Relion 670 SERIES

Busbar protection REB670
Version 2.2
Product guide

Hitachi Energy

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Section 1 Document revision history

Table 1: Document revision history

Document revision	Date	Product version	History
-			Document not released
A	2017-07	2.2.0	First release for product version 2.2
B	2017-10	2.2.1	Ethernet ports with RJ45 connector added. enhancements/ updates made to GENPDIF, ZMFPDIS and ZMFCPDIS.
C	2018-04	2.2.1	Document enhancements and corrections
D			Document not released
E	2018-07	2.2.2	LDCM galvanic X.21 added. Ordering section updated.
F	2018-11	2.2.2	Technical data updated for PSM and EF4PTOC. Corrections/ enhancements made to OC4PTOC, TRPTTR, UV2PTUV and OV2PTOV. Case dimensions updated.
G	2018-11	2.2.3	Functions CHMMHAI, VHMMHAI, DELVSPVC, DELISPVC and DELSPVC added. Updates/enhancements made to Busbar differential protection (2 zones), CCRBRF, CCSRBRF, REALCOMP and FNKEYMDx. Ordering section updated.
H	2019-05	2.2.3	PTP enhancements and corrections
J			Document not released
K			Document not released
L			Document not released
M	2020-09	2.2.4	Functions IEC 61850SIM and ALGOS added. Updates/ enhancements made to functions EF4PTOC, ROV2PTOV, SAPTUF, SAPTOF, FUFSPVC, SESRSYN, SSIMG, and SSIML. Ordering section updated. Previous revisions of SOM removed, heavy duty SOM only alternative. Certification section included.
N	2021-06	2.2.5	Functions FLTMMXU, HOLDMINMAX, INT_REAL, CONST_INT, INTSEL, LIMITER, ABS, POL_REC, RAD_DEG, CONST_REAL, REALSEL, STOREINT, STOREREAL, DEG_RAD and RSTP added. Support for COMTRADE2013 added. Updates/ enhancements made to functions EF4PTOC, PH4SPTOC, OC4PTOC, NS4PTOC, CHMMHAI, VHMMHAI, CVGAPC, DRPRDRE, SXSWI and SXCBR. Ordering section updated.
P	2021-06	2.2.5	Added note to Disturbance report and IEC 60870-5-103 protocol
Q	2022-07	2.2.5.4	Introduced RIA600, which is a software implementation of the IED LHMI panel.
R			Document not released
S	2023-06	2.2.6	Busbar differential protection for 4 zones, three phase/12 bays, SNMP support, support for 12 MUs, IEC 61850 Ed2.1, new variants of single mode SFP added. Functions B4CTZCONN, BRPTOC, BTFPTRC, BICTPTRC_BIC, BTZNPDIF, BTSMGAPC, BDZS4GAPC, BTCZPDIF, B4CTZCONN, GOOSEACRCV, SNMPSERVERCONF, SNMPUSERCONF, C1RADR, C2RADR and C3RADR added. Functions BDCGAPC, INTERRSIG, SETGRPS, TESTMODE, TERMINALID, VDCPTDV, CVGAPC, SCSWI, VSGAPC, BTIGAPC, BCTZCONN, ITBGAPC, CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU, SSCBR, DRPRDRE, A4RADR, IEC61850-8-1, ACTIVLOG, AP_1-6 and LDCMTRN updated. Ordering section updated.
T	2024-03	2.2.6.3	"Front with status LEDs, Ethernet port" option removed from ordering option Document enhancements and corrections

Section 2 New features

The following are the new features added/updated in the current release:

- SNMP support added
- Three new variants of single mode SFP added
- Support for IEC 61850 Ed2.1
- Support for 12 merging units
- Phasor measurement data streaming and reporting feature according to IEC/IEEE 60255-118 (C37.118)
- Three-phase four-zone busbar differential protection
- Improvements related to apparatus control functions
- Enhancements and corrections

Section 3 Application

3.1 Application

The Intelligent Electronic Device (IED) is designed for the selective, reliable and fast differential protection of busbars, T-connections and meshed corners in up to 6 zones. It can be used for protection of single, double and triple 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 (upto total 36 analogue inputs via TRMs or MUs). 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. For the operating slope of the bias differential operating characteristic (see figure 1),

The fast tripping time (minimum trip time is 5ms when SOM output module is used) 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.

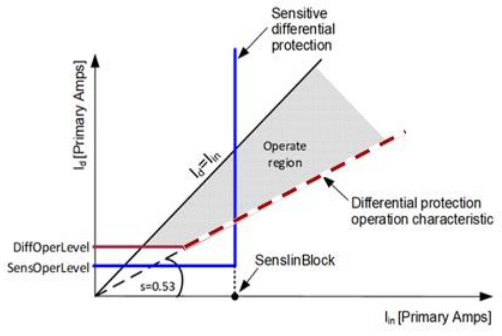
All CT inputs are provided with a restraint feature. The operation is based on the well-proven RADSS percentage restraint stabilization principle, with an extra stabilization feature to stabilize for very heavy CT saturation. Stability for external faults is guaranteed if a CT is not saturated for at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

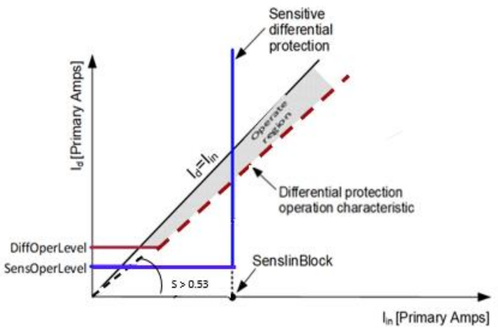
Differential protection zones in the IED include a sensitive operational level. This sensitive operational level is designed to be able to detect internal busbar earth faults in low impedance earthed power systems (that is, power systems where the earth-fault current is limited to a certain level, typically 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).

For the operating slope of the bias differential operating characteristic, see Figure 1 below:

- In two-zone and six-zone busbar differential protections, the operating slope is fixed in the algorithm, with s = 53%.
- In four-zone busbar differential protection, the slope is user settable by a setting, with any value among [0.53, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85]



Two-zone or six-zone busbar differential protection with fixed slope



Four-zone busbar differential protection with settable slope

Figure 1: IED operating characteristic

Integrated overall check zone feature, independent from any disconnector position, is available. It can be used in double or triple 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, triple 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 or more differential zones when required by substation topology (that is load-transfer)
- Easy zone merging initiated by closing of bus-sectionalizing disconnectors
- 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. And optionally also available another simpler overcurrent protections, non-directional overcurrent protections with binary release, which is recommended to be used when MUs are involved.

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.

The IED can be used in applications with IEC/UCA 61850-9-2LE process bus with up to twelve merging units (MU) depending on the other functionality included in the IED. Each MU has eight analog channels, four currents and four voltages. Conventional and Merging Unit channels can be mixed freely in the application.

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.

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

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

The Flexible Product Naming allows the customer to use an IED-vendor independent IEC 61850 model of the IED. This customer model will be 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.

3.2 IED variants and versions

In general, four different types of busbar differential protections are available, namely,

- Single-phase two-zone busbar differential protection
- Three-phase two-zone busbar differential protection
- Single-phase six-zone busbar differential protection
- Three-phase four-zone busbar differential protection.

More specifically, there are the following six versions of busbar differential protection Intelligent Electronic Device (IED) intended for different application areas.

1. Two-zone three-phase four-ACI IED,
    - Accommodate up to two low-impedance differential protection zones and up to four three-phase ACI (analog current inputs).
    - Intended for simpler applications such as T-connections, meshed corners, H-scheme, ring bus
    - Available in 1/2 x 19” case.
2. Two-zone three-phase eight-ACI IED,
    - Accommodate up to two low-impedance differential protection zones and up to eight three-phase analog current inputs.
    - Intended for applications on smaller busbar, with up to two differential zones and eight analog current inputs.
    - Available in 1/1 x 19” case.
3. Two-zone single-phase twelve-ACI IED,
    - Accommodate up to two low-impedance differential protection zones and up to twelve single-phase analog current inputs.
    - Available in either 1/2 x 19” or 1/1 x 19” case.
    - The IED in 1/2 x 19” case is intended for busbar applications without need for dynamic zone selection. Typical examples are substations with single busbar with or without bus-section breaker, one-and-half breaker or double breaker arrangements.
    - The IED in 1/1 x 19” case is intended for busbar applications with need for dynamic zone selection or large number of binary inputs and outputs. Typical examples are double busbar station with or without transfer bus with up to two differential zones and twelve analog current inputs.
    - Can be optionally used with external auxiliary summation transformers.
4. Two-zone single-phase twenty-four-ACI IED,
    - Accommodate up to two low-impedance differential protection zones and up to twenty-four single-phase analog current inputs.
    - Intended for busbar applications in large substation requiring dynamic zone selection, large number of binary inputs and outputs, or large number of analog current inputs. Typical examples are double busbar station with or without transfer bus with up to two differential zones and analog current inputs.
    - Can be optionally used with external auxiliary summation transformers.
    - Available in 1/1 x 19” case.
5. Six-zone single-phase twenty-four-ACI IED,
    - Accommodate up to six freely configurable low-impedance differential protection zones, up to twenty-four freely configurable feeder bays, up to five freely configurable bus-section or bus-coupler bays, and up to twenty-four freely configurable single-phase analog current inputs.
      Note that the twenty-four analog current inputs do limit the total amount of feeder, bus-section or bus-coupler bays which can be used.
    - Intended for busbar applications with complex substation arrangements requiring dynamic zone selection, large number of binary inputs and outputs, or large number of analog current inputs. Typical examples are double or triple busbar stations with or without transfer bus, with or without sectionlization, up to six differential zones and twenty-four analog current inputs.
    - Available in 1/1 x 19” case.
6. Four-zone three-phase twelve-ACI IED,

- Accommodate up to four freely configurable low-impedance differential protection zones, and up to twelve freely configurable three-phase analog current inputs.
  Note that the twelve analog current inputs do limit the total amount of feeder, bus-section or bus-coupler and can be configured:
  - up to twelve freely configurable feeder bays
  - up to four freely configurable bus-section or bus-coupler bays
- Intended for busbar applications with complex substation arrangements requiring dynamic zone selection, large number of binary inputs and outputs, or large number of analog current inputs. Typical examples are double busbar stations with or without transfer bus, with or without sectionlization, up to four differential zones and twelve analog current inputs.
- Available in 1/1 x 19” case.

Table 2: Typical IED configuration for busbar differential protection

IED version			Maximum number of ACIs per IED
Function description	**IEC 61850 identification**	**ANSI/IEEE C37.2 device number**	
Two-zone three-phase four-ACI IED	BUTPTRC_Bx, (1≤x≤4), BZNTPDIF_x, (x = A,B), BCZTPDIF BZITGGIO	87B	4
	BDCGAPC (128 instances)	-	
Two-zone three-phase eight-ACI IED	BUTPTRC_Bx, (1≤x≤4 or 8), BZNTPDIF_x, (x = A,B), BCZTPDIF, BZITGGIO	87B	8
	BDCGAPC (128 instances)	-	
Two-zone single-phase twelve-ACI IED	BUSPTRC_Bx, (1≤x≤6 or 12), BZNSPDIF_x, (x = A,B), BCZSPDIF, BZISGGIO	87B	12
	BDCGAPC (128 instances)	-	
Two-zone single-phase twenty-four-ACI IED	BUSPTRC_Bx, (1≤x≤12 or 24), BZNSPDIF_x, (x = A,B), BCZSPDIF, BZISGGIO	87B	24
	BDCGAPC (128 instances)	-	
Six-zone single-phase twenty-four-ACI IED	BFPTRC_Fx, (1≤x≤24), BICPTRC_x, (1≤x≤5), BZNPDIF_Zx, (1≤x≤6), BCZPDIF, BDZSGAPC	87B	24
	BDCGAPC (128 instances)	-	
Four-zone three-phase twelve-ACI IED	BTFPTRC_Fx, (1≤x≤12), BICTPTRC_BICx, (1≤x≤4), BTZNPDIF_Zx, (1≤x≤4), BTCZPDIF, BDZS4GAPC	87B	12
	BDCGAPC (128 instances)	-	
ACI* = analog current inputs			

3.3 Functionality

The busbar differential protection IEDs are numerical and low-impedance differential protection:

- Intended for protection and monitoring of busbar, T-connection and meshed corner,
- Selective, reliable and fast fault clearance for 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,
  - Selective operation of busbar differential protection to ensure tripping only the faulty part of the busbar system
  - Fast operating with short tripping time
  - Stable for external faults, even with heavy CT saturation
  - Stable for external fault clearance or auto-reclosing
  - Advanced open CT detection with settable blocking of differential protection
  - Additional station wide stability with independent check zone
  - Increased sensitivity with independent sensitive differential protection.
- Applicable for a wide range of switchgear layouts,
  - Applicable for up to six freely configurable differential protection zones and up to 12 freely Configurable bays, when MUs are involved, otherwise up to 8 bays.
  - Applicable for single and multiple busbar with or without transfer bus, double circuit breaker or one-and-half circuit breaker stations
  - Easy incorporation of bus-section and/or bus-coupler bays (that is, tie-breakers) with one or two sets of analog current inputs
  - Easy extendibility for future bays
- Adaptable dynamically to most common busbar configurations,
  - The integrated dynamic zone selection (also referred to as busbar replica) for multi-zone applications. No need of auxiliary relays to include and exclude currents from differential zones
  - Efficient merging of differential zones when required by substation topology (that is, zone interconnection or load-transfer)
  - Easy merging of differential zones initiated externally by closing of bus-sectionalizing disconnectors
- Applicable for the protection of medium voltage (MV), high voltage (HV) and extra high voltage (EHV) installations at a power system with frequency of 50Hz or 60Hz,
- Applicable for both conventional substations (with or without extended with some bays utilizing process-bus technology, for example, IEC 61850-9-2LE SVs) and digital substation.
  Note that in mixed mode, that is, when conventional substations extend with some bays utilizing process-bus technology, it is important to make sure binary data and analogue data are properly coordinated.
- Completely phase segregated measurement.

3.4 Description of pre-configured packages

There are five pre-configured variants of REB670 for two-zone busbar differential protections. They are described in the following Table:

Table 3: 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**
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**

3.5 Available ACT configurations for pre-configured REB670

Three configurations have been made available for pre-configured REB670 IED with two zones. Product variant with six zone is available as customized product only. 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

3.6 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.

3.7 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.

3.8 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 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.

3.9 Application examples of REB670

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

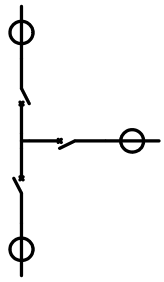


Figure 2: Example of T-connection

Table 4: 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

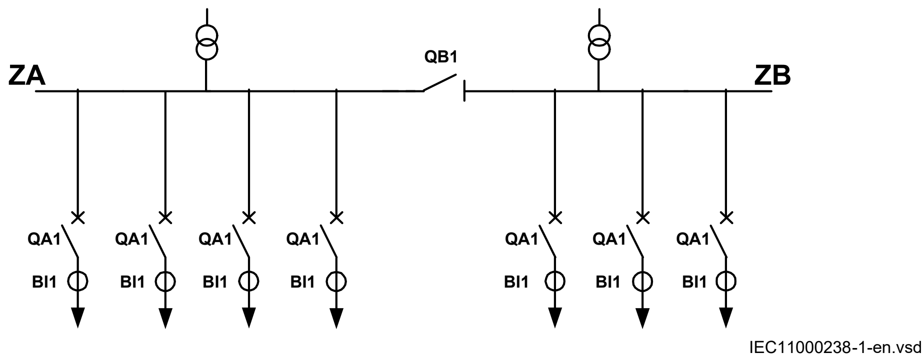


Figure 3: Example of two busbar sections connected with bus-sectionalizing disconnector

Table 5: 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

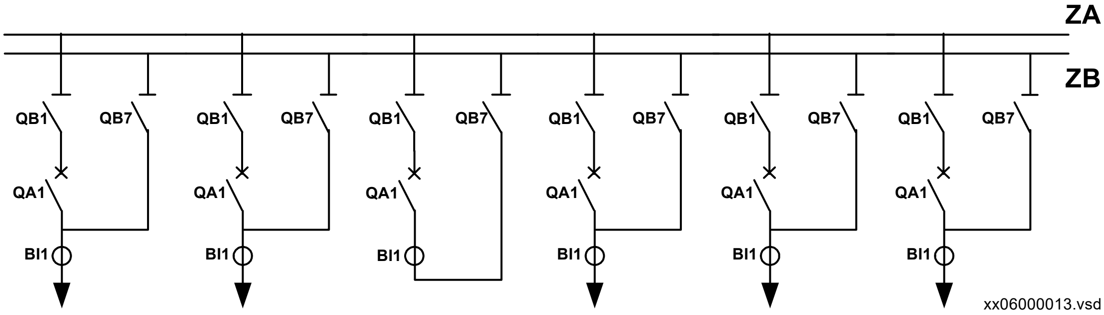


Figure 4: Example of single bus station with transfer bus

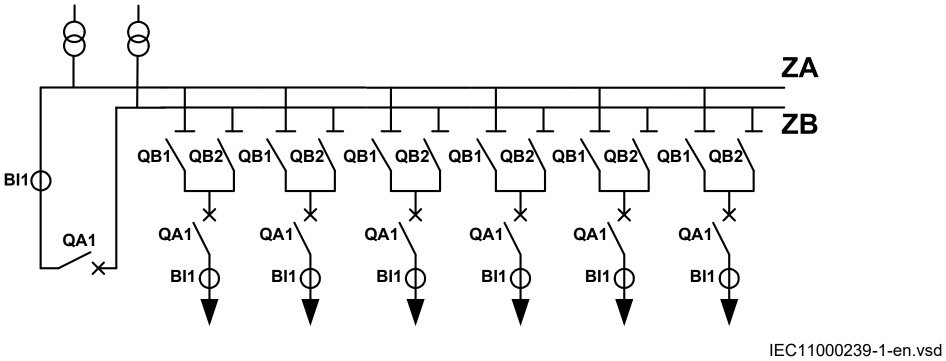


Figure 5: Example of double bus-single breaker station

Table 6: 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		

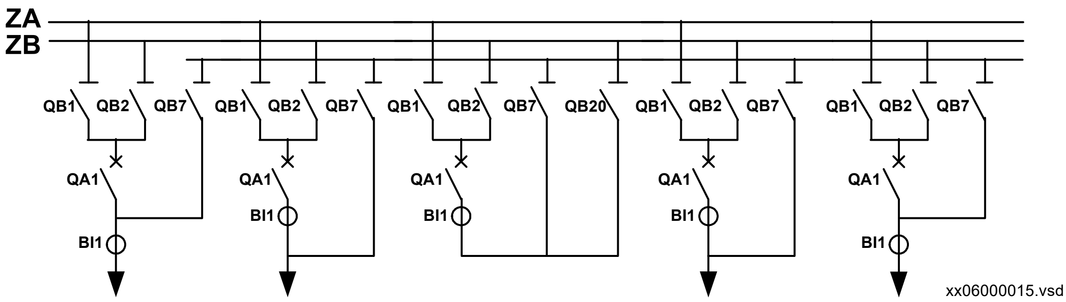


Figure 6: Example of double bus-single breaker station with transfer bus

Table 7: 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		

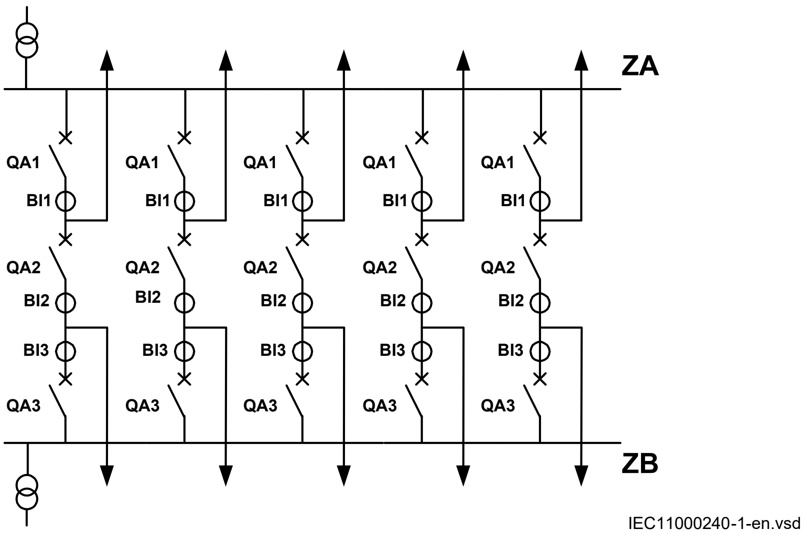


Figure 7: Example of one-and-a-half breaker station

Table 8: 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

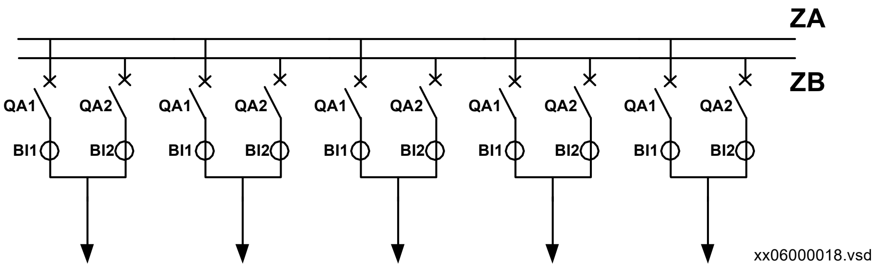


Figure 8: Example of double bus-double breaker station

Table 9: 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

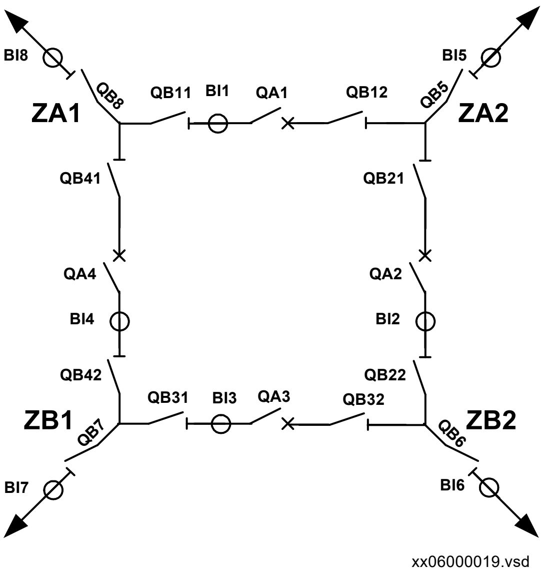


Figure 9: Example of mesh or ring bus station

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 USB flash drive. For the product covering up to six busbar zones, configuration examples are provided in the REB670 Application Manual 1MRK505370-UEN.

