor bank protection CBPGAPC

Function	Range or value	Accuracy
Operate value, overcurrent	(10-900)% of lBase	±2.0% of I_r at $I \leq I_r$ ±2.0% of I at $I > I_r$
Reset ratio, overcurrent	>95% at (100-900)% of IBase	-
Start time, overcurrent, at 0.5 to 2 x Iset	Min. = 5 ms Max. = 20 ms	-
Reset time, overcurrent, at 2 x Iset to 0.5	Min. = 25 ms Max. = 40 ms	-
Critical impulse time, overcurrent protection start	2 ms typically at 0.5 to 2 x Iset 1 ms typically at 0.5 to 10 x Iset	-
Impulse margin time, overcurrent protection start	10 ms typically	
Operate value, undercurrent	(5-100)% of IBase	±2.0% of I_r
Reset ratio, undercurrent	<105% at (30-100)% of IBase	-
Operate value, reconnection inhibit function	(4-1000)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Operate value, reactive power overload function	(10-900)%	±1.0% of S_r at $S \leq S_r$ ±1.0% of S at $S > S_r$
Operate value, voltage protection function for harmonic overload (Definite time)	(10-500)%	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Operate value, voltage protection function for harmonic overload (Inverse time)	(80-200)%	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Inverse time characteristic	According to IEC 60871-1 (2005) and IEEE/ANSI C37.99 (2000)	±20% or ±200 ms whichever is greater
Maximum trip delay, harmonic overload IDMT	(0.05-6000.00) s	±20% or ±200 ms whichever is greater
Minimum trip delay, harmonic overload IDMT	(0.05-60.00) s	±20% or ±200 ms whichever is greater
Independent time delay, overcurrent at 0 to 2 x Iset	(0.00-6000.00) s	±0.2% or ±30 ms whichever is greater
Independent time delay, undercurrent at 2 x Iset to 0	(0.00-6000.00) s	±0.2% or ±60 ms whichever is greater
Independent time delay, reactive power overload function at 0 to 2 x QOL>	(1.00-6000.00) s	±0.2% or ±100 ms whichever is greater
Independent time delay, harmonic overload at 0 to 2 x HOL>	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater

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20.6 Voltage protection

Table 47: 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
Absolute hysteresis	(0.0–50.0)% of *UBase*	±0.5% of U_r
Internal blocking level, step 1 and step 2	(1–50)% of *UBase*	±0.5% of U_r
Inverse time characteristics for step 1 and step 2, see Table 137	-	See Table 137
Definite time delay, step 1 at 1.2 to 0 x U_{set}	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 to 0 x U_{set}	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000–60.000) s	±0.5% or ±40ms whichever is greater
Operate time, start at 2 to 0 x U_{set}	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 to 0 x U_{set}	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 to 0 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 48: 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 $U > U_r$
Absolute hysteresis	(0.0–50.0)% of *UBase*	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Inverse time characteristics for steps 1 and 2, see Table 136	-	See Table 136
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±45 ms whichever is greater
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Minimum operate time, Inverse characteristics	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

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Table 49: Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and step 2	(1.0-200.0)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0.0–50.0)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Inverse time characteristics for low and high step, see	-	See
Definite time delay low step (step 1) at 0 to 1.2 x U_{set}	(0.00–6000.00) s	± 0.2% or ± 45 ms whichever is greater
Definite time delay high step (step 2) at 0 to 1.2 x U_{set}	(0.000–60.000) s	± 0.2% or ± 45 ms whichever is greater
Minimum operate time	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 50: Voltage differential protection VDCPTOV

Function	Range or value	Accuracy
Voltage difference for alarm and trip	(2.0–100.0) % of *UBase*	±0.5% of U_r
Under voltage level	(1.0–100.0) % of *UBase*	±0.5% of U_r
Independent time delay for voltage differential alarm at 0.8 to 1.2 x UDAlarm	(0.000–60.000)s	±0.2% or ±40 ms whichever is greater
Independent time delay for voltage differential trip at 0.8 to 1.2 x UDTrip	(0.000–60.000)s	±0.2% or ±40 ms whichever is greater
Independent time delay for voltage differential reset at 1.2 to 0.8 x UDTrip	(0.000–60.000)s	±0.2% or ±40 ms whichever is greater

Table 51: Loss of voltage check LOVPTUV

Function	Range or value	Accuracy
Operate voltage	(1–100)% of UBase	±0.5% of U_r
Pulse timer when disconnecting all three phases	(0.050–60.000) s	±0.2% or ±15 ms whichever is greater
Time delay for enabling the functions after restoration	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater
Operate time delay when disconnecting all three phases	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater
Time delay to block when all three phase voltages are not low	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater

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20.7 Frequency protection

Table 52: Underfrequency protection SAPTUF

Function	Range or value		Accuracy
Operate value, start function, at symmetrical three phase voltage	(35.00-75.00) Hz		±2.0 mHz
Operate time, start at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	fn = 50 Hz	Min. = 80 ms	-
		Max. = 95 ms	
	fn = 60 Hz	Min. = 65 ms	
		Max. = 80 ms	
Reset time, start at f_{set} - 0.02 Hz to f_{set} + 0.02 Hz	Min. = 15 ms Max. = 30 ms		-
Operate time, definite time function at f_{set} + 0.02 Hz to f_{set} - 0.02 Hz	(0.000-60.000)s		±0.2% or ±100 ms whichever is greater
Reset time, definite time function at f_{set} - 0.02 Hz to f_{set} + 0.02 Hz	(0.000-60.000)s		±0.2% or ±120 ms whichever is greater
Voltage dependent time delay	Settings: UNom=(50-150)% of U_{base} UMin=(50-150)% of U_{base} Exponent=0.0-5.0 tMax =(0.010–60.000)s tMin =(0.010–60.000)s		±1.0% or ±120 ms whichever is greater

$$t = \left[\frac{U - UMin}{UNom - UMin}\right]^{Exponent} \cdot \left(tMax - tMin\right) + tMin$$

(Equation 2)

U=$U_{measured}$

Table 53: Overfrequency protection SAPTOF

Function	Range or value		Accuracy
Operate value, start function at symmetrical three-phase voltage	(35.00-90.00) Hz		±2.0 mHz
Operate time, start at f_{set} -0.02 Hz to f_{set} +0.02 Hz	fn = 50Hz	Min. = 80 ms Max. = 95 ms	-
	fn = 60 Hz	Min. = 65 ms Max. = 80 ms	
Reset time, start at f_{set} +0.02 Hz to f_{set} -0.02 Hz	Min. = 15 ms Max. = 30 ms		-
Operate time, definite time function at f_{set} -0.02 Hz to f_{set} +0.02 Hz	(0.000-60.000)s		±0.2% ±100 ms whichever is greater
Reset time, definite time function at f_{set} +0.02 Hz to f_{set} -0.02 Hz	(0.000-60.000)s		±0.2% ±120 ms, whichever is greater

