RELION® 670 SERIES

Phasor measurement unit RES670 Version 2.1

Product guide

Contents

1. Application

RES670 is a Phasor Measurement Unit (PMU) that provides power system AC voltages and currents as phasors for all voltage levels in power system networks. Phasors are provided as real and imaginary or as magnitude and phase angle. The reference for the phase angle is the NavStar Global Positioning System – GPS that also supplies highly accurate time and date. The measured data in each PMU is time-synchronized via Global Positioning System (GPS) receivers – with an accuracy of one microsecond – and transmitted to Phasor Data Concentrators (every 100 milliseconds for example). The accurate time tagging of measurements taken at different geographical locations makes it possible to derive the synchronized phasor quantities (synchrophasors). Based on synchrophasors, a number of power system applications are available.

The PMUs are installed at substation level, and can be connected directly to current and voltage transformers within the substations. Each RES670 can have its own antenna and GPS system for time synchronization purposes or it can receive the IRIG-B signal from an external GPS-based clock. It is also possible to have both direct GPS and IRIG-B connection to provide time synchronization redundancy for the PMU. RES670 streams out its synchrophasor data according to IEEE C37.118 and/or IEEE 1344 standards for synchrophasor data streaming and with user-selectable reporting rates. RES670 supports reporting rates of 10, 25, 50, 100, and 200 frames per second for 50Hz system (or 10, 12, 15, 30, 60, 120, and 240 frames per second for 60Hz system). Each RES670 can communicate its synchrophasor data to up to eight independent clients over TCP and/or six independent UDP channels (unicast/multicast), simultaneously. More information is available in RES670 Application Manual under Wide Area Measurement System section.

In addition to the synchrophasor communication standard (IEEE 1344, IEEE C37.118), RES670 is also compliant to IEC 61850-8-1 standard for integration to substation automation systems and exchange of GOOSE messages, when necessary. RES670 is able to communicate over IEC 62439-3 PRP for redundant station bus communication for both IEEE C37.118 and IEC 61850-8-1, simultaneously.

Figure 1 shows an example of a system architecture for a Wide Area Monitoring System (WAMS). PMUs are the building blocks for a WAMS. The architecture of a WAMS consists of the following main components:

- **PMU** Phasor Measurement Unit, including all accessories for time synchronization
- **TCP/IP** and/or **UDP/IP** communication network infra-structure
- **PDC** Phasor Data Concentrator, including wide area applications

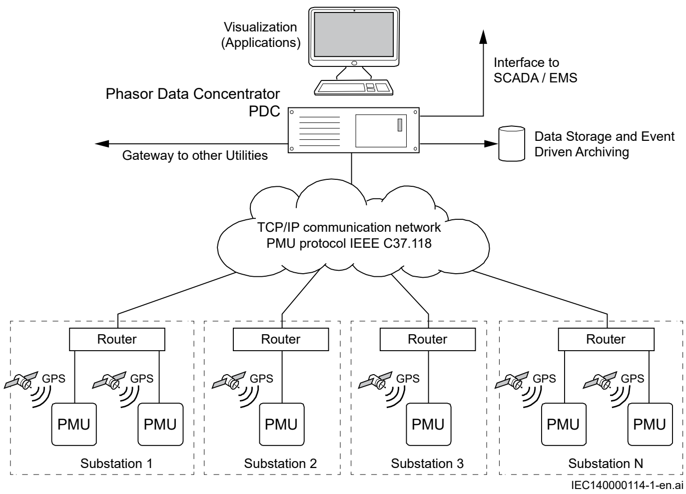

Figure 1. Wide Area Monitoring System architecture — overview

A Wide Area Monitoring System collects, stores, transmits and provides ways to analyze critical data from key points across the power networks and over large geographical areas. The architecture of the WAMS can provide a scalable solution, from small installations for data collection and basic visualization (PDC) to larger systems with intelligent monitoring using wide area applications. The Wide Area Monitoring applications are designed to detect abnormal system conditions and evaluate large area disturbances in order to preserve system integrity and maintain acceptable power system performance.

The WAMS is configured in a way to acquire synchrophasor data from several PMUs. Based on the data collected in the PDCs, WAMS is able to present the state of the grid to the power system operator, and to provide monitoring of the power system based on real-time measurements and the results of on-line applications. In addition, the data available from PDCs enables off-line analysis of the power system for post-disturbance assessments. It is possible to communicate the PMU measurements and the results of the advanced applications to SCADA/EMS systems as a way to improve the supervision of the system, providing the operator with a clear indication how likely the system is to collapse, thus giving the possibility to react in time.

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

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

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

Description of configuration A20

The configuration of the IED is shown in figure 2.

RES670 A20 configuration is applicable for a typical single busbar single breaker arrangement monitoring up to three bays. RES670 A20 is delivered in 1/2, 3/4 and full (1/1)19" rack casing. For this application 12 analog inputs are used, thus only one transformer module (TRM) with 12 analog inputs (9I+3U) is available in A20 standard configuration. As shown in figure 2, RES670 A20 configuration as a PMU is measuring one 3-phase voltage of the busbar and three 3-phase currents of bays 1 to 3. There are two instances of PMU reporting functionality available in A20 configuration, meaning two independent IEEE C37.118/1344 data streams. In the standard A20 configuration, each instance of PMU, in addition to frequency-deviation and rate-of-change-of-frequency data, is reporting 16 synchrophasors over IEEE C37.118/1344; that is four 3-phase synchrophasors and 12 single phase synchrophasors in each data stream corresponding to the AC voltage and current measurements.

In addition, each data stream includes 8 analog and 8 binary reporting channels over IEEE C37.118/1344 in the standard configuration. The number of analog and binary reporting channels can be extended to maximum 24 channels per PMU instance (on each data stream) on request. This can be done when ordering the RES670 A20 configuration. In the standard A20 configuration, the analog reporting channels are used for reporting P and Q measurements from each bay over IEEE C37.118/1344.

In addition to the binary reporting channels, there are 4 trigger bits (FREQTRIG, DFDTTRIG, OCTRIG and UVTRIG) available per PMU instance, which are used to report the existing protection function triggers over IEEE C37.118/1344.

The main functionality of the RES670 is synchrophasor reporting or PMU functionality. In addition, this configuration also includes general back-up protection functions which are mainly intended for alarm purposes. Available protection functions in standard A20 configuration are Overvoltage, Undervoltage, Overfrequency, Underfrequency and Rate-of-change frequency.

Measuring functions for S, P, Q, I, U, PF, f are available for local presentation on the local HMI and remote presentation via IEEE C37.118/1344 and/or via IEC 61850. The calibration parameters on the measurement function allows calibration at site to very high accuracy.

As shown in figure 2, there are optional functions such as Earth fault protection (EF4 PTOC), Overcurrent protection (OC4 PTOC), Under/Over power protection (GUPPDUP, GOPPDOP), etc. which can be added per request. RES670 A20 function library also includes additional functions, which are available but not configured. Note that RES670 A20 must be reconfigured if any additional functions are used.

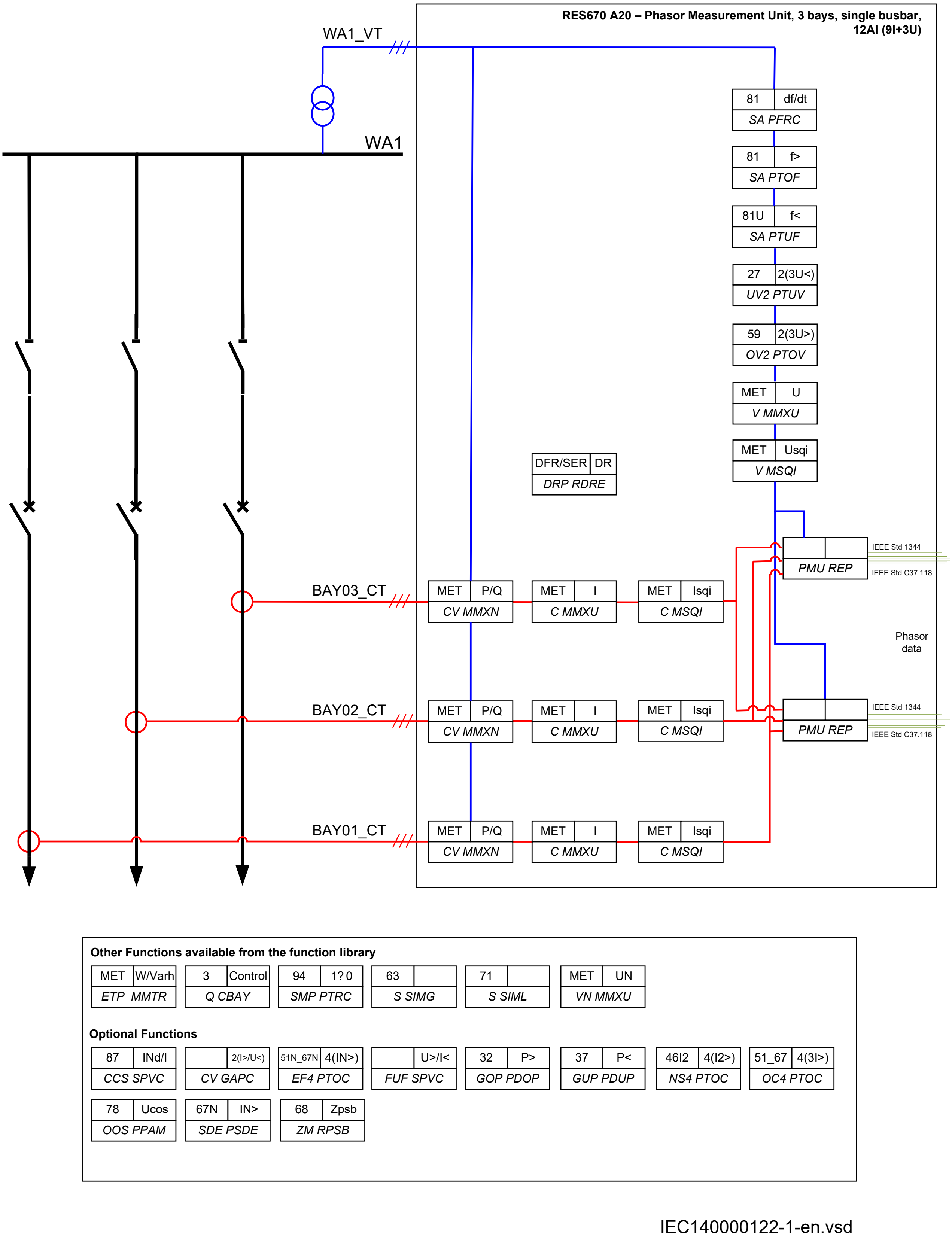

Figure 2. Configuration diagram for configuration A20

Description of configuration B20
The configuration of the IED is shown in figure 3.

RES670 B20 configuration is applicable for a typical double busbar single breaker arrangement monitoring up to six bays. RES670 B20 is delivered in ¾, and full (1/1)19" rack casing. For this application 24 analog inputs are used, thus two transformer modules (TRM) with 12 analog inputs (9I+3U) per TRM are available in B20 standard configuration. As shown in figure 3, RES670 B20 configuration as a PMU is measuring two 3-phase voltages of the busbars and six 3-phase currents of bays 1 to 6. There are two instances of PMU reporting functionality available in B20 configuration, meaning two independent IEEE C37.118/1344 data streams. Each instance of PMU is reporting frequency-deviation and rate-of-change-of-frequency data. In the standard B20 configuration, in addition to frequency data, first instance of PMU (first data stream) is reporting 32 synchrophasors over IEEE C37.118/1344; that is eight 3-phase synchrophasors and 24 single phase synchrophasors corresponding to the AC voltage and current measurements. Second instance of PMU (second data stream) is reporting 16 synchrophasors over IEEE C37.118/1344; that is four 3-phase synchrophasors and 12 single phase synchrophasors corresponding to the AC voltage and current measurements. The number of synchrophasor reporting channels on second instance of PMU can be extended to 32 channels per request. This can be done when ordering the RES670 B20 configuration.