3.10 Typical station requiring six/four-zone differential protection

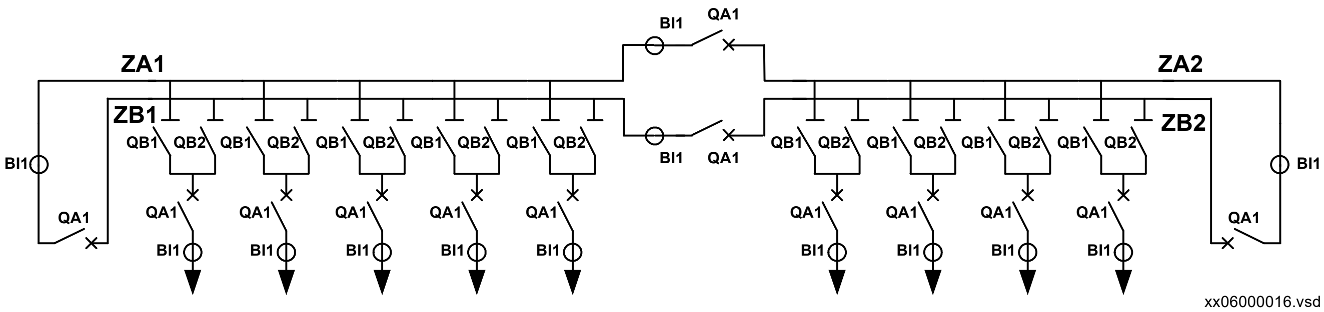


Figure 10: Example of double bus-single breaker station with two bus-section and two bus-coupler breakers (typical GIS station layout)

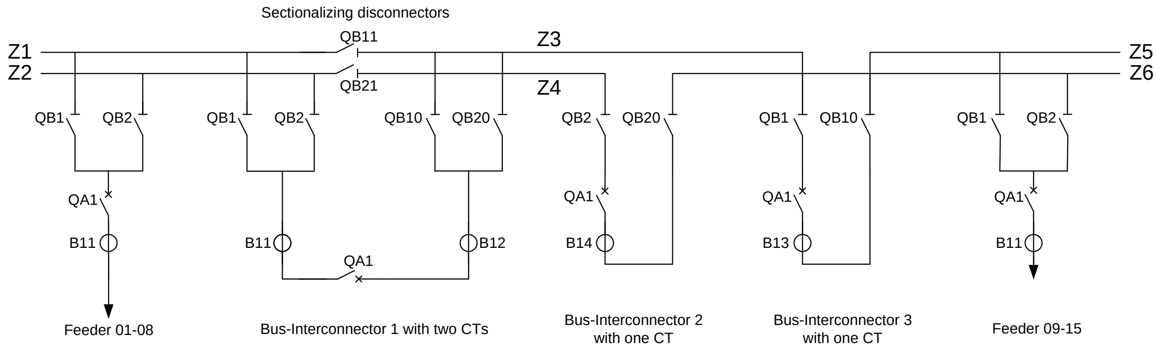


Figure 11: Double busbar station with six protection zones

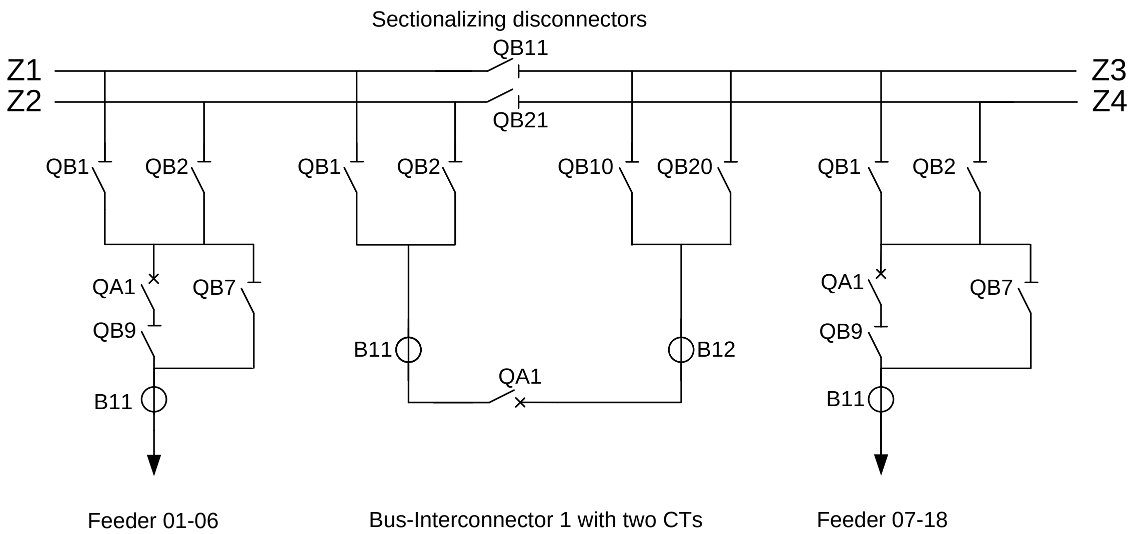


Figure 12: Double busbar station with breaker bypass facility and four protection zones

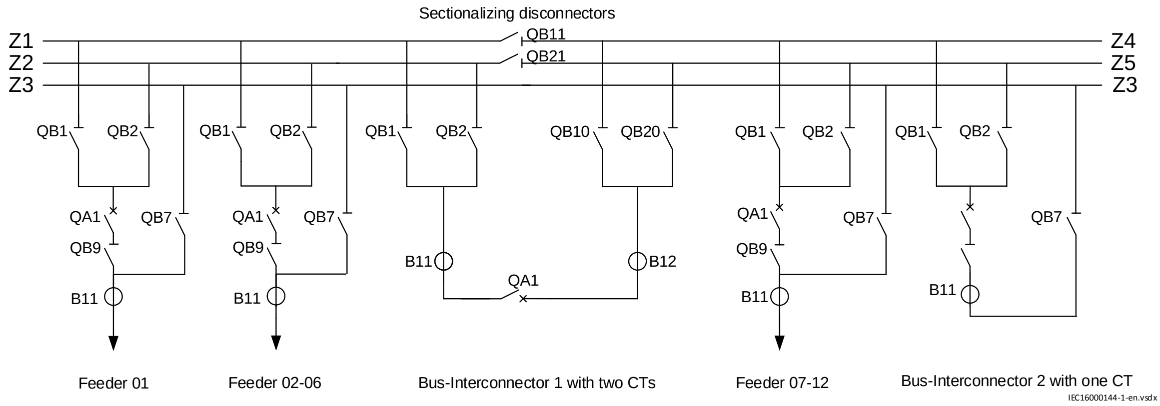


Figure 13: Double busbar station with transfer bus and five protection zones

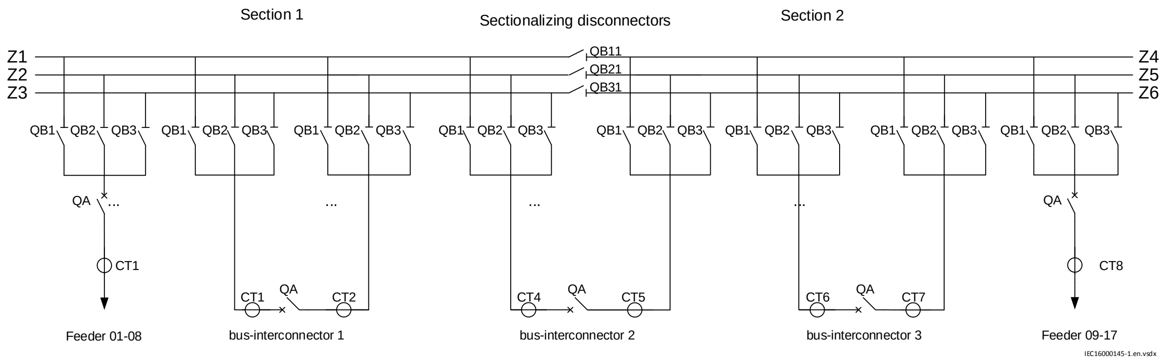


Figure 14: Triple busbar station with two sections and six protection zones

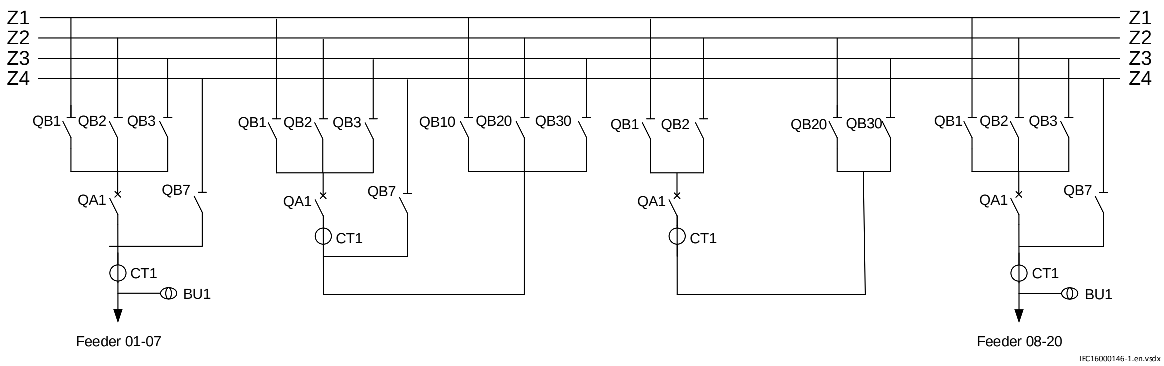


Figure 15: Triple busbar station with transfer bus and four protection zones

For six/four-zone differential protection, there is no pre-configuration available. The configuration is always customized, depending on the applications.

Section 4 Available functions

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

Table 10: Example of quantities

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

4.1 Main protection functions

IEC 61850 or function name	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
BDZSGAPC, BFPTRC, BICPTRC, BZNPDIF, BCZPDIF, BSMGAPC	87B	Busbar differential protection, 6 zones, single phase/24 bays	1					
BTFPTRC, BICTPTRC, BTZNPDIF, BTSMGAPC, BDZS4GAPC, BTCZPDIF	87B	Busbar differential protection, 4 zones, three phase/12 bays	1					
BDCGAPC	87B	Status of primary switching object for busbar protection zone selection	128	20	40	60	60	96

4.2 Back-up protection functions

IEC 61850 or function name	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
Current protection								
OC4PTOC	51_67 1)	Directional phase overcurrent protection, four steps	0-12	4-C06	8-C07			
PH4SPTOC	51	Single phase overcurrent protection, four steps	0-24			12-C08	12-C08	24-C09
EF4PTOC	51N_67N 2)	Directional residual overcurrent protection, four steps	0-12					
NS4PTOC	46I2	Directional negative phase sequence overcurrent protection, four steps	0-12					
TRPTTR	49	Thermal overload protection, two time constants	0-2					
CCRBRF	50BF	Breaker failure protection	0-12	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					
BRPTOC	50	Overcurrent protection with binary release	0-24					
Voltage protection								
UV2PTUV	27	Two step undervoltage protection	0-2					
OV2PTOV	59	Two step overvoltage protection	0-2					
ROV2PTOV	59N	Residual overvoltage protection, two steps	0-2					
VDCPTDV	87V	Voltage differential protection	0-2					
LOVPTUV	27	Loss of voltage check	0-2					
Frequency protection								
SAPTUF	81	Underfrequency protection	0-10					
SAPTOF	81	Overfrequency protection	0-6					
SAPFRC	81	Rate-of-change of frequency protection	0-6					
Multipurpose protection								
CVGAPC		General current and voltage protection	0-6					

Table Note:

1) 67 requires voltage
2) 67N requires voltage

4.3 Control and monitoring functions

IEC 61850 or function name	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
Control								
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	Control functionality for up to 6 bays, max 30 objects (6CBs), including interlocking (see Table 12)	0-1					
QCBAY		Bay control	1+5/APC30	1	1	1	1	1
LOCREM		Handling of local/remote switch positions	1+5/APC30	1	1	1	1	1
LOCREMCTRL		WebUI control of the permitted source to operate (PSTO)	1	1	1	1	1	1
SXCBR		Circuit breaker	24	24	24	24	24	24
SLGAPC		Logic rotating switch for function selection and WebUI presentation	15	15	15	15	15	15
VSGAPC		Selector mini switch	30	30	30	30	30	30
DPGAPC		Generic communication function for Double Point indication	32	32	32	32	32	32
SPC8GAPC		Single point generic control function, 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 inputs	8	8	8	8	8	8
I103CMD		Function commands for IEC 60870-5-103	1	1	1	1	1	1
I103GENCMD		Function commands for IEC 60870-5-103, generic	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	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					
DELVSPVC	7V_78V	Voltage delta supervision	4	4	4	4	4	4
DELISPVC	7I	Current delta supervision	4	4	4	4	4	4
DELSPVC	78	Real delta supervision, real	4	4	4	4	4	4
Logic								
TMAGAPC		Trip matrix logic	12	12	12	12	12	12
Table continues on next page								

IEC 61850 or function name	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
ALMCALH		Logic for group alarm	5	5	5	5	5	5
WRNCALH		Logic for group warning	5	5	5	5	5	5
INDCALH		Logic for group indication	5	5	5	5	5	5
AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SRMEMORY, TIMERSET, XOR		Basic configurable logic blocks (see Table 11)	40-496	40-496	40-496	40-496	40-496	40-496
ANDQT, INDCOMBSPQT, INDEXTSPQT, INVALIDQT, INVERTERQT, ORQT, PULSETIMERQT, RSMEMORYQT, SRMEMORYQT, TIMERSETQT, XORQT		Configurable logic blocks Q/T (see Table 13)	0-1					
AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SLGAPC, SRMEMORY, TIMERSET, VSGAPC, XOR		Extension logic package (see Table 14)	0-1					
FXDSIGN		Fixed signal function block	1	1	1	1	1	1
B16I		Boolean to integer conversion, 16 bit	18	18	18	18	18	18
BTIGAPC		Boolean to integer conversion with logical node representation, 16 bit	16	16	16	16	16	16
IB16		Integer to Boolean 16 conversion	24	24	24	24	24	24
BCTZCONN		Integer to Boolean conversion for six-zone busbar	0/34					
B4CTZCONN		Integer to Boolean conversion for four-zone busbar	0/20					
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	30	30	30	30	30	30
REALCOMP		Comparator for real inputs	30	30	30	30	30	30
HOLDMINMAX		Hold minimum and maximum of input	20	20	20	20	20	20
INT_REAL		Converter integer to real	20	20	20	20	20	20
CONST_INT		Definable constant for logic functions	10	10	10	10	10	10

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
INTSEL		Analog input selector for integer values	5	5	5	5	5	5
LIMITER		Definable limiter	20	20	20	20	20	20
ABS		Absolute value	20	20	20	20	20	20
POL_REC		Polar to rectangular converter	20	20	20	20	20	20
RAD_DEG		Radians to degree angle converter	20	20	20	20	20	20
CONST_REAL		Definable constant for logic functions	10	10	10	10	10	10
REALSEL		Analog input selctor for real values	5	5	5	5	5	5
STOREINT		Store value for integer inputs	10	10	10	10	10	10
STOREREAL		Store value for real inputs	10	10	10	10	10	10
DEG_RAD		Degree to radians angle converter	20	20	20	20	20	20
Monitoring								
CVMMXN		Power system measurement	6	6	6	6	6	6
CMMXU		Current measurement	12	10	10	10	10	10
VMMXU		Voltage measurement phase-phase	6	6	6	6	6	6
CMSQI		Current sequence measurement	6	6	6	6	6	6
VMSQI		Voltage sequence measurement	6	6	6	6	6	6
VNMMXU		Voltage measurement phase-earth	6	6	6	6	6	6
AISVBAS		General service value presentation of analog inputs	1	1	1	1	1	1
EVENT		Event function	20	20	20	20	20	20
DRPRDRE, A1RADR-A4RADR, B1RBDR-B22RBDR, C1RADR-C3RADR		Disturbance report	1	1	1	1	1	1
SPGAPC		Generic communication function for single point indication, 1 input	128	128	128	128	128	128
SP16GAPC		Generic communication function for single point indication, 16 inputs	16	16	16	16	16	16
MVGAPC		Generic communication function for measured values	60	60	60	60	60	60
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	Insulation supervision for gas medium	21	21	21	21	21	21
SSIML	71	Insulation supervision for liquid medium	3	3	3	3	3	3
SSCBR		Circuit breaker condition monitoring	0-24	12	12	12	12	24

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
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	6
CHMMHAI	ITHD	Current harmonic monitoring, 3 phase	0-3	3-M23	3-M23	3-M23	3-M23	3-M23
VHMMHAI	VTHD	Voltage harmonic monitoring, 3 phase	0-3	3-M23	3-M23	3-M23	3-M23	3-M23
FLTMMXU		Fault current and voltage monitoring	12	8	8	8	8	8
Metering								
PCFCNT		Pulse-counter logic	16	16	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	6	6	6	6	6	6

Table 11: Total number of instances for basic configurable logic blocks

Basic configurable logic block	Total number of instances
AND	328
GATE	64
INV	492
LLD	40
OR	496
PULSETIMER	40
RSMEMORY	40
SRMEMORY	40
TIMERSET	108
XOR	40

Table 12: Number of function instances in APC30

Function name	Function description	Total number of instances
SCILO	Interlocking	30
BB_ES		6
A1A2_BS		4
A1A2_DC		6
ABC_BC		2
BH_CONN		2
BH_LINE_A		2
BH_LINE_B		2
DB_BUS_A		3
DB_BUS_B		3
DB_LINE		3
ABC_LINE		6
AB_TRAFO		4
SCSWI	Switch controller	30
SXSWI	Circuit switch	24
QCRSV	Reservation function block for apparatus control	6
RESIN1		1
RESIN2		59
POS_EVAL	Evaluation of position indication	30
QCBAY	Bay control	5
LOCREM	Handling of LR-switch positions	5
XLNPROXY	Proxy for signals from switching device via GOOSE	42
GOOSEXLNRCV	GOOSE function block to receive a switching device	42

Table 13: 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 14: Total number of instances for extended logic package

Extended configurable logic block	Total number of instances
AND	220
GATE	49
INV	220
LLD	49
OR	220

Table continues on next page

Extended configurable logic block	Total number of instances
PULSETIMER	89
RSMEMORY	40
SLGAPC	74
SRMEMORY	130
TIMERSET	113
VSGAPC	120
XOR	89

4.4 Communication

IEC 61850 or function name	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
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
MSTSER		DNP3.0 serial master	1	1	1	1	1	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for TCP/IP 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		IEC 61850	1	1	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59	59	59
IEC 61850SIM		IEC 61850 simulation mode	1	1	1	1	1	1
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

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64	64	64
ALGOS		Supervision of GOOSE subscription	100	100	100	100	100	100
MULTICMDRCV, MULTICMDSND		Multiple command receive and send	60/10	60/10	60/10	60/10	60/10	60/10
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
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1	1	1
FSTACCSNA		Field service tool access via SPA protocol over Ethernet communication	1	1	1	1	1	1
FSTACCS		Field service tool access	1	1	1	1	1	1
GOOSEACRCV		GOOSE function block to receive a protection activation information	16	16	16	16	16	16
		IEC 61850-9-2 Process bus communication, 12 merging units	0-1	1-P30	1-P30	1-P30	1-P30	1-P30
ACTIVLOG		Activity logging	1	1	1	1	1	1
ALTRK		Service tracking	1	1	1	1	1	1
PRP		IEC 62439-3 Parallel redundancy protocol	0-1	1-P23	1-P23	1-P23	1-P23	1-P23
HSR		IEC 62439-3 High-availability seamless redundancy	0-1	1-P24	1-P24	1-P24	1-P24	1-P24
RSTP		IEC 62439-3 Rapid spanning tree protocol	0-1	1-P25	1-P25	1-P25	1-P25	1-P25
SNMPSERVERCONF		SNMPServerConfiguration	1	1	1	1	1	1
SNMPUSERCONF		SNMPUserConfiguration	2	2	2	2	2	2
PMUCONF, PMUREPORT, PHASORREPORT1 - PHASORREPORT4, ANALOGREPORT1 - ANALOGREPORT3, BINARYREPORT1 - BINARYREPORT3, SMAI1 - SMAI12, 3PHSUM, PMUSTATUS		Synchrophasor report, 32 phasors (see Table 15)	0-1					
AP_1-AP_6		AccessPoint_ABS	1	1	1	1	1	1