Table 54: Rate-of-change of frequency protection SAPFRC

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	±10.0 mHz/s
Operate value, restore enable frequency	(45.00-65.00) Hz	±2.0 mHz
Definite restore time delay	(0.000-60.000) s	±0.2% or ±100 ms whichever is greater
Definite time delay for frequency gradient trip	(0.000-60.000) s	±0.2% or ±120 ms whichever is greater
Definite reset time delay	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater

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20.8 Multipurpose protection

Table 55: General current and voltage protection CVGAPC

Function	Range or value	Accuracy
Measuring current input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Measuring voltage input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Start overcurrent, step 1 - 2	(2 - 5000)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Start undercurrent, step 1 - 2	(2 - 150)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Independent time delay, overcurrent at 0 to 2 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undercurrent at 2 to 0 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overcurrent (non-directional):		
Start time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Start time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Undercurrent:		
Start time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Overcurrent:		
Inverse time characteristics, see Table 133, Table 134 and Table 135	16 curve types	See Table 133, Table 134 and Table 135
Overcurrent:		
Minimum operate time for inverse curves, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	±0.5% of U_r
Start overvoltage, step 1 - 2	(2.0 - 200.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Start undervoltage, step 1 - 2	(2.0 - 150.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Independent time delay, overvoltage at 0.8 to 1.2 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undervoltage at 1.2 to 0.8 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overvoltage:		
Start time at 0.8 to 1.2 x U_{set}	Min. = 15 ms Max. = 30 ms	-

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Function	Range or value	Accuracy
Reset time at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Undervoltage: Start time at 1.2 to 0.8 x U_{set} Reset time at 1.2 to 0.8 x U_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overvoltage: Inverse time characteristics, see Table 136	4 curve types	See Table 136
Undervoltage: Inverse time characteristics, see Table 137	3 curve types	See Table 137
High and low voltage limit, voltage dependent operation, step 1 - 2	(1.0 - 200.0)% of UBase	±1.0% of U_r at U ≤ U_r ±1.0% of U at U > U_r
Directional function	Settable: NonDir, forward and reverse	-
Relay characteristic angle	(-180 to +180) degrees	±2.0 degrees
Relay operate angle	(1 to 90) degrees	±2.0 degrees
Reset ratio, overcurrent	> 95%	-
Reset ratio, undercurrent	< 105%	-
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x I_{set} 15 ms typically	 - -
Undercurrent: Critical impulse time Impulse margin time	 10 ms typically at 2 to 0 x I_{set} 15 ms typically	 - -
Overvoltage: Critical impulse time Impulse margin time	 10 ms typically at 0.8 to 1.2 x U_{set} 15 ms typically	 - -
Undervoltage: Critical impulse time Impulse margin time	 10 ms typically at 1.2 to 0.8 x U_{set} 15 ms typically	 - -

20.9 Secondary system supervision

Table 56: 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
Table continues on next page		

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Function	Range or value	Accuracy
Operate phase dead line current	(1–100)% of IBase	±0.5% of I_r
Operate time, start, 1 ph, at 1 to 0 x U_r	Min. = 10 ms Max. = 25 ms	-
Reset time, start, 1 ph, at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	-

Table 57: Fuse failure supervision VDSPVC

Function	Range or value	Accuracy
Operate value, block of main fuse failure	(10.0-80.0)% of UBase	±0.5% of Ur
Reset ratio	<110%	
Operate time, block of main fuse failure at 1 to 0 x U_r	Min. = 5 ms	–
	Max. = 15 ms	
Reset time, block of main fuse failure at 0 to 1 x U_r	Min. = 15 ms	–
	Max. = 30 ms	
Operate value, alarm for pilot fuse failure	(10.0-80.0)% of UBase	±0.5% of Ur
Reset ratio	<110%	–
Operate time, alarm for pilot fuse failure at 1 to 0 x U_r	Min. = 5 ms	–
	Max. = 15 ms	
Reset time, alarm for pilot fuse failure at 0 to 1 x U_r	Min. = 15 ms	–
	Max. = 30 ms	

20.10 Control

Table 58: Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, j_{line} - j_{bus}	(-180 to 180) degrees	-
Voltage high limit for synchronizing and synchrocheck	(50.0-120.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line for synchrocheck	(0.003-1.000) Hz	±2.5 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	±2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	(0.02-0.5) p.u	±0.5% of U_r
Time delay output for synchrocheck when angle difference between bus and line jumps from “PhaseDiff” + 2 degrees to “PhaseDiff” - 2 degrees	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	±2.5 mHz
Frequency difference maximum limit for synchronizing	(0.050-0.500) Hz	±2.5 mHz
Breaker closing pulse duration	(0.050-60.000) s	±0.2% or ±15 ms whichever is greater
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-6000.00) s	±0.2% or ±35 ms whichever is greater

Table continues on next page

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Function	Range or value	Accuracy
Minimum time to accept synchronizing conditions	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Voltage high limit for energizing check	(50.0-120.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Reset ratio, voltage high limit	> 95%	-
Voltage low limit for energizing check	(10.0-80.0)% of UBase	±0.5% of U_r
Reset ratio, voltage low limit	< 105%	-
Maximum voltage for energizing	(50.0-180.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Time delay for energizing check when voltage jumps from 0 to 90% of Urated	(0.000-60.000) s	±0.2% or ±100 ms whichever is greater
Operate time for synchrocheck function when angle difference between bus and line jumps from “PhaseDiff” + 2 degrees to “PhaseDiff” - 2 degrees	Min. = 15 ms Max. = 30 ms	–
Operate time for energizing function when voltage jumps from 0 to 90% of Urated	Min. = 70 ms Max. = 90 ms	–

Table 59: Autorecloser SMBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 1Ph shot 1 - t1 2Ph shot 1 - t1 3PhHS shot 1 - t1 3Ph	(0.000-120.000) s	±0.2% or ±35 ms whichever is greater
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Extended autorecloser open time	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Maximum operate pulse duration	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Reclaim time	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Circuit breaker closing pulse length	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Wait for master release	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Inhibit reset time	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Autorecloser maximum wait time for sync	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
CB check time before unsuccessful	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
Wait time after close command before proceeding to next shot	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater

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20.11 Logic

Table 60: Number of TMAGAPC instances

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

Table 61: Number of ALMCALH instances

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

Table 62: Number of WRNCALH instances

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

Table 63: Number of INDCALH instances

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

Table 64: Number of AND instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
AND	108	60	160

Table 65: Number of GATE instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
GATE	34	10	20

Table 66: Number of INV instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INV	114	114	240

Table 67: Number of LLD instances

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

Table 68: Number of OR instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
OR	213	108	160

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Table 69: 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 70: Number of RSMEMORY instances

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

Table 71: Number of SRMEMORY instances

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

Table 72: Number of TIMERSET instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
TIMERSET	15	39	30	(0.000–90000.000) s	±0.5% ±10 ms