In addition, each data stream includes 16 analog and 16 binary reporting channels over IEEE C37.118/1344 in the standard configuration. The number of analog and binary reporting channels can be extended to maximum 24 channels per PMU instance (on each data stream) on request. This can be done when ordering the RES670 B20 configuration. In the standard B20 configuration the analog reporting channels are used for reporting P and Q measurements from each bay over IEEE C37.118/1344.

In addition to the binary reporting channels there are 4 trigger bits (FREQTRIG, DFDTTRIG, OCTRIG, and UVTRIG) available per PMU instance which are used to report the existing protection function triggers over IEEE C37.118/1344.

The main functionality of the RES670 is synchrophasor reporting or PMU functionality. In addition, this configuration also includes general back-up protection functions which are mainly intended for alarm purposes. Available protection functions in standard B20 configuration are Over Voltage, Under Voltage, Over Frequency, Under Frequency and Rate of Change of Frequency.

Measuring functions for S, P, Q, I, U, PF, f are available for local presentation on the local HMI and remote presentation via IEEE C37.118/1344 and/or via IEC 61850. The calibration parameters on the measurement function allows calibration at site to very high accuracy.

As shown in figure 3, there are optional functions such as Earth fault protection (EF4 PTOC), Overcurrent protection (OC4 PTOC), Under/Over power protection (GUPPDUP, GOPPDOP), etc. which can be added per request. RES670 B20 function library also includes additional functions which are available but not configured. Note that RES670 B20 must be reconfigured if any additional functions are used.

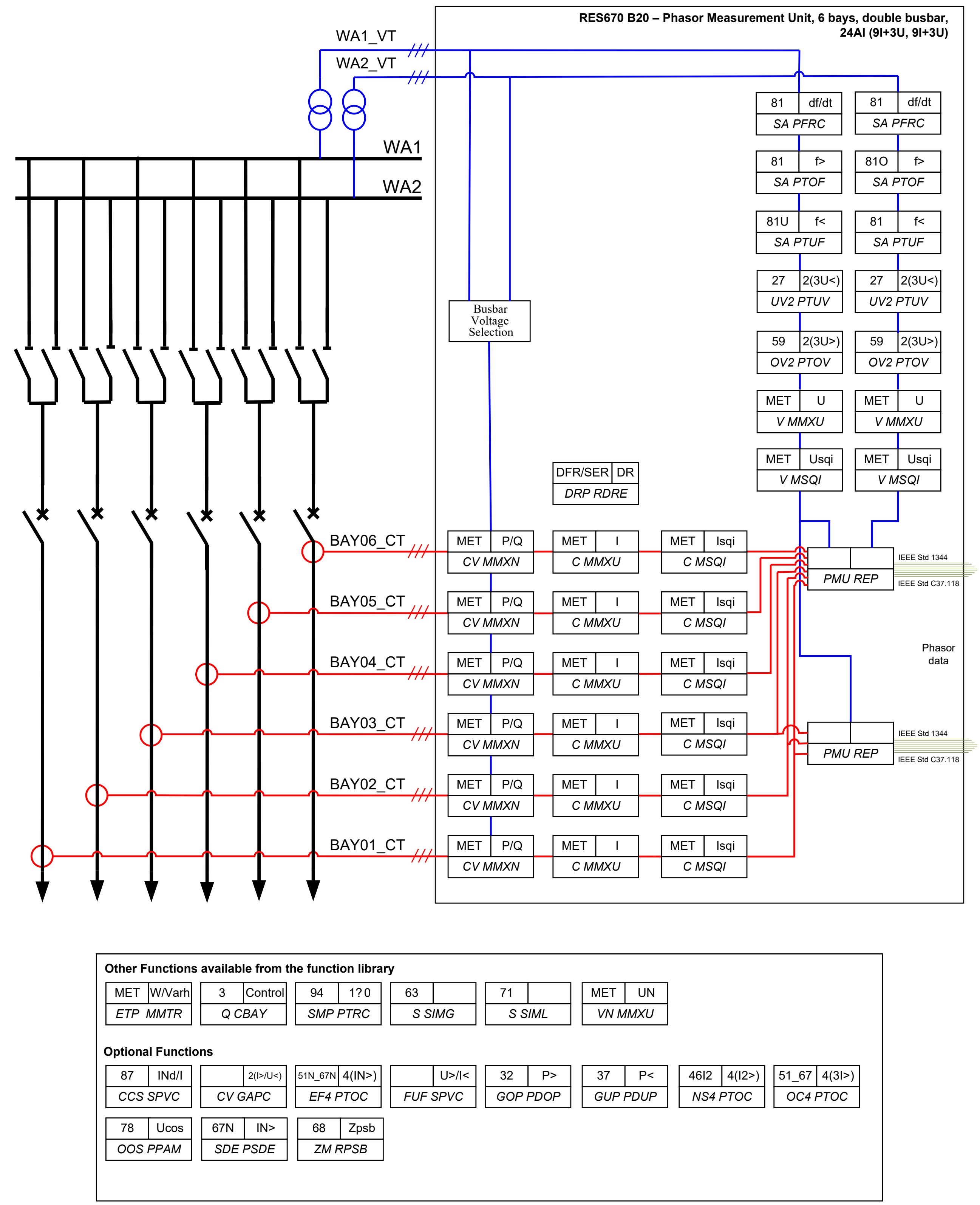

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Figure 3. Configuration diagram for configuration B20

2. Available functions

Wide area measurement functions

IEC 61850	ANSI	Function description	Phasor Measurement Unit	Phasor measurement unit	
			RES670 (Customized)	RES670 (A20)	RES670 (B20)
PMUCONF		Configuration parameters for IEEE1344 and C37.118 protocol	1	1	1
PMUREPORT		Protocol reporting via IEEE1344 and C37.118	1–2	2	2
PHASORREPORT1		Protocol reporting of phasor data via IEEE 1344 and C37.118, phasors 1-8	1-2	2	2
PHASORREPORT2		Protocol reporting of phasor data via IEEE 1344 and C37.118, phasors 9-16	0-2	2	2
PHASORREPORT3		Protocol reporting of phasor data via IEEE 1344 and C37.118, phasors 17-24	0-2		1B, 1-P11
PHASORREPORT4		Protocol reporting of phasor data via IEEE 1344 and C37.118, phasors 25-32	0-2		1B, 1-P11
ANALOGREPORT1		Protocol reporting of analog data via IEEE 1344 and C37.118, analogs 1-8	0-2	2	2
ANALOGREPORT2		Protocol reporting of analog data via IEEE 1344 and C37.118, analogs 9-16	0-2	1-P12/ 2-P13	2
ANALOGREPORT3		Protocol reporting of analog data via IEEE 1344 and C37.118, analogs 17-24	0-2	1-P12/ 2-P13	1-P14/ 2-P15
BINARYREPORT1		Protocol reporting of binary data via IEEE 1344 and C37.118, binary 1-8	0-2	2	2
BINARYREPORT2		Protocol reporting of binary data via IEEE 1344 and C37.118, binary 9-16	0-2	1-P16/ 2-P17	2
BINARYREPORT3		Protocol reporting of binary data via IEEE 1344 and C37.118, binary 17-24	0-2	1-P16/ 2-P17	1-P18/ 2-P19
PMUSTATUS		Diagnostics for C37.118 2011 and IEEE1344 protocol	1	1	1

Back-up protection functions

IEC 61850	ANSI	Function description	Phasor measurement unit		
			RES670 (Customized)	RES670 (A20)	RES670 (B20)
Impedance protection					
ZMRPSB	68	Power swing detection	0-1	1-B23	1-B23
OOSPPAM	78	Out-of-step protection	0-2	2-B23	2-B23
Current protection					
OC4PTOC	51_67[1]	Four step phase overcurrent protection	0-6	3-C26	6-C27
EF4PTOC	51N 67N[2]	Four step residual overcurrent protection	0-6	3–C26	6–C27
NS4PTOC	46I2	Four step directional negative phase sequence overcurrent protection	0-6	3-C26	6-C27
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0-6	3-C26	6-C27
LCPTTR	26	Thermal overload protection, one time constant, Celsius	0–6		
LFPTTR	26	Thermal overload protection, one time constant, Fahrenheit	0–6		
GUPPDUP	37	Directional underpower protection	0-4	3C-18	4C-25
GOPPDOP	32	Directional overpower protection	0-4	3C-18	4C-25
Voltage protection					
UV2PTUV	27	Two step undervoltage protection	0-4	1	2
OV2PTOV	59	Two step overvoltage protection	0-4	1	2
Frequency protection					
SAPTUF	81	Underfrequency protection	0-6	1	2
SAPTOF	81	Overfrequency protection	0-6	1	2
SAPFRC	81	Rate-of-change frequency protection	0-6	1	2
FTAQFVR	81A	Frequency time accumulation protection	0-4		
Multipurpose protection					
CVGAPC		General current and voltage protection	0-8	4–F01	6–F02
SMAIHPAC		Multipurpose filter	0-6		

1) 67 requires voltage
2) 67N requires voltage

Control and monitoring functions

IEC 61850	ANSI	Function description	Phasor measurement unit	Phasor measurement unit	
			RES670	RES670 (A20)	RES670 (B20)
Control					
QCBAY		Apparatus control	1	1	1
LOCREM		Handling of LRswitch positions	1	1	1
LOCREMCTRL		LHMI control of PSTO	1	1	1
SLGAPC		Logic rotating switch for function selection and LHMI presentation	15	15	15
VSGAPC		Selector mini switch	20	20	20
DPGAPC		Generic communication function for Double Point indication	16	16	16
SPC8GAPC		Single point generic control 8 signals	5	5	5
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3
SINGLECMD		Single command, 16 signals	4		
I103CMD		Function commands for IEC 60870-5-103	1	1	1
I103GENCMD		Function commands generic for IEC 60870-5-103	50	50	50
I103POSCMD		IED commands with position and select for IEC 60870-5-103	50	50	50
I103POSCMDV		IED direct commands with position for IEC 60870-5-103	50	50	50
I103IEDCMD		IED commands for IEC 60870-5-103	1	1	1
I103USRCMD		Function commands user defined for IEC 60870-5-103	4	4	4
Secondary system supervision					
CCSSPVC	87	Current circuit supervision	0–5	3–G01	5–G02
FUFSPVC		Fuse failure supervision	0-4	1–G01	2–G02
Logic					
SMPPTRC	94	Tripping logic	6	6	6
TMAGAPC		Trip matrix logic	12	12	12
ALMCALH		Logic for group alarm	5	5	5
WRNCALH		Logic for group warning	5	5	5
INDCALH		Logic for group indication	5	5	5
AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SRMEMORY, TIMERSET, XOR		Basic configurable logic blocks (see Table 1)	40-280	40–280	40–280