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Busbar					
			REB670 (Customized)	REB670 (A20)	REB670 (A31)	REB670 (B20)	REB670 (B21)	REB670 (B31)
AP_FRONT		Access point front	1	1	1	1	1	1
PTP		Precision time protocol	1	1	1	1	1	1
ROUTE_1-ROUTE_6		Route_ABS1-Route_ABS6	1	1	1	1	1	1
FRONTSTATUS		Access point diagnostic for front Ethernet port	1	1	1	1	1	1
SCHLCCH		Access point diagnostic for non-redundant Ethernet port	6	6	6	6	6	6
RCHLCCH		Access point diagnostic for redundant Ethernet ports	3	3	3	3	3	3
DHCP		DHCP configuration for front access point	1	1	1	1	1	1
QUALEXP		IEC 61850 quality expander	96	96	96	96	96	96
Remote communication								
BinSignRec1_1 BinSignRec1_2 BinSignReceive2		Binary signal transfer, receive	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6
BinSignTrans1_1 BinSignTrans1_2 BinSignTransm2		Binary signal transfer, transmit	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6
BSR2M_305 BSR2M_312 BSR2M_322 BSR2M_306 BSR2M_313 BSR2M_323		Binary signal transfer, 2Mbit receive	1	1	1	1	1	1
BST2M_305 BST2M_312 BST2M_322 BST2M_306 BST2M_313 BST2M_323		Binary signal transfer, 2Mbit transmit	1	1	1	1	1	1
LDCMTRN		Transmission of analog data from LDCM	1	1	1	1	1	1
LDCMTRN_2M_305 LDCMTRN_2M_306 LDCMTRN_2M_312 LDCMTRN_2M_313 LDCMTRN_2M_322 LDCMTRN_2M_323		Transmission of analog data from LDCM, 2Mbit	1	1	1	1	1	1
LDCMRecBinStat1 LDCMRecBinStat3		Receive binary status from remote LDCM	6/3	6/3	6/3	6/3	6/3	6/3
LDCMRecBinStat2		Receive binary status from LDCM	3	3	3	3	3	3
LDCM2M_305 LDCM2M_312 LDCM2M_322		Receive binary status from LDCM, 2Mbit	1	1	1	1	1	1
LDCM2M_306 LDCM2M_313 LDCM2M_323		Receive binary status from remote LDCM, 2Mbit	1	1	1	1	1	1

Table 15: Number of function instances in Synchrophasor report, 32 phasors

Function name	Function description	Total number of instances
PMUCONF	Configuration parameters for IEC/IEEE 60255-118 (C37.118) 2011 and IEEE1344 protocol	1
PMUREPORT	Protocol reporting via IEEE 1344 and IEC/IEEE 60255-118 (C37.118)	2
PHASORREPORT1	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 1-8	2
PHASORREPORT2	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 9-16	2
PHASORREPORT3	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 17-24	2
PHASORREPORT4	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 25-32	2
ANALOGREPORT1	Protocol reporting of analog data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), analogs 1-8	2
ANALOGREPORT2	Protocol reporting of analog data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), analogs 9-16	2
ANALOGREPORT3	Protocol reporting of analog data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), analogs 17-24	2
BINARYREPORT1	Protocol reporting of binary data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), binary 1-8	2
BINARYREPORT2	Protocol reporting of binary data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), binary 9-16	2
BINARYREPORT3	Protocol reporting of binary data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), binary 17-24	2
SMAI1–SMAI12	Signal matrix for analog inputs	1
3PHSUM	Summation block 3 phase	6
PMUSTATUS	Diagnostics for IEC/IEEE 60255-118 (C37.118) 2011 and IEEE1344 protocol	1

4.5 Basic IED functions

Table 16: Basic IED functions

IEC 61850 or function name	Description
INTERRSIG SELFSUPEVLST	Self supervision with internal event list
TIMESYNCHGEN	Time synchronization module
BININPUT, SYNCHCAN, SYNCHGPS, SYNCHCMPPS, SYNCHLON, SYNCHPPH, SYNCHPPS, SNTP, TIMEZONE	Time synchronization
DSTBEGIN	GPS time synchronization module
DSTENABLE	Enables or disables the use of daylight saving time
DSTEND	GPS time synchronization module
IRIG-B	Time synchronization
SETGRPS	Number of setting groups
ACTVGRP	Active parameter setting group
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
TERMINALID	IED identifiers
Table continues on next page	

IEC 61850 or function name	Description
PRODINF	Product information
SYSTEMTIME	System time
LONGEN	LON communication
RUNTIME	IED Runtime component
SMBI	Signal matrix for binary inputs
SMBO	Signal matrix for binary outputs
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
BCSCONF	Basic communication system
GBASVAL	Global base values for settings
PRIMVAL	Primary system values
SAFEFILECOPY	Safe file copy function
ALTMS	Time master supervision
ALTIM	Time management
CAMCONFIG	Central account management configuration
CAMSTATUS	Central account management status
TOOLINF	Tools information
COMSTATUS	Protocol diagnostic

Table 17: Local HMI functions

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

Section 5 Differential protection

5.1 Differential protection

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

5.2 Busbar differential protection

This protection function is intended for fast and selective tripping of faults within the protected zone. For each current input, the CT ratio can be set from the local HMI or via the parameter-setting tool in 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.

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.

5.3 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. start signal 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.

5.4 Check zone

For busbar protection in stations with double or triple busbars 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 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.

5.5 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 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 from the local HMI via the 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.

5.6 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.

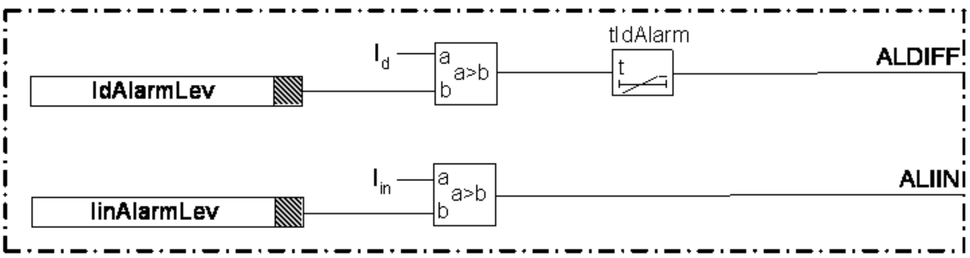


Figure 16: Simplified logic for Zone supervision features

Section 6 Zone selection

6.1 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.

6.2 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.

6.3 Switch status monitoring

For stations with complex primary layout 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 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 18 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 the 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.

Table 18: 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

6.4 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.

From a bay function, it is also possible to take any bay (that is, CT input) out of service or bypass it.

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.

Section 7 Wide area measurement system

7.1 Synchrophasor report, 32 phasors

7.2 Configuration parameters for IEEE 1344 and IEC/IEEE 60255-118 (C37.118) protocol PMUCONF

The IED supports the following IEEE synchrophasor standards:

- IEEE 1344-1995 (Both measurements and data communication)
- IEEE Std IEC/IEEE 60255-118 (C37.118) (Both measurements and data communication)
- IEEE Std IEC/IEEE 60255-118 (C37.118) and IEC/IEEE 60255-118 (C37.118).1a-2014 (Measurements)
- IEEE Std IEC/IEEE 60255-118 (C37.118) (Data communication)

PMUCONF contains the PMU configuration parameters for both IEC/IEEE 60255-118 (C37.118) and IEEE 1344 protocols. This means all the required settings and parameters in order to establish and define a number of TCP and/or UDP connections with one or more PDC clients (synchrophasor client). This includes port numbers, TCP/UDP IP addresses, and specific settings for IEC/IEEE 60255-118 (C37.118) as well as IEEE 1344 protocols.

7.3 Protocol reporting via IEEE 1344 and IEC/IEEE 60255-118 (C37.118) PMUREPORT

The phasor measurement reporting block moves the phasor calculations into an IEC/IEEE 60255-118 (C37.118) and/or IEEE 1344 synchrophasor frame format. The PMUREPORT block contains parameters for PMU performance class and reporting rate, the IDCODE and Global PMU ID, format of the data streamed through the protocol, the type of reported synchrophasors, as well as settings for reporting analog and digital signals.

The message generated by the PMUREPORT function block is set in accordance with the IEC/IEEE 60255-118 (C37.118) and/or IEEE 1344 standards.

There are settings for Phasor type (positive sequence, negative sequence or zero sequence in case of 3-phase phasor and L1, L2 or L3 in case of single phase phasor), PMU's Service class (Protection or Measurement), Phasor representation (polar or rectangular) and the data types for phasor data, analog data and frequency data.

Synchrophasor data can be reported to up to 8 clients over TCP and/or 6 UDP group clients for multicast or unicast transmission of phasor data from the IED. More information regarding synchrophasor communication structure and TCP/UDP configuration is available in Application Manual under section IEC/IEEE 60255-118 (C37.118) Phasor Measurement Data Streaming Protocol Configuration.

Multiple PMU functionality can be configured in the IED, which can stream out same or different data at different reporting rates or different performance (service) classes.

Section 8 Current protection

8.1 Directional phase overcurrent protection, four steps OC4PTOC

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

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

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

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

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

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

8.2 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.

8.3 Directional residual overcurrent protection, four steps EF4PTOC

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

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

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

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

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

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

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

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

8.4 Four step directional negative phase sequence overcurrent protection NS4PTOC

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

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.

8.5 Thermal overload protection, two time constants TRPTTR

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

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

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

The estimated time to trip before operation is presented.

8.6 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 measurement criterion can be current based, CB position based or an adaptive combination of these two conditions.

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

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

CCRBRF provides three different options to select how *t1* and *t2* timers are run:

1. By external start signals which is internally latched
2. Follow external start signal only
3. Follow external start signal and the selected *FunctionMode*

CCRBRF can be single- or three- phase initiated to allow its use with single phase tripping applications. For the three-phase application of the CCRBRF the current criteria can be set to operate only if *“2 elements operates out of three phases and neutral”* for example; two phases or one phase plus the residual current start. This gives a higher security to the backup trip command.

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

8.7 Breaker failure protection, single phase CCSRBRF

Breaker failure protection, single phase version (CCSRBRF) ensures a fast backup tripping of the surrounding breakers in case the own breaker fails to open. CCSRBRF measurement criterion can be current based, CB position based or an adaptive combination of these two conditions.

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

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

The CCSRBRF provides three different options to select how *t1* and *t2* timers are run:

1. By external start signal which is internally latched
2. Follow the external start signal only
3. Follow external start signal and selected *FunctionMode*

The CCSRBRF function can be programmed to give a retrip to its own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect initiation due to mistakes during testing.

8.8 Overcurrent protection with binary release BRPTOC

Overcurrent protection with binary release (BRPTOC) is a simple, non-directional three-phase overcurrent protection function with definite time delay. A single step is available within the function. The current pickup level and definite time delay can be set independently. It is possible to release the function operation via a binary signal. If the binary signal is not connected, the function will automatically operate in a continuous mode of operation. Several function instances are available.

From the measured three-phase currents, various types of measurement modes such as DFT, Peak, and Peak-to-peak can be selected for the BRPTOC operation.

Peak and Peak-to-Peak measurement mode allow this function to be used as instantaneous over-current protection as well. If required by application, short time delay can also be applied.

BRPTOC can be used for different line and transformer protection applications. If required, it can also be used to supervise on-load tap-changer operation.

8.9 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.

8.10 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.

Section 9 Voltage protection

9.1 Two-step undervoltage protection UV2PTUV

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

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

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

9.2 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.

9.3 Residual overvoltage protection, two steps ROV2PTOV

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

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

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

A reset delay ensures operation for intermittent earth faults.

9.4 Voltage differential protection VDCPTDV

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.

9.5 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.

Section 10 Frequency protection

10.1 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.

10.2 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.

10.3 Rate-of-change of frequency protection SAPFRC

The rate-of-change of 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.

Section 11 Multipurpose protection

11.1 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.

Section 12 Secondary system supervision

12.1 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.

12.2 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 fuse failure supervision (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.

12.3 Voltage based delta supervision DELVSPVC

Delta supervision function is used to quickly detect (sudden) changes in the network. This can, for example, be used to detect faults in the power system networks and islanding in grid networks. Voltage based delta supervision (DELVSPVC) is needed at the grid interconnection point.

12.4 Current based delta supervision DELISPVC

Delta supervision function is used to quickly detect (sudden) changes in the network. This can, for example, be used to detect disturbances in the power system network. Current based delta supervision (DELISPVC) provides selectivity between load change and the fault.

Present power system has many power electronic devices or FACTS devices, which injects a large number of harmonics into the system. The function has additional features of 2^{nd} harmonic blocking and 3^{rd} harmonic start level adaption. The 2^{nd} harmonic blocking secures the operation during the transformer charging, when high inrush currents are supplied into the system.

12.5 Delta supervision of real input DELSPVC

Delta supervision functions are used to quickly detect (sudden) changes in the power system. Real input delta supervision (DELSPVC) function is a general delta function. It is used to detect the change measured qualities over a settable time period, such as:

- Power
- Reactive power
- Temperature
- Frequency
- Power factor

Section 13 Control

13.1 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 can run asynchronously, a synchronizing feature is also provided. The main purpose of the synchronizing feature is to provide controlled closing of circuit breakers when two asynchronous systems are in phase and can be connected. The synchronizing feature 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 setting.

13.2 Autorecloser SMBRREC

The auto recloser (SMBRREC) function provides:

- high-speed and/or delayed auto reclosing
- single and/or three phase auto reclosing
- support for single or multi-breaker applications.

The auto recloser can be used for delayed busbar restoration.

Up to five reclosing shots can be performed. The first shot can be single-, two-, and /or three-phase depending on the type of the fault and the selected auto reclosing mode.

Several auto reclosing functions can be provided for multi-breaker arrangements. A priority circuit allows one circuit breaker to reclose first and the second will only close if the fault proved to be transient.

Each auto reclosing function can be configured to co-operate with the synchrocheck function.

13.3 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
- 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.

13.4 Interlocking

The interlocking function blocks the possibility to operate primary switching devices, for instance when a disconnector is under load, in order to prevent material damage and/or accidental human injury.

Each apparatus control function has interlocking modules included for different switchyard arrangements, where each function handles interlocking of one bay. The interlocking function is distributed to each IED and is not dependent on any central function. For the station-wide interlocking, the IEDs communicate via the system-wide interbay bus (IEC 61850-8-1) or by using hard wired binary inputs/outputs. The interlocking conditions depend on the circuit configuration and apparatus position status at any given time.

For easy and safe implementation of the interlocking function, the IED is delivered with standardized and tested software interlocking modules containing logic for the interlocking conditions. The interlocking conditions can be altered, to meet the customer’s specific requirements, by adding configurable logic by means of PCM600 tool.

13.5 Switch controller SCSWI

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

13.6 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.

13.7 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.

13.8 Reservation function QCRSV

The purpose of the reservation (QCRSV) 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.

13.9 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).

13.10 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.

13.11 Proxy for signals from switching device via GOOSE XLNPROXY

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

13.12 GOOSE function block to receive a switching device GOOSEXLNRCV

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

13.13 Local remote LOCREM/Local remote control LOCREMCTRL

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

13.14 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.

13.15 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 a symbol on the single line diagram (SLD) on the local HMI or from binary inputs.

13.16 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.

13.17 Single point generic control 8 signals SPC8GAPC

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

13.18 Automation bits, command function for DNP3.0 AUTOBITS

Automation bits 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).

13.19 Single command, 16 inputs SINGLECMD

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.

Section 14 Logic

14.1 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.

14.2 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.

14.3 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.

14.4 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.

14.5 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.

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

- **AND** function block. The AND function is used to form general combinatory expressions with boolean variables. The AND function block has up to four inputs and two outputs. One of the outputs 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 the input signal to the output.
- **LLD** function block. Loop delay used to delay the output signal one execution cycle.
- **OR** function block. The OR function is used to form general combinatory expressions with boolean variables. The OR function block has up to six inputs and two outputs. One of the outputs is inverted.
- **PULSETIMER** function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- **RSMEMORY** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power

interruption, the flip-flop resets or returns to the state it had before the power interruption. RESET input has priority.

- **SRMEMORY** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, 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** is used to generate combinatory expressions with boolean variables. XOR has two inputs and two outputs. One of the outputs is inverted. The output signal OUT is 1 if the input signals are different and 0 if they are the same.

14.6 Configurable logic blocks Q/T

The configurable logic blocks QT propagate the time stamp and the quality of the input signals (have suffix QT at the end of their function name).

The function blocks assist the user to adapt the IEDs' configuration to the specific application needs. The list below shows a summary of the function blocks and their features.

- **ANDQT** AND function block. The function also propagates the time stamp and the quality of input signals. Each block has four inputs and two outputs where one is inverted.
- **INDCOMBSPQT** combines single input signals to group signal. Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. Quality input bits are copied to the corresponding quality part of SP_OUT output.
- **INDEXTSPQT** extracts individual signals from a group signal input. The value part of single position input is copied to SI_OUT output. The time part of single position input is copied to TIME output. The quality bits in the common part and the indication part of inputs signal are copied to the corresponding quality output.
- **INVALIDQT** function which sets quality invalid of outputs according to a "valid" input. Inputs are copied to outputs. If input VALID is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set to invalid. The time stamp of an output will be set to the latest time stamp of INPUT and VALID inputs.
- **INVERTERQT** function block that inverts the input signal and propagates the time stamp and the quality of the input signal.
- **ORQT** OR function block that also propagates the time stamp and the quality of the input signals. Each block has six inputs and two outputs where one is inverted.
- **PULSETIMERQT** Pulse timer function block can be used, for example, for pulse extensions or limiting of operation of outputs. The function also propagates the time stamp and the quality of the input signal.
- **RSMEMORYQT** 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 the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates the time stamp and the quality of the input signal.
- **SRMEMORYQT** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates the time stamp and the quality of the input signal.

- **TIMERSETQT** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay. The function also propagates the time stamp and the quality of the input signal.
- **XORQT** XOR function block. The function also propagates the time stamp and the quality of the input signals. Each block has two outputs where one is inverted.

14.7 Extension logic package

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

14.8 Fixed signal function block FXDSIGN

The Fixed signals function (FXDSIGN) has nine pre-set (fixed) output 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.

14.9 Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

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

The main features of TEIGAPC

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

14.10 Boolean to integer conversion, 16 bit B16I

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

14.11 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.

14.12 Integer to Boolean 16 conversion IB16

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

14.13 Integer to Boolean conversion for six-zone busbar BCTZCONN

Integer to Boolean conversion for six-zone busbar (BCTZCONN) is used to transform the zone connection integer signal of each CT from one bay function block into 7 binary (logical) signals in the six-zone busbar differential protection. It is intended to facilitate the recording of zone connection information from each bay function block to the disturbance recorder.

The BCTZCONN function does not have a logical node mapping and is designed to receive only an integer input locally.

14.14 Integer to Boolean conversion for four-zone busbar B4CTZCONN

Integer to Boolean conversion for four-zone busbar (B4CTZCONN) is used to transform the zone connection integer signal of each CT from one bay function block into 7 binary (logical) signals in the four-zone busbar differential protection. It is intended to facilitate the recording of zone connection information from each bay function block to the disturbance recorder.

The B4CTZCONN function does not have a logical node mapping and it is designed to receive only an integer input locally.

14.15 Integer to boolean conversion with logical node representation, 16 bit 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 boolean (logic) output signals.

14.16 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.

14.17 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.

14.18 Hold Maximum and Minimum of Input HOLDMINMAX

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

14.19 Converter integer to real INT_REAL

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

14.20 Definable constant for logic function CONST_INT

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

14.21 Analog input selector for integer values INTSEL

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

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

14.22 Definable limiter LIMITER

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

14.23 Absolute value ABS

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

14.24 Polar to rectangular converter POL_REC

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

14.25 Radians to degree angle converter RAD_DEG

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

14.26 Definable constant for logic function CONST_REAL

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

14.27 Analog input selctor for real values REALSEL

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

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

14.28 Store value for integer inputs STOREINT

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

14.29 Store value for real inputs STOREREAL

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

14.30 Degree to radians angle converter DEG_RAD

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

Section 15 Monitoring

15.1 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 analog values from merging units
- 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.

15.2 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.

15.3 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 70 analog and 352 binary signals.

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

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

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

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

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

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

15.4 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 5000 time-tagged events stored in a ring-buffer.

15.5 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.

15.6 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 1056 time-tagged events.

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

15.7 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.

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).

15.8 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 200 disturbances are saved in the IED and the local HMI is used to view the list of recordings .

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

15.10 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.

15.11 Generic communication function for measured values MVGAPC

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

15.12 Measured values 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 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.

15.13 Insulation supervision for gas medium function SSIMG

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

15.14 Insulation supervision for liquid medium SSIML

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

15.15 Circuit breaker condition monitoring SSCBR

The circuit breaker condition 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. Each SCCBR function instance is made to be used with a 1-pole, 1-phase breaker.

15.16 Event counter with limit supervison L4UFCNT

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

Overflow indication is included for each up-counter.

15.17 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

15.18 Current harmonic monitoring CHMMHAI

Current harmonic monitoring function CHMMHAI is used to monitor the current part of the power quality of a system. It calculates the total harmonic distortion (THD) with respect to fundamental signal amplitude, and the total demand distortion (TDD) with respect to maximum demand load current. These indices indicate the current signal quality factor.

Additionally, the function is used to calculate the numerical multiple of rated frequency harmonics amplitude and harmonic distortion up to 9^{th} order. It helps the user to know the predominant harmonic frequencies order and their amplitudes present in the system. The function also calculates the crest factor to indicate the effectiveness of the signal. All calculations in the harmonic monitoring function are based on IEEE 1459 and IEEE 519-2014 standards.

The current harmonic function monitors the harmonic distortion and demand distortion values constantly. Whenever these value crosses their set limit levels, a warning signal will be initiated. If the warning signal persists continuously for the set time, an alarm signal will be generated.

15.19 Voltage harmonic monitoring VHMMHAI

Voltage harmonic monitoring function VHMMHAI is used to monitor the voltage part of the power quality of a system. It calculates the total harmonic distortion (THD) with respect to the fundamental signal amplitude which indicates the voltage signal quality factor.

Additionally, the function is used to calculate the numerical multiple of rated frequency harmonics amplitude and harmonic distortion upto the 9^{th} order. It helps the user to know the predominant harmonic frequencies order and their amplitudes present in the system. The function also calculates the crest factor to indicate the effectiveness of the signal. All calculations in the harmonic monitoring function are based on IEEE 1459 and IEEE 519-2014 standards.

The voltage harmonic function monitors the harmonic distortion value constantly. Whenever these value crosses their set limit levels, a warning signal will be initiated. If the warning signal persists continuously for the set time, an alarm signal will be generated.

15.20 Fault current and voltage monitoring FLTMMXU

The fault current and voltage monitoring function monitors and reports the voltage and current values on occurrence of a trip event.

FLTMMXU function monitors and reports the following values:

- Maximum peak current of individual phases during the trip event
- Maximum RMS current of individual phases during the trip event
- Maximum RMS current of all phases during the trip event

- Fundamental DFT current magnitude and angle of individual phases at the instant of triggering the function via input TRIGFLUI
- Fundamental DFT neutral current magnitude and angle at the instant of triggering the function via input TRIGFLUI
- Fundamental DFT voltage magnitude and angle of individual phases at the instant of triggering the function via input TRIGFLUI
- Fundamental DFT neutral voltage magnitude and angle at the instant of triggering the function via input TRIGFLUI

Section 16 Metering

16.1 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.