Table 73: Number of XOR instances

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

Table 74: Number of ANDQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
ANDQT	-	20	100

Table 75: Number of INDCOMBSPQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INDCOMBSPQT	-	10	10

Table 76: Number of INDEXTSPQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INDEXTSPQT	-	10	10

Table 77: Number of INVALIDQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INVALIDQT	-	6	6

Table 78: Number of INVERTERQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INVERTERQT	-	20	100

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Table 79: Number of ORQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
ORQT	-	20	100

Table 80: Number of PULSETIMERQT instances

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

Table 81: Number of RSMEMORYQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
RSMEMORYQT	-	10	30

Table 82: Number of SRMEMORYQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
SRMEMORYQT	-	10	30

Table 83: Number of TIMERSETQT instances

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

Table 84: Number of XORQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
XORQT	-	10	30

Table 85: Number of instances in the extension logic package

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
AND	40	40	100
GATE	-	-	49
INV	40	40	100
LLD	-	-	49
OR	40	40	100
PULSETIMER	5	5	49
SLGAPC	10	10	54
SRMEMORY	-	-	110
TIMERSET	-	-	49
VSGAPC	10	10	110
XOR	-	-	49

Table 86: Number of B16I instances

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

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Table 87: Number of BTIGAPC instances

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

Table 88: Number of IB16 instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
IB16	6	4	8

Table 89: Number of ITBGAPC instances

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

Table 90: 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 91: Number of TEIGAPC instances

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

Table 92: 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%

20.12 Monitoring

Table 93: Measurements CVMMXN

Function	Range or value	Accuracy
Frequency	(0.95-1.05) x f_r	±2.0 mHz
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
Table continues on next page		

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Function	Range or value	Accuracy
	(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 94: Phase 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 95: Phase-phase voltage measurement 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 96: Phase-neutral voltage measurement 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 97: Current sequence component 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

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Table 98: 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 99: 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 100: Disturbance report DRPRDRE

Function	Range or value	Accuracy
Pre-fault time	(0.05–9.90) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–10.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See Table 129
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	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 101: Insulation gas monitoring function SSIMG

Function	Range or value	Accuracy
Pressure alarm level	1.00-100.00	±10.0% of set value
Pressure lockout level	1.00-100.00	±10.0% of set value
Table continues on next page		

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Function	Range or value	Accuracy
Temperature alarm level	-40.00-200.00	±2.5% of set value
Temperature lockout level	-40.00-200.00	±2.5% of set value
Time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Reset time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250ms whichever is greater
Time delay for pressure 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 102: Insulation liquid monitoring function SSIML

Function	Range or value	Accuracy
Oil alarm level	1.00-100.00	±10.0% of set value
Oil lockout level	1.00-100.00	±10.0% of set value
Temperature alarm level	-40.00-200.00	±2.5% of set value
Temperature lockout level	-40.00-200.00	±2.5% of set value
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 103: 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 104: Event list

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Table continues on next page		

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Function	Value
Resolution	1 ms
Accuracy	Depending on time synchronizing

Table 105: Indications

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	352
	Maximum number of recorded disturbances	100

Table 106: Event recorder

Function		Value
Buffer capacity	Maximum number of events in disturbance report	150
	Maximum number of disturbance reports	100
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 107: Trip value recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	30
	Maximum number of disturbance reports	100

Table 108: Disturbance recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	352
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Table 109: Limit counter L4UFCNT

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

20.13 Metering

Table 110: Pulse-counter logic PCFCNT

Function	Setting range	Accuracy
Input frequency	See Binary Input Module (BIM)	-
Cycle time for report of counter value	(1–3600) s	-

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Table 111: Energy metering ETPMMTR

Function	Range or value	Accuracy
Energy metering	kWh Export/Import, kvarh Export/Import	Input from MMXU. No extra error at steady load

20.14 Station communication

Table 112: Communication protocols

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

Table 113: LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 114: SPA communication protocol

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

Table 115: IEC 60870-5-103 communication protocol

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

Table 116: 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/35ft typically *)
Fiber diameter	Glass fiber: 62.5/125 mm Plastic fiber: 1 mm
*) depending on optical budget calculation	

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Table 117: 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/3000ft m typically *) Plastic fiber: 7 dB (25m/80ft m typically *)
Fiber diameter	Glass fiber: 62.5/125 mm Plastic fiber: 1 mm
*) depending on optical budget calculation	

Table 118: Galvanic X.21 line data communication module (X.21-LDCM)

Quantity	Range or value
Connector, X.21	Micro D-sub, 15-pole male, 1.27 mm (0.050") pitch
Connector, ground selection	2 pole screw terminal
Standard	CCITT X21
Communication speed	64 kbit/s
Insulation	1 kV
Maximum cable length	100 m

Table 119: 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 120: IEC 62439-3 Edition 1 and Edition 2 parallel redundancy protocol

Function	Value
Communication speed	100 Base-FX

20.15 Remote communication

Table 121: Line data communication module

Characteristic	Range or value		
Type of LDCM	**Short range (SR)**	**Medium range (MR)**	**Long range (LR)**
Type of fiber	Multi-mode fiber glass 62.5/125 µm Multi-mode fiber glass 50/125 µm	Single-mode fiber glass 9/125 µm	Single-mode fiber glass 9/125 µm
Peak Emission Wave length Nominal Maximum Minimum	 820 nm 865 nm 792 nm	 1310 nm 1330 nm 1290 nm	 1550 nm 1580 nm 1520 nm
Optical budget Multi-mode fiber glass 62.5/125 mm Multi-mode fiber glass 50/125 mm	18.8 dB (typical distance about 3 km/2 mile *) 11.5 dB (typical distance about 2 km/1 mile *)	26.8 dB (typical distance 80 km/50 mile *)	28.7 dB (typical distance 120 km/68 mile *)
Table continues on next page			

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Characteristic	Range or value		
Type of LDCM	**Short range (SR)**	**Medium range (MR)**	**Long range (LR)**
Optical connector	Type ST	Type FC/PC	Type FC/PC
Protocol	C37.94	C37.94 implementation **)	C37.94 implementation **)
Data transmission	Synchronous	Synchronous	Synchronous
Transmission rate / Data rate	64 kbit/s	64 kbit/s	64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal	Internal or derived from received signal
*) depending on optical budget calculation **) C37.94 originally defined just for multi-mode; using same header, configuration and data format as C37.94			

20.16 Hardware

20.16.1 IED

Table 122: Case

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

Table 123: Water and dust protection level according to IEC 60529

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

Table 124: Weight

Case size	Weight
6U, 1/2 x 19”	£ 10 kg/22 lb
6U, 3/4 x 19”	£ 15 kg/33 lb
6U, 1/1 x 19”	£ 18 kg/40 lb

20.16.2 Electrical safety

Table 125: 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)

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20.16.3 Connection system

Table 126: 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) 2 x 2.5 mm^2 (2 x AWG14)
Terminal blocks suitable for ring lug terminals	250 V AC, 20 A	4 mm^2 (AWG12)

Table 127: Auxiliary power supply and 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)
Terminal blocks suitable for ring lug terminals	300 V AC	3 mm^2 (AWG14)

Because of limitations of space, when ring lug terminal is ordered for Binary I/O connections, one blank slot is necessary between two adjacent IO cards. Please refer to the ordering particulars for details.