IEC 61850	ANSI	Function description	Phasor measurement unit	Phasor measurement unit	
			RES670	RES670 (A20)	RES670 (B20)
ANDQT, INDCOMBSPQT, INDEXTSPQT, INVALIDQT, INVERTERQT, ORQT, PULSETIMERQT, RSMEMORYQT, SRMEMORYQT, TIMERSETQT, XORQT		Configurable logic blocks Q/T (see Table 2)	0–1		
AND, GATE, INV, LLD, OR, PULSETIMER, SLGAPC, SRMEMORY, TIMERSET, VSGAPC, XOR		Extension logic package (see Table 3)	0–1		
FXDSIGN		Fixed signal function block	1	1	1
B16I		Boolean 16 to Integer conversion	18	18	18
BTIGAPC		Boolean 16 to Integer conversion with Logic Node representation	16	16	16
IB16		Integer to Boolean 16 conversion	18	18	18
ITBGAPC		Integer to Boolean 16 conversion with Logic Node representation	16	16	16
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision	12	12	12
INTCOMP		Comparator for integer inputs	12	12	12
REALCOMP		Comparator for real inputs	12	12	12
Monitoring					
CVMMXN, VMMXU, CMSQI, VMSQI, VNMMXU		Measurements	6	6	6
CMMXU		Measurements	10	10	10
AISVBAS		Function block for service value presentation of secondary analog inputs	1	1	1
EVENT		Event function	20	20	20
DRPRDRE, A1RADR-A4RADR, B1RBDR-B8RBDR		Disturbance report	1	1	1
SPGAPC		Generic communication function for Single Point indication	64	64	64
SP16GAPC		Generic communication function for Single Point indication 16 inputs	16	16	16
MVGAPC		Generic communication function for Measured Value	24	24	24
BINSTATREP		Logical signal status report	3	3	3

IEC 61850	ANSI	Function description	Phasor measurement unit	Phasor measurement unit	
			RES670	RES670 (A20)	RES670 (B20)
RANGE_XP		Measured value expander block	66	66	66
SSIMG	63	Gas medium supervision	21	21	21
SSIML	71	Liquid medium supervision	3	3	3
SSCBR		Circuit breaker monitoring	0-18	9-M17	18-M16
I103MEAS		Measurands for IEC 60870-5-103	1	1	1
I103MEASUSR		Measurands user defined signals for IEC 60870-5-103	3	3	3
I103AR		Function status auto-recloser for IEC 60870-5-103	1	1	1
I103EF		Function status earth-fault for IEC 60870-5-103	1	1	1
I103FLTPROT		Function status fault protection for IEC 60870-5-103	1	1	1
I103IED		IED status for IEC 60870-5-103	1	1	1
I103SUPERV		Supervison status for IEC 60870-5-103	1	1	1
I103USRDEF		Status for user defined signals for IEC 60870-5-103	20	20	20
L4UFCNT		Event counter with limit supervision	30	30	
TEILGAPC		Running hour-meter	6	6	6
Metering					
PCFCNT		Pulse-counter logic	16	16	16
ETPMMTR		Function for energy calculation and demand handling	6	6	6

Table 1. Total number of instances for basic configurable logic blocks

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

Table 2. 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 3. Total number of instances for extended logic package

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

Communication

IEC 61850	ANSI	Function description	Phasor measurement unit		
			RES670 (Customized)	RES670 (A20)	RES670 (B20)
Station communication					
LONSPA, SPA		SPA communication protocol	1	1	1
ADE		LON communication protocol	1	1	1
HORZCOMM		Network variables via LON	1	1	1
PROTOCOL		Operation selection between SPA and IEC 60870-5-103 for SLM	1	1	1
RS485PROT		Operation selection for RS485	1	1	1
RS485GEN		RS485	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1
DNPGENTCP		DNP3.0 communication general TCP protocol	1	1	1
CHSERRS485		DNP3.0 for EIA-485 communication protocol	1	1	1
CH1TCP, CH2TCP, CH3TCP, CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1
CHSEROPT		DNP3.0 for TCP/IP and EIA-485 communication protocol	1	1	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for serial communication protocol	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1	1	1
IEC 61850-8-1		Parameter setting function for IEC 61850	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59
GOOSEBINRCV		GOOSE binary receive	16	16	16
GOOSEDPRCV		GOOSE function block to receive a double point value	64	64	64
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	60	60	60
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64
MULTICMDRCV, MULTICMDSND		Multiple command and transmit	60/10	60/10	60/10
FRONT, LANABI, LANAB, LANCDI, LANCD		Ethernet configuration of links	1	1	1
GATEWAY		Ethernet configuration of link one	1	1	1
OPTICAL103		IEC 60870-5-103 Optical serial communication	1	1	1
RS485103		IEC 60870-5-103 serial communication for RS485	1	1	1
AGSAL		Generic security application component	1	1	1
LD0LLN0		IEC 61850 LD0 LLN0	1	1	1
SYSLLN0		IEC 61850 SYS LLN0	1	1	1

IEC 61850	ANSI	Function description	Phasor measurement unit		
			RES670 (Customized)	RES670 (A20)	RES670 (B20)
LPHD		Physical device information	1	1	1
PCMACCS		IED Configuration Protocol	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1
FSTACCS FSTACCSNA		Field service tool access via SPA protocol over ethernet communication	1	1	1
ACTIVLOG		Activity logging parameters	1	1	1
ALTRK		Service Tracking	1	1	1
SINGLELCCH		Single ethernet port link status	1	1	1
PRPSTATUS		Dual ethernet port link status	1	1	1
		Process bus communication IEC 61850-9-2 [1)]			
PRP		IEC 62439-3 parallel redundancy protocol	0-1	1-P03	1-P03
Remote communication					
		Binary signal transfer receive/transmit	3/3/6	3/3/6	3/3/6
		Transmission of analog data from LDCM	1	1	1
		Receive binary status from remote LDCM	6/3/3	6/3/3	6/3/3

1) Only included for 9-2LE products

Basic IED functions

Table 4. Basic IED functions

IEC 61850 or function name	Description
INTERRSIG SELFSUPEVLST	 Self supervision with internal event list
TIMESYNCHGEN	Time synchronization module
SYNCHCAN, SYNCHCMPPS, SYNCHPPS, SNTP, SYNCHCMPPS	Time synchronization
TIMEZONE	Time synchronization
DSTBEGIN, DSTENABLE, DSTEND	GPS time synchronization module
IRIG-B	Time synchronization
SETGRPS	Number of setting groups
ACTVGRP	Parameter setting groups
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
SMBI	Signal matrix for binary inputs
SMBO	Signal matrix for binary outputs
SMMI	Signal matrix for mA inputs
SMAI1 - SMAI12	Signal matrix for analog inputs
3PHSUM	Summation block 3 phase
ATHSTAT	Authority status
ATHCHCK	Authority check
AUTHMAN	Authority management
FTPACCS	FTP access with password
SPACOMMMAP	SPA communication mapping
SPATD	Date and time via SPA protocol
DOSFRNT	Denial of service, frame rate control for front port
DOSLANAB	Denial of service, frame rate control for OEM port AB
DOSLANCD	Denial of service, frame rate control for OEM port CD
DOSSCKT	Denial of service, socket flow control
GBASVAL	Global base values for settings
PRIMVAL	Primary system values
ALTMS	Time master supervision
ALTIM	Time management
MSTSER	DNP3.0 for serial communication protocol
PRODINF	Product information
RUNTIME	IED Runtime Comp
CAMCONFIG	Central account management configuration

Table 4. Basic IED functions, continued

IEC 61850 or function name	Description
CAMSTATUS	Central account management status
TOOLINF	Tools Information component
SAFEFILECOPY	Safe file copy function

Table 5. Local HMI functions

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

3. Differential protection

4. Impedance protection

Power swing detection ZMRPSB

Power swings may occur after disconnection of heavy loads or trip of big generation plants.

Power swing detection function ZMRPSB is used to detect power swings and initiate block of all distance protection zones. Occurrence of earth-fault currents during a power swing inhibits the ZMRPSB function, to allow fault clearance.

Out-of-step protection OOSPPAM

The out-of-step protection OOSPPAM function in the IED can be used for both generator protection and as well for line protection applications.

The main purpose of the OOSPPAM function is to detect, evaluate, and take the required action during pole slipping occurrences in the power system.

The OOSPPAM function detects pole slip conditions and trips the generator as fast as possible, after the first pole-slip if the center of oscillation is found to be in zone 1, which normally includes the generator and its step-up power transformer. If the center of oscillation is found to be further out in the power system, in zone 2, more than one pole-slip is usually allowed before the generator-transformer unit is disconnected. A parameter setting is available to take into account the circuit breaker opening time. If there are several out-of-step relays in the power system, then the one which finds the center of oscillation in its zone 1 should operate first.

Two current channels I3P1 and I3P2 are available in OOSPPAM function to allow the direct connection of two groups of three-phase currents; that may be needed for very powerful generators, with stator windings split into two groups per phase, when each group is equipped with current transformers. The protection function performs a simple summation of the currents of the two channels I3P1 and I3P2.

5. Wide area measurement system

Configuration parameters for IEEE1344 and C37.118 protocol PMUCONF

RES670 supports the following IEEE synchrophasor standards:

- IEEE 1344-1995 (Both measurements and data communication)
- IEEE Std C37.118-2005 (Both measurements and data communication)
- IEEE Std C37.118.1–2011 and C37.118.1a-2014 (Measurements)
- IEEE Std C37.118.2-2011 (Data communication)

PMUCONF contains the PMU configuration parameters for both IEEE 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 IEEE C37.118 as well as IEEE 1344 protocols.

Protocol reporting via IEEE 1344 and C37.118 PMUREPORT

The phasor measurement reporting block moves the phasor calculations into an IEEE 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 IEEE 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 RES670. More information regarding synchrophasor communication structure and TCP/UDP configuration is available in Application Manual under section C37.118 Phasor Measurement Data Streaming Protocol Configuration.

Multiple PMU functionality can be configured in RES670, which can stream out same or different data at different reporting rates or different performance (service) classes.

6. Current protection

Four-step phase overcurrent protection OC4PTOC

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

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

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

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

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

The four step residual overcurrent protection EF4PTOC has an inverse or definite time delay independent for each step.

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

EF4PTOC can be set directional or non-directional independently for each of the steps.

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

Second harmonic blocking can be set individually for each step.

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

EF4PTOC can also be used to provide a system back-up for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

Directional operation can be combined together with corresponding communication logic in permissive or blocking teleprotection scheme. Current reversal and weak-end infeed functionality are available as well.

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

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

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

The directional function is voltage polarized.

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

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

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

Directional operation can be combined together with corresponding communication logic in permissive or blocking teleprotection scheme. The same logic as for directional zero sequence current can be used. Current reversal and weak-end infeed functionality are available.

Sensitive directional residual overcurrent and power protection SDEPSDE
In isolated networks or in networks with high impedance earthing, the earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network. The protection can be selected to use either the residual current or residual power component 3U0·3I0·cos φ, for operating quantity with maintained short circuit capacity. There is also available one nondirectional 3I0 step and one 3U0 overvoltage tripping step.

No specific sensitive current input is needed. SDEPSDE can be set as low 0.25% of IBase.

Thermal overload protection, one time constant LCPTTR/LFPTTR
The increasing utilization of the power system closer to the thermal limits has generated a need of a thermal overload protection for power lines.

A thermal overload will often not be detected by other protection functions and the introduction of the thermal overload protection can allow the protected circuit to operate closer to the thermal limits.

The three-phase current measuring protection has an I^2t characteristic with settable time constant and a thermal memory. The temperature is displayed in either Celsius or Fahrenheit, depending on whether the function used is LCPTTR (Celsius) or LFPTTR (Fahrenheit).

An alarm level gives early warning to allow operators to take action well before the line is tripped.

Estimated time to trip before operation, and estimated time to reclose after operation are presented.

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.

7. Voltage protection

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

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

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

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.

8. Frequency protection

Underfrequency protection SAPTUF

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

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

SAPTUF is provided with undervoltage blocking.

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

Overfrequency protection SAPTOF

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

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

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

SAPTOF is provided with an undervoltage blocking.

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

Rate-of-change frequency protection SAPFRC

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

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

Frequency time accumulation protection FTAQFVR

Frequency time accumulation protection FTAQFVR is based on measured system frequency and time counters. FTAQFVR for generator protection provides the START output for a particular settable frequency limit, when the system frequency falls in that settable frequency band limit and positive sequence voltage within settable voltage band limit. The START signal triggers the individual event timer, which is the continuous time spent within the given frequency band, and the accumulation timer, which is the cumulative time spent within the given frequency band. Once the timers reach their limit, an alarm or trip signal is activated to protect the turbine against the abnormal frequency operation. This function is blocked during generator start-up or shut down conditions by monitoring the circuit breaker position and current threshold value. The function is also blocked when the system positive sequence voltage magnitude deviates from the given voltage band limit which can be enabled by *EnaVoltCheck* setting.