16.2 Function for energy calculation and demand handling ETPMMTR

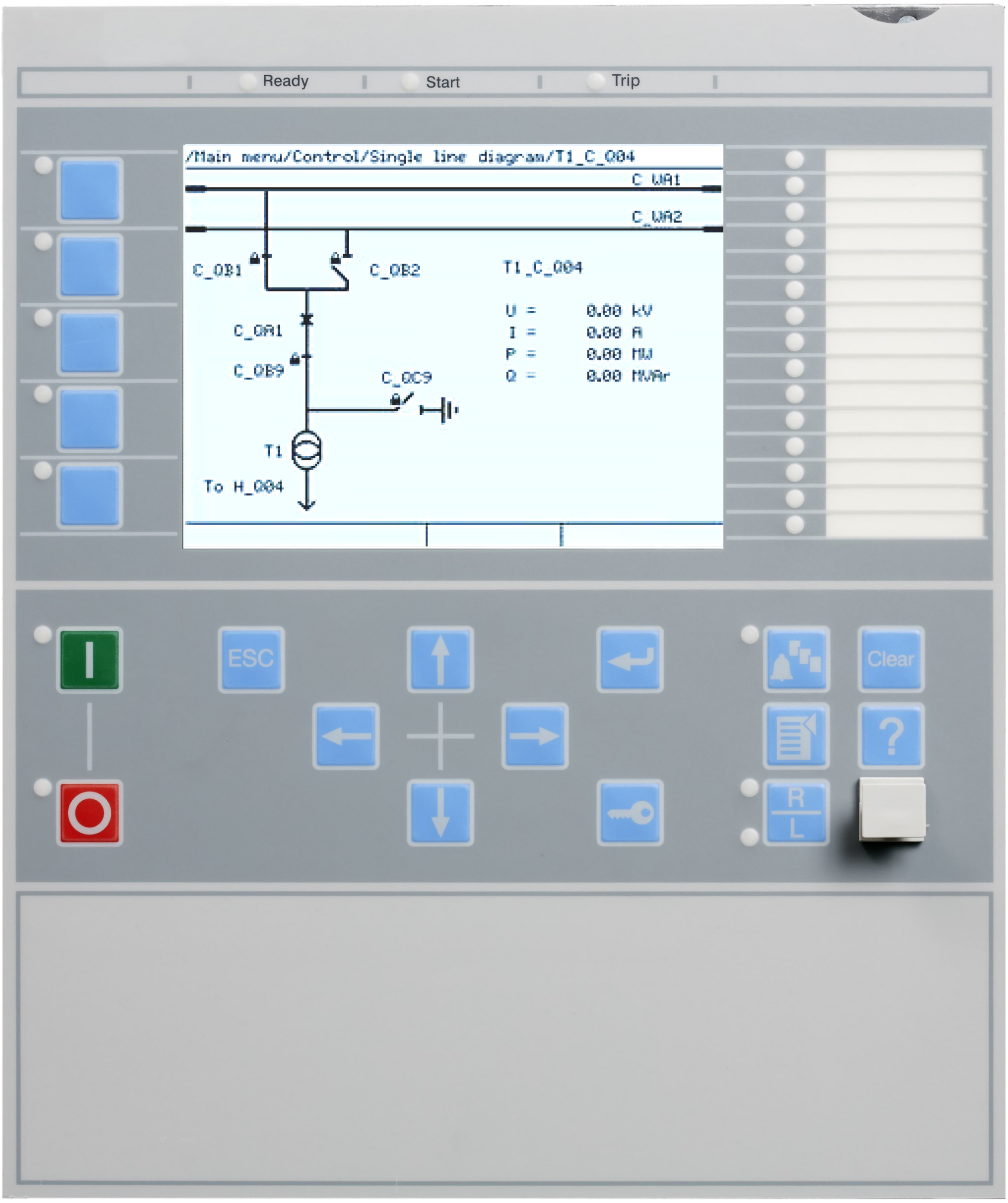
Power system measurement (CVMMXN) can be used to measure active as well as reactive power values. Function for energy calculation and demand handling (ETPMMTR) uses measured active and reactive power as input and calculates the accumulated active and reactive energy pulses, in forward and reverse direction.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

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

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

Section 17 Human machine interface

17.1 Local HMI



IEC13000239-3-en.vsd

Figure 17: 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.

Section 18 Basic IED functions

18.1 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. A common source shall be used for IED and merging unit when IEC/UCA 61850-9-2LE process bus communication is used.

The IED supports SNTPv4 (RFC2030).

Precision time protocol PTP

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

Section 19 Ethernet

19.1 Access points

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

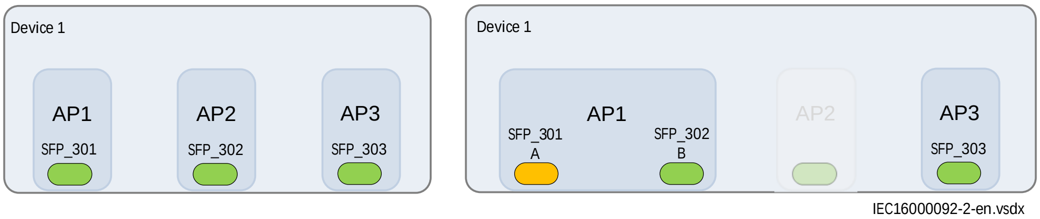


Figure 18: Access points, non redundant (left) and redundant communication (right)

DHCP is available for the front port, and a device connected to it can thereby obtain an automatically assigned IP-address.

19.2 Access points diagnostics

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

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

19.3 Redundant communication

PRP IEC 62439-3 redundant communication

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

HSR IEC 62439-3 High-availability seamless redundancy

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

The HSR ring supports the connection of up to 30 relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

Rapid spanning tree protocol RSTP

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

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

19.4 Routes

A route is a specified path for data to travel between the source device in a subnetwork to the destination device in a different subnetwork. A route consists of a destination address and the address of the gateway to be used when sending data to the destination device, see Figure 19.

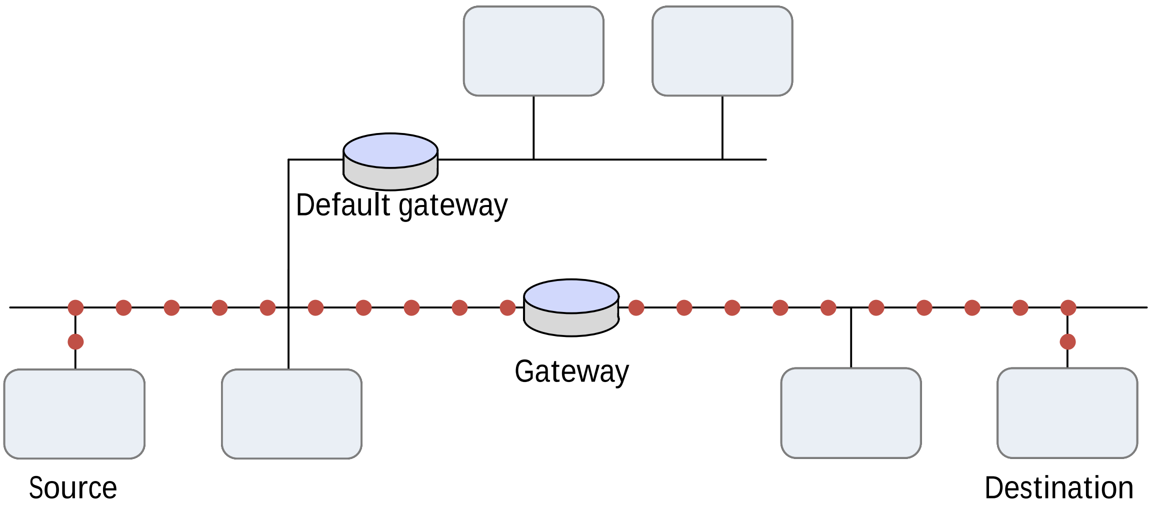


Figure 19: Route from source to destination through gateway

Section 20 Station communication

20.1 Communication protocols

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

Available communication protocols are:

- IEC 61850-8-1 communication protocol
- IEC/UCA 61850-9-2LE communication protocol
- LON communication protocol
- SPA communication protocol
- IEC 60870-5-103 communication protocol
- DNP 3.0 communication protocol
- Syslog (RFC 5424) standard

Several protocols can be combined in the same IED.

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

20.2 Simple network management protocol SNMP

Simple Network Management Protocol (SNMP) is an internet standard protocol to get and set data of the connected network devices. It uses UDP protocol for communication.

Here it is used to provide information of the hardware devices, software and attached network interface to the SNMP manager.

The SNMP agent supports the following,

1. SNMPv2c and SNMPv3 are supported and both are enabled by default.
    1.1. SNMPv2c sends community strings which are used for authentication in clear text format.
    1.2. User based security model (USM) for SNMPv3 require the users/ password and the encryption password to be predefined. A maximum of 2 users are supported.
2. Public IF-MIB and Hitachi Energy MIB with specific objects (Object Identifiers) are supported.
3. User profiles can be configured from the PCM600 tool and only these users are supported for SNMP communication.
4. Traps are not supported.

20.3 IEC 61850-8-1 communication protocol

IEC 61850 Ed. 1, Ed. 2 or Ed. 2.1 can be chosen by a setting in PCM600. The IED is equipped with up to six (order dependent) optical Ethernet rear ports for IEC 61850-8-1 station bus communication. The IEC 61850-8-1 communication is also possible from the electrical Ethernet front port. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. IED-to-IED communication using GOOSE and client-server communication over MMS are supported. Disturbance recording file (COMTRADE) uploading can be done over MMS or FTP.

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

20.4 IEC 61850 quality expander QUALEXP

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

20.5 Supervision of GOOSE subscription (ALGOS)

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

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

All attributes, both mandatory and optional, according to IEC 61850-7-4 Edition 2, Edition 2.1 are supported.

ALGOS is not defined in IEC 61850 Edition 1 and is only supported in Edition 2 and Edition 2.1 mode.

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

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

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

The attributes *St* and *SimSt* are supported as well as the setting *SvCBRef*, according to IEC 61850-7-4 Edition 2 and Edition 2.1.

ALSVS is not defined in IEC 61850 Edition 1 and is only supported in Edition 2 and Edition 2.1 mode.

20.7 IEC/UCA 61850-9-2LE communication protocol

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

20.8 LON communication protocol

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

20.9 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.

20.10 IEC 60870-5-103 communication protocol

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

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

20.11 Measurands for IEC 60870-5-103 I103MEAS

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

20.12 Measurands user-defined signals for IEC 60870-5-103 I103MEASUSR

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

20.13 Function status auto-recloser for IEC 60870-5-103 I103AR

I103AR is a function block with defined functions for autorecloser indications in monitor direction. This block includes the *FunctionType* parameter, and the *information number* parameter is defined for each output signal.

20.14 Function status earth-fault for IEC 60870-5-103 I103EF

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

20.15 Function status fault protection for IEC 60870-5-103 I103FLTPROT

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

20.16 IED status for IEC 60870-5-103 I103IED

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

20.17 Supervison status for IEC 60870-5-103 I103SUPERV

I103SUPERV is a function block with defined functions for supervision indications in monitor direction. This block includes the *FunctionType* parameter; the *information number* parameter is defined for each output signal.

20.18 Status for user-defined signals for IEC 60870-5-103 I103USRDEF

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

20.19 Function commands for IEC 60870-5-103 I103CMD

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

20.20 IED commands for IEC 60870-5-103 I103IEDCMD

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

20.21 Function commands user-defined for IEC 60870-5-103 I103USRCMD

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

20.22 Function commands generic for IEC 60870-5-103 I103GENCMD

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

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

20.23 IED commands with position and select for IEC 60870-5-103 I103POSCMD

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

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

20.24 DNP3.0 communication protocol

An electrical RS485 serial port, optical serial ports on the serial communication module (SLM), optical Ethernet ports are available for DNP3.0 communication. DNP3.0 Level 2 communication with unsolicited events, time synchronization and disturbance reporting is provided for communication to RTUs, Gateways or HMI systems.

20.25 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).

Section 21 Remote communication

21.1 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.

21.2 Binary signal transfer

The remote end data communication is used for the transmission of analog values for line differential protection or for the transmission of only binary signals between IEDs. The binary signals are freely configurable and can thus be used for any purpose, such as communication scheme related signals, transfer trip and/or other binary signals between IEDs.

Communication between two IEDs requires that each IED is equipped with a Line Data Communication Module (LDCM). The LDCM then acts as an interface to 64 kbit/s and 2Mbit/s communication channels for duplex communication between the IEDs. In 2Mbit/s mode, each LDCM can send and receive up to 9 analog and up to 192 binary signals simultaneously. In 64kbit/s mode, the LDCM can be configured to work in either analog mode or binary mode. In analog mode, the IED can send and receive up to 3 analog signals and up to 8 binary signals. In binary mode, the LDCM can send and receive only binary data (up to 192 binary signals).

The IED can be equipped with up to four short range, medium range or long range LDCMs.

In general, using LDCM for busbar differential protection is not recommended, specifically for sharing analog data. To share binary data between single-phase REB670 IEDs with LDCMs is possible. However please consider GOOSE with HSR instead when available.

21.3 Line data communication module, short, medium and long range LDCM

The line data communication module (LDCM) is used for communication between the IEDs situated at a distance <110 km/68 miles or from the IED to the optical-to-electrical converter with G.703 or G.703E1 interface located at a distance < 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.

21.4 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.

21.5 Galvanic interface G.703 resp G.703E1

The external galvanic data communication converter G.703/G.703E1 makes an optical-to-galvanic conversion for connection to a multiplexer. These units are designed for 64 kbit/s resp 2Mbit/s operation. The converter is delivered with 19” rack mounting accessories.

Section 22 Hardware description

22.1 Hardware modules

22.1.1 Numeric processing module NUM

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

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

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

22.1.2 Power supply module PSM

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

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

22.1.3 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.

22.1.4 Binary output module BOM

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

22.1.5 Static binary output module SOM

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

22.1.6 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.

22.1.7 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.

22.1.8 Optical Ethernet module

The optical Ethernet module (OEM) provides two additional optical Ethernet ports. The port connectors are:

- SFP Optical LC (single mode and multi mode)
- Galvanic RJ45

Ethernet ports can be configured as two separate or in redundant mode PRP or HSR.

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

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

22.1.10 Line data communication module LDCM

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

Alternative modules are:

Short range LDCM (820 nm multi mode fiber),

Medium range (1310 nm single mode fiber)

and Long range (1550 nm single mode fiber) .

22.1.11 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.

22.1.12 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.

22.1.13 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 is supported.

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

22.1.14 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.

Ring lug or compression type connectors can be ordered.

22.2 Layout and dimensions

22.2.1 Dimensions

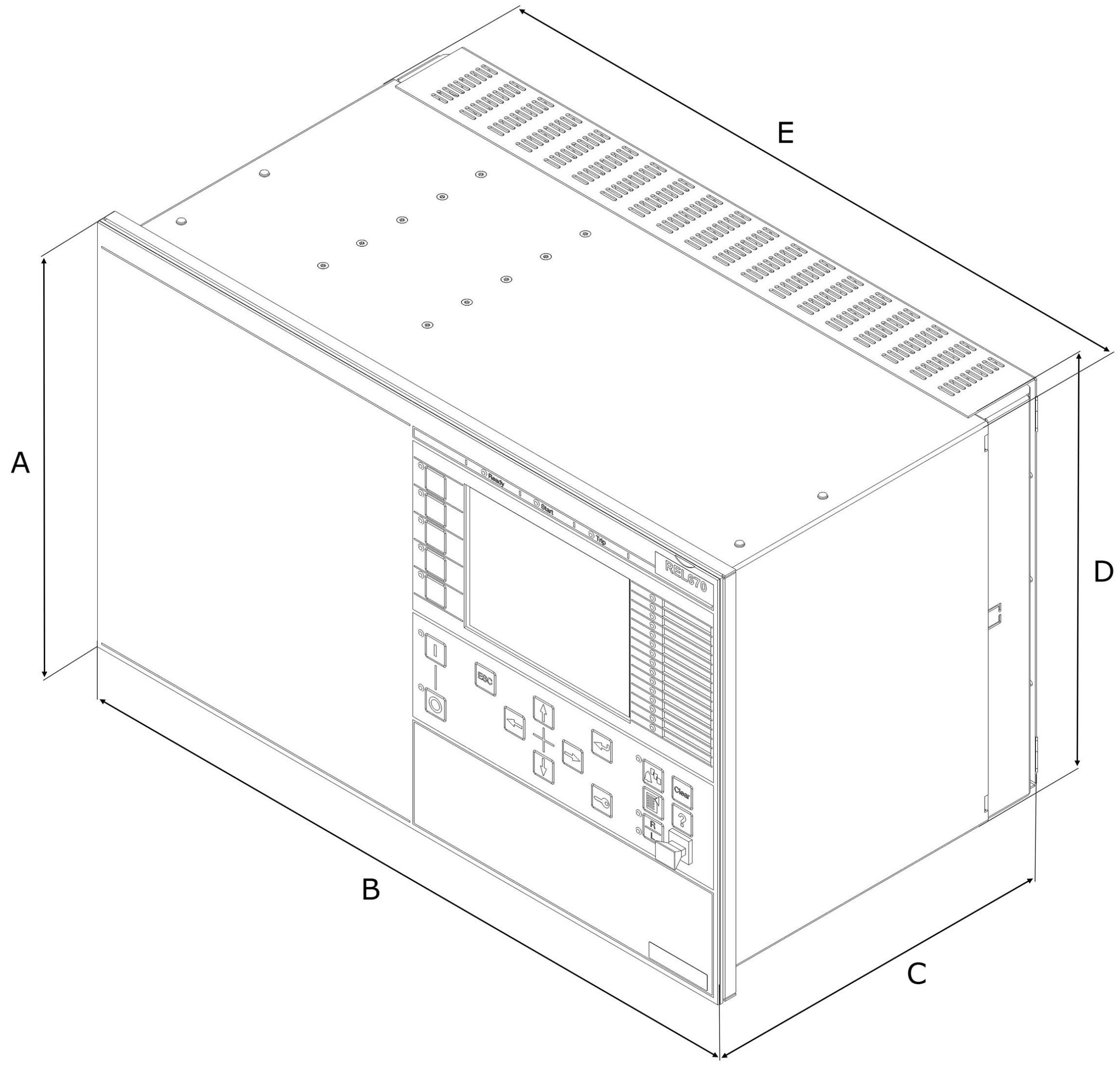


Figure 20: Case with rear cover

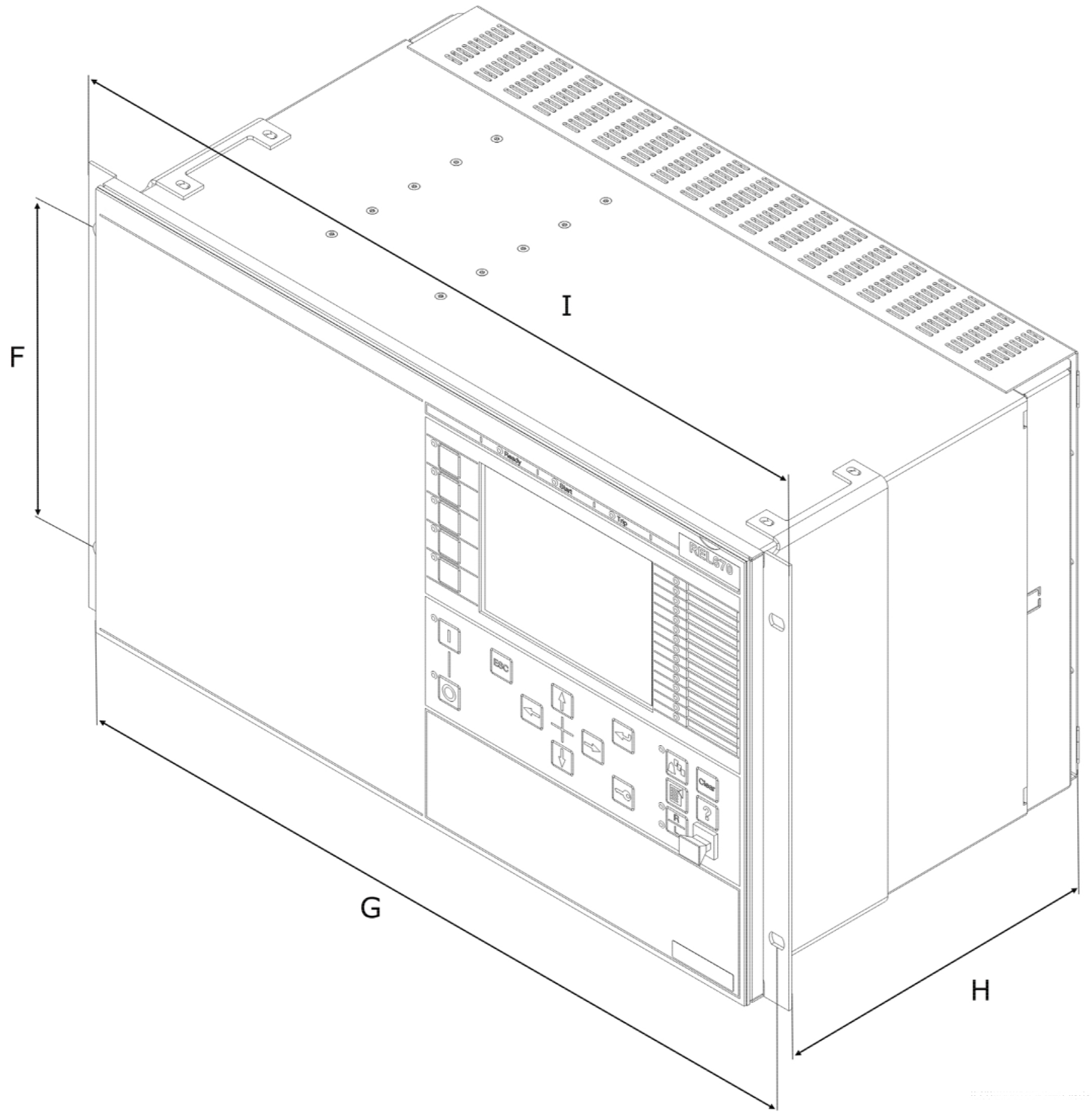


Figure 21: Case with rear cover and 19” rack mounting kit

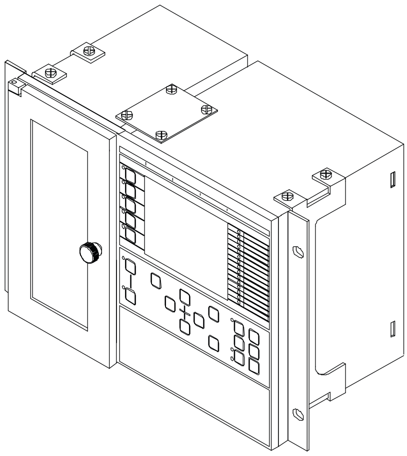


Figure 22: A 1/2 x 19” size IED side-by-side with RHGS6.