20.17 Basic IED functions

Table 128: Self supervision with internal event list

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

Table 129: 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 130: GPS time synchronization module (GTM)

Function	Range or value	Accuracy
Receiver	–	±1µs relative UTC
Time to reliable time reference with antenna in new position or after power loss longer than 1 month	<30 minutes	–
Time to reliable time reference after a power loss longer than 48 hours	<15 minutes	–
Time to reliable time reference after a power loss shorter than 48 hours	<5 minutes	–

Table 131: GPS – Antenna and cable

Function	Value
Max antenna cable attenuation	26 db @ 1.6 GHz
Antenna cable impedance	50 ohm
Lightning protection	Must be provided externally
Table continues on next page	

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Function	Value
Antenna cable connector	SMA in receiver end TNC in antenna end
Accuracy	+/-1μs

Table 132: IRIG-B

Quantity	Rated value
Number of channels IRIG-B	1
Number of optical channels	1
Electrical connector:	
Electrical connector IRIG-B	BNC
Pulse-width modulated	5 Vpp
Amplitude modulated – low level – high level	 1-3 Vpp 3 x low level, max 9 Vpp
Supported formats	IRIG-B 00x, IRIG-B 12x
Accuracy	+/-10μs for IRIG-B 00x and +/-100μs for IRIG-B 12x
Input impedance	100 k ohm
Optical connector:	
Optical connector IRIG-B	Type ST
Type of fiber	62.5/125 μm multimode fiber
Supported formats	IRIG-B 00x
Accuracy	+/- 1μs

20.18 Inverse characteristic

Table 133: ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1\right)} + B\right) \times k$ Reset characteristic: $t = \frac{t_r}{\left(I^{2} - 1\right)} \cdot k$ $I = I_{measured}/I_{set}$	0.05 ≤ k ≤ 999.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	ANSI/IEEE C37.112 , ±2.0% or ±40 ms whichever is greater
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	
ANSI Very inverse	A=19.61, B=0.491, P=2.0 , tr=21.6	
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, tr=4.85	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

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Table 134: 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 ≤ k ≤ 999.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
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	
Programmable characteristic Operate characteristic: $t = \left(\frac{A}{\left(I^{P} - C \right)} + B \right) \cdot k$ Reset characteristic: $t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	

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.

Table 135: RI and RD type inverse time characteristics

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 ≤ k ≤ 999.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot In \frac{I}{k} \right)$ $I = I_{measured}/I_{set}$		

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Table 136: 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	±5.0% or ±45 ms whichever is greater
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	
Programmable curve: $t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 137: 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	±5.0% or ±45 ms whichever is greater
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	
Programmable curve: $t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U < -U}{U<} - C\right)^{P}}\right] + D$ U< = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

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Section 21 Ordering for customized IED

Table 138: General guidelines

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.

Table 139: Example ordering code

To obtain the complete ordering code, please combine code from the selection tables, as given in the example below. The selected qty of each table must be filled in, if no selection is possible the code is 0 Example of a complete code: REB670*2.1-F00X00 - A01010000000000 - B00000000000000000000000000 - C08240880002824004402000000 - D22202020 - E6660 - F6 - S0 - G022 - H13021110000 - K00000000 - L0011 - M80 - P01 - B1X0 - AC - MB - B - A3X0 - D1D1ARGN1N1XXXXXXX - AAFXXX - AX

Product definition					-	**Differential protection**															-
REB670*	2.1	-		X00	-	A	0		0		0	0	0	0	0	0	0	0	0	0	-

Impedance protection																											-
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-

Current protection																											-
C	0			0			0	0	0				0	0			0		0	0	0	0	0				-

Voltage protection									-	**Frequency protection**					-	**Multipurpose protection**			-	**General calculation**		-
D				0		0		0	-	E				0	-	F			-	S	0	-

Secondary system supervision					-	**Control**																					-
G		0	0		-	H	0		0		0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	-

Scheme communication									-	**Logic**			-	**Monitoring**			-	**Station communication**															-
K	0	0	0	0	0	0	0	0	-	L			-	M		0	-	P	0		0	0	0	0	0	0	0	0	0	0	0	-

Language	-	**Casing and Mounting**	-	**Connection and power**			-	**HMI**	-	**Analog input**					-	**Binary input/output**																-
B1		-			-				-		-					-															-

Remote end serial communication						-	**Serial communication unit for station communication**	
						-		

Table 140: Product definition

REB670*	2.1		X00

Table 141: Product definition ordering codes

Product	REB670*
Software version	2.1
Configuration alternatives	
Busbar protection REB670	F00
Selection:	
ACT configuration	
No ACT configuration downloaded	X00

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Table 142: Differential protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0		0		0	0	0	0	0	0	0	0	0	0

Table 143: Differential functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Busbar differential protection, 2 zones, three phase/8 bays	BBP3PH8B	1MRK005904-AC	2	0–1		Note: Only one Busbar differential protection must be ordered .
Busbar differential protection, 2 zones, single phase/24 bays	BBP1PH24B	1MRK005904-BC	4	0–1		

Table 144: Impedance protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 145: Current protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
C	0			0			0	0	0				0	0			0		0	0	0	0	0

Table 146: Current functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Four step phase overcurrent protection	OC4PTOC	1MRK005910-BB	2	0–8		**Note**: Only one PTOC may be selected
Four step single phase overcurrent protection	PH4SPTOC	1MRK005910-CA	3	00–24		
Four step residual overcurrent protection	EF4PTOC	1MRK005910-EC	5	0–8		
Four step directional negative phase sequence overcurrent protection	NS4PTOC	1MRK005910-FB	6	0–8		
Thermal overload protection, two time constants	TRPTTR	1MRK005910-HB	10	0–2		
Breaker failure protection	CCRBRF	1MRK005910-LA	11	0–8		**Note**: Only one BRF may be selected
Breaker failure protection, single phase version	CCSRBRF	1MRK005910-MA	12	00–24		
Directional Underpower protection	GUPPDUP	1MRK005910-RA	15	0–4		

Table continues on next page

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Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Directional Overpower protection	GOPPDOP	1MRK005910-TA	16	0–4		
Capacitor bank protection	CBPGAPC	1MRK005910-UA	18	0–2		

Table 147: Voltage protection

Position	1	2	3	4	5	6	7	8
D				0		0		0

Table 148: Voltage functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Two step undervoltage protection	UV2PTUV	1MRK005912-AA	1	0–2		
Two step overvoltage protection	OV2PTOV	1MRK005912-BA	2	0–2		
Two step residual overvoltage protection	ROV2PTOV	1MRK005912-CC	3	0–2		
Voltage differential protection	VDCPTOV	1MRK005912-EA	5	0–2		
Loss of voltage check	LOVPTUV	1MRK005912-GA	7	0–2		

