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Relion 670 SERIES

Generator protection REG670
Version 2.2
Product guide

Hitachi Energy

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Conformity

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

Contents

1. Document revision history

Table 1. Document revision history

Document revision	Date	Product version	History
-	2017-07	2.2.0	First release for product version 2.2
A	2017-10	2.2.1	Ethernet ports with RJ45 connector added. enhancements/updates made to GENPDIF, ZMFPDIS and ZMFCPDIS.
B	2018-04	2.2.1	Document enhancements and corrections
C			Document not released
D	2018-07	2.2.2	LDCM galvanic X.21 added. Function PTRSTHR added. Ordering section updated.
E	2018-11	2.2.2	Technical data updated for PSM, EF4PTOC and T2WPDIF/T3WPDIF. Corrections/enhancements made to OC4PTOC, TRPTTR, UV2PTUV and OV2PTOV. Case dimensions updated.
F			Document not released
G	2018-12	2.2.3	Functions CHMMHAI, VHMMHAI, DELVSPVC, DELISPVC and DELSPVC added. Updates/enhancements made to ZMFPDIS, ZMFCPDIS, CCRBRF, REALCOMP, PTRSTHR and FNKEYMDx. Ordering section updated.
H	2019-05	2.2.3	PTP enhancements and corrections
J			Document not released
K			Document not released
L			Document not released
M	2020-09	2.2.4	Functions APPTEF, IEC 61850SIM and ALGOS added. Updates/ enhancements made to functions REFPDIF, ZMFPDIS, ZMFCPDIS, ROTIPHIZ, STTIPHIZ, EF4PTOC, ROV2PTOV, SAPTUF, SAPTOF, CCSSPVC, FUFSPVC, SESRSYN, SMPPTRC, SSIMG, and SSIML. Ordering section updated. Previous revisions of SOM removed, heavy duty SOM only alternative. Certification section included.
N	2021-06	2.2.5	Functions FLTMMXU, BRPTOC, HOLDMINMAX, INT_REAL, CONST_INT, INTSEL, LIMITER, ABS, POL_REC, RAD_DEG, CONST_REAL, REALSEL, STOREINT, STOREREAL, DEG_RAD and RSTP added. Support for COMTRADE2013 added. Updates/enhancements made to functions ZMFPDIS, ZMFCPDIS, EF4PTOC, CHMMHAI, VHMMHAI, OC4PTOC, NS4PTOC, CVGAPC, DRPRDRE, SXSWI and SXCBR. Ordering section updated.
P	2021-06	2.2.5	Added note to Disturbance report and IEC 60870-5-103 protocol

Table 1. Document revision history, continued

Document revision	Date	Product version	History
Q	2022-07	2.2.5.4	Introduced RIA600, which is a software implementation of the IED LHMI panel.
R			Document not released
S	2023-06	2.2.6	SNMP support, support for 12 MUs, IEC 61850 Ed2.1, new variants of single mode SFP added. Functions C1RADR, C2RADR, C3RADR, GOOSEACRCV, SNMPSERVERCONF, and SNMPUSERCONF added. Functions INTERRSIG, SETGRPS, TERMINALID, ZMFPDIS, ZMFCPDIS, PSPPPAM, ROTIPHIZ, STTIPHIZ, OC4PTOC, EF4PTOC, NS4PTOC, VRPVOC, APPTEF, OEXPVPH, VDCPTDV, CVGAPC, SCSWI, SXSWI, TCMYLTC, TCLYLTC, VSGAPC, SMPPTRC, BTIGAPC, IB16, ITBGAPC, CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU, SSCBR, SPGAPC, SP16GAPC, IEC61850-8-1, LD0LLN0, GOOSEACRCV, AP_1, AP_FRONT, FLTMMXU, LDCMTRN, and MVGAPC updated. Ordering section updated.

2. New features

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

- SNMP support added
- Three new variants of single mode SFP added
- Support for IEC 61850 Ed2.1
- Support for 12 merging units
- Improvements to high speed line distance protection
- Improvements to fault detection by injection functionality
- Improvements related to apparatus control functions
- Enhancements and corrections

3. Application

The REG670 is used for protection, control and monitoring of generators and generator-transformer blocks from relatively small units up to the largest generating units. The IED has a comprehensive function library, covering the requirements for most generator applications. The large number of analog inputs available enables, together with the large functional library, integration of many functions in one IED. In typical applications two IED units can provide total functionality, also providing a high degree of redundancy. REG670 can as well be used for protection and control of shunt reactors.

Stator earth fault protection, both traditional 95% as well as 100% injection and 3rd harmonic based are included. When the injection based protection is used, 100% of the machine stator winding, including the star point, is protected under all operating modes. The 3rd harmonic based 100% stator earth fault protection uses 3rd harmonic differential voltage principle. Injection based 100% stator earth fault protection can operate even when machine is at standstill. Well proven algorithms for pole slip, underexcitation, rotor earth fault, negative sequence current protections, and so on, are included in the IED.

The generator differential protection in the REG670 adapted to operate correctly for generator applications where factors as long DC time constants and requirement on short trip time have been considered.

As many of the protection functions can be used as multiple instances there are possibilities to protect more than one object in one IED. It is possible to have protection for an auxiliary power transformer integrated in the same IED having main protections for the generator. The concept thus enables very cost effective solutions.

The REG670 also enables valuable monitoring possibilities as many of the process values can be transferred to an operator HMI.

The wide application flexibility makes this product an excellent choice for both new installations and for refurbishment in existing power plants.

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

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

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

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

Communication via optical connections ensures immunity against disturbances.

By using patented algorithm REG670 (or any other product from 670 series) can track the power system frequency in quite wide range from 9Hz to 95Hz (for 50Hz power system). In order to do that preferably the three-phase voltage signal from the generator terminals shall be connected to the IED. Then IED can adopt its filtering algorithm in order to properly measure phasors of all current and voltage signals connected to the IED. This feature is essential for proper operation of the protection during generator start-up and shut-down procedure.

REG670 can be used in applications with the IEC/UCA 61850-9-2LE process bus with up to twelve merging units (MU) depending on the other functionality included in the IED.

Description of configuration A20

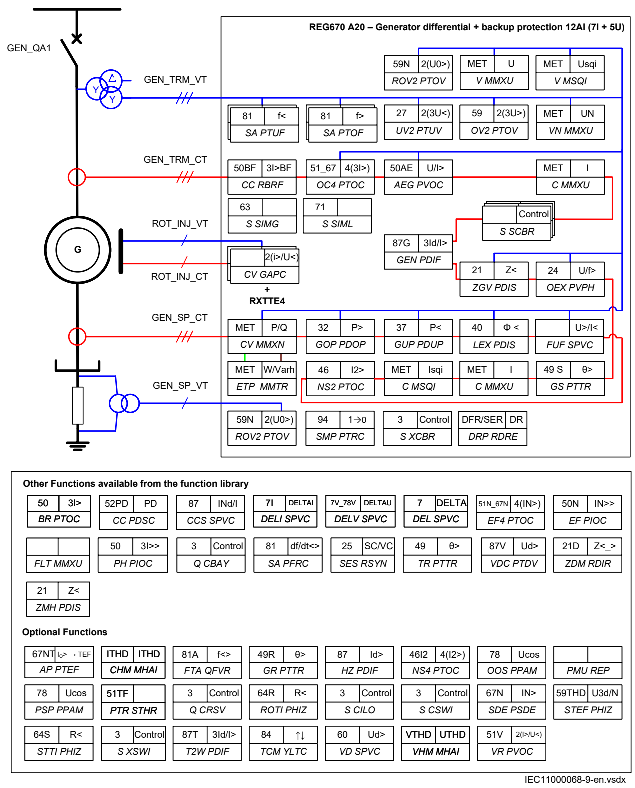
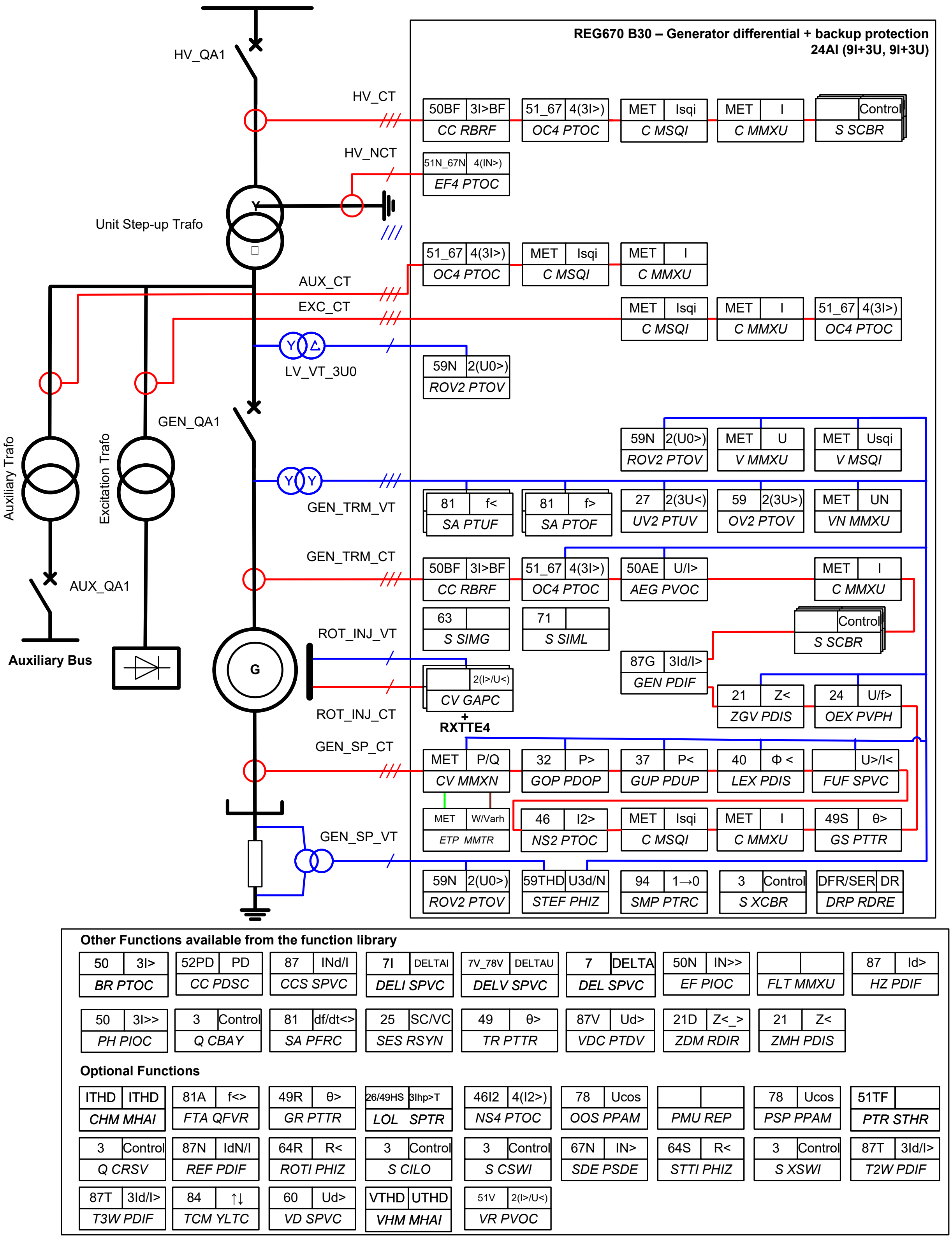


Figure 1. Typical generator protection application with generator differential and back-up protection, including 12 analog inputs transformers in half 19" case size.