Table 19: Case dimensions

Case size (mm)/(inches)	A	B	C	D	E	F	G	H	I
6U, 1/2 x 19”	265.9/10.47	223.7/8.81	247.5/9.74	255.0/10.04	205.8/8.10	190.5/7.50	466.5/18.36	232.5/9.15	482.6/19
6U, 3/4 x 19”	265.9/10.47	335.9/13.23	247.5/9.74	255.0/10.04	318.0/12.52	190.5/7.50	466.5/18.36	232.5/9.15	482.6/19
6U, 1/1 x 19”	265.9/10.47	448.0/17.65	247.5/9.74	255.0/10.04	430.1/16.86	190.5/7.50	466.5/18.36	232.5/9.15	482.6/19
The G and H dimensions are defined by the 19” rack mounting kit.									

22.2.2 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.

Section 23 Connection diagrams

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

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

Connection diagrams for IEC Customized products

Connection diagram, 670 series 2.2 1MRK002801-AG

Connection diagrams for Configured products

Connection diagram, REB670 2.2, A20X01 1MRK002807-BH

Connection diagram, REB670 2.2, A31X01 1MRK002807-BK

Connection diagram, REB670 2.2, A31X02 1MRK002807-BL

Connection diagram, REB670 2.2, A31X03 1MRK002807-BM

Connection diagram, REB670 2.2, B20X01 1MRK002807-BA

Connection diagram, REB670 2.2, B21X01 1MRK002807-BB

Connection diagram, REB670 2.2, B21X02 1MRK002807-BC

Connection diagram, REB670 2.2, B21X03 1MRK002807-BD

Connection diagram, REB670 2.2, B31X01 1MRK002807-BE

Connection diagram, REB670 2.2, B31X02 1MRK002807-BF

Connection diagram, REB670 2.2, B31X03 1MRK002807-BG

Connection diagrams for ANSI Customized products

Connection diagram, 670 series 2.2 1MRK002802-AG

Section 24 Certification

The following are the list of certification for Relion 670 series.

UL certification* for Relion 670 series	E502400
IEC 60255-1 Environmental & functional issued by DNV GL	1418-18 1446-18
G3 Compliance Certificate Sulphur dioxide test for contacts and connections Hydrogen sulphide test for contacts and connections Flowing mixed gas corrosion test	 IEC 60068-2-42: 2003 IEC 60068-2-43: 2003 IEC 60068-2-60: 2015
IEC 61850 Ed2 level A1 certificate issued by DNV GL	10289889-INC-21-2985
IEC 61850 Ed1 level B1 certificate issued by Hitachi ABB Power Grids, SVC Baden	1KHL050134
IEC 62439-3 Ed3 certificate issued by DNV GL	10257149-INC 21-2619rev1
IEC 60870-5-103 certificate issued by DNV GL	10021419-OPE/INC 16-2490
DNP 3.0 certificate issued by DNV GL	10021419-OPE/INC 16-2532
* Valid for IEDs produced at factory in Sweden.	

Section 25 Technical data

25.1 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

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

25.1.1 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:
   - √3 × *IBase* × *UBase*
7. The rated secondary quantities have the following values:
   - Rated secondary phase current I_r is either 1 A or 5 A depending on selected TRM.
   - Rated secondary phase-to-phase voltage U_r is within the range from 100 V to 120 V.
   - Rated secondary power for three-phase system $S_r = \sqrt{3} \times U_r \times I_r$
8. For operate and reset time testing, the default setting values of the function and BOM module are used if not explicitly stated otherwise.

All reset times are measured using BOM output contacts if not explicitly stated otherwise. The operate/reset times are determined by characteristics of the output module used.

9. During testing, signals with rated frequency have been injected if not explicitly stated otherwise.
10. All declared operate times are with BOM module unless specified. All the declared operate (trip) times can be reduced by 3-4 ms when using SOM module.

25.2 Energizing quantities, rated values and limits

25.2.1 Analog inputs

Table 20: TRM - Energizing quantities, rated values and limits for protection transformer

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

Table 21: 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

Table continues on next page

Description	Value	
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 22: MIM - mA input module

Quantity:	Rated value:	Nominal range:
Input resistance	R_{in} = 194 Ohm	-
Input range	±5, ±10, ±20 mA 0-5, 0-10, 0-20, 4-20 mA	-
Power consumption each mA board each mA input	 ≤ 2 W ≤ 0.1 W	-

25.2.2 Auxiliary DC voltage

Table 23: 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	-
Supply interruption bridging time	< 50 ms	-

25.2.3 Binary inputs and outputs

Table 24: 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	-
Table continues on next page		

Quantity	Rated value	Nominal range
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	
*Debounce filter	Settable 1–20 ms	
Binary input operate time (Debounce filter set to 0 ms)	3 ms	-
* Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.		

Table 25: BIM - Binary input module with enhanced pulse counting capabilities

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

Table 26: IOM - Binary input/output module

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

Table 27: IOM - Binary input/output module contact data (reference standard: IEC 61810-1)

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

Table Note:

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

Table 28: IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-1)

Function or quantity	Trip and Signal relays	Fast signal relays (parallel reed relay)
Binary outputs	IOM: 10	IOM: 2
Max system voltage	250 V AC/ DC	250 V DC
Min load voltage	24 V DC	-
Test voltage across open contact, 1 min	250 V rms	250 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A	 8 A 10 A 12 A

Table continues on next page

Function or quantity	Trip and Signal relays	Fast signal relays (parallel reed relay)
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	 220–250 V/0.4 A 110–125 V/0.4 A 48–60 V/0.2 A 24–30 V/0.1 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms (According to IEC 61810-1)	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A	110 V / 0.3 A
Breaking capacity for DC with resistive load	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A
Maximum capacitive load	-	10 nF
Max operations with inductive load L/R ≤ 40 ms	1000	-
Max operations with resistive load	2000	
Max operations with no load	30 million	-
Operating time	< 6 ms	<= 1 ms

Table 29: SOM - Static Output Module data (reference standard: IEC 61810-1): Heavy duty static binary outputs

Function of quantity	Static binary output trip
Max system voltage	250 V DC
Number of outputs	6
Impedance open state	High impedance
Test voltage across open contact, 1 min	350 V rms
Current carrying capacity: Continuous 1.0 s	 6 A 20 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 30 A 20 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 20 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 20 A
Breaking capacity for DC with L/R ≤ 40 ms (Auto-reclose scheme) (On ≤ 0.2 s) 0.2 s – on 0.2 s – off 0.2 s – on 20 s – off 0.2 s – on 30 s – off 0.2 s – on 120 s – off (for thermal dissipation)	24-60 V / 30 A 110-125 V / 20 A 220-250 V / 10 A
Table continues on next page	

Function of quantity	Static binary output trip
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1) 4 operations/min and 2 min pause for thermal dissipation	6 A
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A
Breaking capacity at resistive load	6 A
Max operations with inductive load L/R ≤ 40 ms	1000
Max operations with resistive load	2000
Max operations with resistive load (On ≤ 0.2 s)	10000
Max operations with no load	30 million
Operating time	< 1 ms

Table 30: SOM - Static Output module data (reference standard: IEC 61810-1): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250 V AC/DC
Min load voltage	24 V DC
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
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 30 A 10 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 10 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos ϕ > 0.4	250 V / 8 A
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1)	48 V / 1 A 110 V / 0.4 A 125 V / 0.35 A 220 V / 0.2 A 250 V / 0.15 A
Max operations with inductive load L/R ≤ 40 ms	1 000
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A
Breaking capacity for DC with resistive load	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A
Max operations with resistive load	2 000
Max operations with no load	30 million
Operating time	< 6 ms

Table 31: BOM - Binary output module contact data (reference standard: IEC 61810-1)

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC/DC
Min load voltage	24 V DC
Test voltage across open contact, 1 min	1000 V rms
Table continues on next page	

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

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

Table 32: IRF - Internal Fail relay output

Quantity	Rated value
Max. system voltage	250 V DC
Min. load voltage	24 V DC
Number of outputs	1
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 4 A 8 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 20 A 8 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 20 A 8 A
Making capacity at resistive load 0.2 s 1.0 s	 20 A 8 A
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1)	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A

Table continues on next page

Quantity	Rated value
Breaking capacity for DC with L/R=100 ms	110 V/0.3 A
Breaking capacity for DC with resistive load	48 V/2 A 110 V/0.5 A 125 V/0.45 A 220 V/0.35 A 250 V/0.3 A
Max. operations with inductive load L/R ≤ 40 ms	1000
Max. operations with resistive load	2000
Max. operations with no load	30 million

25.2.4 Influencing factors

Table 33: Temperature and humidity influence

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

Table 34: 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% 90-250 V DC ± 20%	No restart Correct behaviour at power down < 300 s

Table 35: 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%

25.3 Type tests according to standards

Table 36: Electromagnetic compatibility

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

Table 37: Insulation

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

Table 38: Environmental conditions

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

Table 39: Environmental tests

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

Table 40: CE compliance

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

Table 41: Mechanical tests

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

25.4 Differential protection

25.4.1 Two-zone busbar differential protections

Function	Range or value	Accuracy
Operating characteristic	Slope = 0.53 fixed	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Differential protection operation level "DiffOperLev"	(100 - 50000) A	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Reset ratio, differential protection	>98%	-
Operate time for differential protection at 0 to 2 x DiffOperLev	Min = 15 ms Max = 25 ms	-
Operate time for differential protection at 0 to 10 x DiffOperLev	Min = 5 ms Max = 15 ms	-
Drop-off time delay for zone trip “tTripHold” at 2 x DiffOperLev to 0	(0.000 - 60.000) s	± 0.2% or ± 25 ms whichever is greater
Check zone operation level "OperLevel"	(100 - 50000) A	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Check zone slope	(0.10 - 0.90)	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Reset ratio, check zone	>98%	-
Sensitive differential protection operation level "SensOperLev"	(50 - 9999) A	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Table continues on next page		

Function	Range or value	Accuracy
Reset ratio, sensitive differential protection	>98%	-
Operate time for sensitive differential protection at 0 to 2 x SensOperLev	Min = 10 ms Max = 20 ms	-
Operate time for sensitive differential protection at 0 to 10 x SensOperLev	Min = 5 ms Max = 15 ms	-
Independent time delay for sensitive differential protection “tSensDiff” at 0 to 2 x SensOperLev	(0.000 - 60.000) s	± 0.2% or ± 25 ms whichever is greater
Incoming current level above which sensitive differential protection is blocked "SenslinBlkLev"	(100 - 20000) A	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Differential current alarm level "IdAlarmLev"	(50 - 20000) A	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Independent time delay for differential current alarm “tIdAlarm” at 0 to 2 x IdAlarmLev	(0.00 - 600.00) s	± 0.2% or ± 25 ms whichever is greater
Incoming current alarm level "IinAlarmLev"	(50 - 50000) A	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I > I_r$
Open CT operation level "OCTOperLev"	(50 - 10000) A	± 5.0% of I_r at $I \leq I_r$ ± 5.0% of I at $I > I_r$
Open CT blocking release level in supervision mode "OCTReleaseLev"	(100 - 50000) A	± 5.0% of I_r at $I \leq I_r$ ± 5.0% of I at $I > I_r$
Independent time delay for slow open CT alarm “tSlowOCT” at 2 x OCTOperLev to 0	(1.00 - 600.00) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay to force bay current to zero via binary signal “tZeroCurrent”	(0.000 - 60.000) s	± 0.2% or ± 20 ms whichever is greater
Independent time delay to invert bay current via binary signal "tInvertCurrent"	(0.000 - 60.000) s	± 0.2% or ± 20 ms whichever is greater
Independent time delay to activate load transfer alarm “tAlarm”	(0.00 - 6000.00) s	± 0.2% or ± 20 ms whichever is greater
Minimum duration of bay trip signals "tTripPulse"	(0.025 - 60.000) s	± 0.2% or ± 20 ms whichever is greater

25.4.2 Six/Four-zone busbar differential protection

Function	Range or value	Accuracy
Operating characteristic	Slope = 0.53, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I> I_r$
Differential protection operation level "DiffOperLev"	(100 - 50000) A	± 2.0% of I_r at $I \leq I_r$ ± 2.0% of I at $I> I_r$
Reset ratio, differential protection	>98%	-
Operate time for differential protection at 0 to 2 x DiffOperLev	Slope = 0.53, 0.60, 0.65, 0.70 Min = 15 ms Max = 25 ms	-
	Slope = 0.75, 0.80, 0.85 Min = 20 ms Max = 30 ms	-
Table continues on next page		

Function	Range or value	Accuracy
Operate time for differential protection at 0 to 10 x DiffOperLev	Slope = 0.53, 0.60, 0.65, 0.70 Min = 5 ms Max = 15 ms	-
	Slope = 0.75, 0.80, 0.85 Min = 10 ms Max = 20 ms	-
Drop-off time delay for zone trip “tTripHold” at 2 x DiffOperLev to 0	(0.05 - 60.00) s	± 0.2% or ± 25 ms whichever is greater
Check zone operation level "OperLevel"	(100 - 50000) A	± 2.0% of I_r at I ≤ I_r ± 2.0% of I at I > I_r
Check zone slope “SlopeCZ”	(0.10 - 0.90)	± 2.0% of I_r at I ≤ I_r ± 2.0% of I at I > I_r
Reset ratio, check zone	>98%	-
Sensitive differential protection operation level "SensOperLev"	(50 - 9999) A	± 2.0% of I_r at I ≤ I_r ± 2.0% of I at I > I_r
Reset ratio, sensitive differential protection	>98%	-
Independent time delay for sensitive differential protection “tSensDiff” at 0 to 2 x SensOperLev	(0.05 - 6.00) s	± 0.2% or ± 25 ms whichever is greater
Incoming current level above which sensitive differential protection is blocked "SensIinBlkLev"	(100 - 20000) A	± 2.0% of I_r at I ≤ I_r ± 2.0% of I at I > I_r
Differential current alarm level "IdAlarmLev"	(50 - 20000) A	± 2.0% of I_r at I ≤ I_r ± 2.0% of I at I > I_r
Independent time delay for differential current alarm “tIdAlarm” at 0 to 2 x IdAlarmLev	(5.0 - 600.0) s	± 0.2% or ± 25 ms whichever is greater
Incoming current alarm level "IinAlarmLev"	(50 - 50000) A	± 2.0% of I_r at I ≤ I_r ± 2.0% of I at I > I_r
Open CT operation level "OCTOperLev"	(50 - 10000) A	± 5.0% of I_r at I ≤ I_r ± 5.0% of I at I > I_r
Open CT blocking release level in supervision mode "OCTReleaseLev"	(100 - 50000) A	± 5.0% of Ir at I ≤ I_r ± 5.0% of I at I > I_r
Independent time delay for slow open CT alarm “tSlowOCT” at 2 x OCTOperLev to 0	(1.0 - 600.0) s	± 0.2% or ± 25 ms whichever is greater
*Minimum time delay to automatically reset fast OCT alarm “tAutoRstFOCT”	(1.0 - 2.0) s	± 0.2% or ± 25 ms whichever is greater
Independent time delay to force bay current to zero via binary signal “tZeroI_Feeder”	(0.04 - 1.00) s	± 0.2% or ± 20 ms whichever is greater
Independent time delay to force bus-interconnector current to zero “tZeroI_BIC”	(0.04 - 1.00) s	± 0.2% or ± 20 ms whichever is greater
Independent time delay to invert bus-interconnector current via binary signal “tInvertI_BIC”	(0.04 - 1.00) s	± 0.2% or ± 20 ms whichever is greater
Independent time delay to activate zone merging alarm “tMergALM”	(10 - 6000) s	± 0.2% or ± 20 ms whichever is greater
Minimum duration of bay trip signals "tTripPulse"	(0.03 - 60.00) s	± 0.2% or ± 20 ms whichever is greater
*Note: Auto-reset of latched fast OCT alarm is not available for six-zone busbar differential protection		

25.5 Wide area measurement system

The IED is compliant with the synchrophasor measurement requirements of IEEE C37.118.1-2011, including the amendment (IEEE C37.118.1a-2014) for both P and M performance classes. The IED is also compliant with synchrophasor data transfer requirements of IEEE C37.118.2-2011. There are two types of internal current transformer cores in the IED, protection and measuring cores. Using the measuring cores, the IED is compliant with all the synchrophasor measurement requirements. If using the protection core, for the “signal magnitude-current” steady state test (mentioned in Table 3 of IEEE C37.118.1-2011 standard), the compliancy to the standard is limited to the current range between 50% and 200% of rated current for both P and M classes of the standard. The reason is that protection cores are not designed for accurate measurements on low current levels.

The compliancy to IEEE C37.118.1-2011 standard (including IEEE C37.118.1a-2014) is limited to the reporting rates up to 60 frames per second which is required by the standard. This means 10, 25, and 50 frames per second for 50 Hz system frequency and 10, 12, 15, 20, 30, and 60 frames per second for 60 Hz system frequency.

Table 42: Protocol reporting via IEEE 1344 and IEC/IEEE 60255-118 (C37.118) PMUREPORT

Influencing quantity	Range	Accuracy
Signal frequency	± 0.1 x f_r	≤ 1.0% TVE
Signal magnitude: Voltage phasor Current phasor	 (0.1–1.2) x U_r (0.5–2.0) x I_r	
Phase angle	± 180°	
Harmonic distortion	10% from 2nd – 50th	
Interfering signal: Magnitude Minimum frequency Maximum frequency	 10% of fundamental signal 0.1 x f_r 1000 Hz	

25.6 Current protection

Table 43: 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 $I \leq I_r$ ±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 $I \leq I_r$ ±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 168, table 169 and table 170	16 curve types	See table 168, table 169 and table 170
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	-

Table continues on next page

Function	Range or value	Accuracy
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 44: 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 168, table 169, and table 170	16 curve types	See table 168, table 169, and table 170
Operate time, start at 0 to 2 x I_{set}	Min = 15 ms Max = 30 ms	-
Reset time, start at 2 x I_{set} to 0	Min = 15 ms Max = 30 ms	-
Operate time, start at 0 to 10 x I_{set}	Min = 5 ms Max = 20 ms	-
Reset time, start at 10 x I_{set} to 0	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 45: 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
Definite Reset Time	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.8) x I_{set}	±0.2% or ±40 ms whichever is greater
Table continues on next page		

Function	Range or value	Accuracy
Operate time for I_{set} = 1% (ANSI)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±10.0% or ±40 ms whichever is greater
Reset time for I_{set} = 1% (ANSI)	0.01 ≤ k ≤ 15.00, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±12.0% or ±160 ms whichever is greater.
Operate time for I_{set} = 1% (IEC)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±8.0% or ±100 ms whichever is greater
Reset time for I_{set} = 1% (IEC)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Operate time for I_{set} = 1% (RI&RD)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±2.0% or ±40 ms whichever is greater
Reset time for I_{set} = 1% (RI&RD)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Inverse time characteristics, see Table 168, Table 169 and Table 170	16 curve types	See Table 168, Table 169 and Table 170
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) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/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 46: Four step directional negative phase sequence overcurrent protection NS4PTOC

Function	Range or value	Accuracy
Operate current, step 1 - 4	(1-2500)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1 - 4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Definite Reset Time	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.8) x I_{set}	±0.2% or ±40 ms whichever is greater
Operate time for I_{set} = 1% (ANSI)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±10.0% or ±40 ms whichever is greater
Reset time for I_{set} = 1% (ANSI)	0.01 ≤ k ≤ 15.00, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±12.0% or ±160 ms whichever is greater.
Operate time for I_{set} = 1% (IEC)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±8.0% or ±100 ms whichever is greater
Reset time for I_{set} = 1% (IEC)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Table continues on next page		

Function	Range or value	Accuracy
Operate time for I_{set} = 1% (RI&RD)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±2.0% or ±40 ms whichever is greater
Reset time for I_{set} = 1% (RI&RD)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Inverse time characteristics, see table 168, table 169 and table 170	16 curve types	See table 168, table 169 and table 170
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
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) Ω/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	-
Transient overreach	<10% at τ = 100 ms	-

Table 47: 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	IEC 60255-149, ±5.0% or 250 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 48: 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 $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, phase current	> 95%	-
Operate residual current	(2-200)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Phase current level for blocking of contact function	(5-200)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time for current detection	15 ms typically	-
Reset time for current detection	15 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
Time delay for backup 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 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 49: 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 $I \leq I_r$ ±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 $I \leq I_r$ ±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
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
Minimum trip pulse duration	(0.010-60.000) s	±0.2% or ±10 ms whichever is greater

Table 50: 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 $S \leq S_r$ ±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 x S_r to 0.5 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 51: 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 x S_r to 2 x S_r and *k=0.000*	Min. =10 ms Max. = 25 ms	
Reset time, start at 2 x S_r 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 x S_r to 2 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 52: Capacitor bank protection CBPGAPC

Function	Range or value	Accuracy
Operate value, overcurrent	(10-900)% of IBase	±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 x Iset to 2 x Iset	Min. = 5 ms Max. = 20 ms	-
Reset time, overcurrent, at 2 x Iset to 0.5 x Iset	Min. = 25 ms Max. = 45 ms	-
Critical impulse time, overcurrent protection start	2 ms typically at 0.5 x Iset to 2 x Iset 1 ms typically at 0.5 x Iset 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
Table continues on next page		