Table 149: Frequency protection

Position	1	2	3	4
E				00

Table 150: Frequency functions

Function	Function identification	Ordering no	position	Available qty	Selected qty	Notes and rules
Underfrequency protection	SAPTUF	1MRK005914-AA	1	0–6		
Overfrequency protection	SAPTOF	1MRK005914-BA	2	0–6		
Rate-of-change frequency protection	SAPFRC	1MRK005914-CA	3	0–6		

Table 151: Multipurpose protection

Position	1
F	

Table 152: Multipurpose functions

Function	Function identification	Ordering no	Position	Available qty	Selected Qty	Notes and rules
General current and voltage protection	CVGAPC	1MRK005915-AA	1	0–6		

Table 153: General calculation

Position	1
S	0

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Table 154: Secondary system supervision

Position	1	2	3
G	0		

Table 155: Secondary system supervision functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Fuse failure supervision	FUFSPVC	1MRK005916-BA	2	0–2		
Fuse failure supervision based on voltage difference	VDRFUF	1MRK005916-CA	3	0–2		

Table 156: Control

Position	1	2	3	4	5	6	7	8	9	10	11
H	0		0		0	0		0	0	0	0

Table 157: Control functions

Function	Function identification	Ordering no	Position	Available qty	Selected Qty	Notes and rules
Synchrocheck, energizing check and synchronizing	SESRSYN	1MRK005917-XA	2	0–3		
Autorecloser	SMBRREC	1MRK005917-XB	4	0–2		
Apparatus control for up to 6 bays, max 30 app. (6CBs) incl. Interlocking	APC30	1MRK005917-CY	7	0–1		

Table 158: Scheme communication

Position	1	2	3	4	5	6	7	8
K	0	0	0	0	0	0	0	0

Table 159: Logic

Position	1	2
L		

Table 160: Logic functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Configurable logic blocks Q/T		1MRK005922-MX	1	0–1		
Extension logic package		1MRK005922-AY	2	0–1		

Table 161: Monitoring

Position	1	2
M		0

Table 162: Monitoring functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Circuit breaker condition monitoring	SSCBR	1MRK005924-HA	1	00–24		

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Table 163: Station communication

Position	1	2	3	4	5	6	7	8	9	10	11	12	13
P	0		0	0	0	0	0	0	0	0	0	0	0

Table 164: Station communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
IEC 62439-3 parallel redundancy protocol	PRP	1MRK002924-YB	2	0–1		**Note**: Require 2-channel OEM

Table 165: Language selection

First local HMI user dialogue language	Selection		Notes and Rules
HMI language, English IEC	B1		
Additional HMI language			
No additional HMI language		X0	
HMI language, English US		A12	
Selected			

Table 166: Casing selection

Casing	Selection	Notes and Rules
1/2 x 19" case	A	
3/4 x 19" rack casing 1 TRM slot	B	
3/4 x 19" case 2 TRM slots	C	
1/1 x 19" case 1 TRM slot	D	
1/1 x 19" case 2 TRM slots	E	
Selected		

Table 167: Mounting selection

Mounting details with IP40 of protection from the front	Selection	Notes and Rules
No mounting kit included	X	
19" rack mounting kit for 1/2 x 19" case of 2xRHGS6 or RHGS12	A	
19" rack mounting kit for 3/4 x 19" case or 3xRGHS6	B	
19" rack mounting kit for 1/1 x 19" case	C	
Wall mounting kit	D	Note: Wall mounting not recommended with communication modules with fiber connection (SLM, OEM, LDCM)
Flush mounting kit	E	
Flush mounting kit + IP54 mounting seal	F	
Selected		

Table 168: Connection type

Connection type for Power supply module	Selection		Notes and Rules
Compression terminals	M		
Ringlug terminals	N		
Connection type for Input/Output modules			

Table continues on next page

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Connection type for Power supply module	Selection		Notes and Rules
Compression terminals		P	
Ringlug terminals		R	
Selected			

Table 169: Auxiliary power supply

	Selection	Notes and Rules
24-60 VDC	A	
90-250 VDC	B	
Selected		

Table 170: Human machine interface selection

Human machine hardware interface	Selection	Notes and Rules
Medium size - graphic display, IEC keypad symbols	B	
Medium size - graphic display, ANSI keypad symbols	C	
Selected		

Table 171: Analog system selection

Analog system	Selection				Notes and Rules
Compression terminals	A				**Note**: Only the same type of TRM (compression or ringlug) in the same terminal.
Ringlug terminals	B				
First TRM 12I 1A, 50/60Hz		1			
First TRM 12I 5A, 50/60Hz		2			
First TRM 9I+3U 1A, 100/220V, 50/60Hz		3			
First TRM 9I+3U 5A, 100/220V, 50/60Hz		4			
First TRM 6I+6U 1A, 100/220V, 50/60Hz		6			
First TRM 6I+6U 5A, 100/220V, 50/60Hz		7			
No second TRM included			X0		
Compression terminals			A		
Ringlug terminals			B		
Second TRM 12I 1A, 50/60Hz				1	
Second TRM 12I 5A, 50/60Hz				2	
Second TRM 9I+3U 1A, 100/220V, 50/60Hz				3	
Second TRM 9I+3U 5A, 100/220V, 50/60Hz				4	
Second TRM 6I+6U 1A, 100/220V, 50/60Hz				6	
Second TRM 6I+6U 5A, 100/220V, 50/60Hz				7	
Selected					

Table 172: Maximum quantity of I/O modules

When ordering I/O modules, observe the maximum quantities according to the table below
Note: Standard order of location for I/O modules is BIM-BOM-SOM-IOM-MIM from left to right as seen from the rear side of the IED, but can also be freely placed.
Note: The maximum quantity of I/O modules depends on the type of connection terminals.