Description of configuration B30



IEC11000071-8-en.vsd

Figure 2. Enhanced generator protection application with generator differential and back-up protection, including 24 analog inputs in full 19" case size. Optional pole slip protection, 100% stator earth fault protection and overall differential protection can be added.

Description of configuration C30

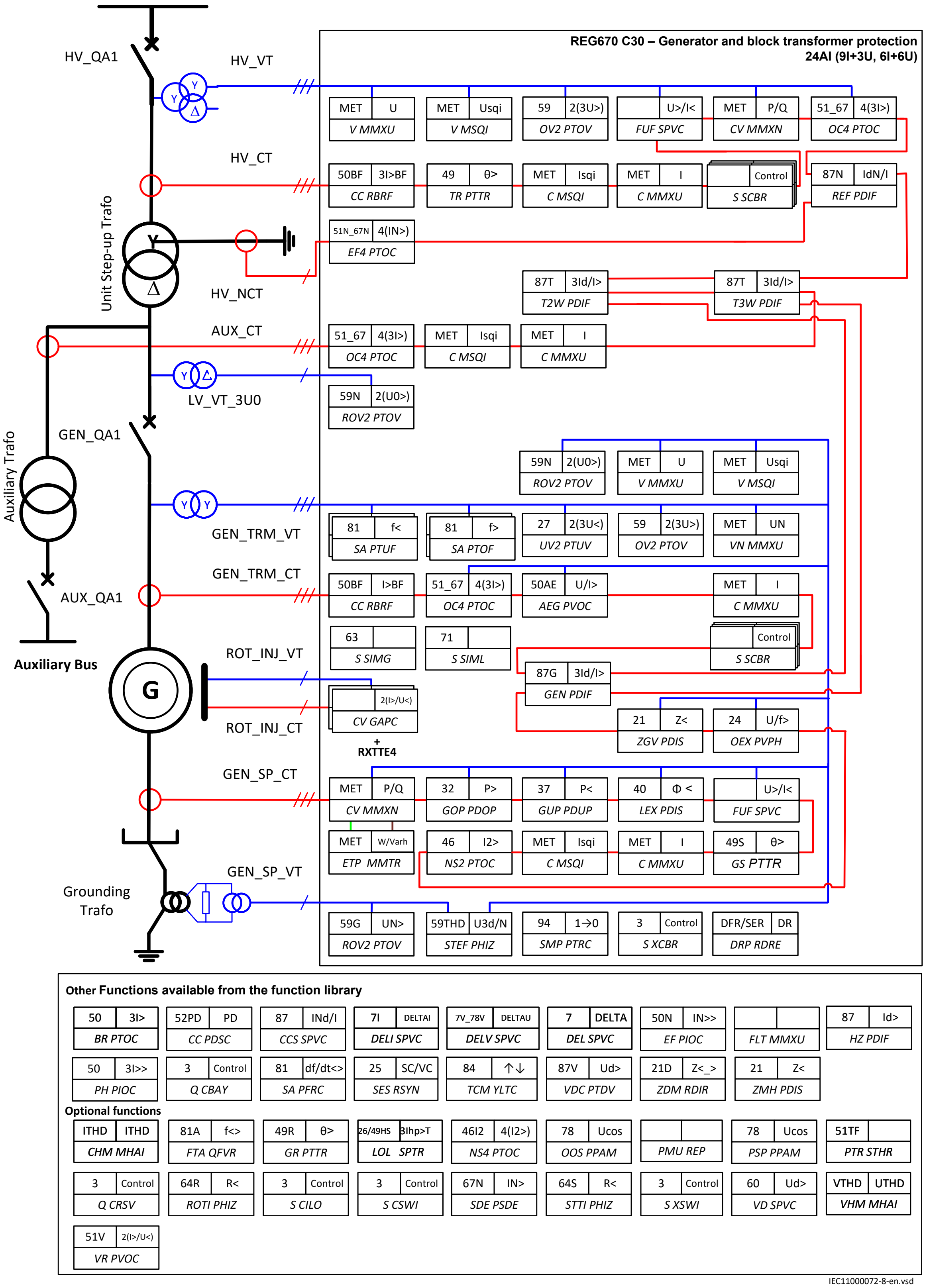


Figure 3. Unit protection including generator and generator transformer protection with 24 analog inputs in full 19" case size. Optional pole slip protection and 100% stator earthfault protection can be added.

4. Available functions

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

Table 2. Example of quantities

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

Main protection functions

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
Differential protection						
T2WPDIF	87T	Transformer differential protection, two winding	0-2	1-A31	1-A33	1
T3WPDIF	87T	Transformer differential protection, three winding	0-2		1-A33	1
HZPDIF	87	High impedance differential protection, single phase	0-6	3-A02	3	6
GENPDIF	87G	Generator differential protection	0-2	1	2	2
REFPDIF	87N	Restricted earth fault protection, low impedance	0-3		1-A01	1
Impedance protection						
ZMHPDIS	21	Full-scheme distance protection, mho characteristic	0-4	3	3	3
ZDMRDIR	21D	Directional impedance element for mho characteristic	0-2	1	1	1
ZMFPDIS	21	High speed distance protection, quad and mho characteristic	0-1			
ZMFCPDIS	21	High speed distance protection for series comp. lines, quad and mho characteristic	0-1			
PSPPPAM	78	Pole slip/out-of-step protection	0-1	1-B22	1-B22	1-B22
OOSPPAM	78	Out-of-step protection	0-1	1-B22	1-B22	1-B22
LEXPDIS	40	Loss of excitation	0-2	1	2	2

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
ROTIPHIZ	64R	Sensitive rotor earth fault protection, injection based	0-1	1-B31	1-B31	1-B31
STTIPHIZ	64S	100% stator earth fault protection, injection based	0-1	1-B32	1-B32	1-B32
ZGVPDIS	21	Underimpedance protection for generators and transformers	0-2	1	1	1

Back-up protection functions

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
Current protection						
PHPIOC	50	Instantaneous phase overcurrent protection	0-4	1	2	2
OC4PTOC	51_67 1)	Directional phase overcurrent protection, four steps	0-6	4	4	4
EFPIOC	50N	Instantaneous residual overcurrent protection	0-2	1	2	2
EF4PTOC	51N_67N 2)	Directional residual overcurrent protection, four steps	0-6	1	5	5
NS4PTOC	46I2	Directional negative phase sequence overcurrent protection, four steps	0-2	1-C41	2-C42	2-C42
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0-2	1-C16	1-C16	1-C16
TRPTTR	49	Thermal overload protection, two time constants	0-3	1	2	3
CCRBRF	50BF	Breaker failure protection	0-4	2	4	4
CCPDSC	52PD	Pole discordance protection	0-4	2	4	4
GUPPDUP	37	Directional underpower protection	0-4	2	4	4
GOPPDOP	32	Directional overpower protection	0-4	2	4	4
NS2PTOC	46I2	Negative sequence time overcurrent protection for machines, two steps	0-2	1	1	1
AEGPVOC	50AE	Accidental energizing protection for synchronous generators	0-2	1	1	1

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
VRPVOC	51V	Voltage restrained overcurrent protection	0-3	3-C36	3-C36	3-C36
GSPTTR	49S	Stator overload protection	0-1	1	1	1
GRPTTR	49R	Rotor overload protection	0-1	1-C38	1-C38	1-C38
APPTEF	67NT	Average power transient earth fault protection	0-1	1-C54		
BRPTOC	50	Overcurrent protection with binary release	0-4	1	2	2
Voltage protection						
UV2PTUV	27	Two step undervoltage protection	0-2	2	2	2
OV2PTOV	59	Two step overvoltage protection	0-2	2	2	2
ROV2PTOV	59N	Residual overvoltage protection, two steps	0-3	3	3	3
OEXPVPH	24	Overexcitation protection	0-2	1	1	2
VDCPTDV	87V	Voltage differential protection	0-2	2	2	2
STEFPHIZ	59THD	100% stator earth fault protection, 3rd harmonic based	0-1	1-D21	1	1
Frequency protection						
SAPTUF	81	Underfrequency protection	0-10	3	6	6
SAPTOF	81	Overfrequency protection	0-6	3	6	6
SAPFRC	81	Rate-of-change of frequency protection	0-6	1	3	3
FTAQFVR	81A	Frequency time accumulation protection	0-12	12-E03	12-E03	12-E03
Multipurpose protection						
CVGAPC		General current and voltage protection	0-9	6	6	6
General calculation						
SMAIHPAC		Multipurpose filter	0-6			

1) 67 requires voltage
2) 67N requires voltage

Control and monitoring functions

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
Control						
SESRSYN	25	Synchrocheck, energizing check and synchronizing	0-2	1	2	2
APC30	3	Control functionality for up to 6 bays, max 30 objects (6CBs), including interlocking (see Table 4)	0-1	1-H39	1-H39	1-H39
QCBAY		Bay control	1+5/APC30	1+5/APC30	1+5/APC30	1+5/APC30
LOCREM		Handling of local/remote switch positions	1+5/APC30	1+5/APC30	1+5/APC30	1+5/APC30
LOCREMCTRL		LHMI control of the permitted source to operate (PSTO)	1	1	1	1
SXCBR		Circuit breaker	18	18	18	18
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs	0-4	1-A31	2-A33	2
TCLYLTC	84	Tap changer control and supervision, 32 binary inputs	0-4			
SLGAPC		Logic rotating switch for function selection and LHMI presentation	15	15	15	15
VSGAPC		Selector mini switch	30	30	30	30
DPGAPC		Generic communication function for Double Point indication	32	32	32	32
SPC8GAPC		Single point generic control function, 8 signals	5	5	5	5
AUTOBITS		Automation bits, command function for DNP3.0	3	3	3	3
SINGLECMD		Single command, 16 inputs	8	8	8	8
I103CMD		Function commands for IEC 60870-5-103	1	1	1	1
I103GENCMD		Function commands for IEC 60870-5-103, generic	50	50	50	50
I103POSCMD		IED commands with position and select for IEC 60870-5-103	50	50	50	50
I103POSCMDV		IED direct commands with position for IEC 60870-5-103	50	50	50	50
I103IEDCMD		IED commands for IEC 60870-5-103	1	1	1	1
I103USRCMD		Function commands user defined for IEC 60870-5-103	4	4	4	4
Secondary system supervision						

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
CCSSPVC	87	Current circuit supervision	0-5	4	5	5
FUFSPVC		Fuse failure supervision	0-3	2	3	3
VDSPVC	60	Fuse failure supervision based on voltage difference	0-2	1-G03	1-G03	1-G03
DELVSPVC	7V_78V	Voltage delta supervision	4	4	4	4
DELISPVC	7I	Current delta supervision	4	4	4	4
DELSPVC	78	Real delta supervision, real	4	4	4	4
Logic						
SMPPTRC	94	Tripping logic	12	12	12	12
SMAGAPC		General start matrix block	12	12	12	12
STARTCOMB		Start combinator	32	32	32	32
TMAGAPC		Trip matrix logic	12	12	12	12
ALMCALH		Logic for group alarm	5	5	5	5
WRNCALH		Logic for group warning	5	5	5	5
INDCALH		Logic for group indication	5	5	5	5
AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SRMEMORY, TIMERSET, XOR		Basic configurable logic blocks (see Table 3)	40-420	40-420	40-420	40-420
ANDQT, INDCOMBSPQT, INDEXTSPQT, INVALIDQT, INVERTERQT, ORQT, PULSETIMERQT, RSMEMORYQT, SRMEMORYQT, TIMERSETQT, XORQT		Configurable logic blocks Q/T (see Table 5)	0-1			
AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SLGAPC, SRMEMORY, TIMERSET, VSGAPC, XOR		Extension logic package (see Table 6)	0-1			
FXDSIGN		Fixed signal function block	1	1	1	1
B16I		Boolean to integer conversion, 16 bit	18	18	18	18