Function	Range or value	Accuracy
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

Table 53: Overcurrent protection with binary release BRPTOC

Function	Range or value	Accuracy
Operating current	(5-2500)% of *IBase*	*DFT*: ± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
		Peak and Peak to peak: ± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Reset ratio	> 95% at (25-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	*DFT*: ±0.2% or ±30 ms whichever is greater
		Peak to peak: ±0.2% or ±25 ms whichever is greater
		Peak: ±0.2% or ±20 ms whichever is greater
Operate time, start at 0 to 1.2 x I_{set}	*DFT*: Min.= 15 ms Max. = 30 ms	-
	Peak to peak: Min.= 10 ms Max. =25 ms	
	Peak: Min.= 5 ms Max. = 20 ms	
Reset time, start at 1.2 x I_{set} to 0	< 60 ms	-
Operate time, start at 0 to 2 x I_{set}	*DFT*: Min.= 10 ms Max. = 25 ms	-
	Peak to peak: Min.= 5 ms Max. =20 ms	
	Peak: Min.= 5 ms Max. = 15 ms	
Reset time, start at 2 x I_{set} to 0	< 60 ms	-
Table continues on next page		

Function	Range or value	Accuracy
Operate time, start at 0 to 5 x I_{set}	*DFT*: Min.= 5 ms Max. = 20 ms	-
	Peak to peak: Min.= 5 ms Max. =15 ms	
	Peak: Min.= 5 ms Max. = 10 ms	
Reset time, start at 5 x I_{set} to 0	< 60 ms	-
Critical impulse time	*DFT:* 10 ms typically at 0 to 2 x I_{set}	-
	Peak to peak: 5 ms typically at 0 to 2 x I_{set}	
	Peak: 1 ms typically at 0 to 2 x I_{set}	

25.7 Voltage protection

Table 54: 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 172	-	See table 172
Definite time delay, step 1 at 1.2 x U_{set} to 0	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 x U_{set} to 0	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000–60.000) s	±0.5% or ±40ms whichever is greater
Operate time, start at 2 x U_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 1.2 x U_{set} to 0	Min. = 5 ms Max. = 25 ms	-
Reset time, start at 0 to 1.2 x U_{set}	Min. = 15 ms Max. = 35 ms	-
Critical impulse time	5 ms typically at 1.2 x U_{set} to 0	-
Impulse margin time	15 ms typically	-

Table 55: 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 171	-	See table 171
Table continues on next page		

Function	Range or value	Accuracy
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 x U_{set} to 0	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 x U_{set} to 0	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 56: Residual overvoltage protection, two steps ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 - 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 table	-	See table 171
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 x U_{set} to 0	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 x U_{set} to 0	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 57: Voltage differential protection VDCPTDV

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 x UDAlarm 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 x UDTrip 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 x UDTrip to 0.8 x UDTrip	(0.000–60.000)s	±0.2% or ±40 ms whichever is greater

Table 58: 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

25.8 Frequency protection

Table 59: Underfrequency protection SAPTUF

Function	Range or Value			Accuracy
Operate value, start function, at symmetrical three phase voltage, *StartFrequency* 1)	(35.00 - 75.00) Hz			±2.0 mHz
Reset hysteresis	10.0 mHz fixed			±2.0 mHz
Operate time 1)	fr = 50 Hz	Start time measurement with sudden frequency change	Min. = 175 ms	-
			Max. = 195 ms	
		Start time measurement with frequency ramp	Min. = 70 ms	
			Max. = 90 ms	
	fr = 60 Hz	Start time measurement with sudden frequency change	Min. = 150 ms	-
			Max. = 165 ms	
		Start time measurement with frequency ramp	Min. = 60 ms	
			Max. = 75 ms	
Disengaging time 1)	fr = 50 Hz	Start time measurement with sudden frequency change	Min. = 170 ms	-
			Max. =195 ms	
		Start time measurement with frequency ramp	Min. = 75 ms	
			Max. = 100 ms	
	fr = 60 Hz	Start time measurement with sudden frequency change	Min. = 140 ms	-
			Max. =165 ms	
		Start time measurement with frequency ramp	Min. = 65 ms	
			Max. = 90 ms	
Table continues on next page				

Function	Range or Value		Accuracy
Operate time delay, *tDelay* 1)	fr = 50 Hz	(0.000-60.000)s	±0.2% or ±200 ms whichever is greater
	fr = 60 Hz		±0.2% or ±175 ms whichever is greater
Voltage dependent time delay	Settings: *UNom* = (50-150)% of UBase *UMin* = (50-150)% of UBase *Exponent* = 0.0-5.0 *tMax* = (0.010-60.000)s *tMin* = (0.010- 60.000)s $t = \left[\frac{U - UMin}{UNom - UMin} \right]^{Exponent} \cdot (tMax - tMin) + tMin$ $U = U_{measured}$		±1.0% or ±120 ms whichever is greater
Note: The stated accuracy is valid for the voltage range 50 V – 250 V secondary.			
Table Note: 1) The settings and test conditions are in accordance with IEC 60255-181 standard (section 6.2 – 6.7).			

Table 60: Underfrequency protection SAPTOF

Function	Range or Value			Accuracy
Operate value, start function, at symmetrical three phase voltage, *StartFrequency* 1)	(35.00 - 90.00) Hz			±2.0 mHz
Reset hysteresis 1)	10.0 mHz fixed			±2.0 mHz
Operate time 1)	fr = 50 Hz	Start time measurement with sudden frequency change	Min. = 175 ms	-
			Max. = 195 ms	
		Start time measurement with frequency ramp	Min. = 70 ms	
			Max. = 90 ms	
	fr = 60 Hz	Start time measurement with sudden frequency change	Min. = 150 ms	-
			Max. = 165 ms	
		Start time measurement with frequency ramp	Min. = 60 ms	
			Max. = 75 ms	
Disengaging time 1)	fr = 50 Hz	Start time measurement with sudden frequency change	Min. = 170 ms	-
			Max. = 195 ms	
		Start time measurement with frequency ramp	Min. = 75 ms	
			Max. = 100 ms	
	fr = 60 Hz	Start time measurement with sudden frequency change	Min. = 140 ms	-
			Max. = 165 ms	
		Start time measurement with frequency ramp	Min. = 65 ms	
			Max. = 90 ms	
Operate time delay, *tDelay* 1)	fr = 50 Hz	(0.000-60.000)s		±0.2% or ±200 ms whichever is greater
	fr = 60 Hz			±0.2% or ±175 ms whichever is greater
Note: The stated accuracy is valid for the voltage range 50 V – 250 V secondary.				
Table Note: 1) The settings and test conditions are in accordance with IEC 60255-181 standard (section 6.2 – 6.7).				

Table 61: Rate-of-change frequency protection SAPFRC

Function	Range and value			Accuracy
Operate value, start function, at symmetrical three phase voltage *, *StartFreqGrad* or *Gs* per IEC 60255-181 standard	Positive gradient: from 0.05 to 10.00 Hz/s ** Negative gradient: from -0.05 to -10.00 Hz/s **			±10.0 mHz/s
Reset hysteresis *	< 15.0 mHz/s			
Operate value, restore enable frequency, at symmetrical three phase voltage, *RestoreFreq*	(45.00 - 65.00) Hz			±2.0 mHz
Restore time delay, *tRestore*	fr = 50 Hz	(0.025 - 60.000) s		±0.2% or ±110 ms whichever is greater
Test conditions: Restore time delay measurement with sudden frequency change from *RestoreFreq* -0.02 Hz to *RestoreFreq* + 0.02 Hz	fr = 60 Hz			±0.2% or ±100 ms whichever is greater
Start time *	fr = 50 Hz	Gs: ±0.05 & ±0.50 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 110 ms Max. = 290 ms	
		Gs: ±1.00 Hz/s Tested frequency slope: 1.2, 2.0, 5.0 x Gs	Min. = 180 ms Max. = 300 ms	
		Gs: ±3.00, ±6.00 & ±10.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 300 ms Max. = 390 ms	
	fr = 60 Hz	Gs: ±0.05 & ±0.50 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 90 ms Max. = 220 ms	
		Gs: ±1.00 Hz/s Tested frequency slope: 1.2, 2.0, 5.0 x Gs	Min. = 140 ms Max. = 240 ms	
		Gs: ±3.00, ±6.00 & ±10.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 180 ms Max. = 300 ms	
Disengaging time *	fr = 50 Hz	Gs: ±0.05 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 130 ms Max. = 270 ms	
		Gs: ±5.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 130 ms Max. = 210 ms	
		Gs: ±10.00 Hz/s Tested frequency slope: 1.2 x Gs	Min. = 130 ms Max. = 160 ms	
	fr = 60 Hz	Gs: ±0.05 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 100 ms Max. = 210 ms	
		Gs: ±5.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 100 ms Max. = 170 ms	
		Gs: ±10.00 Hz/s Tested frequency slope: 1.2 x Gs	Min. = 100 ms Max. = 130 ms	

Table continues on next page

Function	Range and value		Accuracy
Operate time delay *, *tDelay* Test conditions: Gs: ± 0.2 Hz/s Frequency slope: 0.4 Hz/s Test points: 10%, 20%, 30%, 50% and 100% of the time delay setting range	fr = 50 Hz	(0.000-60.000) s	±0.2% or ±220 ms whichever is greater
	fr = 60 Hz		±0.2% or ±180 ms whichever is greater
Reset time delay, *tReset* Test conditions: Gs: ±0.2 Hz/s Frequency slope: 0.4 Hz/s	fr = 50 Hz	(0.000-60.000) s	±0.2% or ±220 ms whichever is greater
	fr = 60 Hz		±0.2% or ±180 ms whichever is greater
* The settings and test conditions are in accordance with IEC 60255-181 standard (section 6.2 – 6.7). ** The value ±0.05 Hz/s is used as minimum pickup value for frequency gradient.			
Note! The stated accuracy is valid for phase-to-earth voltage range from 50 V to 250 V secondary. During testing three phase-to-earth voltages with magnitude of 110/sqrt(3)=63.5 V were always used.			

25.9 Multipurpose protection

Table 62: 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 $I \leq I_r$ ±1.0% of I at $I > I_r$
Start undercurrent, step 1 - 2	(2 - 150)% of IBase	±1.0% of I_r at $I \leq I_r$ ±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 x I_{set} to 0, 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} Reset time at 2 x I_{set} to 0 Start time at 0 to 10 x I_{set} Reset time at 10 x I_{set} to 0	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms Min. = 5 ms Max. = 20 ms Min. = 20 ms Max. = 35 ms	 - - - -
Undercurrent: Start time at 2 x I_{set} to 0 Reset time at 0 to 2 x I_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overcurrent:		

Table continues on next page

Function	Range or value	Accuracy
Inverse time characteristics, see table 168, 169 and table 170	16 curve types	See table 168, 169 and table 170
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 $U \leq U_r$ ±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 $U \leq U_r$ ±0.5% of U at $U > U_r$
Independent time delay, overvoltage at 0.8 x U_{set} 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 x U_{set} 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 x U_{set} to 1.2 x U_{set} Reset time at 1.2 x U_{set} to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	- -
Undervoltage: Start time at 1.2 x U_{set} to 0.8 x U_{set} Reset time at 1.2 x U_{set} to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	- -
Overvoltage: Inverse time characteristics, see table 171	4 curve types	See table 171
Undervoltage: Inverse time characteristics, see table 172	3 curve types	See table 172
High and low voltage limit, voltage dependent operation, step 1 - 2	(1.0 - 200.0)% of UBase	±1.0% of U_r at $U \leq U_r$ ±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% at (10 - 5000)% of IBase	-
Reset ratio, undercurrent	< 105% at (10 - 150)% of IBase	-
Reset ratio, overvoltage	> 98% at (10 - 200)% of UBase	-
Reset ratio, undervoltage	< 102% at (10 - 200)% of UBase	-
Operate frequency	10-90 Hz	-
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 x I_{set} to 0 15 ms typically	- -
Overvoltage: Critical impulse time Impulse margin time	10 ms typically at 0.8 x U_{set} to 1.2 x U_{set} 15 ms typically	- -
Table continues on next page		

Function	Range or value	Accuracy
Undervoltage:		
Critical impulse time	10 ms typically at 1.2 x U_{set} to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

25.10 Secondary system supervision

Table 63: Fuse failure supervision FUFSPVC

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, zero sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage, negative sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, negative sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage change level	(1-100)% of UBase	±10.0% of U_r
Operate current change level	(1–100)% of IBase	±10.0% of I_r
Operate phase voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase current	(1–100)% of IBase	±0.5% of I_r
Operate phase dead line voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase dead line current	(1–100)% of IBase	±0.5% of I_r
Operate time, start, 1 ph, at 1 x U_r to 0	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 64: 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 x U_r to 0	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 x U_r to 0	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	–

Table 65: Voltage based delta supervision DELVSPVC

Function	Range or value	Accuracy
Minimum Voltage	(5.0 - 50.0)% of UBase	±0.5% of Ur at U ≤ Ur
DelU>	(2.0 - 500.0)% of UBase	Instantaneous 1 cycle & Instantaneous 2 cycle mode:±20% of Ur at U ≤ Ur±20% of U at U > Ur RMS & DFT Mag mode:±10% of Ur at U ≤ Ur±10% of U at U > Ur
DelUAng>	(2.0 - 40.0) degrees	±2.0 degrees
Operate time for changeat Ur to (Ur + 2 x DelU>)at Ur to (Ur + 5 x DelU>)		Instantaneous 1 cycle & Instantaneous 2 cycle mode - <20msRMS & DFT Mag mode - <30ms
Operate time for jump from Zero degrees to 'AngStVal' + 2 degrees		Vector shift mode - <60ms

Table 66: Current based delta supervision DELISPVC

Function	Range or value	Accuracy
Minimum current	(5.0 - 50.0)% of IBase	±1.0% of Ir at I ≤ Ir±1.0% of I at I > Ir
DelI>	(10.0 - 500.0)% of IBase	Instantaneous 1 cycle & Instantaneous 2 cycle mode: ±20% of Ir at I ≤ Ir±20% of I at I > Ir RMS & DFT Mag mode: ±10% of Ir at I ≤ Ir±10% of I at I > Ir
Second harmonic blocking	(5.0 - 100.0)% of fundamental	±2.0% of Ir
Third harmonic restraining	(5.0 - 100.0)% of fundamental	±2.0% of Ir
Operate time for changeat Ir to (Ir + 2 x DelI>)at Ir to (Ir + 5 x DelI>)		Instantaneous 1 cycle & Instantaneous 2 cycle mode - <20ms RMS & DFT Mag mode - <30ms

25.11 Control

Table 67: Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, $\varphi_{line} - \varphi_{bus}$	(-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	(0.050-1.000) Hz	±2.5 mHz
Table continues on next page		

Function	Range or value	Accuracy
Maximum closing angle between bus and line for synchronizing	(15-30) degrees	±2.0 degrees
Breaker closing pulse duration	(0.050-1.000) 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
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 $U \leq U_r$ ±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 $U \leq U_r$ ±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 68: Autorecloser SMBRREC

Function	Range or value	Accuracy
Dead time: shot 1 “t1 1Ph” shot 1 “t1 2Ph” shot 1 “t1 3Ph “ shot 1 “t1 3PhHS”	(0.000-120.000) s	±0.2% or ±35 ms whichever is greater
Dead time: 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
Extend three-phase dead time duration “tExtended t1”	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum time that circuit breaker must be closed before new sequence is allowed “tCBClosedMin”	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Wait time for the slave to close when WAIT input has reset “tSlaveDeadTime”	(0.100-60.000) s	±0.2% or ±35 ms whichever is greater
Maximum allowed start pulse duration “tLongStartInh”	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Circuit breaker closing pulse duration “tPulse”	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Reclaim time ”tReclaim”	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Maximum wait time for release from master “tWaitForMaster”	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Reset time for reclosing inhibit “tInhibit”	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Wait time after close command before proceeding to next shot “tAutoContWait”	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater

Table continues on next page

Function	Range or value	Accuracy
Maximum wait time for fulfilled synchrocheck conditions “tSync”	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
Delay time before indicating successful reclosing “tSuccessful”	(0.000-60.000) s	±0.2% or ±50 ms whichever is greater
Maximum wait time for circuit breaker closing before indicating unsuccessful “tUnsucCl”	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater

25.12 Logic

Table 69: Number of TMAGAPC instances

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

Table 70: Number of ALMCALH instances

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

Table 71: Number of WRNCALH instances

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

Table 72: Number of INDCALH instances

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

Table 73: Number of AND instances

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

Table 74: Number of GATE instances

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

Table 75: Number of INV instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INV	138	114	240

Table 76: Number of LLD instances

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

Table 77: Number of OR instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
OR	228	108	160

Table 78: 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 79: Number of RSMEMORY instances

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

Table 80: Number of SRMEMORY instances

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

Table 81: Number of TIMERSET instances

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

Table 82: Number of XOR instances

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

Table 83: Number of ANDQT instances

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

Table 84: Number of INDCOMBSPQT instances

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

Table 85: Number of INDEXTSPQT instances

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

Table 86: Number of INVALIDQT instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
INVALIDQT	10	6	6

Table 87: Number of INVERTERQT instances

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

Table 88: Number of ORQT instances

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

Table 89: 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 90: Number of RSMEMORYQT instances

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

Table 91: Number of SRMEMORYQT instances

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

Table 92: 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 93: Number of XORQT instances

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

Table 94: Number of instances in the extension logic package

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
SLGAPC	10	10	54
VSGAPC	10	10	100
AND	80	40	100
OR	80	40	100
PULSETIMER	20	20	49
GATE	—	—	49
TIMERSET	34	30	49
XOR	10	10	69
LLD	—	—	49
Table continues on next page			

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
SRMEMORY	10	10	110
INV	80	40	100
RSMEMORY	10	10	20

Table 95: Number of B16I instances

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

Table 96: Number of BTIGAPC instances

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

Table 97: Number of IB16 instances

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

Table 98: Integer to Boolean conversion for six-zone busbar BCTZCONN

Function	Quantity with cycle time
	3ms
BCTZCONN	34

Table 99: Number of ITBGAPC instances

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

Table 100: 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 101: Number of TEIGAPC instances

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

Table 102: Number of INTCOMP instances

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

Table 103: Number of REALCOMP instances

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

Table 104: Number of HOLDMINMAX instances

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

Table 105: Number of INT_REAL instances

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

Table 106: Number of CONST_INT instances

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

Table 107: Number of INTSEL instances

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

Table 108: Number of LIMITER instances

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

Table 109: Number of ABS instances

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

Table 110: Number of POL_REC instances

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

Table 111: Number of RAD_DEG instances

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

Table 112: Number of CONST_REAL instances

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

Table 113: Number of REALSEL instances

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

Table 114: Number of STOREINT instances

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

Table 115: Number of STOREREAL instances

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

Table 116: Number of DEG_RAD instances

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

25.13 Monitoring

Table 117: Power system measurement CVMMXN

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

Table 118: 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 119: Voltage measurement phase-phase VMMXU

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

Table 120: Voltage measurement phase-earth VNMMXU

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

Table 121: Current sequence measurement CMSQI

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

Table 122: 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 123: 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 124: 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	200, first in - first out	-
Time tagging resolution	1 ms	See table 163
Maximum number of analog inputs	40 + 30 (external + internally derived)	-
Maximum number of binary inputs	352	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	352	-
Maximum number of events in the Event recording per recording	1056	-
Maximum number of events in the Event list	5000, first in - first out	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 125: Insulation supervision for gas medium function SSIMG

Function	Range or value	Accuracy
Pressure alarm level	1.00-100.00	±10.0% of set value or 0.2 whichever is greater
Pressure lockout level	1.00-100.00	±10.0% of set value or 0.2 whichever is greater
Temperature alarm level	-40.00-200.00	±2.5% of set value or 1 whichever is greater
Temperature lockout level	-40.00-200.00	±2.5% of set value or 1 whichever is greater
Time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Reset time delay for pressure alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Time delay for pressure lockout	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Reset time delay for temperature alarm	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater
Time delay for temperature lockout	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater

Table 126: Insulation supervision for liquid medium function SSIML

Function	Range or value	Accuracy
Oil alarm level	1.00-100.00	±10.0% of set value or 0.2 whichever is greater
Oil lockout level	1.00-100.00	±10.0% of set value or 0.2 whichever is greater
Temperature alarm level	-40.00-200.00	±2.5% of set value or 1 whichever is greater
Temperature lockout level	-40.00-200.00	±2.5% of set value or 1 whichever is greater
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
Table continues on next page		

Function	Range or value	Accuracy
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 127: Circuit breaker condition monitoring SSCBR

Function	Range or value	Accuracy
Alarm level for open and close operation 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 Operation Time, opening and closing		±3 ms
Remaining Life of CB		±2 operations
Accumulated contact abrasion		±1.0% or ±0.5 whichever is greater

Table 128: Event list

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

Table 129: Indications

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

Table 130: Event recorder

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

Table 131: Trip value recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of disturbance reports	200

Table 132: Disturbance recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	70
	Maximum number of binary inputs	352
	Maximum number of disturbance reports	200
Format Types	COMTRADE Format	1999 (Int16) 2013 (Int16) 2013 (Float32)

Relion 670 series can store up to 10240 security events.