It is possible to create functionality with more than one frequency band limit by using multiple instances of the function. This can be achieved by a proper configuration based on the turbine manufacturer specification.

9. Multipurpose protection

General current and voltage protection CVGAPC

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

CVGAPC can also be used to improve phase selection for high resistive earth faults, outside the distance protection reach, for the transmission line. Three functions are used, which measures the neutral current and each of the three phase voltages. This will give an independence from load currents and this phase selection will be used in conjunction with the detection of the earth fault from the directional earth fault protection function.

10. Secondary system supervision

Current circuit supervision CCSSPVC

Open or short circuited current transformer cores can cause unwanted operation of many protection functions such as differential, earth-fault current and negative-sequence current functions.

Current circuit supervision (CCSSPVC) compares the residual current from a three phase set of current transformer cores with the neutral point current on a separate input taken from another set of cores on the current transformer.

A detection of a difference indicates a fault in the circuit and is used as alarm or to block protection functions expected to give inadvertent tripping.

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.

Multipurpose filter SMAIHPAC

The multi-purpose filter function block, SMAIHPAC, is arranged as a three-phase filter. It has very much the same user interface (e.g. inputs and outputs) as the standard pre-processing function block SMAI. However the main difference is that it can be used to extract any frequency component from the input signal. Thus it can, for example, be used to build sub-synchronous resonance protection for synchronous generator.

11. Control

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.

Local remote LOCREM/Local remote control LOCREMCTRL

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

Logic rotating switch for function selection and LHMI presentation SLGAPC

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

Selector mini switch VSGAPC

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

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

Generic communication function for Double Point indication DPGAPC

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

Single point generic control 8 signals SPC8GAPC
The Single point generic control 8 signals SPC8GAPC function block is a collection of 8 single point commands, designed to bring in commands from REMOTE (SCADA) to those parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. Confirmation (status) of the result of the commands is supposed to be achieved by other means, such as binary inputs and SPGAPC function blocks. The commands can be pulsed or steady with a settable pulse time.

AutomationBits, command function for DNP3.0 AUTOBITS
AutomationBits function for DNP3 (AUTOBITS) is used within PCM600 to get into the configuration of the commands coming through the DNP3 protocol. The AUTOBITS function plays the same role as functions GOOSEBINRCV (for IEC 61850) and MULTICMDRCV (for LON).

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

12. Logic

Tripping logic SMPPTRC
A function block for protection tripping is always provided as basic for each circuit breaker involved in the tripping of the fault. It provides a settable pulse prolongation to ensure a trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block also includes a settable latch functionality for evolving faults and breaker lock-out.

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.

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

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

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

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

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

- **AND** function block. Each block has four inputs and two outputs where one is inverted.
- **GATE** function block is used for whether or not a signal should be able to pass from the input to the output.
- **INVERTER** function block that inverts one input signal to the output.
- **LLD** function block. Loop delay used to delay the output signal one execution cycle.
- **OR** function block. Each block has up to six inputs and two outputs where one is inverted.
- **PULSETIMER** function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- **RSMEMORY** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power interruption, the flip-flop resets or returns to the state it had before the power interruption. RESET input has priority.
- **SRMEMORY** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power interruption,

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

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

Extension logic package

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

Logic rotating switch for function selection and LHMI presentation SLGAPC

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

Selector mini switch VSGAPC

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

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

Fixed signal function block

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

One FXDSIGN function block is included in all IEDs.

Elapsed time integrator with limit transgression and overflow supervision (TEIGAPC)

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

The main features of TEIGAPC

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

Boolean 16 to Integer conversion B16I

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

Boolean to integer conversion with logical node representation, 16 bit BTIGAPC

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

Integer to Boolean 16 conversion IB16

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

Integer to Boolean 16 conversion with logic node representation ITBGAPC

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

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

Comparator for integer inputs INTCOMP

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

Comparator for real inputs REALCOMP

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

13. Monitoring

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

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

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- measured analog values from merging units
- primary phasors
- positive, negative and zero sequence currents and voltages
- mA, input currents
- pulse counters

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.

Disturbance report DRPRDRE

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

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 128 binary signals.

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

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

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

A disturbance is defined as an activation of an input to the AnRADR or BnRBDR function blocks, which are set to trigger the disturbance recorder. All connected signals from start of pre-fault time to the end of post-fault time will be included in the recording.

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

Event list DRPRDRE

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

The event list logs all binary input signals connected to the Disturbance recorder function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

Indications DRPRDRE

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

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

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

Event recorder DRPRDRE

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

The event recorder logs all selected binary input signals connected to the Disturbance recorder function. Each recording can contain up to 150 time-tagged events.

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

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

Trip value recorder DRPRDRE

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

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

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

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

Disturbance recorder DRPRDRE

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

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance recorder function (maximum 40 analog and 128 binary signals). The binary signals available are the same as for the event recorder function.

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

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

Event function

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

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

Generic communication function for Single Point indication SPGAPC

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

Generic communication function for Measured Value MVGAPC

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

Measured value expander block RANGE_XP

The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGAPC) are provided with measurement 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.

Gas medium supervision SSIMG

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

Liquid medium supervision SSIML

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

Breaker monitoring SSCBR

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

Event counter with limit supervison L4UFCNT

The 30 limit counter L4UFCNT provides a settable counter with four independent limits where the number of positive and/or negative flanks on the input signal are counted against the setting values for limits. The output for each limit is activated when the counted value reaches that limit.

Overflow indication is included for each up-counter.

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

14. Metering

Pulse-counter logic PCFCNT

Pulse-counter logic (PCFCNT) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the 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.

Function for energy calculation and demand handling (ETPMMTR)

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

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

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

15. Human machine interface

Local HMI

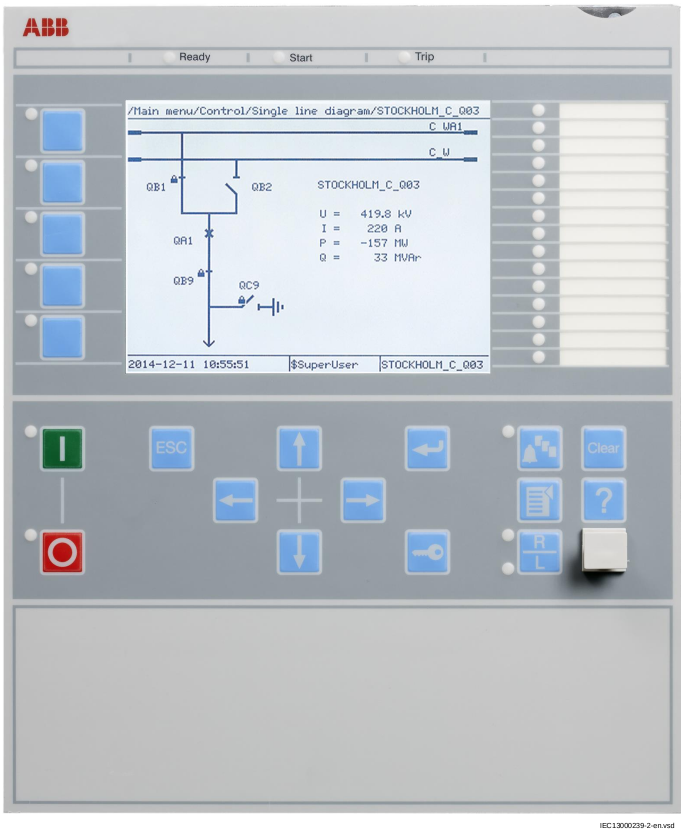

Figure 4. Local human-machine interface

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.

16. Basic IED functions

Time synchronization
The time synchronization source selector is used to select a common source of absolute time for the IED. For RES670 as a Phasor Measurement Unit (PMU) an accurate time synchronization is essential to allow the comparison of phasors measured at different locations in a Wide Area Monitoring System (WAMS). For an IED as part of a protection system, time synchronization is required to compare event and disturbance data between all IEDs in a substation automation system. A common source shall be used for IED and merging unit when IEC 61850-9-2LE process bus communication is used.

Only GPS and IRIG-B (Optical IRIG-B 00X is recommended), with IEEE1344 support, are the acceptable time synchronization sources for synchrophasor measurement applications and RES670 supports both.

17. Station communication

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

Available communication protocols are:

- IEC 61850-8-1 communication protocol
- IEC 61850-9-2LE communication protocol
- LON communication protocol
- SPA or IEC 60870-5-103 communication protocol
- DNP3.0 communication protocol
- C37.118 communication protocol

Several protocols can be combined in the same IED.

IEC 61850-8-1 communication protocol
IEC 61850 Ed.1 or Ed.2 can be chosen by a setting in PCM600. The IED is equipped with double 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.

IEC 61850-9-2LE communication protocol
Single optical Ethernet port communication standard IEC 61850-9-2LE for process bus is provided. IEC 61850-9-2LE allows Non Conventional Instrument Transformers (NCIT) with Merging Units (MU) or stand alone Meging Units to exchange information with the IED and simplifies SA engineering.

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

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

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

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

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).

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

18. Remote communication

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.

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

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

19. Hardware description

Hardware modules
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.

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

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

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

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.

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.

Optical ethernet module OEM
The optical fast-ethernet module is used for fast and interference-free communication of synchrophasor data over IEEE C37.118 and/or IEEE 1344 protocols. It is also used to connect an IED to the communication buses (like the station bus) that use the IEC 61850-8-1 protocol (OEM rear port A, B). The process bus use the IEC 61850-9-2LE protocol (OEM rear port C, D). The module has one or two optical ports with ST connectors.

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.

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.