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
BTIGAPC		Boolean to integer conversion with logical node representation, 16 bit	16	16	16	16
IB16		Integer to Boolean 16 conversion	26	26	26	26
ITBGAPC		Integer to boolean conversion with logical node representation, 16 bit	16	16	16	16
TIGAPC		Delay on timer with input signal integration	30	30	30	30
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12
INTCOMP		Comparator for integer inputs	30	30	30	30
REALCOMP		Comparator for real inputs	30	30	30	30
HOLDMINMAX		Hold minimum and maximum of input	20	20	20	20
INT_REAL		Converter integer to real	20	20	20	20
CONST_INT		Definable constant for logic functions	10	10	10	10
INTSEL		Analog input selector for integer values	5	5	5	5
LIMITER		Definable limiter	20	20	20	20
ABS		Absolute value	20	20	20	20
POL_REC		Polar to rectangular converter	20	20	20	20
RAD_DEG		Radians to degree angle converter	20	20	20	20
CONST_REAL		Definable constant for logic functions	10	10	10	10
REALSEL		Analog input selctor for real values	5	5	5	5
STOREINT		Store value for integer inputs	10	10	10	10
STOREREAL		Store value for real inputs	10	10	10	10
DEG_RAD		Degree to radians angle converter	20	20	20	20
Monitoring						
CVMMXN		Power system measurement	6	6	6	6
CMMXU		Current measurement	10	10	10	10
VMMXU		Voltage measurement phase-phase	6	6	6	6
CMSQI		Current sequence measurement	6	6	6	6

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
VMSQI		Voltage sequence measurement	6	6	6	6
VNMMXU		Voltage measurement phase-earth	6	6	6	6
AISVBAS		General service value presentation of analog inputs	1	1	1	1
EVENT		Event function	20	20	20	20
DRPRDRE, A1RADR-A4RADR, B1RBDR-B22RBDR, C1RADR-C3RADR		Disturbance report	1	1	1	1
SPGAPC		Generic communication function for single point indication, 1 input	128	128	128	128
SP16GAPC		Generic communication function for single point indication, 16 inputs	16	16	16	16
MVGAPC		Generic communication function for measured values	60	60	60	60
BINSTATREP		Logical signal status report	3	3	3	3
RANGE_XP		Measured value expander block	66	66	66	66
SSIMG	63	Insulation supervision for gas medium	21	21	21	21
SSIML	71	Insulation supervision for liquid medium	3	3	3	3
SSCBR		Circuit breaker condition monitoring	0-12	6	12	12
LOLSPTR	26/49HS	Transformer insulation loss of life monitoring	0-4		4-M21	4-M21
I103MEAS		Measurands for IEC 60870-5-103	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC 60870-5-103	3	3	3	3
I103AR		Function status auto-recloser for IEC 60870-5-103	1	1	1	1
I103EF		Function status earth-fault for IEC 60870-5-103	1	1	1	1
I103FLTPROT		Function status fault protection for IEC 60870-5-103	1	1	1	1
I103IED		IED status for IEC 60870-5-103	1	1	1	1
I103SUPERV		Supervision status for IEC 60870-5-103	1	1	1	1
I103USRDEF		Status for user defined signals for IEC 60870-5-103	20	20	20	20

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
L4UFCNT		Event counter with limit supervision	30	30	30	30
TEILGAPC		Running hour meter	6	6	6	6
PTRSTHR	51TF	Through fault monitoring	0-2	2-M22	2-M22	2-M22
CHMMHAI	ITHD	Current harmonic monitoring, 3 phase	0-3	3-M23	3-M23	3-M23
VHMMHAI	VTHD	Voltage harmonic monitoring, 3 phase	0-3	3-M23	3-M23	3-M23
FLTMMXU		Fault current and voltage monitoring	3	3	3	3
Metering						
PCFCNT		Pulse-counter logic	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	6	6	6	6

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

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

Table 4. Number of function instances in APC30

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

Table 5. 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

Table 5. Total number of instances for configurable logic blocks Q/T, continued

Configurable logic blocks Q/T	Total number of instances
SRMEMORYQT	40
TIMERSETQT	40
XORQT	40

Table 6. Total number of instances for extended logic package

Extended configurable logic block	Total number of instances
AND	220
GATE	49
INV	220
LLD	49
OR	220
PULSETIMER	89
RSMEMORY	40
SLGAPC	74
SRMEMORY	130
TIMERSET	113
VSGAPC	120
XOR	89

Communication

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
Station communication						
LONSPA, SPA		SPA communication protocol	1	1	1	1
ADE		LON communication protocol	1	1	1	1
HORZCOMM		Network variables via LON	1	1	1	1
PROTOCOL		Operation selection between SPA and IEC 60870-5-103 for SLM	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1
RS485GEN		RS485	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1
CHSERRS485		DNP3.0 for EIA-485 communication protocol	1	1	1	1
CH1TCP, CH2TCP, CH3TCP, CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
CHSEROPT		DNP3.0 for TCP/IP and EIA-485 communication protocol	1	1	1	1
MSTSER		DNP3.0 serial master	1	1	1	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1	1	1	1
IEC 61850-8-1		IEC 61850	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59
IEC 61850SIM		IEC 61850 simulation mode	1	1	1	1
GOOSEBINRCV		GOOSE binary receive	16	16	16	16
GOOSEDPRCV		GOOSE function block to receive a double point value	64	64	64	64
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	60	60	60	60
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64
ALGOS		Supervision of GOOSE subscription	100	100	100	100
MULTICMDRCV, MULTICMDSND		Multiple command receive and send	60/10	60/10	60/10	60/10
OPTICAL103		IEC 60870-5-103 Optical serial communication	1	1	1	1
RS485103		IEC 60870-5-103 serial communication for RS485	1	1	1	1
AGSAL		Generic security application component	1	1	1	1
LD0LLN0		IEC 61850 LD0 LLN0	1	1	1	1
SYSLLN0		IEC 61850 SYS LLN0	1	1	1	1
LPHD		Physical device information	1	1	1	1
PCMACCS		IED configuration protocol	1	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1
FSTACCSNA		Field service tool access via SPA protocol over Ethernet communication	1	1	1	1
FSTACCS		Field service tool access	1	1	1	1
GOOSEACRCV		GOOSE function block to receive a protection activation information	16	16	16	16

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
		IEC 61850-9-2 Process bus communication, 12 merging units	0-1	1-P30	1-P30	1-P30
ACTIVLOG		Activity logging	1	1	1	1
ALTRK		Service tracking	1	1	1	1
PRP		IEC 62439-3 Parallel redundancy protocol	0-1	1-P23	1-P23	1-P23
HSR		IEC 62439-3 High-availability seamless redundancy	0-1	1-P24	1-P24	1-P24
RSTP		IEC 62439-3 Rapid spanning tree protocol	0-1	1-P25	1-P25	1-P25
SNMPSERVERCONF		SNMPServerConfiguration	1	1	1	1
SNMPUSERCONF		SNMPUserConfiguration	2	2	2	2
PMUCONF, PMUREPORT, PHASORREPORT1, ANALOGREPORT1, BINARYREPORT1, SMAI1 - SMAI12, 3PHSUM, PMUSTATUS		Synchrophasor report, 16 phasors (see Table 7)	0-1	1-P34	1-P34	1-P34
AP_1-AP_6		AccessPoint_ABS	1	1	1	1
AP_FRONT		Access point front	1	1	1	1
PTP		Precision time protocol	1	1	1	1
ROUTE_1-ROUTE_6		Route_ABS1-Route_ABS6	1	1	1	1
FRONTSTATUS		Access point diagnostic for front Ethernet port	1	1	1	1
SCHLCCH		Access point diagnostic for non-redundant Ethernet port	6	6	6	6
RCHLCCH		Access point diagnostic for redundant Ethernet ports	3	3	3	3
DHCP		DHCP configuration for front access point	1	1	1	1
QUALEXP		IEC 61850 quality expander	96	96	96	96
Remote communication						
BinSignRec1_1 BinSignRec1_2 BinSignReceive2		Binary signal transfer, receive	3/3/6	3/3/6	3/3/6	3/3/6
BinSignTrans1_1 BinSignTrans1_2 BinSignTransm2		Binary signal transfer, transmit	3/3/6	3/3/6	3/3/6	3/3/6

IEC 61850 or function name	ANSI	Function description	Generator			
			REG670 (Customized)	REG670 (A20)	REG670 (B30)	REG670 (C30)
BSR2M_305 BSR2M_312 BSR2M_322 BSR2M_306 BSR2M_313 BSR2M_323		Binary signal transfer, 2Mbit receive	1	1	1	1
BST2M_305 BST2M_312 BST2M_322 BST2M_306 BST2M_313 BST2M_323		Binary signal transfer, 2Mbit transmit	1	1	1	1
LDCMTRN		Transmission of analog data from LDCM	1	1	1	1
LDCMTRN_2M_305 LDCMTRN_2M_306 LDCMTRN_2M_312 LDCMTRN_2M_313 LDCMTRN_2M_322 LDCMTRN_2M_323		Transmission of analog data from LDCM, 2Mbit	1	1	1	1
LDCMRecBinStat1 LDCMRecBinStat3		Receive binary status from remote LDCM	6/3	6/3	6/3	6/3
LDCMRecBinStat2		Receive binary status from LDCM	3	3	3	3
LDCM2M_305 LDCM2M_312 LDCM2M_322		Receive binary status from LDCM, 2Mbit	1	1	1	1
LDCM2M_306 LDCM2M_313 LDCM2M_323		Receive binary status from remote LDCM, 2Mbit	1	1	1	1

Table 7. Number of function instances in Synchrophasor report, 16 phasors

Function name	Function description	Total number of instances
PMUCONF	Configuration parameters for IEC/IEEE 60255-118 (C37.118) 2011 and IEEE1344 protocol	1
PMUREPORT	Protocol reporting via IEEE 1344 and IEC/IEEE 60255-118 (C37.118)	2
PHASORREPORT1	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 1-8	2
ANALOGREPORT1	Protocol reporting of analog data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), analogs 1-8	2
BINARYREPORT1	Protocol reporting of binary data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), binary 1-8	2

Table 7. Number of function instances in Synchrophasor report, 16 phasors, continued

Function name	Function description	Total number of instances
SMAI1–SMAI12	Signal matrix for analog inputs	1
3PHSUM	Summation block 3 phase	6
PMUSTATUS	Diagnostics for IEC/IEEE 60255-118 (C37.118) 2011 and IEEE1344 protocol	1

Basic IED functions

Table 8. Basic IED functions

IEC 61850 or function name	Description
INTERRSIG SELFSUPEVLST	Self supervision with internal event list
TIMESYNCHGEN	Time synchronization module
BININPUT, SYNCHCAN, SYNCHGPS, SYNCHCMPPS, SYNCHLON, SYNCHPPH, SYNCHPPS, SNTP, TIMEZONE	Time synchronization
DSTBEGIN	GPS time synchronization module
DSTENABLE	Enables or disables the use of daylight saving time
DSTEND	GPS time synchronization module
IRIG-B	Time synchronization
SETGRPS	Number of setting groups
ACTVGRP	Active parameter setting group
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
TERMINALID	IED identifiers
PRODINF	Product information
SYSTEMTIME	System time
LONGEN	LON communication
RUNTIME	IED Runtime component
SMBI	Signal matrix for binary inputs
SMBO	Signal matrix for binary outputs
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

Table 8. Basic IED functions, continued

IEC 61850 or function name	Description
SPACOMMMAP	SPA communication mapping
SPATD	Date and time via SPA protocol
BCSCONF	Basic communication system
GBASVAL	Global base values for settings
PRIMVAL	Primary system values
SAFEFILECOPY	Safe file copy function
ALTMS	Time master supervision
ALTIM	Time management
CAMCONFIG	Central account management configuration
CAMSTATUS	Central account management status
TOOLINF	Tools information
COMSTATUS	Protocol diagnostic

Table 9. Local HMI functions

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

5. Differential protection

Generator differential protection GENPDIF

Short circuit between the phases of the stator windings causes normally very large fault currents. The short circuit gives risk of damages on insulation, windings and stator iron core. The large short circuit currents cause large forces, which can cause damage even to other components in the power plant, such as turbine and generator-turbine shaft.