Table 133: Event counter with limit supervision L4UFCNT

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

Table 134: 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%

Table 135: Current harmonic monitoring CHMMHAI (50/60 Hz)

Function	Range or value		Accuracy
	Fundamental	Harmonic	
Frequency	(0.95 to 1.05) X f_r	2^{nd} order to 9^{th} order (0.1 - 0.5) X I_r	±2 mHz
True RMS	(0.2 to 2) X I_r	No superimposed harmonics	±0.5% of I_r at $I \leq I_r$ ±0.5% of I at $I > I_r$
	(0.2 to 2) X I_r	2^{nd} order to 5^{th} order (0.1 - 0.5) X I_r	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
	(0.2 to 2) X I_r	6^{th} order to 9^{th} order (0.1 - 0.5) X I_r	±5.0% of I_r at $I \leq I_r$ ±5.0% of I at $I > I_r$
Fundamental	(0.2 to 2) X I_r	No superimposed harmonics	±0.5% of I_r at $I \leq I_r$ ±0.5% of I at $I > I_r$
	(0.2 to 2) X I_r	2^{nd} order to 9^{th} order (0.1 - 0.5) X I_r	±0.5% of I_r at $I \leq I_r$ ±0.5% of I at $I > I_r$
Crest Factor	(0.2 to 2) X I_r	No superimposed harmonics	±2.0%
Harmonic Amplitude	(0.2 to 2) X I_r	2^{nd} order to 9^{th} order (0.1 - 0.5) X I_r	±2.0% of I_r at $I \leq I_r$ ±4.0% of I_H at $I > I_r$
Total Demand Distortion (TDD)	(0.2 to 2) X I_r	2^{nd} order to 9^{th} order (0.1 - 0.5) X I_r	±5.0% at $I \leq I_r$ ±5.0% of ITDD at $I > I_r$
Total Harmonic Distortion (ITHD)	(0.2 to 2) X I_r	2^{nd} order to 9^{th} order (0.1 - 0.5) X I_r	±5.0%
Note: The column header Fundamental gives the accuracy of fundamental measurement, which is also assessed in the presence of Harmonics. This is to check the accuracy of filters in detecting the fundamental component even in case of a distorted signal.			

Table 136: Voltage harmonic monitoring VHMMHAI (50/60 Hz)

Function	Range or value		Accuracy
	Fundamental	Harmonic	
Frequency	(0.95 to 1.05) X f_r	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±2 mHz
True RMS	(10 to 150) V	No superimposed harmonics	±0.5% of U
	(10 to 150) V	2^{nd} order to 5^{th} order (0.1 - 0.5) X U_F	±2.0% of U
	(10 to 150) V	6^{th} order to 9^{th} order (0.1 - 0.5) X U_F	±5.0% of U
Fundamental	(10 to 150) V	No superimposed harmonics	±0.5% of U_F
	(10 to 150) V	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±0.5% of U_F
Crest Factor	(10 to 150) V	No superimposed harmonics	±2.0%
Harmonic Amplitude	(10 to 150) V	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±4.0% of U_H
Total Harmonic Distortion (VTHD)	(10 to 150) V	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±3.0%
Note: The column header Fundamental gives the accuracy of fundamental measurement, which is also assessed in the presence of Harmonics. This is to check the accuracy of filters in detecting the fundamental component even in case of a distorted signal. U_F - Applied Voltage Fundamental U_H - Applied Voltage Harmonic (of respective harmonics) U - Actual Voltage = RMS (U_F and U_H)			

Table 137: Fault current and voltage monitoring FLTMMXU

Function	Range or value	Accuracy
Voltage, FLTULxMAG	(1 to 300) V	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Current, FLTILxMAG	(0.1-10.0) x I_r	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Phase angle, FLTULxANG	(1 to 300) V	±2 degrees at U ≤ 5 V ±0.5 degrees at U > 5 V
Phase angle, FLTILxANG	(0.1-10.0) x I_r	±1.0 degrees at $0.1 \times I_r < I \leq 0.5 \times I_r$ ±0.5 degrees at $0.5 \times I_r < I \leq 10.0 \times I_r$

25.14 Metering

Table 138: 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	-

Table 139: Function for energy calculation and demand handling ETPMMTR

Function	Range or value	Accuracy
Active Energy, Wp (Export/Import)	(10 to 300) V (0.1-4.0) x I_r at unity power factor	±1.0% of Wp
Reactive Energy, Wq (Export/Import)	(10 to 300) V (0.1-4.0) x I_r at zero power factor	±1.0% of Wq
Maximum power demand	(10 to 300) V (0.1-4.0) x I_r	±1.0% of S_r at $S \leq 0.5 \times S_r$ ±1.0% of S at $S > 0.5 \times S_r$

25.15 Station communication

Table 140: Communication protocols

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

Table 141: IEC 61850-9-2 communication protocol

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

Table 142: LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 143: SPA communication protocol

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

Table 144: IEC 60870-5-103 communication protocol

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

Table 145: SLM – LON port

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

Table 146: SLM – SPA/IEC 60870-5-103/DNP3 port

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

Table 147: 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 148: SFP - Optical ethernet port

Quantity	Rated value
Number of channels	Up to 6 single or 3 redundant or a combination of single and redundant links for communication using any protocol
Standard	IEEE 802.3u 100BASE-FX
Type of fiber	1MRK005500-AA: 62.5/125 μm, 50/125 μm multimode OM1, OM2, OM3, OM4 1MRK005500-DA: 9/125 μm single mode fiber, OS1, OS2 1MRK005500-EA: 9/125 μm single mode fiber, OS2 1MRK005500-FA: 9/125 μm single mode fiber, OS2
Wavelength and distance	1MRK005500-AA: 1310 nm, 1 m - 2 km 1MRK005500-DA: 1310 nm, 1 m - 10 km (OS1), 1 m - 30 km (OS2[1)]) 1MRK005500-EA: 1310 nm, 10 km - 60 km (OS2[1)]) 1MRK005500-FA: 1550 nm, 10 km - 120 km (OS2[1)]) (All are Class 1 laser safety)
Optical connector	Type LC
Communication speed	Fast Ethernet 100 Mbit/s

Table Note:

1) For distances above approximately 60% of maximum specified fiber length special care needs to be taken and fiber used should have an attenuation <0.25 dB/km

Table 149: SFP - Galvanic RJ45

Quantity	Rated value
Number of channels	Up to 6 single or 3 redundant or a combination of single and redundant links for communication using any protocol
Standard	IEEE 802.3u 100BASE-TX
Type of cable	Cat5e FTP
Connector	Type RJ45
Communication Speed	Fast Ethernet 100 Mbit/s

Table 150: Ethernet redundancy protocols, IEC 62439-3

Function	Value
Protocol	IEC 62439-3 Ed.1 Parallel Redundancy Protocol (PRP-0)
Communication speed	100Base-FX
Protocol	IEC 62439-3 Ed.3 Parallel Redundancy Protocol (PRP-1)

Table continues on next page

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

Table 151: Rapid spanning tree protocol (RSTP)

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

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

25.16 Remote communication

Table 152: 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 µm Multi-mode fiber glass 50/125 µm	18.8 dB (typical distance about 3 km/2 mile [1]) 11.8 dB (typical distance about 2 km/1 mile [1])	28.8 dB (typical distance 80 km/50 mile [1]) 30.8 dB [2]	28.7 dB (typical distance 120 km/75 mile [1])
Optical connector	Type ST	Type FC/PC	Type FC/PC
Protocol	C37.94	C37.94 implementation [3]	C37.94 implementation [3]
Table continues on next page			

Characteristic	Range or value		
Type of LDCM	Short range (SR)	Medium range (MR)	Long range (LR)
Data transmission	Synchronous	Synchronous	Synchronous
Transmission rate / Data rate	2 Mbit/s / 64 kbit/s	2 Mbit/s / 64 kbit/s	2 Mbit/s / 64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal	Internal or derived from received signal

Table Note:

1) depending on optical budget calculation
2) Applicable for revision r11 of MR LDCM and later.
3) C37.94 originally defined just for multi-mode; using same header, configuration and data format as C37.94

Class 1 laser product. Take adequate measures to protect the eyes. Never look into the laser beam. Complies to laser safety classification according to IEC 60825-1.

Table 153: 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	10 m

25.17 Hardware

25.17.1 IED

Table 154: Case

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

Table 155: Water and dust protection level according to IEC 60529

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

Table 156: Weight

Case size	Weight
6U, 1/2 x 19”	≤ 7.5 kg/16 lb
6U, 3/4 x 19”	≤ 15 kg/33 lb
6U, 1/1 x 19”	≤ 15 kg/33 lb

25.17.2 Electrical safety

Table 157: 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)

25.17.3 Connection system

Table 158: CT and VT circuit connectors

Connector type	Rated voltage and current	Maximum conductor area	Tightening torque
Screw compression type	250 V AC, 20 A	4 mm^2 (AWG12) 2 x 2.5 mm^2 (2 x AWG14)	0.6 Nm
Ring lug type	250 V AC, 20 A	4 mm^2 (AWG12)	1.5 Nm

Table 159: Auxiliary power supply and binary I/O connectors

Connector type	Rated voltage	Maximum conductor area	Tightening torque
Screw compression type	250 V AC	2.5 mm^2 (AWG14) 2 × 1 mm^2 (2 x AWG18)	0.5 Nm
Ring lug type 1)	300 V AC	3 mm^2 (AWG13)	1.1 Nm

Table Note:

1) Ring lug type is available for auxiliary power supply connectors only.

Table 160: NUM: Communication ports

NUM	4 Ethernet ports 1 Basic, 3 Optional
Ethernet connection type	SFP Optical LC or Galvanic RJ45
Carrier modules supported	OEM, LDCM

Table 161: OEM: Number of Ethernet ports

OEM	2 Ethernet Ports
Ethernet connection type	SFP Optical LC or Galvanic RJ45

25.18 Basic IED functions

Table 162: Self supervision with internal event list

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

Table 163: 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 164: Time synchronization PTP: IEC/IEEE 61850-9-3

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

Table 165: 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 166: 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
Antenna cable connector	SMA in receiver end TNC in antenna end
Accuracy	+/-1μs

Table 167: 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
Table continues on next page	

Quantity	Rated value
Type of fiber	62.5/125 μm multimode fiber
Supported formats	IRIG-B 00x
Accuracy	+/- 1μs

25.19 Inverse characteristic

Table 168: ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1\right)} + B \right) \cdot k$ Operate time for I_{set} = 10%, 195%, 400% of IBase (for all curves)	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	ANSI/IEEE C37.112 , ±7.0% or ±80 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	ANSI/IEEE C37.112 , ±3.0% or ±50 ms whichever is greater
Reset characteristic for ANSI curves: $t = \frac{t_r}{\left(I^{2} - 1\right)} \cdot k$ I = $I_{measured}/I_{set}$ Reset time for I_{set} = 10%, 195%, 400% of IBase	0.01 ≤ k ≤ 15.00 0 x I_{set} - 0.8 x I_{set}	ANSI/IEEE C37.112 , ±8.0% or ±350 ms whichever is greater
Definite reset timer	(0.000 - 60.000) s 0 x I_{set} - 0.8 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	

Table 169: IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1\right)} \right) \cdot k$ Operate time for I_{set} = 10%, 195%, 400% of IBase (for all curves)	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±7.0% or ±80 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±3.0% or ±50 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	
Table continues on next page		

Function	Range or value	Accuracy
Programmable characteristic Operate characteristic: $t = \left(\frac{A}{(I^P - C)} + B \right) \cdot k$ Operate time for I_{set} = 10%, 195%, 400% of IBase	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±7.0% or ±80 ms whichever is greater*
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±3.0% or ±50 ms whichever is greater*
Reset characteristic: $t = \frac{TR}{(I^{PR} - CR)} \cdot k$ I = $I_{measured}/I_{set}$ Reset time for I_{set} = 10%, 195%, 400% of IBase	0.01 ≤ k ≤ 15.00 0 x I_{set} - 0.8 x I_{set}	IEC 60255-151, ±8.0% or ±350 ms whichever is greater*
	k = (0.01 - 999.00) 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	*Data evaluated at default parameter values

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 170: 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 = $I_{measured}/I_{set}$	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±2.0% or ±20 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±2.0% or ±20 ms whichever is greater
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k} \right)$ I = $I_{measured}/I_{set}$	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±2.0% or ±50 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±2.0% or ±40 ms whichever is greater

Table 171: 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: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U_n >}{U_n >} - 0.5\right)^{2.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U_n >}{U >} - 0.5\right)^{3.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
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 172: 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	

Table 173: Inverse time characteristics for residual overvoltage protection

Function	Range or value	Accuracy
Type A curve: $t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$ $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% 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	

Section 26 Ordering for customized IED

Table 174: 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 175: 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*2.2 - F00X00 - A10000000000000000 - B00000000000000000000000000 - C0824088000282400440200000000 - D22202020 - T0000 - E1066600 - F6 - S0 - G022 - H03020010000 - K00000000 - L1134020 - M24000000 - P1110000000000000011 - B1X0 - AC - CA - B - A3X0 - CD1D1ARGN1N1XXXXXXX - KKKXXHKKLAGXSX

Product definition					-	**Differential protection**																	-
REB670*	2.2	-	F00	X00	-	A				0	0	00	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	0		-

Voltage protection									-	**Unbalance protection**					-	**Frequency protection**					-	**Multipurpose protection**		-	**General calculation**		-
D				0		0		0	-	T	0	0	0	0	-	E				00	-	F		-	S	0	-

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

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

Station communication																			-
P				0	0	0	0	0	0	0	0	0	0	0	0	0	0			-

Language		-	**Casing and mounting**		-	**Power supply**		-	**HMI**	-	**Analog system**		-	**Binary input/output**															-
B1		-			-			-		-			-																-

Station communication, remote end serial communication and time synchronization													
K													

Table 176: Product definition

REB670*	2.2	F00	X00

Table 177: Product definition ordering codes

Product	REB670*
Product version	2.2
Configuration alternative	
Busbar protection REB670	F00
ACT configuration	
No ACT configuration downloaded	X00
Ordering number	
Busbar protection REB670	1MRK002820-AG

Table 178: Differential protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A				0	0	00	0	0	0	0	0	0	0	0	0	0	

Table 179: 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-ZK	1	0–1		1)
Busbar differential protection, 2 zones, single phase/24 bays	BBP1PH24B	1MRK005904-ZG	2	0–1		2)
Busbar differential protection, 6 zones, single phase/24 bays	BBP61PH24B	1MRK005904-ZE	3	0–1		
Busbar differential protection, 4 zones, three phase/12 bays	BBP43PH12B	1MRK005904-ZL	17	0-1		3)

Table Note:

1) Only one Busbar differential protection must be ordered
2) If BBP1PH24B or BBP61PH24B is selected then only PH4SPTOC and CCSRBRF are allowed
3) If BBP43PH12B is selected then only OC4PTOC and CCRBRF are allowed

Table 180: 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	26
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

Table 181: 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	24	25
C	0			0			0	0	0				0	0			0		0	0	0	0	0	0	

Table 182: Current functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Directional phase overcurrent protection, four steps	OC4PTOC	1MRK005910-BE	2	00–12		1)
Single phase overcurrent protection, four steps	PH4SPTOC	1MRK005910-CB	3	00–24		
Directional residual overcurrent protection, four steps	EF4PTOC	1MRK005910-EK	5	00–12		
Directional negative phase sequence overcurrent protection, four steps	NS4PTOC	1MRK005910-FE	6	00–12		
Thermal overload protection, two time constants	TRPTTR	1MRK005910-HC	10	0–2		
Breaker failure protection	CCRBRF	1MRK005910-LC	11	00–12		2)
Breaker failure protection, single phase version	CCSRBRF	1MRK005910-MB	12	00–24		
Directional underpower protection	GUPPDUP	1MRK005910-RA	15	0–4		
Directional overpower protection	GOPPDOP	1MRK005910-TA	16	0–4		
Capacitor bank protection	CBPGAPC	1MRK005910-UB	18	0–2		
Overcurrent protection with binary release	BRPTOC	1MRK005910-NG	25	00–24		

Table Note:

1) Only one type of PTOC may be selected.
2) Only one type of RBRF may be selected.

Table 183: Voltage protection

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

Table 184: 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		
Residual overvoltage protection, two steps	ROV2PTOV	1MRK005912-CE	3	0–2		
Voltage differential protection	VDCPTDV	1MRK005912-EC	5	0–2		
Loss of voltage check	LOVPTUV	1MRK005912-GA	7	0–2		

Table 185: Unbalance protection

Position	1	2	3	4
T	0	0	0	0

Table 186: Frequency protection

Position	1	2	3	4
E				00

Table 187: Frequency functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Underfrequency protection	SAPTUF	1MRK005914-AC	1	00–10		
Overfrequency protection	SAPTOF	1MRK005914-BB	2	0–6		
Rate-of-change of frequency protection	SAPFRC	1MRK005914-CB	3	0–6		

Table 188: Multipurpose protection

Position	1
F	

Table 189: Multipurpose functions

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

Table 190: General calculation

Position	1
S	0

Table 191: Secondary system supervision

Position	1	2	3
G	0		

Table 192: 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	VDSPVC	1MRK005916-CA	3	0–2		

Table 193: Control

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

Table 194: Control functions

Function	Function identification	Ordering no	Position	Available qty	Selected Qty	Notes and rules
Synchrocheck, energizing check and synchronizing	SESRSYN	1MRK005917-XD	2	0–3		
Autorecloser	SMBRREC	1MRK005917-XE	4	0–2		
Control functionality for up to 6 bays, max 30 objects (6CBs), including interlocking	APC30	1MRK005917-MZ	7	0–1		

Table 195: Scheme communication

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

Table 196: Logic

Position	1	2	3	4	5
L				0	

Table 197: 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-DB	2	0–1		
Integer to Boolean conversion for six-zone busbar	BCTZCONN	1MRK005922-VB	3	00-34		1)
Integer to Boolean conversion for four-zone busbar	B4CTZCONN	1MRK005922-XA	5	00-20		2)

Table Note:

1) If Busbar differential protection, 6 zones, single phase/24 bays (BBP61PH24B) is selected, 34 is required. Otherwise, select 00.
2) If Busbar differential protection, 4 zones, three phase/12 bays (BBP43PH12B) is selected, 20 is required. Otherwise, select 00

Table 198: Monitoring

Position	1	2	3	4	5	6	7
M		0	0	0			0

Table 199: 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		
Current harmonic monitoring, 3 phase	CHMMHAI	1MRK005924-QB	5	0–3		
Voltage harmonic monitoring, 3 phase	VHMMHAI	1MRK005924-SB	6	0–3		

Table 200: Station communication

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
P				0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Table 201: Station communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
IEC 61850-9-2 Process bus communication, 12 merging units		1MRK005933-HE	1	0–1		
IEC 62439-3 Parallel redundancy protocol	PRP	1MRK005932-FA	2	0–1		1)
IEC 62439-3 High-availability seamless redundancy	HSR	1MRK005932-NA	3	0–1		
IEC 62439-3 Rapid spanning tree protocol	RSTP	1MRK005933-SA	18	0-1		2)
Synchrophasor report, 32 phasors	SYNCHREP 32PH	1MRK005933-KB	19	0-1		

Table Note:

1) PRP or HSR requires two SFPs placed in pairs (P30:1 and P30:2, P30:3 and P30:4 or P30:6:1 and P30:6:2)
2) Option RSTP require 2 SFP placed in pairs (P30:1 and P30:2 or P30:3 and P30:4)

Table 202: Language selection

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

Table Note:

1) Additional 2nd languages are continuously being added. Please get in touch with local Hitachi Energy sales contact.

Table 203: Casing selection

Casing	Ordering no	Selection	Notes and rules
1/2 x 19" rack casing, 1 TRM	1MRK000151-VA	A	
3/4 x 19" rack casing, 1 TRM	1MRK000151-VB	B	
3/4 x 19" rack casing, 2 TRM	1MRK000151-VE	C	
1/1 x 19" rack casing, 1 TRM	1MRK000151-VC	D	
1/1 x 19" rack casing, 2 TRM	1MRK000151-VD	E	
	Selected		

Table 204: Mounting selection

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

Table Note:

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

Table 205: Power supply module selection

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

Table 206: Human machine interface selection

Human machine hardware interface	Case size	Ordering no	Selection	Notes and rules
Medium size - graphic display, IEC keypad symbols	1/2 x 19", IEC 3/4 x 19", IEC 1/1 x 19", IEC	1MRK000028-AA 1MRK000028-CA 1MRK000028-BA	B	
Medium size - graphic display, ANSI keypad symbols	1/2 x 19", ANSI 3/4 x 19", ANSI 1/1 x 19", ANSI	1MRK000028-AB 1MRK000028-CB 1MRK000028-BB	C	
		Selected		

Table 207: Analog system selection

Analog system	Ordering no	Selection		Notes and rules
When more than one TRM is selected, the connector type on both TRMs must be the same (A compression or B ring lug).				
Slot position (front view/rear view)		P40/X401	P41/X411	
No Transformer input module included		X0	X0	1)
TRM 12I 1A, 50/60Hz, compression terminals	1MRK002247-CG	A1	A1	
TRM 12I 5A, 50/60Hz, compression terminals	1MRK002247-CH	A2	A2	
TRM 9I 1A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BG	A3	A3	
TRM 9I 5A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BH	A4	A4	
TRM 6I 1A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AG	A6	A6	
TRM 6I 5A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AH	A7	A7	
TRM 12I 1A, 50/60Hz, ring lug terminals	1MRK002247-CC	B1	B1	
TRM 12I 5A, 50/60Hz, ring lug terminals	1MRK002247-CD	B2	B2	
TRM 9I 1A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BC	B3	B3	
TRM 9I 5A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BD	B4	B4	
TRM 6I 1A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AC	B6	B6	
TRM 6I 5A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AD	B7	B7	
Selected				

Table Note:

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

Table 208: Maximum quantity of I/O modules, with compression terminals

When ordering I/O modules, observe the maximum quantities according to the tables 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” rack casing, one (1) TRM	14	6	4	6	14 *)
1/1 x 19” rack casing, two (2) TRM	11	6	4	6	11 *)
3/4 x 19” rack casing, one (1) TRM	8	6	4	6	8 *)
3/4 x 19” rack casing, two (2) TRM	5	5	4	5	5 *)
1/2 x 19” rack casing, one (1) TRM	3	3	3	1	3 **)
*) Including a combination of maximum four modules of type BOM or SOM and six modules of type MIM. **) Max 2 SOM possible					

Table 209: 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	6	7 *) possible locations: P3, P5, P7, P9, P11, P13, P15
1/1 x 19” rack casing, two (2) TRM	5	5	4	5	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 or SOM and six modules of type MIM.					