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

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

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

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

Layout and dimensions
Dimensions

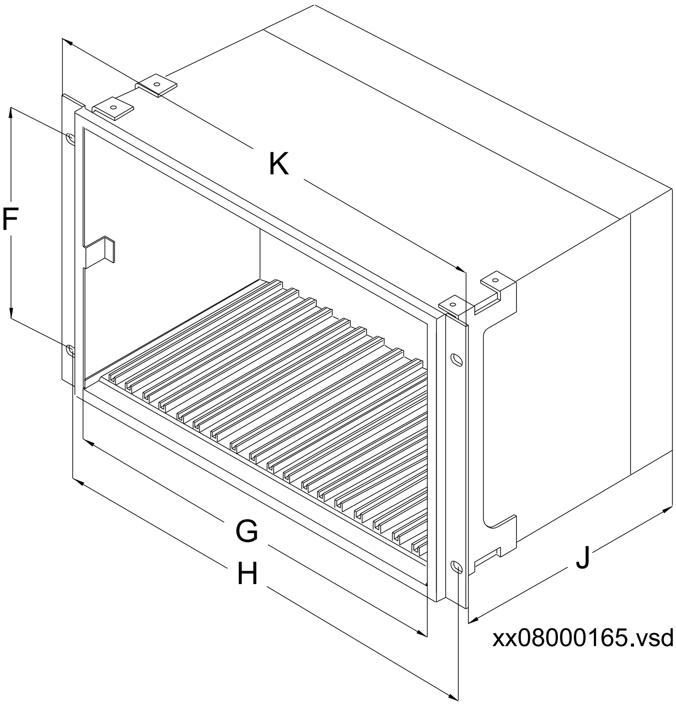

Figure 6. Case with rear cover and 19” rack mounting kit

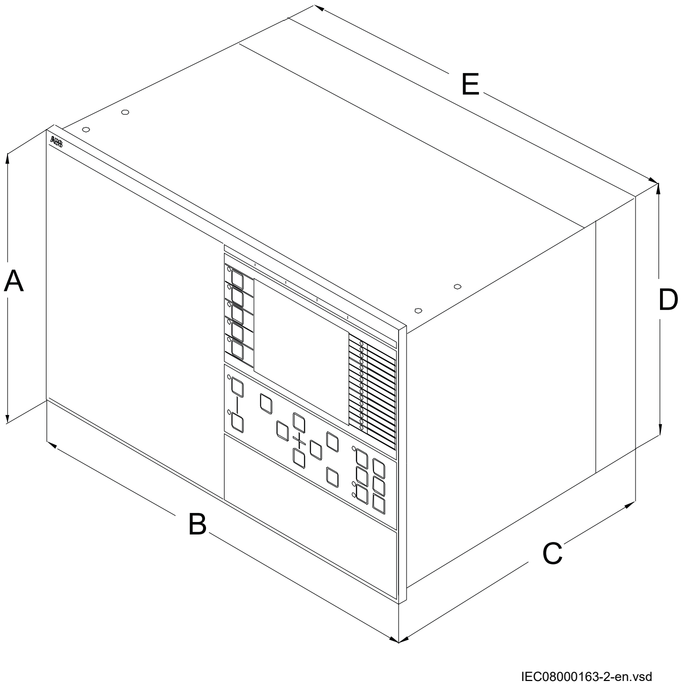

Figure 5. Case with rear cover

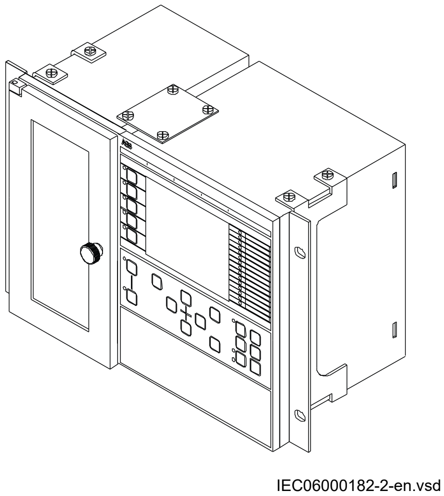

Figure 7. A 1/2 x 19” size IED side-by-side with RHGS6.

Case size (mm)/ (inches)	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”	265.9/ 10.47	223.7/ 8.81	242.1/ 9.53	255.8/ 10.07	205.7/ 8.10	190.5/ 7.50	203.7/ 8.02	-	228.6/ 9.00	-
6U, 3/4 x 19”	265.9/ 10.47	336.0/ 13.23	242.1/ 9.53	255.8/ 10.07	318.0/ 12.52	190.5/ 7.50	316.0/ 12.4	-	228.6/ 9.00	-
6U, 1/1 x 19”	265.9/ 10.47	448.3/ 17.65	242.1/ 9.53	255.8/ 10.07	430.3/ 16.86	190.5/ 7.50	428.3/ 16.86	465.1/ 18.31	228.6/ 9.00	482.6/19.00

The H and K dimensions are defined by the 19” rack mounting kit.

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”
  - 3/4 case size (h) 254.3 mm/10.01” (w) 322.4 mm/ 12.69”
  - 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.

20. Connection diagrams

Connection diagrams

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

The latest versions of the connection diagrams can be downloaded from http://www.abb.com/substationautomation.

Connection diagrams for Customized products

Connection diagram, 670 series 2.11MRK002801-AF

Connection diagrams for Configured products

Connection diagram, RES670 2.1, A20 1MRK002803-NA

Connection diagram, RES670 2.1, B20 1MRK002803-NB

Connection diagrams for Customized products

Connection diagram, 670 series 2.1 1MRK002802-AF

21. Technical data

General

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

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 are used if not explicitly stated otherwise.
9. During testing, signals with rated frequency have been injected if not explicitly stated otherwise.

Energizing quantities, rated values and limits

Analog inputs

Table 6. 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 7. TRM - Energizing quantities, rated values and limits for measuring transformer

Description	Value	
Frequency		
Rated frequency f_r	50/60 Hz	
Operating range	f_r ± 10%	
Current inputs		
Rated current I_r	1A	5 A
Operating range	(0-1.8) × I_r	(0-1.6) × I_r
Thermal withstand	80 × I_r for 1 s 25 × I_r for 10 s 10 × I_r for 1 min 1.8 × I_r for 30 min 1.1 × I_r continuously	65 × I_r for 1 s 20 × I_r for 10 s 8 × I_r for 1 min 1.6 × I_r for 30 min 1.1 × I_r continuously
Burden	< 200 mVA at I_r	< 350 mVA at I_r
Voltage inputs *)		
Rated voltage U_r	110 or 220 V	
Operating range	0 - 340 V	
Thermal withstand	450 V for 10 s 420 V continuously	
Burden	< 20 mVA at 110 V < 80 mVA at 220 V	
*) all values for individual voltage inputs		
Note! All current and voltage data are specified as RMS values at rated frequency		

Table 8. MIM - mA input module

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

Table 9. OEM - Optical ethernet module

Quantity	Rated value
Number of channels	1 or 2 (port A, B for IEC 61850-8-1 / IEEE C37.118 and port C, D for IEC 61850-9-2LE / IEEE C37.118)
Standard	IEEE 802.3u 100BASE-FX
Type of fiber	62.5/125 μm multimode fiber
Wave length	1300 nm
Optical connector	Type ST
Communication speed	Fast Ethernet 100 Mbit/s

Auxiliary DC voltage

Table 10. 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	-

Binary inputs and outputs

Table 11. BIM - Binary input module

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

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

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

Table 12. BIM - Binary input module with enhanced pulse counting capabilities

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

Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

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

Table 13. SOM - Static Output Module (reference standard: IEC 61810-2): Static binary outputs

Function of quantity	**Static binary output trip**	
Rated voltage	48-60 VDC	110-250 VDC
Number of outputs	6	6
Impedance open state	~300 kΩ	~810 kΩ
Test voltage across open contact, 1 min	No galvanic separation	No galvanic separation
Current carrying capacity:		
Continuous	5 A	5 A
1.0 s	10 A	10 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF :		
0.2 s	30 A	30 A
1.0 s	10 A	10 A
Breaking capacity for DC with L/R ≤ 40 ms	48 V/1 A 60 V/0.75 A	110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Operating time	< 1 ms	< 1 ms

Table 14. SOM - Static Output module data (reference standard: IEC 61810-2): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250 V AC/DC
Min load voltage	24VDC
Number of outputs	6
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 8 A 10 A
Max operations with load	1000
Max operations with no load	10000
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for DC with L/R ≤ 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Operating time	< 6 ms

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

Table 15. BOM - Binary output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC, DC
Min load voltage	24VDC
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A
Max operations with load	1000
Max operations with no load	10000
Making capacity at inductive load with L/R > 10 ms 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos 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
Operating time	< 6 ms

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

Influencing factors

Table 16. Temperature and humidity influence

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

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

Dependence on	Reference value	Within nominal range	Influence
Ripple, in DC auxiliary voltage Operative range	max. 2% Full wave rectified	15% of EL	0.01%/%
Auxiliary voltage dependence, operate value		±20% of EL	0.01%/%
Interrupted auxiliary DC voltage		24-60 V DC ± 20% 100-250 V DC ±20%	
Interruption interval 0–50 ms			No restart
0–∞ s			Correct behaviour at power down
Restart time			< 300 s

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

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±1.0%/Hz
Harmonic frequency dependence (20% content)	2^{nd}, 3^{rd} and 5^{th} harmonic of f_r	±2.0%

Type tests according to standards

Table 19. 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, Class III
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Class IV
Surge withstand capability test	2.5 kV, oscillatory 4.0 kV, fast transient	IEEE/ANSI C37.90.1
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-26 IEC 61000-4-2, Class IV
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.1
Fast transient disturbance	4 kV 2 kV, MIM mA-inputs	IEC 60255-26, Zone A IEC 60255-26, Zone B
Surge immunity test	2-4 kV, 1.2/50μs 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	15 Hz-150 kHz	IEC 61000-4-16, Class IV
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8, Class V
Pulse magnetic field immunity test	1000 A/m	IEC 61000–4–9, Class V
Damped oscillatory magnetic field test	100 A/m	IEC 61000-4-10, Class V
Radiated electromagnetic field disturbance	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-26
Radiated electromagnetic field disturbance	20 V/m 80-1000 MHz 10 V/m, 5.1-6.0 GHz	IEEE/ANSI C37.90.2 EN 50121-5
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEEE/ANSI C63.4, FCC
Conducted emission	0.15-30 MHz	IEC 60255-26

Table 20. Insulation

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

Table 21. 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 10 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 22. CE compliance

Test	According to
Immunity	EN 60255–26
Emissivity	EN 60255–26
Low voltage directive	EN 60255–27

Table 23. Mechanical tests

Test	Type test values	Reference standards
Vibration response test	Class II	IEC 60255-21-1
Vibration endurance test	Class I	IEC 60255-21-1
Shock response test	Class I	IEC 60255-21-2
Shock withstand test	Class I	IEC 60255-21-2
Bump test	Class I	IEC 60255-21-2
Seismic test	Class II	IEC 60255-21-3

Differential protection

Impedance protection

Table 24. Power swing detection ZMRPSB

Function	Range or value	Accuracy
Reactive reach	(0.10-3000.00) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach	(0.10–1000.00) Ω/loop	
Power swing detection operate time	(0.000-60.000) s	±0.2% or ±10 ms whichever is greater
Second swing reclaim operate time	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Minimum operate current	(5-30)% of IBase	±1.0% of I_r

Table 25. Out-of-step protection OOSPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00 - 1000.00)% of Zbase	±2.0% of $U_r/(\sqrt{3} \cdot I_r)$
Rotor start angle	(90.0 - 130.0) degrees	±5.0 degrees
Rotor trip angle	(15.0 - 90.0) degrees	±5.0 degrees
Zone 1 and Zone 2 trip counters	(1 - 20)	-

Wide area measurement system

RES670 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. RES670 is also compliant with synchrophasor data transfer requirements of IEEE C37.118.2-2011. There are two types of internal current transformer cores in RES670, protection and measuring cores. Using the measuring cores, RES670 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.

Current protection

Table 26. 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 $I \le I_r$ ±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 $I \le I_r$ ±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 111, table 112 and table 113	16 curve types	See table 111, table 112 and table 113
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Operate frequency, directional overcurrent	38-83 Hz	-
Operate frequency, non-directional overcurrent	10-90 Hz	-

Table 27. 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 $I \leq I_r$ ±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 $I \leq I_r$ ±2.5% of I at $I > I_r$
Independent time delay at 0 to 2 x I_{set}, step 1-4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1-4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see Table 111, Table 112 and Table 113	16 curve types	See Table 111, Table 112 and Table 113
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 28. Four step negative sequence overcurrent protection NS4PTOC