Case sizes	BIM	IOM	BOM/ SOM	MIM	Maximum in case
1/1 x 19”, one (1) TRM	14	6	4	4	14 cards, including a combination of four cards of type BOM, SOM and MIM
1/1 x 19”, two (2) TRM	11	6	4	4	11 cards, including a combination of four cards of type BOM, SOM and MIM

Table continues on next page

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When ordering I/O modules, observe the maximum quantities according to the table below Note: Standard order of location for I/O modules is BIM-BOM-SOM-IOM-MIM from left to right as seen from the rear side of the IED, but can also be freely placed. Note: The maximum quantity of I/O modules depends on the type of connection terminals.					
3/4 x 19”, one (1) TRM	8	6	4	4	8 cards, including a combination of four cards of type BOM, SOM and maximun oen MIM
3/4 x 19”, two (2) TRM	5	5	4	4	5 cards, including a combination of four cards of type BOM, SOM and maximun oen MIM
1/2 x 19”, one (1) TRM	3	3	3	1	3 cards

Table 173: Maximum quantity of I/O modules, with ringlug terminals

Note: Only every second slot can be used.					
Case sizes	BIM	IOM	BOM/ SOM	MIM	Maximum in case
1/1 x 19” rack casing, one (1) TRM	7	6	4	4	7 **) possible locations: P3, P5, P7, P9, P11, P13, P15
1/1 x 19” rack casing, two (2) TRM	5	5	4	4	5 **) possible locations: P3, P5, P7, P9, P11
3/4 x 19” rack casing, one (1) TRM	4	4	4	4	4 **) possible locations: P3, P5, P7, P9
3/4 x 19” rack casing, two (2) TRM	2	2	2	2	2, possible locations: P3, P5
1/2 x 19” rack casing, one (1) TRM	1	1	1	1	1, possible location: P3
**) including a combination of maximum four modules of type BOM, SOM and MIM					

Table 174: Binary input/output module selection

Binary input/ output modules	Selection														Notes and Rules
Slot position (rear view)	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	X141	X151	X161	Note! Max 3 positions in 1/2 rack, 8 in 3/4 rack with 1 TRM, 5 in 3/4 rack with 2 TRM, 11 in 1/1 rack with 2 TRM and 14 in 1/1 rack with 1 TRM
1/2 Case with 1 TRM	■	■	■												
3/4 Case with 1 TRM	■	■	■	■	■	■	■	■							
3/4 Case with 2 TRM	■	■	■	■	■										
1/1 Case with 1 TRM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1/1 Case with 2 TRM	■	■	■	■	■	■	■	■	■	■	■				
No board in slot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
BIM 16 inputs, RL24-30 VDC, 50 mA	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	
Table continues on next page															

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Binary input/ output modules	Selection														Notes and Rules
BIM 16 inputs, RL48-60 VDC, 50 mA	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110-125 VDC, 50 mA	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220-250 VDC, 50 mA	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, 220-250 VDC, 120mA	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIMp 16 inputs, RL24-30 VDC, 30 mA, for pulse counting	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
BIMp 16 inputs, RL48-60 VDC, 30 mA, for pulse counting	G	G	G	G	G	G	G	G	G	G	G	G	G	G	
BIMp 16 inputs, RL110-125 VDC, 30 mA, for pulse counting	H	H	H	H	H	H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220-250 VDC, 30 mA, for pulse counting	K	K	K	K	K	K	K	K	K	K	K	K	K	K	
IOM 8 inputs, 10+2 output, RL24-30 VDC, 50 mA	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, 10+2 output, RL48-60 VDC, 50 mA	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs, 10+2 output, RL110-125 VDC, 50 mA	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, 10+2 output, RL220-250 VDC, 50 mA	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM 8 inputs 10+2 output relays, 220-250 VDC, 110mA	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs, 10-2 output, 24-30 VDC, 30 mA	U	U	U	U	U	U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, 10-2 output, 48-60 VDC, 30 mA	V	V	V	V	V	V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, 10-2 output, 110-125 VDC, 30 mA	W	W	W	W	W	W	W	W	W	W	W	W	W	W	

Table continues on next page

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Binary input/ output modules	Selection														Notes and Rules
IOM with MOV 8 inputs, 10-2 output, 220-250 VDC, 30 mA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
SOM Static output module, 12 outputs, 48-60 VDC	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	Note: SOM must not to be placed in position nearest to NUM; 1/2 case slot P5, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 1 TRM slot P16, 1/1 case 2 TRM slot P13
SOM static outputs module, 12 outputs, 110-250 VDC	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	
Selected.															

Table 175: Remote end serial communication selection

Remote end communication, DNP serial comm. and time synchronization modules	Selection						Notes and Rules
Slot position (rear view)	X312	X313	X302	X303	X322	X323	Note: The maximum number and type of LDCM modules supported depend on the total amount of modules (BIM, BOM, LDCM, OEM, GTM, SLM, RS485, IRIG-B) in the IED.
Available slots in 1/2, 3/4 and 1/1 case with 1TRM	■	■	■	■			Note: Max 2 LDCM in 1/2 case
Available slots in 3/4 and 1/1 case with 2 TRM	■	■	■	■	■	■	
No remote communication board included	X	X	X	X	X	X	
Optical short range LDCM	A	A	A	A	A	A	Note: Max 2 LDCM (same or different type) can be selected Rule: Always place LDCM modules on the same board to support redundant communication; in P30:2 and P30:3, P31:2 and P31:3 or P32:2 and P32:3
Optical medium range, LDCM 1310 nm	B	B	B	B	B	B	
Optical long range, LDCM 1550 nm	C	C	C	C	C	C	
Galvanic X21 line data communication module	E	E	E	E	E	E	
IRIG-B Time synchronization module	F	F	F	F	F	F	
Galvanic RS485 communication module	G	G	G	G	G	G	
GPS time synchronization module	S	S			S	S	
Selected							

Table 176: Serial communication unit for station communication selection

Serial communication unit for station communication	Selection		Notes and Rules
Slot position (rear view)	X301	X311	
No communication board included	X	X	
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	A		
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	B		
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	C		
Optical ethernet module, 1 channel glass		D	
Optical ethernet module, 2 channel glass		E	
Selected.			

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Section 22 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: REB670 *2.1-A30X00- A02H02-B1A3-AC-MB-B-A3X0-DAB1RGN1N1XXXXXXX-AXFXXX-AX. Using the code of each position #1-13 specified as REB70*1-2 2-3 3 3 3 3 3 3 3-4 4-5-6-7 8-9-10 10 10 10-11 11 11 11 11 11 11 11 11 11-12 12 12 12 12 12-13 13

#	1	-	2		-	3												-	4		-	5	6	-	7		8	-	9	-
REB670*		-			-													-			-			-				-		-

10				-	11												-	12							-	13		
				-													.								-			

	Position	
SOFTWARE	**#1**	**Notes and Rules**
Version number		
Version no	2.1	
Selection for position #1.		

Configuration alternatives	**#2**		**Notes and Rules**
3 phase, 4 bays	A20		
3 phase, 8 bays	A31		
1 phase, 12 bays, single busbar	B20		
1 phase, 12 bays, double busbar	B21		
1 phase, 24 bays	B31		
ACT configuration			
Simple station layout, 1 1/2 CB, 2 CB, 1 CB, b-contacts, BBP only		X01	
Double busbar - 1 CB, a and b contacts, BBP only		X02	Note: Only for A31, B21 and B31
Double busbar - 1 CB, a and b contacts, BBP, EnFP and OCP		X03	Note: Only for A31, B21 and B31 **Note: One each of Breaker failure protection and Overcurrent protection must be ordered**
Selection for position #2.			