Table 210: Binary input/output module selection

Binary input/ output modules	**Ordering no**	**Selection**															**Notes and rules**
Slot position (front view/ rear view)			P3/X31	P4/X41	P5/X51	P6/X61	P7/X71	P8/X81	P9/X91	P10/X101	P11/X111	P12/X121	P13/X131	P14/X141	P15/X151	P16/X161	
1/2 case with 1 TRM			■	■	■												1)
3/4 case with 1 TRM			■	■	■	■	■	■	■	■							
3/4 case with 2 TRM			■	■	■	■	■										
1/1 case with 1 TRM			■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1/1 case with 2 TRM			■	■	■	■	■	■	■	■	■	■	■				
Compression terminals	1MRK002960-KA	C															
Ringlug terminals	1MRK002960-LA	R															2)
No board in slot			X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Table continues on next page																	

Binary input/ output modules	Ordering no	Selection															Notes and rules
Binary output module 24 output relays (BOM)	1MRK000614-AB		A	A	A	A	A	A	A	A	A	A	A	A	A	A	
BIM 16 inputs, RL24, 24-30VDC, 50mA	1MRK000508-DD		B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	
BIM 16 inputs, RL48, 48-60VDC, 50mA	1MRK000508-AD		C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110, 110-125VDC, 50mA	1MRK000508-BD		D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220, 220-250VDC, 50mA	1MRK000508-CD		E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, RL220, 220-250VDC, 120mA	1MRK000508-CE		E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIM 16 inputs, RL24, 24-30VDC, 50mA, enhanced pulse counting	1MRK000508-HA		F	F	F	F	F	F	F	F	F	F	F	F	F	F	
BIM 16 inputs, RL48, 48-60VDC, 50mA, enhanced pulse counting	1MRK000508-EA		G	G	G	G	G	G	G	G	G	G	G	G	G	G	
BIM 16 inputs, RL110, 110-125VDC, 50mA, enhanced pulse counting	1MRK000508-FA		H	H	H	H	H	H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220, 220-250VDC, 50mA, enhanced pulse counting	1MRK000508-GA		K	K	K	K	K	K	K	K	K	K	K	K	K	K	
IOM 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GD		L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AE		M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BE		N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CE		P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	

Table continues on next page

Binary input/ output modules	Ordering no	Selection															Notes and rules
IOM 8 inputs, RL 220-250 VDC, 110mA, 10+2 output relays	1MRK000173-CF		P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GC		U	U	U	U	U	U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AD		V	V	V	V	V	V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BD		W	W	W	W	W	W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CD		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels	1MRK000284-AB		R	R	R	R	R	R	R	R	R	R	R	R	R	R	
SOM static output module, 6 heavy duty static outputs, 250 VDC + 6 output relays	1MRK002614-CA		T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2		3)
Selected																	

Table Note:

1) These black marks indicate the maximum number of modules per casing type and the slots that can be occupied.
2) Only every second slot can be used; see Table 209
3) SOM must not to be placed in the 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 2 TRM slot P13, 1/1 case, 1 TRM slot P16.

Table 211: Station communication, remote end serial communication and time synchronization selection

Station communication, remote end serial communication and time synchronization	Ordering no	Selection														Notes and rules
Slot position (front view/rear view)		P30:1/X301	P30:2/X302	P30:3/X303	P30:4/X304	P30:5/X305	P30:6/X306	P30:6:1/X3061	P30:6:2/X3062	P31:1/X311	P31:2/X312	P31:3/X313	P32:2/X322	P32:3/X323	LDCM mode	1)
Available slots in 1/2, 3/4 and 1/1 case with 1 TRM		■	■	■	■	■	■	■	■	■	■	■			■	2)
Available slots in 3/4 and 1/1 case with 2 TRM		■	■	■	■	■	■	■	■	■	■	■	■	■	■	
No communication board included			X	X	X	X	X	X	X	X	X	X	X	X		
Ethernet SFP, optical LC connector, multi mode 2 km	1MRK005500-AA	K	K	K	K			K	K							3)
Ethernet SFP, RJ45 connector	1MRK005500-BA	P	P	P	P			P	P							
Ethernet SFP, optical LC connector, single mode 30 km	1MRK005500-DA	Q	Q	Q	Q			Q	Q							
Ethernet SFP, optical LC connector, single mode 60 km	1MRK005500-EA	R	R	R	R			R	R							

Table continues on next page

Station communication, remote end serial communication and time synchronization	Ordering no	Selection														Notes and rules
Ethernet SFP, optical LC connector, single mode 120 km	1MRK005500-FA	T	T	T	T			T	T							
Optical Ethernet module	1MRK002266-EA						H									
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	1MRK001608-AB									L						
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	1MRK001608-BB									M						
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	1MRK001608-CB									N						
Galvanic RS485 communication module	1MRK002309-AA											G	G	G		
Optical short range LDCM, 820nm	1MRK002122-AB					A	A				A	A	A	A		4)
Optical medium range LDCM, 1310 nm	1MRK002311-AA					B	B				B	B	B	B		
Optical long range LDCM, 1550 nm	1MRK002311-BA					C	C				C	C	C	C		
Galvanic X21 line data communication module	1MRK002307-AA										E	E	E	E		
Line data communication, default 64kbps mode	—														X	5)
Allow line data communication in 2Mbps mode	1MRK007002-AA														Y	
GPS time module	1MRK002282-AB										S	S	S	S		
IRIG-B time synchronization module, with PPS	1MRK002305-AA										F	F	F	F		
	Selected															

Table Note:

1) The maximum number and type of LDCM modules supported depend on the total amount of I/O and communication modules in the IED.
2) Max 2 LDCM in 1/2 case
3) Ethernet SFP is basic in P30:1. P30:6:1 and P30:6:2 require the Optical Ethernet module in P30:6.
4) Max 4 LDCMs can be ordered. Always place LDCM modules on the same board to support redundant communication: in P30:5 and P30:6, P31:2 and P31:3 or P32:2 and P32:3.
5) Default if no LDCM is selected

Section 27 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 *2.2-A31X02- C07H05-B1A12-AC-CA-B-A1A1-CDAB1RGN1N1XXXXXXX-KKKKXHKKLAGFSX. Using the code of each position #1-11 specified as REB70*1-2 2-3 3 3 3 3 3 3-4 4-5 6-7 7- 8-9 9 9 9-10 10 10 10 10 10 10 10 10 10 10 10-11 11 11 11 11 11 11 11 11 11 11 11 11 11

	Product version		Configuration alternatives			Software options								Language		
#	1	-	2		-	3							-	4		-
REB670*	2.2	-			-								-			-

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

Binary input/output modules													Station communication, remote end serial communication and time synchronization													
10												-	11													
												-														

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

Configuration alternatives	Ordering no	#2		Notes and rules
Busbar protection, 2 zones, 3 phase, 4 bays	1MRK004006-AG	A20		
Busbar protection, 2 zones, 3 phase, 8 bays	1MRK004006-BG	A31		
Busbar protection, 2 zones, 1 phase, 12 bays, single busbar	1MRK004006-CG	B20		
Busbar protection, 2 zones, 1 phase, 12 bays, double busbar	1MRK004006-DG	B21		
Busbar protection, 2 zones, 1 phase, 24 bays	1MRK004006-EG	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	1)
Double busbar - 1 CB, a and b contacts, BBP, BFP, EnFP and OCP			X03	1), 2)
	Selection for position #2			

Table Note:

1) Only for A31, B21 and B31
2) **One each of Breaker failure protection and Overcurrent protection must be ordered**

Software options	Ordering no	#3	Notes and rules
No option		X00	1)
Four step phase overcurrent protection - 4 bays	1MRK004001-CF	C06	2)
Four step phase overcurrent protection - 8 bays	1MRK004001-CG	C07	3)
Four step single phase overcurrent protection - 12 bays	1MRK004001-CH	C08	4)
Four step single phase overcurrent protection - 24 bays	1MRK004001-CK	C09	5)
Breaker failure protection, 4 bays	1MRK004001-CL	C10	2)
Breaker failure protection, 8 bays	1MRK004001-CM	C11	3)
Breaker failure protection, 12 bays, single phase	1MRK004001-CN	C12	4)
Breaker failure protection, 24 bays, single phase	1MRK004001-CP	C13	5)
Autorecloser, 2 circuit breakers	1MRK004001-GE	H05	
Harmonic monitoring	1MRK004001-KS	M23	
IEC 62439-3 parallel redundancy protocol	1MRK004001-PP	P23	6)
IEC 62439-3 High-availability seamless redundancy	1MRK004001-PR	P24	

Table continues on next page

Software options	Ordering no	#3	Notes and rules
IEC 62439-3 Rapid spanning tree protocol	1MRK004001-PY	P25	
IEC 61850-9-2 Process Bus communication, 12 merging units	1MRK004001-PT	P30	
	Selection for position #3		

Table Note:

1) All fields in the ordering form do not need to be filled in.
2) Only for A20
3) Only for A31
4) Only for B20/B21
5) Only for B31
6) Options P23, P24 and P25 require two SFPs placed in pairs.

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

Table Note:

1) Additional 2nd languages are continuously being added. Please get in touch with local Hitachi Energy sales contact

Casing	Ordering no	#5	Notes and rules
1/2 x 19" rack casing, 1 TRM	1MRK000151-VA	A	1)
3/4 x 19" rack casing, 1 TRM	1MRK000151-VB	B	1)
3/4 x 19” rack casing, 2 TRM	1MRK000151-VE	C	2)
1/1 x 19" rack casing, 2 TRM	1MRK000151-VD	E	2)
	Selection for position #5		

Table Note:

1) Only for A20/B20
2) Only for A31/B21/B31

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

Table Note:

1) Only for A20/B20
2) Wall mounting not recommended with communication modules with fiber connection.

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

Human machine hardware interface	Case size	Ordering no	#8	Notes and rules
Medium size - graphic display, IEC symbols	1/2 x 19", IEC	1MRK000028-AA	B	1)
	3/4 x 19”, IEC	1MRK000028-CA		
	1/1 x 19”, IEC	1MRK000028-BA		2)

Table continues on next page

Human machine hardware interface	Case size	Ordering no	#8	Notes and rules
Medium size - graphic display, ANSI symbols	1/2 x 19", ANSI	1MRK000028-AB	C	1)
	3/4 x 19", ANSI	1MRK000028-CB		
	1/1 x 19", ANSI	1MRK000028-BB		2)
		Selection for position #8		

Table Note:

1) Only for A20/B20
2) Only for A31/B21/B31

Analog system	Ordering no	#9		Notes and rules
When more than one TRM is selected, the connector type on both TRMs must be the same (A compression or B ring lug).				
Slot position (front view/rear view)		P40/X401	P41/X411	1)
No Transformer input module included		X0	X0	2)
TRM 12I 1A, 50/60 Hz, compression terminals	1MRK002247-CG	A1	A1	
TRM 12I 5A, 50/60 Hz, compression terminals	1MRK002247-CH	A2	A2	
TRM 12I 1A, 50/60 Hz, ring lug terminals	1MRK002247-CC	B1	B1	
TRM 12I 5A, 50/60 Hz, ring lug terminals	1MRK002247-CD	B2	B2	
	Selection for position #9			

Table Note:

1) Transformer input module in slot P41/X411 is optional for B21 and not valid for A20 and B20. A31/B31 require two TRMs.
2) Only valid if IEC 61850-9-2 Process bus communication is selected.

Binary input/output modules	Ordering no	#10												Notes and rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM included in A20, A31 and B20. 2 BIM and 1 BOM included in B21 and B31														
Slot position (front view/rear view)			P3/X31	P4/X41	P5/X51	P6/X61	P7/X71	P8/X81	P9/X91	P10/X101	P11/X111	P12/X121	P13/X131	1)
1/2 case with 1 TRM			■	■	■									2)
3/4 case with 1 TRM			■	■	■	■	■	■	■	■				2)
3/4 case with 2 TRM			■	■	■	■	■							3)
1/1 case with 2 TRM			■	■	■	■	■	■	■	■	■	■	■	3)
Compression terminals		C												
No board in slot					X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)	1MRK000614-AB			A	A	A	A	A	A	A	A	A	A	4), 5)
BIM 16 inputs, RL24, 24-30VDC, 50mA	1MRK000508-DD		B1		B1	B1	B1	B1	B1	B1	B1	B1	B1	6)
BIM 16 inputs, RL48, 48-60VDC, 50mA	1MRK000508-AD		C1		C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110, 110-125VDC, 50mA	1MRK000508-BD		D1		D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220, 220-250VDC, 50mA	1MRK000508-CD		E1		E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, RL220, 220-250VDC, 120mA	1MRK000508-CE		E2		E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIM 16 inputs, RL24, 24-30VDC, 50mA, enhanced pulse counting	1MRK000508-HA				F	F	F	F	F	F	F	F	F	7)
BIM 16 inputs, RL48, 48-60VDC, 50mA, enhanced pulse counting	1MRK000508-EA				G	G	G	G	G	G	G	G	G	
BIM 16 inputs, RL110, 110-125VDC, 50mA, enhanced pulse counting	1MRK000508-FA				H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220, 220-250VDC, 50mA, enhanced pulse counting	1MRK000508-GA				K	K	K	K	K	K	K	K	K	
IOM 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GD				L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AE				M1	M1	M1	M1	M1	M1	M1	M1	M1	

Table continues on next page

Binary input/output modules	Ordering no	#10												Notes and rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM included in A20, A31 and B20. 2 BIM and 1 BOM included in B21 and B31														
IOM 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BE				N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CE				P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM 8 inputs, RL 220-250 VDC, 110mA, 10+2 output relays	1MRK000173-CF				P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GC				U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AD				V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BD				W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CD				Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels	1MRK000284-AB				R	R	R	R	R	R	R	R	R	
SOM static output module, 6 heavy duty static outputs, 250 VDC + 6 output relays	1MRK002614-CA				T2	T2	T2	T2	T2	T2	T2	T2		8), 7)
	Selection for position #10	C												

Table Note:

1) 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
2) Only for A20/B20
3) Only for A31/B21/B31
4) Maximum 4 BOM+SOM boards. P5 not in B21/B31.
5) One BOM required in postion P4.
6) 1 BIM required in position P3. 2 BIMs required in position P3 and P5 for B21 and B31.
7) P5 not in B21/B31
8) SOM must not to be placed in the 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 2 TRM slot P13, 1/1 case, 1 TRM slot P16.

Station communication, remote end serial communication and time synchronization modules	Ordering no	#11														Notes and rules
Slot position (front view/rear view)		P30:1/X301	P30:2/X302	P30:3/X303	P30:4/X304	P30:5/X305	P30:6/X306	P30:6:1/X3061	P30:6:2/X3062	P31:1/X311	P31:2/X312	P31:3/X313	P32:2/X322	P32:3/X323	LDCM mode	1)
Available slots in 1/2 and 3/4 case with 1 TRM		■	■	■	■	■	■	■	■	■	■	■			■	
Available slots in 3/4 and 1/1 case with 2 TRM		■	■	■	■	■	■	■	■	■	■	■	■	■	■	
No communication board included			X	X	X	X	X	X	X	X	X	X	X	X		
Ethernet SFP, optical LC connector, multi mode 2 km	1MRK005500-AA	K	K	K	K			K	K							2)
Ethernet SFP, RJ45 connector	1MRK005500-BA	P	P	P	P			P	P							
Ethernet SFP, optical LC connector, single mode 30 km	1MRK005500-DA	Q	Q	Q	Q			Q	Q							
Ethernet SFP, optical LC connector, single mode 60 km	1MRK005500-EA	R	R	R	R			R	R							
Ethernet SFP, optical LC connector, single mode 120 km	1MRK005500-FA	T	T	T	T			T	T							
Optical Ethernet module	1MRK002266-EA						H									
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	1MRK001608-AB									L						
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	1MRK001608-BB									M						
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	1MRK001608-CB									N						

Table continues on next page

Station communication, remote end serial communication and time synchronization modules	Ordering no	#11														Notes and rules
Galvanic RS485 communication module	1MRK002309-AA											G	G	G		
Optical short range LDCM, single channel 3 km	1MRK002122-AB					A	A				A	A	A	A		3)
Line data communication, default 64kbps mode	—														X	4)
Allow line data communication in 2Mbps mode	1MRK007002-AA														Y	
GPS time module	1MRK002282-AB										S	S	S	S		
IRIG-B time synchronization module, with PPS	1MRK002305-AA										F	F	F	F		
	Selection for position #11															

Table Note:

1) The maximum number and type of LDCM modules supported depend on the total amount of I/O and communication modules in the IED.
2) Ethernet SFP is basic in P30:1. P30:6:1 and P30:6:2 require the Optical Ethernet module in P30:6.
3) Max 2 LDCMs can be ordered. Always place LDCM modules on the same board to support redundant communication: in P30:5 and P30:6, P31:2 and P31:3 or P32:2 and P32:3.
4) Default if no LDCM is selected

Section 28 Ordering for Accessories

28.1 Accessories

28.1.1 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:	☐	1MRK000643-EA
3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 5/1 A	Quantity:	☐	1MRK000643-FA
3 pcs SLCE 8–1 summation transformers on apparatus plate (2U high), 2/1 A	Quantity:	☐	1MRK000643-GA

28.1.2 GPS antenna and mounting details

GPS antenna, including mounting kits	Quantity:	☐	1MRK001640-AA
Cable for antenna, 20 m (Appx. 65 ft)	Quantity:	☐	1MRK001665-AA
Cable for antenna, 40 m (Appx. 131 ft)	Quantity:	☐	1MRK001665-BA

28.1.3 Interface converter (for remote end data communication)

External interface converter from C37.94 (64kbps) to G703	Quantity:	1 ☐ 2 ☐	1MRK002245-AA
External interface converter from C37.94 (64kbps/2Mbps) to G703.E1	Quantity:	1 ☐ 2 ☐	1MRK002245-BA

28.1.4 Test switch

The test system COMBITEST intended for use with the IEDs is described in 1MRK512001-BEN and 1MRK001024-CA. Please refer to the website: 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

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.

28.1.5 Protection cover

Protective cover for rear side of RHGS6, 6U, 1/4 x 19”	Quantity:		1MRK002420-AE
Protective cover for rear side of terminal, 6U, 1/2 x 19”	Quantity:		1MRK002420-AC
Protective cover for rear side of terminal, 6U, 3/4 x 19”	Quantity:		1MRK002420-AB
Protective cover for rear side of terminal, 6U, 1/1 x 19”	Quantity:		1MRK002420-AA

28.1.6 Combiflex

28.1.6.1 Key switch for settings

Key switch for lock-out of settings via LHMI	Quantity:		1MRK000611-A

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

Mounting kit			
Side-by-side mounting kit	Quantity:		1MRK000420-Z

28.1.7 Configuration and monitoring tools

Front connection cable between LHMI and PC	Quantity:		1MRK001665-CA
LED Label special paper A4, 1 pc	Quantity:		1MRK002038-CA
LED Label special paper Letter, 1 pc	Quantity:		1MRK002038-DA

28.2 Manuals

The IED Connect USB flash drive contains user documentation, Connectivity packages and LED label templates.

Specify quantity of IED Connect USB flash drive requested.		Quantity:	☐	1MRK002700-AA
User documentation				
Specify the number of printed manuals requested				
Application manual	IEC	Quantity:	☐	1MRK505370-UEN
	ANSI	Quantity:	☐	1MRK505370-UUS
Technical manual	IEC	Quantity:	☐	1MRK505371-UEN
	ANSI	Quantity:	☐	1MRK505371-UUS
Commissioning manual	IEC	Quantity:	☐	1MRK505372-UEN
	ANSI	Quantity:	☐	1MRK505372-UUS
Communication protocol manual, IEC 61850 Edition 1	IEC	Quantity:	☐	1MRK511392-UEN
Communication protocol manual, IEC 61850 Edition 2 and Edition 2.1	IEC	Quantity:	☐	1MRK511393-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity:	☐	1MRK511394-UEN
Communication protocol manual, LON	IEC	Quantity:	☐	1MRK511395-UEN
Communication protocol manual, SPA	IEC	Quantity:	☐	1MRK511396-UEN
Communication protocol manual, DNP	ANSI	Quantity:	☐	1MRK511391-UUS
Point list manual, DNP	ANSI	Quantity:	☐	1MRK511397-UUS
Operation manual	IEC	Quantity:	☐	1MRK500127-UEN
	ANSI	Quantity:	☐	1MRK500127-UUS
Installation manual	IEC	Quantity:	☐	1MRK514026-UEN
	ANSI	Quantity:	☐	1MRK514026-UUS

Table continues on next page

Engineering manual	IEC	Quantity:	☐	1MRK511398-UEN
	ANSI	Quantity:	☐	1MRK511398-UUS
Cyber security deployment guideline	IEC	Quantity:	☐	1MRK511399-UEN
Application guide, Communication set-up	IEC	Quantity:	☐	1MRK505382-UEN

28.3 Reference information

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

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

28.4 Related documents

Documents related to REB670	Document numbers
Application manual	IEC: 1MRK505370-UEN ANSI: 1MRK505370-UUS
Commissioning manual	IEC: 1MRK505372-UEN ANSI: 1MRK505372-UUS
Product guide	1MRK505373-BEN
Technical manual	IEC: 1MRK505371-UEN ANSI: 1MRK505371-UUS
Type test certificate	IEC: 1MRK505373-TEN ANSI: 1MRK505373-TUS

670 series manuals	Document numbers
Operation manual	IEC: 1MRK500127-UEN ANSI: 1MRK500127-UUS
Engineering manual	IEC: 1MRK511398-UEN ANSI: 1MRK511398-UUS
Installation manual	IEC: 1MRK514026-UEN ANSI: 1MRK514026-UUS
Communication protocol manual, DNP3	1MRK511391-UUS
Communication protocol manual, IEC 60870-5-103	1MRK511394-UEN
Communication protocol manual, IEC 61850 Edition 1	1MRK511392-UEN
Communication protocol manual, IEC 61850 Edition 2 and Edition 2.1	1MRK511393-UEN
Communication protocol manual, LON	1MRK511395-UEN
Communication protocol manual, SPA	1MRK511396-UEN
Point list manual, DNP3	1MRK511397-UUS
Accessories guide	IEC: 1MRK514012-BEN ANSI: 1MRK514012-BUS
Cyber security deployment guideline	1MRK511399-UEN
Connection and Installation components	1MRK513003-BEN
Test system, COMBITEST	1MRK512001-BEN
Application guide, Communication set-up	1MRK505382-UEN

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