Function	Range or value	Accuracy
Operate current, step 1 - 4	(1-2500)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1 - 4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see table 111, table 112 and table 113	16 curve types	See table 111, table 112 and table 113
Minimum operate current, step 1 - 4	(1.00 - 10000.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±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 $I \le I_r$ ±2.5% of I at $I > I_r$
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	±1.0% of I_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) 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 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 29. Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot \cos\varphi$ directional residual overcurrent	(0.25-200.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Operate level for $\cdot 3I_0 \cdot 3U_0$ $\cos\varphi$ directional residual power	(0.25-200.00)% of *SBase*	±1.0% of S_r at $S \le S_r$ ±1.0% of S at $S > S_r$
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of *IBase*	±1.0% of I_r at $\le I_r$ ±1.0% of I at $I > I_r$
Operate level for non-directional overcurrent	(1.00-400.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Operate level for non-directional residual overvoltage	(1.00-200.00)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Residual release current for all directional modes	(0.25-200.00)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Residual release voltage for all directional modes	(1.00-300.00)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Operate time for non-directional residual overcurrent at 0 to 2 x Iset	Min. = 40 ms Max. = 65 ms	
Reset time for non-directional residual overcurrent at 2 to 0 x Iset	Min. = 40 ms Max. = 65 ms	
Operate time for directional residual overcurrent at 0 to 2 x Iset	Min. = 110 ms Max. = 160 ms	
Reset time for directional residual overcurrent at 2 to 0 x Iset	Min. = 20 ms Max. = 60 ms	
Independent time delay for non-directional residual overvoltage at 0.8 to 1.2 x Uset	(0.000 – 60.000) s	±0.2% or ± 75 ms whichever is greater
Independent time delay for non-directional residual overcurrent at 0 to 2 x Iset	(0.000 – 60.000) s	±0.2% or ± 75 ms whichever is greater
Independent time delay for directional residual overcurrent at 0 to 2 x Iset	(0.000 – 60.000) s	±0.2% or ± 170 ms whichever is greater
Inverse characteristics, see table "", table "" and table ""	16 curve types	See table "", table "" and table ""
Relay characteristic angle (RCADir)	(-179 to 180) degrees	±2.0 degrees
Relay operate angle (ROADir)	(0 to 90) degrees	±2.0 degrees

Table 30. Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(2-400)% of IBase	±1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	±1.0°C, ±2.0°F
Operate time: $$t = \tau \ln \left[\frac{I^2 - I_p^2}{I^2 - \frac{T_{Trip} - T_{Amb}}{T_{ref}} \cdot I_{ref}^2} \right]$$ (Equation 1) T_{Trip}= set operate temperature T_{Amb} = ambient temperature T_{ref} = temperature rise above ambient at I_{ref} I_{ref} = reference load current I = actual measured current I_p = load current before overload occurs	Time constant τ = (1–1000) minutes	IEC 60255-149, ±5.0% or ±200 ms whichever is greater
Alarm temperature	(0-200)°C, (0-400)°F	±2.0°C, ±4.0°F
Operate temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F
Reset level temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F

Table 31. 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 $S \le S_r$ ±1.0% of S at $S > S_r$ where $S_r = 1.732 \cdot U_r \cdot I_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	±2.0 degrees
Independent time delay to operate for Step 1 and Step 2 at 2 to 0.5 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 32. 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 $S \le S_r$ ±1.0% of S at $S > S_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	±2.0 degrees
Operate time, start at 0.5 to 2 x S_r and *k=0.000*	Min. =10 ms Max. = 25 ms	
Reset time, start at 2 to 0.5 x S_r and *k=0.000*	Min. = 35 ms Max. = 55 ms	
Independent time delay to operate for Step 1 and Step 2 at 0.5 to 2 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Voltage protection

Table 33. Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1.0–100.0)% of *UBase*	±0.5% of U_r
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 115	-	See table 115
Definite time delay, step 1 at 1.2 to 0 x U_{set}	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 to 0 x U_{set}	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000–60.000) s	±0.5% or ±40ms whichever is greater
Operate time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Reset time, start at 0 to 1.2 x U_{set}	Min. = 15 ms Max. = 35 ms	-
Critical impulse time	5 ms typically at 1.2 to 0 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 34. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1.0-200.0)% of *UBase*	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
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 114	-	See table 114
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±45 ms whichever is greater
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Minimum operate time, Inverse characteristics	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Frequency protection

Table 35. Underfrequency protection SAPTUF

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

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

(Equation 2)

$U=U_{measured}$

Table 36. Overfrequency protection SAPTOF

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

Table 37. Rate-of-change of frequency protection SAPFRC

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

Table 38. Frequency accumulation protection FTAQFVR

Function	Range or value	Accuracy
Operate value, frequency high limit level at symmetrical three phase voltage	(35.00 – 90.00) Hz	±2.0 mHz
Operatevalue, frequency low limit level at symmetrical three phase voltage	(30.00 – 85.00) Hz	±2.0 mHz
Operate value, voltage high and low limit for voltage band limit check	(0.0 – 200.0)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Operate value, current start level	(5.0 – 100.0)% of IBase	±1.0% of I_r or 0.01 A at $I \leq I_r$
Independent time delay for the continuous time limit at f_{set}+0.02 Hz to f_{set}-0.02 Hz	(0.0 – 6000.0) s	±0.2% or ±200 ms whichever is greater
Independent time delay for the accumulation time limit at f_{set}+0.02 Hz to f_{set}-0.02 Hz	(10.0 – 90000.0) s	±0.2% or ±200 ms whichever is greater

Multipurpose protection

Table 39. 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 to 0 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overcurrent (non-directional): Start time at 0 to 2 x I_{set} Reset time at 2 to 0 x I_{set} Start time at 0 to 10 x I_{set} Reset time at 10 to 0 x I_{set}	 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 to 0 x I_{set} Reset time at 0 to 2 x I_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overcurrent: Inverse time characteristics, see table 111, 112 and table 113	 16 curve types	 See table 111, 112 and table 113
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 to 1.2 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater

Table 39. General current and voltage protection CVGAPC , continued

Function	Range or value	Accuracy
Independent time delay, undervoltage at 1.2 to 0.8 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overvoltage:		
Start time at 0.8 to 1.2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Undervoltage:		
Start time at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Overvoltage:		
Inverse time characteristics, see table 114	4 curve types	See table 114
Undervoltage:		
Inverse time characteristics, see table 115	3 curve types	See table 115
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%	-
Reset ratio, undercurrent	< 105%	-
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent:		
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Undercurrent:		
Critical impulse time	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time	15 ms typically	-
Overvoltage:		
Critical impulse time	10 ms typically at 0.8 to 1.2 x U_{set}	-
Impulse margin time	15 ms typically	-
Undervoltage:		
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

Secondary system supervision

Table 40. Current circuit supervision CCSSPVC

Function	Range or value	Accuracy
Operate current	(10-200)% of IBase	±10.0% of I_r at $I \leq I_r$ ±10.0% of I at $I > I_r$
Reset ratio, Operate current	>90%	
Block current	(20-500)% of IBase	±5.0% of I_r at $I \leq I_r$ ±5.0% of I at $I > I_r$
Reset ratio, Block current	>90% at (50-500)% of IBase	

Table 41. 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 to 0 x U_r	Min. = 10 ms Max. = 25 ms	-
Reset time, start, 1 ph, at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	-

Logic

Table 42. Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph, 1/3-ph, 1/2/3-ph	-
Minimum trip pulse length	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
3-pole trip delay	(0.020-0.500) s	±0.2% or ±15 ms whichever is greater
Evolving fault delay	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 43. Number of SMPPTRC instances

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

Table 44. Number of TMAGAPC instances

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

Table 45. Number of ALMCALH instances

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

Table 46. Number of WRNCALH instances

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

Table 47. Number of INDCALH instances

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

Table 48. Number of AND instances

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

Table 49. Number of GATE instances

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

Table 50. Number of INV instances

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

Table 51. Number of LLD instances

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

Table 52. Number of OR instances

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

Table 53. 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 54. Number of RSMEMORY instances

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

Table 55. Number of SRMEMORY instances

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

Table 56. Number of TIMERSET instances

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

Table 57. Number of XOR instances

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

Table 58. Number of ANDQT instances

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

Table 59. Number of INDCOMBSPQT instances

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

Table 60. Number of INDEXTSPQT instances

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

Table 61. Number of INVALIDQT instances

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

Table 62. Number of INVERTERQT instances

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

Table 63. Number of ORQT instances

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

Table 64. 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 65. Number of RSMEMORYQT instances

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

Table 66. Number of SRMEMORYQT instances

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

Table 67. 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 68. Number of XORQT instances

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

Table 69. Number of instances in the extension logic package

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

Table 70. Number of B16I instances

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

Table 71. Number of BTIGAPC instances

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

Table 72. Number of IB16 instances

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

Table 73. Number of ITBGAPC instances

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

Table 74. 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 75. Number of TEIGAPC instances

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

Table 76. 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%

Monitoring

Table 77. Measurements CVMMXN

Function	Range or value	Accuracy
Frequency	(0.95-1.05) x f_r	±2.0 mHz
Voltage	(10 to 300) V	±0.3% of U at U≤ 50 V ±0.2% of U at U> 50 V
Current	(0.1-4.0) x I_r	±0.8% of I at 0.1 x I_r< I < 0.2 x I_r ± 0.5% of I at 0.2 x I_r< I < 0.5 x I_r ±0.2% of I at 0.5 x I_r< I < 4.0 x I_r
Active power, P	(10 to 300) V (0.1-4.0) x I_r	±0.5% of S_r at S ≤0.5 x S_r ±0.5% of S at S > 0.5 x S_r
	(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 78. Phase current measurement CMMXU

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

Table 79. Phase-phase voltage measurement VMMXU

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

Table 80. Phase-neutral voltage measurement VNMMXU

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

Table 81. Current sequence component measurement CMSQI

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

Table 82. 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 83. 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 84. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Pre-fault time	(0.05–9.90) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–10.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See table 107
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	128	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 85. Insulation gas monitoring function SSIMG

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

Table 86. Insulation liquid monitoring function SSIML

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

Table 87. Circuit breaker condition monitoring SSCBR

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

Table 88. Event list

Function		Value
Buffer capacity	Maximum number of events in the list	1000
Resolution		1 ms
Accuracy		Depending on time synchronizing

Table 89. Indications

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

Table 90. Event recorder

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

Table 91. Trip value recorder

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

Table 92. Disturbance recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	128
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Table 93. Limit counter L4UFCNT

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

Metering

Table 94. 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 95. Energy metering ETPMMTR

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

Station communication

Table 96. Communication protocols

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

Table 97. IEC 61850-9-2 communication protocol

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

Table 98. 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 99. IEC 62439-3 Edition 1 and Edition 2 parallel redundancy protocol

Function	Value
Communication speed	100 Base-FX

Hardware

IED

Table 100. Case

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

Table 101. Water and dust protection level according to IEC 60529

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

Table 102. Weight

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

Electrical safety

Table 103. Electrical safety according to IEC 60255-27

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

Connection system

Table 104. CT and VT circuit connectors

Connector type	Rated voltage and current	Maximum conductor area
Screw compression type	250 V AC, 20 A	4 mm^2 (AWG12) 2 x 2.5 mm^2 (2 x AWG14)
Terminal blocks suitable for ring lug terminals	250 V AC, 20 A	4 mm^2 (AWG12)

Table 105. Auxiliary power supply and binary I/O connectors

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

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

Basic IED functions

Table 106. Self supervision with internal event list

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

Table 107. Time synchronization, time tagging

Function	Value
Time tagging accuracy of the synchrophasor data	± 1 µs

Table 108. 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 109. 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 110. IRIG-B

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

Inverse characteristic

Table 111. ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1 \right)} + B \right) \cdot k$ Reset characteristic: $t = \frac{t_r}{\left(I^{2} - 1 \right)} \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 999.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	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 112. IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^P - 1 \right)} \right) \cdot k$$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 999.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	
Programmable characteristic Operate characteristic: $$t = \left(\frac{A}{\left(I^P - C \right)} + B \right) \cdot k$$ Reset characteristic: $$t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	

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

Table 113. RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 999.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
RD type logarithmic inverse characteristic $$t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k}\right)$$ $I = I_{measured}/I_{set}$		

Table 114. Inverse time characteristics for overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0}} + 0.035$$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 115. 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	

22. Ordering for customized IED

Table 116. 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 117. 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: RES670*2.1-F00X00 - A00000000000000 - B000000000000000100020000 - C06000666660000004400000000 - D22000000 - E66600 - F6 - S0 - G220 - H00000000000 - K00000000 - L11 - M080 - P0111001100110 - B1X0 - AC - MB - B - A3X0 - D1AN1 - FSXX - XD

Product definition					-	Differential protection															-
RES670*	2.1	-		X00	-	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-

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

Current protection																								-
C	0		00	0						0	0	00	0	0			0	0	0	0	0	0	0	-