Software options	**#3**					**Notes and Rules**
No option	X00					All fields in the ordering form do not need to be filled in
Four step phase overcurrent protection, 4 bays	C06					Note: Only for A20
Four step phase overcurrent protection, 8 bays	C07					Note: Only for A31
Four step single phase overcurrent protection, 12 bays	C08					Note: Only for B20 and B21
Four step single phase overcurrent protection, 24 bays	C09					Note: Only for B31
Breaker failure protection, 4 bays		C10				Note: Only for A20
Breaker failure protection, 8 bays		C11				Note: Only for A31

Table continues on next page

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Software options	#3					Notes and Rules
Breaker failure protection, 12 bays, single phase		C12				Note: Only for B20 and B21
Breaker failure protection, 24 bays, single phase		C13				Note: Only for B31
Autorecloser, 2 circuit breakers			H05			
Circuit breaker condition monitoring - 12CB				M12		Note: M12 only for A20, B20 and B21. M14 only for A31 and B31.
Circuit breaker condition monitoring - 24CB				M14		
IEC 62439-3 parallel redundancy protocol					P03	Note: P03 requires a 2–channel OEM.
Selection for position #3						

First local HMI user dialogue language	#4		Notes and Rules
HMI language, English IEC	B1		
Additional local HMI user dialogue language			
No additional HMI language		X0	
HMI language, English US		A12	
Selection for position #4.			

Casing	#5	Notes and Rules
1/2 x 19" case	A	Note: Only for A20/B20
3/4 x 19" case 1 TRM	B	Note: Only for A20/B20
3/4 x 19” case 2 TRM	C	Note: Only for A31/B21/B31
1/1 x 19" case 2 TRM slots	E	Note: Only for A31/B21/B31
Selection for position #5.		

Mounting details with IP40 of protection from the front	#6	Notes and Rules
No mounting kit included	X	
19" rack mounting kit for 1/2 x 19" case of 2xRHGS6 or RHGS12	A	Note: Only for A20/B20
19" rack mounting kit for 3/4 x 19" case or 3xRGHS6	B	
19" rack mounting kit for 1/1 x 19" case	C	
Wall mounting kit	D	Note: Wall mounting not recommended with communication modules with fiber connection (SLM, OEM, LDCM)
Flush mounting kit	E	
Flush mounting kit + IP54 mounting seal	F	
Selection for position #6.		

Connection type	#7		Notes and Rules
Connection type for Power supply module			
Compression terminals	M		
Ringlug terminals	N		
Connection type for input/output and communication modules			
Compression terminals		P	Note: Not in A31A
Ringlug terminals		R	Note: Only for A31A
Selection for position #7.			

Auxiliary power supply	#8	Notes and Rules
24-60 VDC	A	
90-250 VDC	B	
Selection for position #8.		

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Human machine hardware interface	#9	Notes and Rules
Medium size - graphic display, IEC keypad symbols	B	
Medium size - graphic display, ANSI keypad symbols	C	
Selection for position #9.		

Connection type for Analog modules	#10				Notes and Rules
Compression terminals	A				
Ringlug terminals	B				
Analog system					
First TRM, 12I, 1A		1			
First TRM, 12I, 5A		2			
No second TRM included			X0		Note: A31/B31 must include a second TRM, optional in B21
Compression terminals			A		
Ringlug terminals			B		
Second TRM, 12I, 1A				1	
Second TRM, 12I, 5A				2	
Selection for position #10.					

Binary input/output module, mA and time synchronization boards.	#11											Notes and Rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM included in A20, A31 and B20. 2 BIM and 1 BOM included in B21 and B31												
Slot position (rear view)	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	Note: Max 3 positions in 1/2 rack, 8 in 3/4 rack with 1 TRM, 5 in 3/4 rack with 2 TRM and 11 in 1/1 rack with 2 TRM
1/2 Case with 1 TRM	■	■	■									Note: Only for A20/B20. Only position X31 to X51 can be selected
3/4 Case with 1 TRM	■	■	■	■	■	■	■	■				Note: Only for A20/B20
3/4 Case with 2 TRM	■	■	■	■	■							Note: Only for A31/B21/B31
1/1 Case with 2 TRM	■	■	■	■	■	■	■	■	■	■	■	Note: Only for A31/B21/B31
No board in slot			X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)		A	A	A	A	A	A	A	A	A	A	Note: Maximum 4 BOM+SOM boards. X51 not in B21/B31
BIM 16 inputs, 24-30 VDC, 50mA	B1		B1	B1	B1	B1	B1	B1	B1	B1	B1	
BIM 16 inputs, 48-60 VDC, 50mA	C1		C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, 110-125 VDC, 50mA	D1		D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, 220-250 VDC, 50mA	E1		E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, 220-250 VDC, 120mA	E2		E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIMp 16 inputs, 24-30 VDC, 30mA, for pulse counting			F	F	F	F	F	F	F	F	F	Note: X51 not in B21/B31.
BIMp 16 inputs, 48-60 VDC, 30mA, for pulse counting			G	G	G	G	G	G	G	G	G	
BIMp 16 inputs, 110-125 VDC, 30mA, for pulse counting			H	H	H	H	H	H	H	H	H	

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Binary input/output module, mA and time synchronization boards.	#11											Notes and Rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM included in A20, A31 and B20. 2 BIM and 1 BOM included in B21 and B31												
BIMp 16 inputs, 220-250 VDC, 30mA, for pulse counting			K	K	K	K	K	K	K	K	K	
IOM 8 inputs 10+2 output relays, 24-30 VDC, 50mA			L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs 10+2 output relays, 48-60 VDC, 50mA			M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs 10+2 output relays, 110-125 VDC, 50mA			N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs 10+2 output relays, 220-250 VDC, 50mA			P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM 8 inputs 10+2 output relays, 220-250 VDC, 110mA			P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs ,10 out, 2 high-speed, 24-30 VDC, 30mA			U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs 10 out, 2 high-speed, 48-60 VDC, 30mA			V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs 10 out, 2 high-speed, 110-125 VDC, 30mA			W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs 10 out, 2 high-speed, 220-250 VDC, 30mA			Y	Y	Y	Y	Y	Y	Y	Y	Y	
SOM Static binary output, 12 outputs; 6 standard relays + 6 static outputs, 48-60 VDC			T1	T1	T1	T1	T1	T1	T1	T1	T1	Note: SOM must not to be placed in position nearest to NUM; 1/2 case slot P5, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 1 TRM slot P16, 1/1 case 2 TRM slot P13 X51 not in B21/B31.
SOM Static binary output, 12 outputs; 6 standard relays + 6 static outputs, 110-250 VDC			T2	T2	T2	T2	T2	T2	T2	T2	T2	
Selection for position #11.												