To limit the damage due to stator winding short circuits, the fault clearance must be as fast as possible (instantaneous).

If the generator block is connected to the power system close to other generating blocks, the fast fault clearance is essential to maintain the transient stability of the non-faulted generators.

Normally, the short circuit fault current is very large, that is, significantly larger than the generator rated current. There is a risk that a short circuit can occur between phases close to the neutral point of the generator, thus causing a relatively small fault current. The fault current can also be limited due to low excitation of the generator. Therefore, it is desired that the detection of generator phase-to-phase short circuits shall be relatively sensitive, detecting small fault currents.

It is also of great importance that the generator differential protection does not trip for external faults, with large fault currents flowing from the generator.

To combine fast fault clearance, as well as sensitivity and selectivity, the generator differential protection is normally the best choice for phase-to-phase generator short circuits.

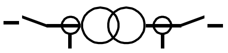
Generator differential protection GENPDIF is also well suited for protection of shunt reactors or small busduct.

Transformer differential protection T2WPDIF/ T3WPDIF

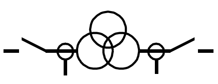
The Transformer differential protection is provided with internal CT ratio matching, vector group compensation and settable zero sequence current elimination.

The function can be provided with up to six three-phase sets of current inputs if enough HW is available. All current inputs are provided with percentage bias restraint features, making the IED suitable for two- or three-winding transformer in multi-breaker station arrangements.

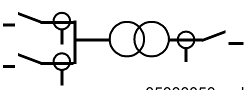
Two-winding applications



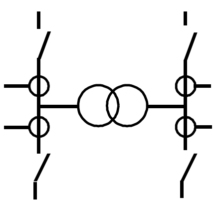
two-winding power transformer



two-winding power transformer with unconnected delta tertiary winding

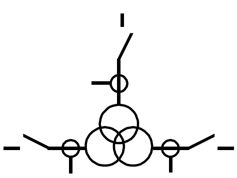


two-winding power transformer with two circuit breakers and two CT-sets on one side

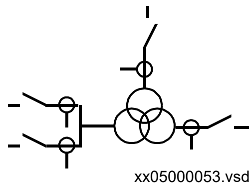


two-winding power transformer with two circuit breakers and two CT-sets on both sides

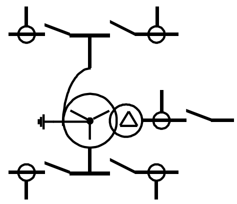
Three-winding applications



three-winding power transformer with all three windings connected



three-winding power transformer with two circuit breakers and two CT-sets on one side



Autotransformer with two circuit breakers and two CT-sets on two out of three sides

Figure 4. CT group arrangement for differential protection

The setting facilities cover the application of the differential protection to all types of power transformers and auto-transformers with or without load tap changer as well as shunt reactors and local feeders within the station. An adaptive stabilizing feature is included for heavy through-fault currents. By introducing the load tap changer position, the differential protection pick-up can be set to optimum sensitivity thus covering internal faults with low fault current level.

Stabilization is included for inrush and overexcitation currents respectively, cross-blocking is also available. Adaptive stabilization is also included for system recovery inrush and CT saturation during external faults. A high set unrestrained differential current protection element is included for a very high speed tripping at high internal fault currents.

Included is an sensitive differential protection element based on the theory of negative sequence current component. This element offers the best possible coverage of power transformer windings turn to turn faults.

High impedance differential protection, single phase HZPDIF

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

The external resistor unit shall be ordered under "External resistor unit" in the Product Guide.

HZPDIF can be used to protect generator stator windings, tee-feeders or busbars, reactors, motors, auto-transformers, capacitor banks and so on. One such function block is used for a high-impedance restricted earth fault protection. Three such function blocks are used to form three-phase, phase-segregated differential protection.

Restricted earth-fault protection, low impedance REFPDIF

Restricted earth-fault protection, low-impedance function (REFPDIF) can be used on all directly or low-impedance earthed windings. The REFPDIF function provides high sensitivity and high speed tripping as it protects each winding separately and thus does not need inrush stabilization.

The REFPDIF function is a percentage biased function with an additional zero sequence current directional comparison criterion. This gives excellent sensitivity and stability during through faults.

REFPDIF can also protect autotransformers. Five currents are measured at the most complicated configuration as shown in Figure 5.

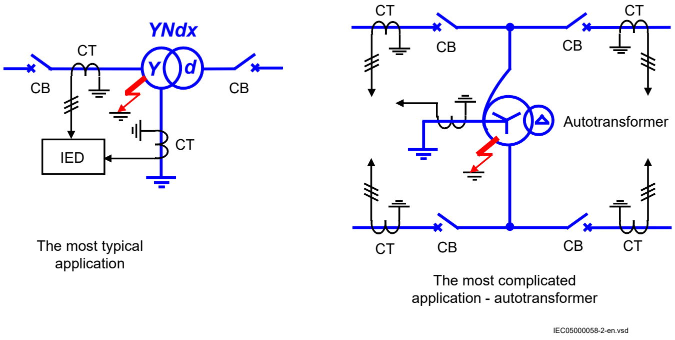


Figure 5. Examples of applications of the REFPDIF

6. Impedance protection

Full-scheme distance measuring, Mho characteristic ZMHPDIS

The numerical mho line distance protection is an up to four zone full scheme protection for back-up detection of short circuit and earth faults.

The full scheme technique provides back-up protection of power lines with high sensitivity and low requirement on remote end communication.

The zones have fully independent measuring and settings, which gives high flexibility for all types of lines.

Built-in selectable zone timer logic is also provided in the function.

The function can be used as under impedance back-up protection for transformers and generators.

Directional impedance element for Mho characteristic ZDMRDIR

The phase-to-earth impedance elements can be optionally supervised by a phase unselective directional function (phase unselective, because it is based on symmetrical components).

High speed distance protection, quadrilateral and mho ZMFPDIS

The high speed distance protection (ZMFPDIS) provides a sub-cycle, down towards a half-cycle operate time. Its seven zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth faults for each of the independent zones, which makes the function suitable for applications with single-phase autoreclosing.

Each measurement zone is designed with the flexibility to operate in either quadrilateral or mho characteristic mode. This can be decided separately for the phase-to-earth or phase-to-phase loops. Out of the seven zones, one zone has fixed directionality to reverse, one zone has fixed directionality to forward, and five zone with directionality independently settable to forward/reverse/non-directional.

The operation of the phase-selection is primarily based on a current change criteria (i.e. delta quantities), however there is also a phase selection criterion operating in parallel which bases its operation on voltage and current phasors exclusively. Additionally, the directional element provides a fast and correct directional decision under difficult operating conditions, including close-in three-phase faults, simultaneous faults and faults with only zero-sequence in-feed.

During phase-to-earth faults on heavily loaded power lines there is an adaptive load compensation algorithm that prevents overreaching of the distance zones in the load exporting end, improving the selectivity of the function. This also reduces underreach in the importing end.

The ZMFPDIS function is also equipped with the parallel line mutual coupling compensation feature based on the parallel line residual current.

High speed distance protection for series comp. lines, quad and mho characteristic ZMFCPDIS

The high speed distance protection (ZMFCPDIS) provides a sub-cycle, down towards a half-cycle operate time. Its seven zone, full scheme protection concept is entirely suitable in applications with single-phase autoreclosing.

High speed distance protection ZMFCPDIS is fundamentally the same function as ZMFPDIS but provides more flexibility in zone settings to suit more complex applications, such as series compensated lines. In operation for series compensated networks, the parameters of the directional function are altered to handle voltage reversal.

Each measurement zone is designed with the flexibility to operate in either quadrilateral or mho characteristic mode. This can even be decided separate for the phase-to-earth or phase-to-phase loops. The seven zones can operate either independent of each other, or their start can be linked (per zone) through the phase selector or the first starting zone. This can provide fast operate times for evolving faults.

The operation of the phase-selection is primarily based on a current change criteria (i.e. delta quantities), however there is also a phase selection criterion operating in parallel which bases its operation on voltage and current phasors exclusively. Additionally the directional element provides a fast and correct directional decision under difficult operating conditions, including close-in three-phase faults, simultaneous faults and faults with only zero-sequence in-feed.

During phase-to-earth faults on heavily loaded power lines there is an adaptive load compensation algorithm that prevents overreaching of the distance zones in the load exporting end, improving the selectivity of the function. This also reduces underreach in the importing end.

The ZMFCPDIS function has another directional element with phase segregated outputs STTDFwLx and STTDRVLx (where, x = 1-3) based on the transient components. It provides directionality with high speed, dependability and security, which is also suitable for extra high voltage and series compensated lines where the fundamental frequency signals are distorted.

The ZMFCPDIS function is also equipped with the parallel line mutual coupling compensation feature based on the parallel line residual current.

Pole slip protection PSPPPAM

Sudden events in an electric power system such as large changes in load, fault occurrence or fault clearance, can cause power oscillations referred to as power swings. In a non-recoverable situation, the power swings become so severe that the synchronism is lost, a condition referred to as pole slipping. The main purpose of the pole slip protection (PSPPPAM) is to detect, evaluate, and take the required action for pole slipping occurrences in the power system.

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.

Loss of excitation LEXPDIS

There are limits for the under-excited operation of a synchronous machine. A reduction of the excitation current weakens the coupling between the rotor and the stator. The machine may lose the synchronism and start to operate like an induction machine. Then, the reactive power consumption will increase. Even if the machine does not loose synchronism it may not be acceptable to operate in this state for a long time. Reduction of excitation increases the generation of heat in the end region of the synchronous machine. The local heating may damage the insulation of the stator winding and the iron core.

To prevent damages to the generator it should be tripped when excitation is lost.

Sensitive rotor earth fault protection, injection based ROTIPHIZ

The sensitive rotor earth fault protection (ROTIPHIZ) is used to detect earth faults in the rotor windings of generators. ROTIPHIZ is applicable for all types of synchronous generators.

To implement the above concept, a separate injection box is required. The injection box generates a square wave signal at a certain preset frequency which is fed into the rotor winding.

The injected voltage is measured at the terminals of the coupling unit REX061. The injected current is measured through a shunt that is located inside the injection unit

REX060. These two measurements are transferred by REX060 to the IED. Based on these two measured quantities, ROTIPHIZ determines the rotor winding resistance to ground. The resistance value is then compared to the settings of the alarm resistance and trip resistance.

The protection function can detect earth faults in the entire rotor winding and associated connections.

The injection unit REX060 and a coupling capacitor unit REX061 are required for correct operation.