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

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

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

Station communication														-
P														-

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

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

Table 118. Product definition

RES670*	2.1		X00

Table 119. Product definition ordering codes

Product	RES670*
Software version	2.1
Configuration alternatives	
RES670 Phasor measurement unit	F00
RES670 61850-9-2LE Phasor measurement unit	N00
Selection:	
ACT configuration	
No ACT configuration downloaded	X00

Table 120. Differential protection

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

Table 121. Impedance protection

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

Table 122. Impedance functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Power swing detection	ZMRPSB	1MRK005907-UA	16	0–1		
Out-of-step protection	OOSPPAM	1MRK005908-GA	20	0–2		

Table 123. Current protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
C	0		00	0						0	0	00	0	0			0	0	0	0	0	0	0

Table 124. Current functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Four step phase overcurrent protection	OC4PTOC	1MRK005910-BB	2	0–6		
Four step residual overcurrent protection	EF4PTOC	1MRK005910-EC	5	0–6		
Four step directional negative phase sequence overcurrent protection	NS4PTOC	1MRK005910-FB	6	0–6		
Sensitive Directional residual over current and power protetcion	SDEPSDE	1MRK005910-GA	7	0–6		
Thermal overload protection, one time constant, Celcius	LCPTTR	1MRK005911-BA	8	0–6		
Thermal overload protection, one time constant, Fahrenheit	LFPTTR	1MRK005911-AA	9	0–6		
Directional Underpower protection	GUPPDUP	1MRK005910-RA	15	0–4		
Directional Overpower protection	GOPPDOP	1MRK005910-TA	16	0–4		

Table 125. Voltage protection

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

Table 126. Voltage functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Two step undervoltage protection	UV2PTUV	1MRK005912-AA	1	0–4		
Two step overvoltage protection	OV2PTOV	1MRK005912-BA	2	0–4		

Table 127. Frequency protection

Position	1	2	3	4
E				

Table 128. Frequency functions

Function	Function identification	Ordering no	position	Available qty	Selected qty	Notes and rules
Underfrequency protection	SAPTUF	1MRK005914-AA	1	0–6		
Overfrequency protection	SAPTOF	1MRK005914-BA	2	0–6		
Rate-of-change frequency protection	SAPFRC	1MRK005914-CA	3	0–6		
Frequency time accumulation protection	FTAQFVR	1MRK005914-DB	4	00–04		

Table 129. Multipurpose protection

Position	1
F	

Table 130. Multipurpose functions

Function	Function identification	Ordering no	Positi on	Available qty	Selected Qty	Notes and rules
General current and voltage protection	CVGAPC	1MRK005915-AA	1	0–8		

Table 131. General calculation

Position	1
S	

Table 132. General calculation functions

Function	Function identification	Ordering no	Positi on	Available qty	Selected Qty	Notes and rules
Multipurpose filter	SMAIHPAC	1MRK005915-KA	1	0–6		

Table 133. Secondary system supervision

Position	1	2	3
G			0

Table 134. Secondary system supervision functions

Function	Function identification	Ordering no	Positi on	Available qty	Selected qty	Notes and rules
Current circuit supervision	CCSSPVC	1MRK005916-AA	1	0–5		
Fuse failure supervision	FUFSPVC	1MRK005916-BA	2	0–4		

Table 135. Control

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

Table 136. Scheme communication

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

Table 137. Logic

Position	1	2
L		

Table 138. Logic functions

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

Table 139. Monitoring

Position	1	2
M		0

Table 140. Monitoring functions

Function	Function identification	Ordering no	Positi on	Available qty	Selected qty	Notes and rules
Circuit breaker condition monitoring	SSCBR	1MRK005924-HA	1	00–18		

Table 141. Station communication

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

Table 142. Station communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Process Bus communication IEC 61850-9-2		1MRK005930-TA	1	0 if F00 is selected, 6 if N00 is selected		**Note:** RES670 customized qty = 0, RES670 61850-9-2 qty = 6 .
IEC 62439-3 parallel redundancy protocol	PRP	1MRK002924-YB	2	0–1		**Note:** not valid for RES670 61850-9-2LE when qty has to be 0. **Note:** requires 2-channel OEM.
Protocol reporting via IEEE 1344 and C37.118	PMUREPORT	1MRK005928-VP	3	1–2		**Note:** Qty of PHASORREPORT1 must be equal to the qty of PMUREPORT
Protocol reporting of Phasor Data via IEEE 1344 and C37.118_Channels 1-8	PHASORREPORT1	1MRK005928-VC	4	1–2		
Protocol reporting of Phasor Data via IEEE 1344 and C37.118_Channels 9-16	PHASORREPORT2	1MRK005928-VD	5	0–2		**Note**: Qty of PHASORREPORT, ANALOGREPORT and BINARYREPORT must be equal or less than PMUREPORT
Protocol reporting of Phasor Data via IEEE 1344 and C37.118_Channels 17-24	PHASORREPORT3	1MRK005928-VE	6	0–2		
Protocol reporting of Phasor Data via IEEE 1344 and C37.118_Channels 25-32	PHASORREPORT4	1MRK005928-VF	7	0–2		
Protocol reporting of Analog Data via IEEE 1344 and C37.118_Channels 1-8	ANALOGREPORT1	1MRK005928-VG	8	0–2		
Protocol reporting of Analog Data via IEEE 1344 and C37.118_Channels 9-16	ANALOGREPORT2	1MRK005928-VH	9	0–2		
Protocol reporting of Analog Data via IEEE 1344 and C37.118_Channels 17-24	ANALOGREPORT3	1MRK005928-VK	10	0–2		
Protocol reporting of Binary Data via IEEE 1344 and C37.118_Channels 1-8	BINARYREPORT1	1MRK005928-VL	11	0–2		
Protocol reporting of Binary Data via IEEE 1344 and C37.118_Channels 9-16	BINARYREPORT2	1MRK005928-VM	12	0–2		
Protocol reporting of Binary Data via IEEE 1344 and C37.118_Channels 17-24	BINARYREPORT3	1MRK005928-VN	13	0–2		

Table 143. Language selection

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

Table 144. Casing selection

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

Table 145. Mounting selection

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

Table 146. Connection type

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

Table 147. Auxiliary power supply

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

Table 148. Human machine interface selection

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

Table 149. Analog system selection

Analog system	Selection				Notes and Rules
No first TRM included	X0				
Compression terminals	A				**Note**: Only the same type of TRM (compression or ringlug) in the same terminal
Ringlug terminals	B				
First TRM 12I 1A, 50/60Hz		1			
First TRM 12I 5A, 50/60Hz		2			
First TRM 9I+3U 1A, 100/220V, 50/60Hz		3			
First TRM 9I+3U 5A, 100/220V, 50/60Hz		4			
First TRM 5I, 1A+4I, 5A+3U, 100/220V, 50/60Hz		5			
First TRM 6I+6U 1A, 100/220V, 50/60Hz		6			
First TRM 6I+6U 5A, 100/220V, 50/60Hz		7			
First TRM 3IM, 1A + 4IP, 1A + 5U, 110/220V, 50/60Hz		17			
First TRM 3IM, 5A + 4IP, 5A + 5U, 110/220V, 50/60Hz		18			
No second TRM included			X0		
Compression terminals			A		
Ringlug terminals			B		
Second TRM 12I 1A, 50/60Hz				1	
Second TRM 12I 5A, 50/60Hz				2	
Second TRM 9I+3U 1A, 100/220V, 50/60Hz				3	
Second TRM 9I+3U 5A, 100/220V, 50/60Hz				4	
Second TRM 5I, 1A+4I, 5A+3U, 100/220V, 50/60Hz				5	
Second TRM 6I+6U 1A, 100/220V, 50/60Hz				6	
Second TRM 6I+6U 5A, 100/220V, 50/60Hz				7	
Second TRM 3IM, 1A + 4IP, 1A + 5U, 110/220V, 50/60Hz				17	
Second TRM 3IM, 5A + 4IP, 5A + 5U, 110/220V, 50/60Hz				18	
Selected					

Table 150. Maximum quantity of I/O modules

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

Case sizes	BIM	IOM	BOM/ SOM	MIM	Maximum in case
1/1 x 19”, one (1) TRM	14	6	4	4	14 cards, including a combination of four cards of type BOM, SOM and MIM
1/1 x 19”, two (2) TRM	11	6	4	4	11 cards, including a combination of four cards of type BOM, SOM and MIM
3/4 x 19”, one (1) TRM	8	6	4	4	8 cards, including a combination of four cards of type BOM, SOM and maximun oen MIM
3/4 x 19”, two (2) TRM	5	5	4	4	5 cards, including a combination of four cards of type BOM, SOM and maximun oen MIM
1/2 x 19”, one (1) TRM	3	3	3	1	3 cards

Table 151. Maximum quantity of I/O modules, with ringlug terminals

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

**) including a combination of maximum four modules of type BOM, SOM and MIM

Table 152. Binary input/output module selection

Binary input/output modules	Selection														Notes and Rules
Slot position (rear view)	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	X141	X151	X161	Note! Max 3 positions in 1/2 rack, 8 in 3/4 rack with 1 TRM, 5 in 3/4 rack with 2 TRM, 11 in 1/1 rack with 2 TRM and 14 in 1/1 rack with 1 TRM
1/2 Case with 1 TRM	■	■	■												
3/4 Case with 1 TRM	■	■	■	■	■	■	■	■							
3/4 Case with 2 TRM	■	■	■	■	■										
1/1 Case with 1 TRM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1/1 Case with 2 TRM	■	■	■	■	■	■	■	■	■	■	■				
No board in slot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
BIM 16 inputs, RL24-30 VDC, 50 mA	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	
BIM 16 inputs, RL48-60 VDC, 50 mA	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110-125 VDC, 50 mA	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220-250 VDC, 50 mA	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, 220-250 VDC, 120mA	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIMp 16 inputs, RL24-30 VDC, 30 mA, for pulse counting	F	F	F	F	F	F	F	F	F	F	F	F	F	F	
BIMp 16 inputs, RL48-60 VDC, 30 mA, for pulse counting	G	G	G	G	G	G	G	G	G	G	G	G	G	G	
BIMp 16 inputs, RL110-125 VDC, 30 mA, for pulse counting	H	H	H	H	H	H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220-250 VDC, 30 mA, for pulse counting	K	K	K	K	K	K	K	K	K	K	K	K	K	K	
IOM 8 inputs, 10+2 output, RL24-30 VDC, 50 mA	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, 10+2 output, RL48-60 VDC, 50 mA	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs, 10+2 output, RL110-125 VDC, 50 mA	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, 10+2 output, RL220-250 VDC, 50 mA	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM 8 inputs 10+2 output relays, 220-250 VDC, 120mA	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs, 10-2 output, 24-30 VDC, 30 mA	U	U	U	U	U	U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, 10-2 output, 48-60 VDC, 30 mA	V	V	V	V	V	V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, 10-2 output, 110-125 VDC, 30 mA	W	W	W	W	W	W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, 10-2 output, 220-250 VDC, 30 mA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels	R	R	R	R	R	R	R	R	R	R	R	R	R	R	

Table 152. Binary input/output module selection, continued

Binary input/output modules	Selection														Notes and Rules
SOM Static output module, 12 outputs, 48-60 VDC	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	Note: SOM must not to be placed in following positions: 1/2 case slot X51, 3/4 case, 1 TRM slot X101, 3/4 case, 2 TRM slot X71, 1/1 case, 1 TRM slot X161, 1/1 case, 2 TRM slot X131.
SOM static outputs module, 12 outputs, 110-250 VDC	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	
Selected.															