Remote end communication, DNP serial comm. and time synchronization modules	#12						Notes and Rules
Slot position (rear view)	X312	X313	X302	X303	X322	X323	Note: The maximum number and type of LDCM modules supported depend on the total amount of modules (BIM, BOM, LDCM, OEM, GTM, SLM, RS485, IRIG-B) in the IED.
Available slots in 1/2 and 3/4 case with 1TRM	▉	▉	▉	▉			Note: Max 2 LDCM in 1/2 case
Available slots in 3/4 and 1/1 case with 2 TRM	▉	▉	▉	▉	▉	▉	
No remote communication board included	X	X	X	X	X	X	
Optical short range LDCM	A	A	A	A	A	A	Note: Max 2 LDCM can be selected. Rule: Always place LDCM modules on the same board to support redundant communication; in P30:2 and P30:3, P31:2 and P31:3 or P32:2 and P32:3
IRIG-B Time synchronization module	F	F	F	F	F	F	
Galvanic RS485 communication module	G	G	G	G	G	G	

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Remote end communication, DNP serial comm. and time synchronization modules	#12						Notes and Rules
GPS time synchronization module	S	S			S	S	
Selection for position #12.							

Serial communication unit for station communication	#13		Notes and Rules
Slot position (rear view)	X301	X311	
No communication board included	X	X	
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	A		
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	B		
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	C		
Optical ethernet module, 1 channel glass		D	
Optical ethernet module, 2 channel glass		E	
Selection for position #13.			

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Section 23 Ordering for Accessories

23.1 Accessories

23.1.1 External current transformer unit

Note: Only for REB670 B20, B21 and B31

3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 1/1 A	Quantity:	☐	1MRK 000 643-EA
3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 5/1 A	Quantity:	☐	1MRK 000 643-FA
3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 2/1 A	Quantity:	☐	1MRK 000 643-GA

23.1.2 GPS antenna and mounting details

GPS antenna, including mounting kits	Quantity:	☐	1MRK 001 640-AA
Cable for antenna, 20 m (Appx. 65 ft)	Quantity:	☐	1MRK 001 665-AA
Cable for antenna, 40 m (Appx. 131 ft)	Quantity:	☐	1MRK 001 665-BA

23.1.3 Interface converter (for remote end data communication)

External interface converter from C37.94 to G703	Quantity:	1 2 ☐ ☐	1MRK 002 245-AA
External interface converter from C37.94 to G703.E1	Quantity:	1 2 ☐ ☐	1MRK 002 245-BA

23.1.4 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: http://www.hitachienergy.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

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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.

23.1.5 Protection cover

Mounting kit	Quantity	Ordering number
Protective cover for rear side of RHGS6, 6U, 1/4 x 19”		1MRK 002 420-AE
Protective cover for rear side of terminal, 6U, 1/2 x 19”		1MRK 002 420-AC
Protective cover for rear side of terminal, 6U, 3/4 x 19”		1MRK 002 420-AB
Protective cover for rear side of terminal, 6U, 1/1 x 19”		1MRK 002 420-AA

23.1.6 Combiflex

23.1.6.1 Key switch for settings

Key switch for lock-out of settings via LCD-HMI 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		Ordering number
Side-by-side mounting kit	Quantity: ☐	1MRK 002 420-Z

23.1.7 Configuration and monitoring tools

Product description	Quantity	Ordering no
Front connection cable between LCD-HMI and PC		1MRK 001 665-CA

Product description	Quantity	Ordering no
LED Label special paper A4, 1 pc		1MRK 002 038-CA
LED Label special paper Letter, 1 pc		1MRK 002 038-DA

23.2 Manuals

Note: One (1) IED Connect CD 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.

Rule: Specify additional quantity of IED Connect CD requested. Quantity: ☐ 1MRK 002 290-AD

User documentation

Rule: Specify the number of printed manuals requested

Application manual IEC Quantity: ☐ 1MRK 505 337-UEN

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	ANSI	Quantity:	☐	1MRK 505 302-UUS
Technical manual	IEC	Quantity:	☐	1MRK 505 338-UEN
	ANSI	Quantity:	☐	1MRK 505 303-UUS
Commissioning manual	IEC	Quantity:	☐	1MRK 505 339-UEN
	ANSI	Quantity:	☐	1MRK 505 304-UUS
Communication protocol manual, IEC 61850 Edition 1	IEC	Quantity:	☐	1MRK 511 349-UEN
Communication protocol manual, IEC 61850 Edition 2	IEC	Quantity:	☐	1MRK 511 350-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity:	☐	1MRK 511 351-UEN
Communication protocol manual, LON	IEC	Quantity:	☐	1MRK 511 352-UEN
Communication protocol manual, SPA	IEC	Quantity:	☐	1MRK 511 353-UEN
Communication protocol manual, DNP	ANSI	Quantity:	☐	1MRK 511 348-UUS
Point list manual, DNP	ANSI	Quantity	☐	1MRK 511 354-UUS
Operation manual	IEC	Quantity:	☐	1MRK 500 123-UEN
	ANSI	Quantity:	☐	1MRK 500 123-UUS
Installation manual	IEC	Quantity:	☐	1MRK 514 024-UEN
	ANSI	Quantity:	☐	1MRK 514 024-UUS
Engineering manual, 670 series	IEC	Quantity:	☐	1MRK 511 355-UEN
	ANSI	Quantity:	☐	1MRK 511 355-UUS
Cyber security guideline	IEC	Quantity:	☐	1MRK 511 356-UEN

23.3 Reference information

For our reference and statistics we would be pleased to be provided with the following application data:		
Country:	End user:	
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Station name:	Voltage level:	kV

23.4 Related documents

Documents related to REB670	Document numbers
Application manual	IEC:1MRK 505 337-UEN ANSI:1MRK 505 337-UUS
Commissioning manual	IEC:1MRK 505 339-UEN ANSI:1MRK 505 339-UUS
Product guide	1MRK 505 340-BEN
Technical manual	IEC:1MRK 505 338-UEN ANSI:1MRK 505 338-UUS
Type test certificate	IEC:1MRK 505 340-TEN ANSI:1MRK 505 340-TUS

670 series manuals	Document numbers
Operation manual	IEC:1MRK 500 123-UEN ANSI:1MRK 500 123-UUS
Engineering manual	IEC:1MRK 511 355-UEN ANSI:1MRK 511 355-UUS
Installation manual	IEC:1MRK 514 024-UEN ANSI:1MRK 514 024-UUS
Communication protocol manual, DNP3	1MRK 511 348-UUS
Communication protocol manual, IEC 60870-5-103	1MRK 511 351-UEN
Communication protocol manual, IEC 61850 Edition 1	1MRK 511 349-UEN
Communication protocol manual, IEC 61850 Edition 2	1MRK 511 350-UEN
Communication protocol manual, LON	1MRK 511 352-UEN
Communication protocol manual, SPA	1MRK 511 353-UEN
Point list manual, DNP3	1MRK 511 354-UUS
Accessories guide	IEC:1MRK 514 012-BEN ANSI:1MRK 514 012-BUS
Cyber security deployment guideline	1MRK 511 356-UEN
Connection and Installation components	1MRK 513 003-BEN
Test system, COMBITEST	1MRK 512 001-BEN

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