100% stator earth fault protection, injection based STTIPHIZ

The 100% stator earth-fault protection (STTIPHIZ) is used to detect the earth faults in the stator windings of generators and motors. STTIPHIZ is applicable for synchronous machines that are connected to the power system through a unit step-up transformer in a block connection. An independent signal with a certain frequency, different from the machine rated frequency, is injected into the stator circuit. The response of this injected signal is used to detect stator STTIPHIZ faults.

To implement the above concept, a separate injection device REX060, a shunt resistor unit REX062 and a Signal Injection Transformer (SIT) are required. The injection device REX060 generates a square wave current signal which is injected into the stator windings through REX062 and SIT.

The high voltage side terminals of SIT are connected between the generator star point (that is the generator neutral) and earth. Neither changes nor rearrangements of the generator neutral grounding equipment are required.

The injected current is measured through a shunt that is inside REX062. The injected voltage signal is measured at the low voltage terminals of SIT.

These two measurements are fed to the function STTIPHIZ. Based on these two measured quantities, STTIPHIZ evaluates the stator windings resistance to ground. The resistance value is then compared to the set alarm and trip levels.

When the synchronous machine is at standstill, the function STTIPHIZ can detect an earth fault at the generator star point, along the stator windings and at the generator terminals, including the connected equipment, like the high voltage windings of the excitation transformer and the bus ducts until the terminals of the generator circuit breaker; in case of a unit group, without the generator circuit breaker, also the high voltage windings of the auxiliary transformer and the low voltage windings of the unit step-up transformer and the bus ducts between them and the generator terminals are inside the zero-sequence reach of STTIPHIZ.

When the synchronous machine is not at standstill, both functions STTIPHIZ and ROV2PTOV cooperate to protect 100% of the machine stator windings. Both STTIPHIZ and ROV2PTOV shall be configured in the same REG670.

The function STTIPHIZ performs the earth-fault protection based on the injection principle and protects the generator neutral point and a section of the stator windings close to it; the function ROV2PTOV performs the standard 95% stator earth-fault protection based on the neutral point fundamental frequency voltage displacement. The settings of the two functions grants an overlapping of the zones that they protect.

The protection function STTIPHIZ is fully operative in all operating conditions when stable measurements are achieved.

Underimpedance protection for generators and transformers ZGVPDIS

The under impedance protection (ZGVPDIS) function is a three zone full scheme impedance protection using offset mho characteristics for detecting faults in the generator, generator-transformer and transmission system. The three zones have fully independent measuring loops and settings. The functionality also comprises an under voltage seal-in feature to ensure issuing of a trip even if the current transformer goes into saturation and, in addition, the positive-sequence-based load encroachment feature for the second and the third impedance zone. Built-in compensation for the unit step-up transformer vector group connection is available.

7. Wide area measurement system

Synchrophasor report, 16 phasors

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

The IED supports the following IEEE synchrophasor standards:

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

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

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

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

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

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

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

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

8. Current protection

Instantaneous phase overcurrent protection PHPIOC

The instantaneous three phase overcurrent (PHPIOC) function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function.

Directional phase overcurrent protection, four steps OC4PTOC

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

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

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

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

Instantaneous residual overcurrent protection EFPIOC

The Instantaneous residual overcurrent protection (EFPIOC) has a low transient overreach and short tripping times to allow the use for instantaneous earth-fault protection, with the reach limited to less than the typical eighty percent of the line at minimum source impedance. EFPIOC is configured to measure the residual current from the three-phase current inputs and can be configured to measure the current from a separate current input.

Directional residual overcurrent protection, four steps EF4PTOC

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

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

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

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

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

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

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

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

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

Four step directional negative phase sequence overcurrent protection NS4PTOC

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

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. Sensitive directional residual overcurrent and power protection (SDEPSDE) can be set as low 0.25% of IBase.

Thermal overload protection, two time constants TRPTTR

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

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

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

The estimated time to trip before operation is presented.

Breaker failure protection CCRBRF

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

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

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

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

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

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

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

Overcurrent protection with binary release BRPTOC

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

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

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

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

Pole discordance protection CCPDSC

An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

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

The Pole discordance protection function (CCPDSC) operates based on information from auxiliary contacts of the circuit breaker for the three phases with additional criteria from unsymmetrical phase currents when required.

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:

- generator reverse power protection
- generator low forward power protection
- detection of over/under excited generator
- detection of reversed active power flow
- detection of high reactive power flow
- excessive line/cable loading with active or reactive power
- generator reverse power protection

Each function has two steps with definite time delay.

By using optional metering class CT inputs accuracy of 0,5% can be achieved for steam turbine applications.

Voltage-restrained time overcurrent protection VRPVOC

Voltage-restrained time overcurrent protection (VRPVOC) function can be used as generator backup protection against short-circuits.

The overcurrent protection feature has a settable current level that can be used either with definite time or inverse time characteristic. Additionally, it can be voltage controlled/ restrained.

One undervoltage step with definite time characteristic is also available within the function in order to provide functionality for overcurrent protection with undervoltage seal-in.

Negative sequence time overcurrent protection for machines NS2PTOC

Negative-sequence time overcurrent protection for machines (NS2PTOC) is intended primarily for the protection of generators against possible overheating of the rotor caused by negative sequence current in the stator current.

The negative sequence currents in a generator may, among others, be caused by:

- Unbalanced loads
- Line to line faults
- Line to earth faults
- Broken conductors
- Malfunction of one or more poles of a circuit breaker or a disconnector

NS2PTOC can also be used as a backup protection, that is, to protect the generator in case line protections or circuit breakers fail to clear unbalanced system faults.

To provide an effective protection for the generator for external unbalanced conditions, NS2PTOC is able to directly measure the negative sequence current. NS2PTOC also has a time delay characteristic which matches the heating characteristic of the generator $I_2^2 t = K$ as defined in standard IEEE C50.13.

where:

I_2	is negative sequence current expressed in per unit of the rated generator current
t	is operating time in seconds
K	is a constant which depends of the generators size and design

NS2PTOC has a wide range of *K* settings and the sensitivity and capability of detecting and tripping for negative sequence currents down to the continuous capability of a generator.

In order to match the heating characteristics of the generator a reset time parameter can be set.

A separate definite time delayed output is available as an alarm feature to warn the operator of a potentially dangerous situation.

Accidental energizing protection for synchronous generators AEGPVOC

Inadvertent or accidental energizing of off-line generators has occurred often enough due to operating errors, breaker head flashovers, control circuit malfunctions, or a combination of these causes. Inadvertently energized generator operates as induction motor drawing a large current from the system. The voltage supervised overcurrent protection is used to detect the inadvertently energized generator.

Accidental energizing protection for synchronous generators (AEGPVOC) takes the maximum phase current input and maximum phase to phase voltage inputs from the terminal side. AEGPVOC is enabled when the terminal voltage drops below the specified voltage level for the preset time.

Stator overload protection GSPTTR

The generator overload function, (GSPTTR) is used to protect the stator winding against excessive temperature as a result of overcurrents. The functions operating characteristic is designed in accordance with the American standard IEEE-C50.13.

If internal generator components exceed its design temperature limit, damage can be the result. Damage to generator insulation can range from minor loss of life to complete failure, depending on the severity and duration of the temperature excursion. Excess temperature can also cause mechanical damage due to thermal expansion. Since temperature increases with current, it is logical to apply overcurrent elements with inverse time characteristics.

For its operation the function either measures the true RMS current of the stator winding or waited sum of the positive and negative sequence components in the stator winding.

The function is designed to work on 50/60 Hz systems.

Rotor overload protection GRPTTR

The generator overload function, (GRPTTR) is used to protect the rotor winding against excessive temperature as a result of overcurrents. The functions operating characteristic is designed in accordance with the American standard IEEE-C50.13.

If internal generator components exceed its design temperature limit, damage can be the result. Damage to generator insulation can range from minor loss of life to complete failure, depending on the severity and duration of the temperature excursion. Excess temperature can also cause mechanical damage due to thermal expansion. Rotor components such as bars and end rings are vulnerable to this damage. Since temperature increases with current, it is logical to apply overcurrent elements with inverse time characteristics.

For its operation the function either measures the true RMS current of the excitation transformer or calculates the DC current in the rotor winding. The rotor winding DC current can be calculated from the AC currents measured on either high voltage side (HV) or low voltage side (LV) side of the excitation transformer. For the HV side measurement ratings of the excitation transformer shall be given. The use of the DC current is default (i.e. recommended) measurement for generators with static excitation system. When the DC current is used, the function can provide a DC current ripple alarm, due to possible problem with the static excitation equipment. The rotor DC current can be also sent to the plant supervisory system via communication channel or displayed on the IED built-in HMI.

The function can also detect undercurrent condition in the rotor winding which indicates either under-excitation or loss of excitation condition of the generator.

The function is designed to work on 50/60 Hz systems.

Average Power Transient Earth Fault Protection APPTEF

The APPTEF (Average Power Transient Earth Fault Protection) function is a transient measuring directional earth-fault protection. Determination of the earth fault direction is based on the short-term built-up transient at the beginning of the earth fault. This transient is to a large extent independent of the neutral point treatment. This means that the function can be used without any modification in all types of high-impedance grounded, resonant grounded or isolated power systems.

For a resonant grounded system, the correct directional measurement is ensured regardless of how many Petersen coils are used throughout the interconnected power network. The function is not sensitive to the actual compensation degree of the coils. It will operate equally well in an under- or over-compensated system. Parallel neutral resistor to the Petersen coil are not needed to correctly determine earth fault direction. However, these neutral resistors can still be used if already installed in the network.

The function is suitable to be used in distribution and in meshed HV sub-transmission networks using high-impedance grounding. In meshed systems a directional permissive scheme is required in order to ensure selective tripping of a faulty line. Alternatively, the function can be used solely for signaling of the earth-fault location to the

SCADA system when the power network is allowed to operate for a longer time with an earth-fault being present.

9. Voltage protection

Two-step undervoltage protection UV2PTUV

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

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

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

Two step overvoltage protection OV2PTOV

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

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.

Residual overvoltage protection, two steps ROV2PTOV

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

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

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

A reset delay ensures operation for intermittent earth faults.

Overexcitation protection OEXPVPH

When the laminated core of a power transformer or generator is subjected to a magnetic flux density beyond its design limits, stray flux will flow into non-laminated components that are not designed to carry flux. This will cause eddy currents to flow. These eddy currents can cause excessive heating and severe damage to insulation and adjacent parts in a relatively short time. The function has settable inverse operating curves and independent alarm stages.

Voltage differential protection VDCPTDV

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

100% Stator earth fault protection, 3rd harmonic based STEFPHIZ

Stator earth fault is a fault type having relatively high fault rate. The generator systems normally have high impedance earthing, that is, earthing via a neutral point resistor. This resistor is normally dimensioned to give an earth fault current in the range 3 – 15 A at a solid earth-fault directly at the generator high voltage terminal. The relatively small earth fault currents give much less thermal and mechanical stress on the generator, compared to the short circuit case, which is between conductors of two phases. Anyhow, the earth faults in the generator have to be detected and the generator has to be tripped, even if longer fault time compared to internal short circuits, can be allowed.

In normal non-faulted operation of the generating unit the neutral point voltage is close to zero, and there is no zero sequence current flow in the generator. When a phase-to-earth fault occurs the neutral point voltage will increase and there will be a current flow through the neutral point resistor.

To detect an earth fault on the windings of a generating unit one may use a neutral point overvoltage protection, a neutral point overcurrent protection, a zero sequence overvoltage protection or a residual differential protection. These protections are simple and have served well during many years. However, at best these simple schemes protect only 95% of the stator winding. They leave 5% close to the neutral end unprotected. Under unfavorable conditions the blind zone may extend up to 20% from the neutral.