Table 153. Remote end serial communication selection

Remote end communication, DNP serial comm. and time synchronization modules	Selection						Notes and Rules
Slot position (rear view)	X312	X313	X302	X303	X322	X323	
Available slots in 1/2, 3/4 and 1/1 case with 1TRM	■	■	■	■			
Available slots in 3/4 and 1/1 case with 2 TRM	■	■	■	■	■	■	
No remote communication board included	X	X	X	X	X	X	
IRIG-B Time synchronization module	F	F	F	F	F	F	Note: One of IRIG-B or GPS time module must be ordered.
Galvanic RS485 communication module	G	G	G	G	G	G	
GPS time module	S	S			S	S	Note: One of IRIG-B or GPS time module must be ordered.
Selected							

Table 154. Serial communication unit for station communication selection

Serial communication unit for station communication	Selection		Notes and Rules
Slot position (rear view)	X301	X311	
No communication board included	X	X	
Optical ethernet module, 1 channel glass		D	Optical ethernet module, 2 channel glass must be ordered for N00.
Optical ethernet module, 2 channel glass		E	
Selected.	X		

23. 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 IED.

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

Example code: RES670*2.1-A20-B23C18C26F01G01M16P03-B1X0-B-B-MA-B3X0-AD1XXXXXX-FSXX-XD. Using the code of each position #1-13 specified as RES670*1-2 2-3 3 3 3 3-4-5-6-7 8-9-10 10 10-11 11 11 11 11 11 11 11 11 11 11-12 12 12 12 12 12-13

#	1	-	2		-	3					-	4	-	5	6	-	7		8	-	9	-
RES670*	2.1	-			-						-		-			-				-		-

10			-	11											-	12						-	13
			-												-							-	

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

Configuration alternatives	#2		Notes and Rules
3 bays, single busbar	A20		
6 bays, double busbar	B20		
ACT configuration			
ABB standard configuration		X00	
Selection for position #2.			

Software options	#3										Notes and Rules
No option	X00										All fields in the ordering form do not need to be filled in
Power swing and out-of-step protection - PMU	B23										
Directional power protection - 3 bays		C18									Note: Only in A20
Directional power protection - 4 bays		C25									Note: Only in B20
Current protection - PMU - 3 bays			C26								Note: Only in A20
Current protection - PMU - 6 bays			C27								Note: Only in B20
General current and voltage protection				F01							Note: Only in A20
General current and voltage protection — transformer				F02							Note: Only in B20
Second system supervision, single busbar					G01						Note: Only in A20
Second system supervision, double busbar					G02						Note: Only in B20
Circuit breaker condition monitoring - 18 CB						M16					Note: Only in B20
Circuit breaker condition monitoring - 9 CB						M17					Note: Only in A20
IEC 62439-3 parallel redundancy protocol							P03				Note: requires 2-channel OEM.
Protocol reporting of phasor data via IEEE 1344 and C37.118, channels 17-32, PMU2								P11			Note: Only in B20
Protocol reporting of analog data via IEEE 1344 and C37.118, channels 9-24, PMU1									P12		Note: Only in A20. Only one to be selected.
Protocol reporting of analog data via IEEE 1344 and C37.118, channels 9-24, PMU1 and PMU2									P13		
Protocol reporting of analog data via IEEE 1344 and C37.118, channels 17-24, PMU1									P14		Note: Only in B20. Only one to be selected.
Protocol reporting of analog data via IEEE 1344 and C37.118, channels 17-24, PMU1 and PMU2									P15		
Protocol reporting of binary data via IEEE 1344 and C37.118, channels 9-24, PMU1										P16	Note: Only in A20. Only one to be selected.
Protocol reporting of binary data via IEEE 1344 and C37.118, channels 9-24, PMU1 and PMU2										P17	
Protocol reporting of binary data via IEEE 1344 and C37.118, channels 17-24, PMU1										P18	Note: Only in B20. Only one to be selected.
Protocol reporting of binary data via IEEE 1344 and C37.118, channels 17-24, PMU1 and PMU2										P19	
Selection for position #3											

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

Casing	#5	Notes and Rules
1/2 x 19" case	A	**Note**: Only in A20
3/4 x 19" case 1 TRM	B	**Note**: Only in A20
3/4 x 19" case 2 TRM	C	**Note**: Only in B20
1/1 x 19" case 1 TRM	D	**Note**: Only in A20
1/1 x 19" case 2 TRM	E	**Note**: Only in B20
Selection for position #5.		

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

Connection type	#7		Notes and Rules
Connection type for Power supply module			
Compression terminals	M		
Ringlug terminals	N		
Connection type for input/output and communication modules			
Compression terminals		P	
Selection for position #7.			

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

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

Connection type for Analog modules	#10				Notes and Rules
Compression terminals	A				
Ringlug terminals	B				
Analog system					
First TRM, 9I+3U 1A, 110/220V		3			
First TRM, 9I+3U 5A, 110/220V		4			
No second TRM included			X0		Note: B20 must include a second TRM
Compression terminals			A		
Ringlug terminals			B		
Second TRM, 9I+3U 1A, 110/220V				3	Note: Only in B20
Second TRM, 9I+3U 5A, 110/220V				4	Note: Only in B20
Selection for position #10.					

Binary input/output module, mA and time synchronizing boards.	#11														Notes and Rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM included in A20 and B20															
Slot position (rear view)	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	X141	X151	X161	Note: Max 3 positions in 1/2 rack, 8 in 3/4 rack with 1 TRM, 5 in 3/4 rack with 2 TRM, 14 in 1/1 rack with 1 TRM and 11 in 1/1 rack with 2 TRM
1/2 Case with 1 TRM	■	■	■												Note: Only in A20
3/4 Case with 1 TRM	■	■	■	■	■	■	■	■							Note: Only in A20
3/4 Case with 2 TRM	■	■	■	■	■										Note: Only in B20
1/1 Case with 1 TRM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	Note: Only in A20
1/1 Case with 2 TRM	■	■	■	■	■	■	■	■	■	■	■				Note: Only in B20
No board in slot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)		A	A	A	A	A	A	A	A	A	A	A	A	A	Note: Maximum 4 (BOM+SOM +MIM) boards.
BIM 16 inputs, RL24-30 VDC, 50 mA	B1		B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	
BIM 16 inputs, RL48-60 VDC, 50 mA	C1		C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110-125 VDC, 50 mA	D1		D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220-250 VDC, 50 mA	E1		E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, 220-250 VDC, 120mA	E2		E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIMp 16 inputs, RL24-30 VDC, 30 mA, for pulse counting			F	F	F	F	F	F	F	F	F	F	F	F	
BIMp 16 inputs, RL48-60 VDC, 30 mA, for pulse counting			G	G	G	G	G	G	G	G	G	G	G	G	
BIMp 16 inputs, RL110-125 VDC, 30 mA, for pulse counting			H	H	H	H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220-250 VDC, 30 mA, for pulse counting			K	K	K	K	K	K	K	K	K	K	K	K	
IOM 8 inputs, 10+2 output, RL24-30 VDC, 50 mA			L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, 10+2 output, RL48-60 VDC, 50 mA			M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs, 10+2 output, RL110-125 VDC, 50 mA			N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, 10+2 output, RL220-250 VDC, 50 mA			P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM 8 inputs 10+2 output relays, 220-250 VDC, 120mA			P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs, 10-2 output, 24-30 VDC, 30 mA			U	U	U	U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, 10-2 output, 48-60 VDC, 30 mA			V	V	V	V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, 10-2 output, 110-125 VDC, 30 mA			W	W	W	W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, 10-2 output, 220-250 VDC, 30 mA			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels			R	R	R	R	R	R	R	R	R	R	R	R	Note: maximum 1 MIM in 1/2 case.

Binary input/output module, mA and time synchronizating boards.	#11														Notes and Rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM included in A20 and B20															
SOM Static output module, 12 outputs, 48-60 VDC			T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	Note: SOM must not be placed in following positions: 1/2 case slot X51, 3/4 case, 1 TRM slot X101, 3/4 case, 2 TRM slot X71, 1/1 case, 1 TRM slot X161, 1/1 case, 2 TRM slot X131.
SOM static outputs module, 12 outputs, 110-250 VDC			T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	
Selection for position #11.															

Remote end communication, DNP serial comm. and time synchronization modules	#12						Notes and Rules
Slot position (rear view)	X312	X313	X302	X303	X322	X323	
Available slots in 1/2 case with 1 TRM	■	■	■	■			
Available slots in 3/4 and 1/1 case with 1 TRM	■	■	■	■			
Available slots in 3/4 and 1/1 case with 2 TRM slots	■	■	■	■	■	■	
No remote communication board included	X	X	X	X	X	X	
IRIG-B Time synchronization module	F	F	F	F	F	F	Note: One of IRIG-B or GPS Time Module must be ordered
Galvanic RS485 communication module	G	G	G	G	G	G	
GPS Time Module	S	S			S	S	Note: One of IRIG-B or GPS Time Module must be ordered
Selection for position #12.							

Serial communication unit for station communication	#13		Notes and Rules
Slot position (rear view)	X301	X311	
No first communication board included	X		
No second communication board included		X	
Optical ethernet module, 1 channel glass		D	Note: Optical ethernet module always included, one must be ordered
Optical ethernet module, 2 channel glass		E	
Selection for position #13.	X		

24. Ordering for Accessories

Accessories

GPS antenna and mounting details

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

Test switch

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

1 TRM Single busbar/2 TRMs Double busbar with 6 bays with internal neutral on currents circuits (ordering number RK926 315–AN).

1 TRM Single busbar/2 TRMs Double busbar with 6 bays with external neutral on currents circuits (ordering number RK926 315–DB).

1 TRM/2 TRM with internal neutral on currents circuits (ordering number RK926 315–AM).

1 TRM/2 TRM with external neutral on currents circuits (ordering number RK926 315–DC).

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

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

Protection cover

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

Combiflex

Key switch for settings

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

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

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

Configuration and monitoring tools

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

Manuals

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

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

User documentation

Rule: Specify the number of printed manuals requested

Application manual	IEC	Quantity:		1MRK 511 364-UEN
	ANSI	Quantity:		1MRK 511 316-UUS
Technical manual	IEC	Quantity:		1MRK 511 365-UEN
	ANSI	Quantity:		1MRK 511 317-UUS
Commissioning manual	IEC	Quantity:		1MRK 511 366-UEN
	ANSI	Quantity:		1MRK 511 318-UUS
Communication protocol manual, IEC 61850 Edition 1	IEC	Quantity:		1MRK 511 349-UEN
Communication protocol manual, IEC 61850 Edition 2	IEC	Quantity:		1MRK 511 350-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity:		1MRK 511 351-UEN
Communication protocol manual, LON	IEC	Quantity:		1MRK 511 352-UEN
Communication protocol manual, SPA	IEC	Quantity:		1MRK 511 353-UEN
Communication protocol manual, DNP	ANSI	Quantity:		1MRK 511 348-UUS
Point list manual, DNP	ANSI	Quantity		1MRK 511 354-UUS
Operation manual	IEC	Quantity:		1MRK 500 123-UEN
	ANSI	Quantity:		1MRK 500 123-UUS
Installation manual	IEC	Quantity:		1MRK 514 024-UEN
	ANSI	Quantity:		1MRK 514 024-UUS

Engineering manual, 670 series	IEC	Quantity:	☐	1MRK 511 355-UEN
	ANSI	Quantity:	☐	1MRK 511 355-UUS
Cyber security guideline	IEC	Quantity:	☐	1MRK 511 356-UEN

Reference information

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

Country: End user:

Station name: Voltage level: kV

Related documents

Documents related to RES670	Document numbers
Application manual	IEC:1MRK 511 364-UEN ANSI:1MRK 511 364-UUS
Commissioning manual	IEC:1MRK 511 366-UEN ANSI:1MRK 511 366-UUS
Product guide	1MRK 511 367-BEN
Technical manual	IEC:1MRK 511 365-UEN ANSI:1MRK 511 365-UUS
Type test certificate	IEC:1MRK 511 367-TEN ANSI:1MRK 511 367-TUS

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

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