The 95% stator earth fault protection measures the fundamental frequency voltage component in the generator star point and it operates when the fundamental frequency voltage exceeds the preset value. By applying this principle approximately 95% of the stator winding can be protected. In order to protect the last 5% of the stator winding close to the neutral end the 3rd harmonic voltage measurement can be performed. In 100% Stator E/F 3rd harmonic protection either the 3rd harmonic voltage differential principle, the neutral point 3rd harmonic undervoltage principle or the terminal side 3rd harmonic overvoltage principle can be applied. However, differential principle is strongly recommended. Combination of these two measuring principles provides coverage for entire stator winding against earth faults.

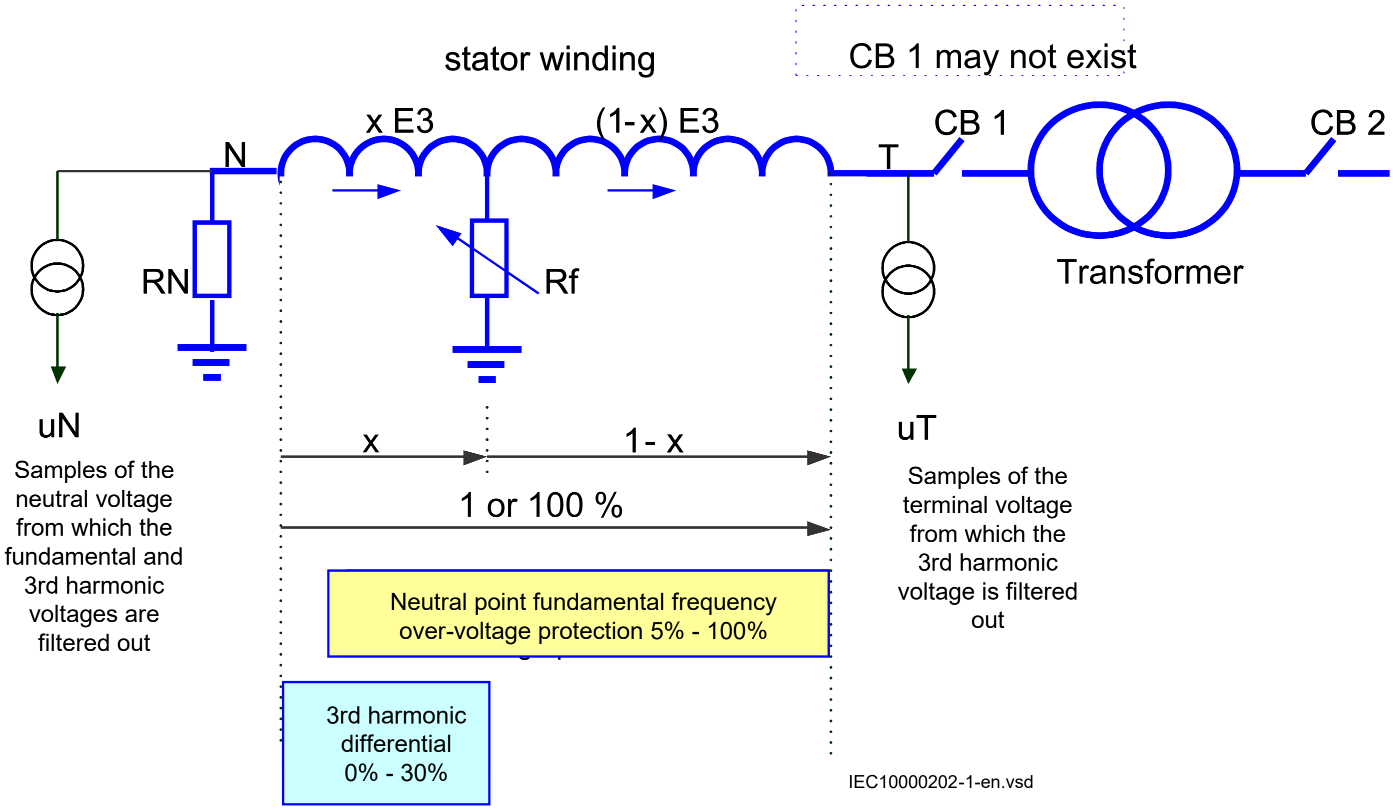


Figure 6. Protection principles for STEFPHIZ function

10. 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.

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.

Rate-of-change of frequency protection SAPFRC

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

SAPFRC is provided with an undervoltage blocking. The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected.

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.

11. Multipurpose protection

General current and voltage protection CVGAPC

The protection module is recommended as a general backup protection with many possible application areas due to its flexible measuring and setting facilities.

The built-in overcurrent protection feature has two settable current levels. Both of them can be used either with definite time or inverse time characteristic. The overcurrent protection steps can be made directional with selectable voltage polarizing quantity. Additionally they can be voltage and/or current controlled/restrained. 2nd harmonic restraining facility is available as well. At too low polarizing voltage the overcurrent feature can be either blocked, made non directional or ordered to use voltage memory in accordance with a parameter setting.

Additionally two overvoltage and two undervoltage steps, either with definite time or inverse time characteristic, are available within each function.

The general function suits applications with underimpedance and voltage controlled overcurrent solutions. The general function can also be utilized for generator transformer protection applications where positive, negative or zero sequence components of current and voltage quantities are typically required.

Additionally, generator applications such as loss of field, inadvertent energizing, stator or rotor overload, circuit breaker head flash-over and open phase detection are just a few of possible protection arrangements with these functions.

Rotor earth fault protection using CVGAPC

The field winding, including the rotor winding and the non-rotating excitation equipment, is always insulated from the metallic parts of the rotor. The insulation resistance is high if the rotor is cooled by air or by hydrogen. The insulation resistance is much lower if the rotor winding is cooled by water. This is true even if the insulation is intact. A fault in the insulation of the field circuit will result in a conducting path from the field winding to earth. This means that the fault has caused a field earth fault.

The field circuit of a synchronous generator is normally unearthed. Therefore, a single earth fault on the field winding will cause only a very small fault current. Thus the earth fault does not produce any damage in the generator. Furthermore, it will not affect the operation of a generating unit in any way. However, the existence of a single earth fault increases the electric stress at other points in the field circuit. This means that the risk for a second earth fault at another point on the field winding has increased considerably. A second earth fault will cause a field short-circuit with severe consequences.

The rotor earth fault protection is based on injection of an AC voltage to the isolated field circuit. In non-faulted conditions there will be no current flow associated to this injected voltage. If a rotor earth fault occurs, this condition will be detected by the rotor earth fault protection. Depending on the generator owner philosophy this operational state will be alarmed and/or the generator will be tripped. An injection unit RXTTE4 and an optional protective resistor on plate are required for correct rotor earth fault protection operation.

12. General calculation

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.

13. 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.

Fuse failure supervision VDSPVC

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

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

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

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

Voltage based delta supervision DELVSPVC

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

Current based delta supervision DELISPVC

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

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

Delta supervision of real input DELSPVC

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

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

14. Control

Synchrocheck, energizing check, and synchronizing SESRSYN

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

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

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

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

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

However this function can not be used to automatically synchronize the generator to the network.

Apparatus control APC

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

Apparatus control features:
- Select-Execute principle to give high reliability
- Selection function to prevent simultaneous operation
- Selection and supervision of operator place
- Command supervision
- Block/deblock of operation
- Block/deblock of updating of position indications
- Substitution of position and quality indications
- Overriding of interlocking functions
- Overriding of synchrocheck
- Operation counter
- Suppression of mid position

Two types of command models can be used:
- Direct with normal security
- SBO (Select-Before-Operate) with enhanced security

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

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

Interlocking

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

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

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

Switch controller SCSWI

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

Circuit breaker SXCBR

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

Circuit switch SXSWI

The purpose of Circuit switch (SXSWI) function is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of disconnectors or earthing switches via binary output boards and to supervise the switching operation and position.

Reservation function QCRSV

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

Reservation input RESIN

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

Bay control QCBAY

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

Proxy for signals from switching device via GOOSE XLNPROXY

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

GOOSE function block to receive a switching device GOOSEXLNRCV

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

Local remote LOCREM/Local remote control LOCREMCTRL

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

Tap changer position reading TCMYLTC and TCLYLTC

On-load tap-changer position can be monitored on-line. This can be done by either using BCD coded binary input signals or alternatively via an mA input signal. The actual tap-position can be used by the transformer or overall differential protection function in order to enable more sensitive pickup setting. This will in turn make differential protection more sensitive for low level internal faults such as winding turn-to-turn faults.

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

Generic communication function for double point indication DPGAPC

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

Single point generic control 8 signals SPC8GAPC

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

Automation bits, command function for DNP3.0 AUTOBITS

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

Single command, 16 inputs SINGLECMD

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

15. Logic

Tripping logic SMPPTRC

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

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

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

The function also captures and reports the magnitude, angle of the voltage and current of each phase and neutral at the instant of fault to IEC 61850, LHMI, signal monitoring tool triggered by TRINx signal activation.

General start matrix block SMAGAPC

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

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

Trip matrix logic TMAGAPC

The 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.

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

- **AND** function block. The AND function is used to form general combinatory expressions with boolean variables. The AND function block has up to four inputs and two outputs. One of the outputs is inverted.
- **GATE** function block is used for whether or not a signal should be able to pass from the input to the output.
- **INVERTER** function block that inverts the input signal to the output.
- **LLD** function block. Loop delay used to delay the output signal one execution cycle.
- **OR** function block. The OR function is used to form general combinatory expressions with boolean variables. The OR function block has up to six inputs and two outputs. One of the outputs is inverted.

- **PULSETIMER** function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- **RSMEMORY** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power interruption, the flip-flop resets or returns to the state it had before the power interruption. RESET input has priority.
- **SRMEMORY** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power interruption, the flip-flop resets or returns to the state it had before the power interruption. The SET input has priority.
- **TIMERSET** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay.
- **XOR** is used to generate combinatory expressions with boolean variables. XOR has two inputs and two outputs. One of the outputs is inverted. The output signal OUT is 1 if the input signals are different and 0 if they are the same.

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

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

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

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

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

One FXDSIGN function block is included in all IEDs.

Delay on timer with input signal integration TIGAPC
The integrator function (TIGAPC) integrates input pulses and compares the integrated time with a settable time delay to operate. Moreover, the time delay to reset the output is settable in this function.

Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

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

The main features of TEIGAPC

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

Boolean to integer conversion, 16 bit B16I

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

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

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

Integer to Boolean 16 conversion IB16

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

Integer to boolean conversion with logical node representation, 16 bit ITBGAPC

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

Comparator for integer inputs INTCOMP

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

Comparator for real inputs REALCOMP

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

Hold Maximum and Minimum of Input HOLDMINMAX

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

Converter integer to real INT_REAL

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

Definable constant for logic function CONST_INT

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

Analog input selector for integer values INTSEL

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

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

Definable limiter LIMITER

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

Absolute value ABS

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

Polar to rectangular converter POL_REC

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

Radians to degree angle converter RAD_DEG

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

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

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

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

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

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

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

16. 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 70 analog and 352 binary signals.

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

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

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

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

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

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

Event list DRPRDRE

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

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

Indications DRPRDRE

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

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

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

Event recorder DRPRDRE

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

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

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

Trip value recorder DRPRDRE

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

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

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

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

Disturbance recorder DRPRDRE

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

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

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

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

Event function

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

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

Generic communication function for single point indication SPGAPC

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

Generic communication function for measured values MVGAPC

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

Measured values expander block RANGE_XP

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

Insulation supervision for gas medium function SSIMG

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

Insulation supervision for liquid medium SSIML

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

Circuit breaker condition monitoring SSCBR

The circuit breaker condition monitoring function (SSCBR) is used to monitor different parameters of the breaker condition. The breaker requires maintenance when the number of operations reaches a predefined value. For a proper functioning of the circuit breaker, it is essential to monitor the circuit breaker operation, spring charge indication or breaker wear, travel time, number of operation cycles and estimate the accumulated energy during arcing periods. Each SCCBR function instance is made to be used with a 1-pole, 1-phase breaker.

Event counter with limit supervison L4UFCNT

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

Overflow indication is included for each up-counter.

Running hour-meter TEILGAPC

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

The main features of TEILGAPC are:

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

Estimation of transformer winding insulation life LOLSPTR

Estimation of transformer winding insulation life (LOLSPTR) is used to calculate transformer winding hot spot temperature using the empirical formulae. It is also used to estimate transformer loss of life from the winding hot spot temperature value. The transformer winding insulation is degraded when the winding hot spot temperature exceeds certain limit. LOLSPTR gives warning and alarm signals when the winding hot spot temperature reaches a set value.

Hot spot temperature calculation requires top oil temperature at a given time. This value can either be a measured value taken through sensors or the one calculated by the function. This decision is made based on the top oil temperature sensor quality. Top oil temperature calculation is done using the method explained in IEC 60076-7 standard.

Inputs required for hot spot temperature calculation are:
- Transformer oil time constant
- Winding time constant
- Loss ratio at different tap positions
- Ambient temperature around the transformer

The oil and winding time constants can be calculated by the function based on transformer parameters if the inputs are not available from the transformer manufacturer.

Ambient temperature to the function can either be provided through the sensor or monthly average ambient temperature settings. This decision is made based on the ambient temperature sensor quality. Additionally, LOLSPTR function provides difference between measured value and calculated value of the top oil temperature.

Additionally, the function calculates loss of life in form of days and years. This information is updated at settable intervals, for example, hourly or daily. Transformer winding percentage loss of life is calculated every day and the information is provided as total percentage loss of life from the installation date and yearly percentage loss of life.

Through fault monitoring PTRSTHR

The through fault monitoring function PTRSTHR is used to monitor the mechanical stress on a transformer and place it against its designed withstand capability. During through faults, the fault-current magnitude is higher as the allowed overload current range. At low fault current magnitudes which are below the overload capability of the transformer, mechanical effects are considered less important unless the frequency of fault occurrence is high. Since through fault current magnitudes are typically closer to the extreme design capabilities of the transformer, mechanical effects are more significant than thermal effects.

For other power system objects, for example, an over-head line, this function can be used to make a log of primary quantities of a protected line.

Current harmonic monitoring CHMMHAI

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

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

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

Voltage harmonic monitoring VHMMHAI

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

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

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

Fault current and voltage monitoring FLTMMXU

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

FLTMMXU function monitors and reports the following values:

- Maximum peak current of individual phases during the trip event
- Maximum RMS current of individual phases during the trip event
- Maximum RMS current of all phases during the trip event
- Fundamental DFT current magnitude and angle of individual phases at the instant of triggering the function via input TRIGFLUI
- Fundamental DFT neutral current magnitude and angle at the instant of triggering the function via input TRIGFLUI
- Fundamental DFT voltage magnitude and angle of individual phases at the instant of triggering the function via input TRIGFLUI
- Fundamental DFT neutral voltage magnitude and angle at the instant of triggering the function via input TRIGFLUI

17. 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

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

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

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

18. Human machine interface

Local HMI

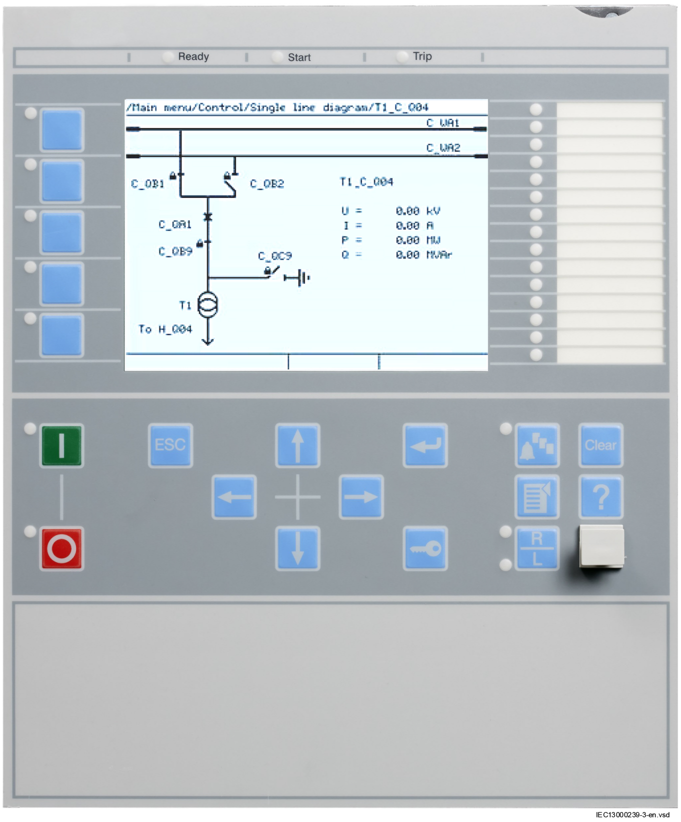


Figure 7. Local human-machine interface

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.

19. Basic IED functions

Time synchronization

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

The IED supports SNTPv4 (RFC2030).

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

20. Ethernet

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

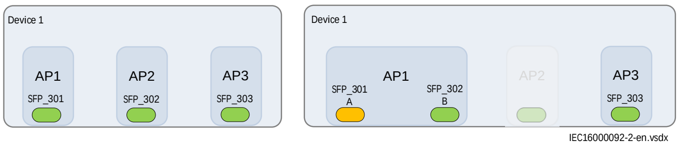


Figure 8. Access points, non redundant (left) and redundant communication (right)

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

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

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

Redundant communication

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

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

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

Rapid spanning tree protocol RSTP
Rapid Spanning Tree Protocol (RSTP) is a network protocol built for loop-free network topology and redundancy/backup connections between switches.
- Support for RSTP is available on the Station level network communication.
- RSTP is only available on the Access Point (AP) 1 or Access Point (AP) 3. AP1 uses port 1 and port 2; AP3 uses port 3 and port 4.
- RSTP can be configured using Ethernet configuration Tool (ECT) and PST in PCM600.

Routes
A route is a specified path for data to travel between the source device in a subnetwork to the destination device in a different subnetwork. A route consists of a destination address and the address of the gateway to be used when sending data to the destination device, see Figure 9.

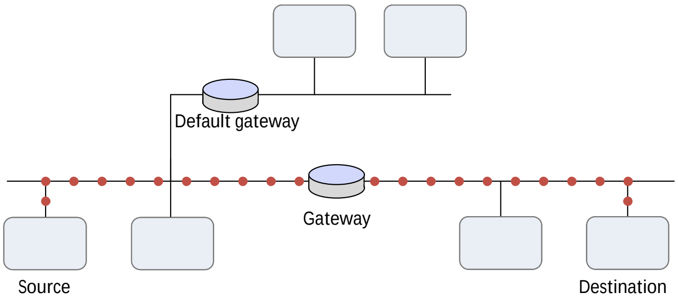


Figure 9. Route from source to destination through gateway

21. Station communication

Communication protocols

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

Available communication protocols are:

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

Several protocols can be combined in the same IED.

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

Simple network management protocol SNMP

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

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

The SNMP agent supports the following,

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

IEC 61850-8-1 communication protocol

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

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

IEC 61850 quality expander QUALEXP

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

Supervision of GOOSE subscription (ALGOS)

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

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

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

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

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

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

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

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

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

IEC/UCA 61850-9-2LE communication protocol

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

LON communication protocol

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

SPA communication protocol

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

IEC 60870-5-103 communication protocol

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

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

Measurands for IEC 60870-5-103 I103MEAS

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

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

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

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

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

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

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

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

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

IED status for IEC 60870-5-103 I103IED

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

Supervison status for IEC 60870-5-103 I103SUPERV

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

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

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

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

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

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

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

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

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

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

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

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

22. 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
The remote end data communication is used for the transmission of analog values for line differential protection or for the transmission of only binary signals between IEDs. The binary signals are freely configurable and can thus be used for any purpose, such as communication scheme related signals, transfer trip and/or other binary signals between IEDs.

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

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

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

This feature can be used, for example, in power stations to exchange up to 192 binary signals (e.g. tripping, signaling, alarming) between the generator and HV station in power plants.

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

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

Galvanic interface G.703 resp G.703E1

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

23. Hardware description

Hardware modules

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

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

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

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

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

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

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

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

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
The optical Ethernet module (OEM) provides two additional optical Ethernet ports. The port connectors are:
- SFP Optical LC (single mode and multi mode)
- Galvanic RJ45

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

Serial and LON communication module (SLM) for SPA/IEC 60870-5-103, LON and DNP 3.0
The Serial and LON communication module (SLM) is used for SPA, IEC 60870-5-103, DNP3 and LON communication. SLM has two optical communication ports for plastic/plastic, plastic/glass or glass/glass fiber cables. One port is used for serial communication (SPA, IEC 60870-5-103 or DNP3 port) and the other port is used for LON communication.

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

Alternative modules are:

Short range LDCM (820 nm multi mode fiber),

Medium range (1310 nm single mode fiber)

and Long range (1550 nm single mode fiber) .

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.

The Pulse Per Second (PPS) input is supported.

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

Transformer input module TRM
The transformer input module is used to galvanically separate and adapt the secondary currents and voltages generated by the measuring transformers. The module has twelve inputs in different combinations of currents and voltage inputs. Either protection class or metering class CT inputs are available.

Ring lug or compression type connectors can be ordered.

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

Layout and dimensions

Dimensions

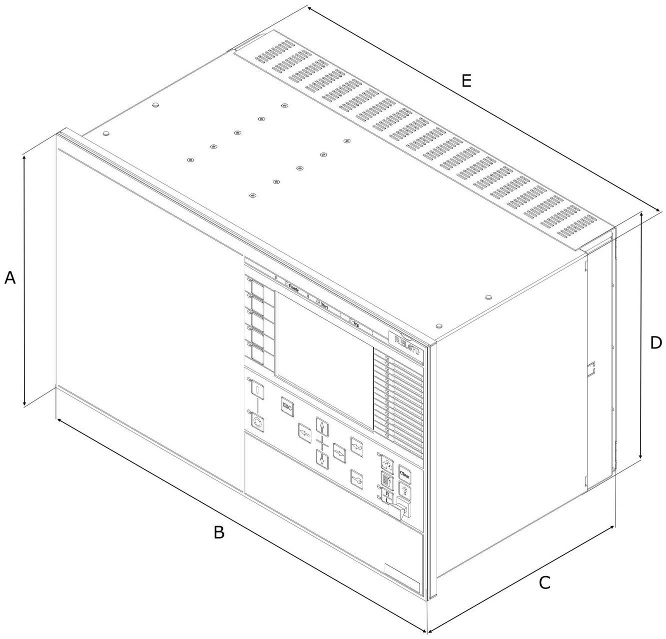


Figure 10. Case with rear cover

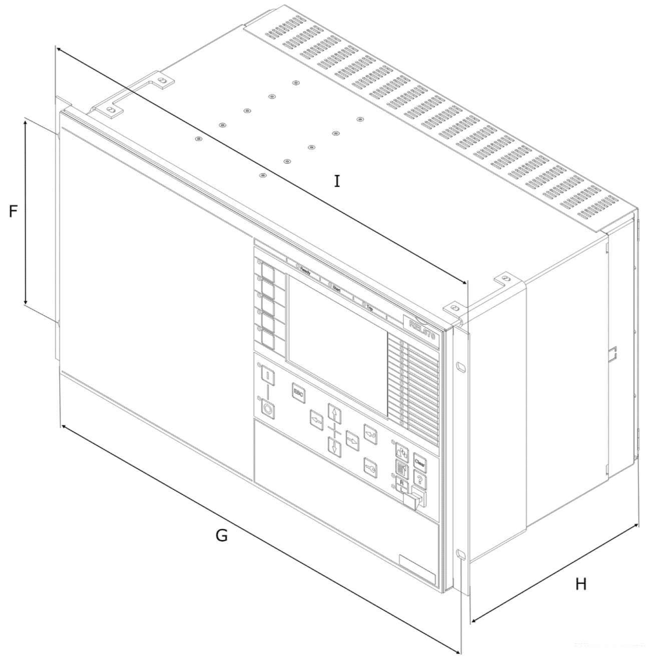


Figure 11. Case with rear cover and 19” rack mounting kit

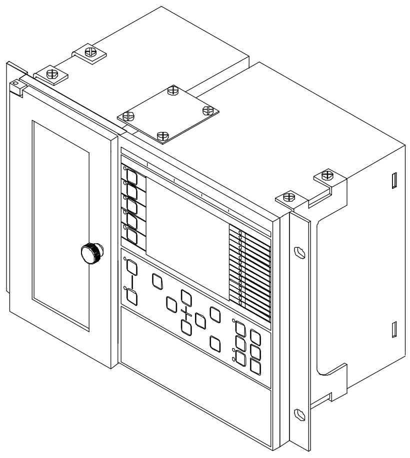


Figure 12. A 1/2 x 19” size IED side-by-side with RHGS6.

Table 10. Case dimensions

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

Mounting alternatives
- 19” rack mounting kit
- Flush mounting kit with cut-out dimensions:
  - 1/2 case size (h) 254.3 mm/10.01” (w) 210.1 mm/8.27”
  - 1/1 case size (h) 254.3 mm/10.01” (w) 434.7 mm/17.11”
- Wall mounting kit

See ordering for details about available mounting alternatives.

Injection equipment hardware

Injection unit REX060

The injection unit REX060 is used to inject voltage and current signals to the generator or motor stator and rotor circuits. REX060 generates two square wave signals with different frequencies for injection into the stator and rotor circuits respectively. The response from the injected voltage and currents are then measured by the REX060 unit and amplified to a level suitable for the analog voltage inputs of IED.

Stator injection module SIM

The SIM module is installed into the REX060 enclosure. The SIM module generates a square wave voltage signal for injection into the stator circuit via the neutral point VT/NGT. The SIM module measures the voltage and current from the injected signal and the IED consecutively calculates the stator to earth impedance. If the calculated impedance is lower than the preset value an ALARM and/or TRIP output is set.

Rotor injection module RIM

The RIM module is installed into the REX060 enclosure. The RIM module generates a square wave voltage signal for injection into the rotor circuit via a capacitor unit REX061 for isolation. The RIM module measures the voltage and current from the injected signal and the IED consecutively calculates the rotor to earth impedance. If the calculated impedance is lower than the preset value an ALARM and/or TRIP output is set.

Coupling capacitor unit REX061
REX061 isolates the injection circuit from the rotor exciter voltage.

The REX061 coupling capacitor unit grounding point and grounding brush of the rotor shaft should be properly interconnected to grant the grounding of the REX061 case to the same ground of the generator.

Shunt resistor unit REX062
REX062 is always required for the stator protection and it allows the injection via the Signal Injection Transformer.

COMBIFLEX Injection equipment
RXTTE4 and optional protective resistor are used to inject fundamental frequency AC voltage into the rotor circuit.

24. Connection diagrams

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

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

Connection diagrams for IEC Customized products

Connection diagram, 670 series 2.2 1MRK002801-AG

Connection diagrams for Configured products

Connection diagram, REG670 2.2, A20X00 1MRK002807-GA

Connection diagram, REG670 2.2, B30X00 1MRK002807-GB

Connection diagram, REG670 2.2, C30X00 1MRK002807-GC

Connection diagrams for ANSI Customized products

Connection diagram, 670 series 2.2 1MRK002802-AG

Connection diagrams for Injection equipment

Connection diagram, Injection unit REX060 1MRK002501-BA

Connection diagram, Generator protection REG670 with injection unit REX060 1MRK002504-BA

Connection diagram, Injection unit REX060 and coupling capacitor unit REX061 1MRK002504-CA

Connection diagram, Injection unit REX060 and optional shunt resistor unit REX062 1MRK002504-DA

Connection diagram, Coupling capacitor unit REX061 1MRK002551-BA

Connection diagram, Shunt resistor unit REX062 1MRK002556-BA

25. Certification

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

UL certification* for Relion® 670 series	E502400
IEC 60255-1 Environmental & functional issued by DNV GL	1418-18 1446-18
G3 Compliance Certificate Sulphur dioxide test for contacts and connections Hydrogen sulphide test for contacts and connections Flowing mixed gas corrosion test	IEC 60068-2-42: 2003 IEC 60068-2-43: 2003 IEC 60068-2-60: 2015
IEC 61850 Ed2 level A1 certificate issued by DNV GL	10289889-INC-21-2985
IEC 61850 Ed1 level B1 certificate issued by Hitachi ABB Power Grids, SVC Baden	1KHL050134
IEC 62439-3 Ed3 certificate issued by DNV GL	10257149-INC 21-2619rev1
IEC 60870-5-103 certificate issued by DNV GL	10021419-OPE/INC 16-2490
DNP 3.0 certificate issued by DNV GL	10021419-OPE/INC 16-2532
IEEE Synchrophasor certificate issued by IEEE SA	IEC/IEEE 60255-118-1:2018, Test report no.: 2020004393
* Valid for IEDs produced at factory in Sweden.	

26. Technical data

General

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

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

Presumptions for Technical Data

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

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

Energizing quantities, rated values and limits

Analog inputs

Table 11. 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 12. 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

Table 12. TRM - Energizing quantities, rated values and limits for measuring transformer , continued

Description	Value	
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 13. MIM - mA input module

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

Auxiliary DC voltage

Table 14. PSM - Power supply module

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

Binary inputs and outputs

Table 15. 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	 -

Table 15. BIM - Binary input module, continued

Quantity	Rated value	Nominal range
Counter input frequency	10 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	
*Debounce filter	Settable 1–20 ms	
Binary input operate time (Debounce filter set to 0 ms)	3 ms	-
* Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.		

Table 16. BIM - Binary input module with enhanced pulse counting capabilities

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

Table 17. IOM - Binary input/output module

Quantity	Rated value	Nominal range
Binary inputs	8	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V, 50 mA 48/60 V, 50 mA 110/125 V, 50 mA 220/250 V, 50 mA 220/250 V, 110 mA	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.5 W/input	-
Counter input frequency	10 pulses/s max	
Oscillating signal discriminator	Blocking settable 1-40 Hz Release settable 1-30 Hz	

Table 17. IOM - Binary input/output module, continued

Quantity	Rated value	Nominal range
*Debounce filter	Settable 1-20 ms	
Binary input operate time (Debounce filter set to 0 ms)	3 ms	-
* Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.		

Table 18. IOM - Binary input/output module contact data (reference standard: IEC 61810-1)

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

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

Table 19. IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-1)

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

Table 20. SOM - Static Output Module data (reference standard: IEC 61810-1): Heavy duty static binary outputs

Function of quantity	Static binary output trip
Max system voltage	250 V DC
Number of outputs	6
Impedance open state	High impedance
Test voltage across open contact, 1 min	350 V rms
Current carrying capacity: Continuous 1.0 s	 6 A 20 A

Table 20. SOM - Static Output Module data (reference standard: IEC 61810-1): Heavy duty static binary outputs, continued

Function of quantity	Static binary output trip
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 30 A 20 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 20 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 20 A
Breaking capacity for DC with L/R ≤ 40 ms (Auto-reclose scheme) (On ≤ 0.2 s) 0.2 s – on 0.2 s – off 0.2 s – on 20 s – off 0.2 s – on 30 s – off 0.2 s – on 120 s – off (for thermal dissipation)	24-60 V / 30 A 110-125 V / 20 A 220-250 V / 10 A
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1) 4 operations/min and 2 min pause for thermal dissipation	6 A
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A
Breaking capacity at resistive load	6 A
Max operations with inductive load L/R ≤ 40 ms	1000
Max operations with resistive load	2000
Max operations with resistive load (On ≤ 0.2 s)	10000
Max operations with no load	30 million
Operating time	< 1 ms

Table 21. SOM - Static Output module data (reference standard: IEC 61810-1): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250 V AC/DC
Min load voltage	24 V DC
Number of outputs	6
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 8 A 10 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 30 A 10 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 10 A

Table 21. SOM - Static Output module data (reference standard: IEC 61810-1): Electromechanical relay outputs, continued

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

Table 22. BOM - Binary output module contact data (reference standard: IEC 61810-1)

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

Table 22. BOM - Binary output module contact data (reference standard: IEC 61810-1), continued

Function or quantity	Trip and Signal relays
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A
Breaking capacity for DC with resistive load	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A
Operating time	< 6 ms

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

Table 23. IRF - Internal Fail relay output

Quantity	Rated value
Max. system voltage	250 V DC
Min. load voltage	24 V DC
Number of outputs	1
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 4 A 8 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 20 A 8 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 20 A 8 A
Making capacity at resistive load 0.2 s 1.0 s	 20 A 8 A
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1)	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Breaking capacity for DC with L/R=100 ms	110 V/0.3 A
Breaking capacity for DC with resistive load	48 V/2 A 110 V/0.5 A 125 V/0.45 A 220 V/0.35 A 250 V/0.3 A
Max. operations with inductive load L/R ≤ 40 ms	1000
Max. operations with resistive load	2000
Max. operations with no load	30 million

Influencing factors

Table 24. Temperature and humidity influence

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

Table 25. Auxiliary DC supply voltage influence on functionality during operation

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

Table 26. Frequency influence (reference standard: IEC 60255–1)

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±1.0%/Hz
Frequency dependence for distance protection operate value	f_r ±2.5 Hz for 50 Hz f_r ±3.0 Hz for 60 Hz	±2.0%/Hz
Harmonic frequency dependence (20% content)	2^{nd}, 3^{rd} and 5^{th} harmonic of f_r	±2.0%
Harmonic frequency dependence for distance protection (10% content)	2nd, 3rd and 5^{th} harmonic of f_r	±10.0%
Harmonic frequency dependence for high impedance differential protection (10% content)	2^{nd}, 3rd and 5^{th} harmonic of f_r	±10.0%
Harmonic frequency dependence for overcurrent protection	2^{nd}, 3^{rd} and 5^{th} harmonic of f_r	±3.0%

Type tests according to standards

Table 27. Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-26
100 kHz slow damped oscillatory wave immunity test	2.5 kV	IEC 61000-4-18, Level 3
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Level 4

Table 27. Electromagnetic compatibility, continued

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

Table 28. Insulation

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

Table 29. Environmental conditions

Description	Value
Operating temperature range	-25°C to +55°C (continuous)
Short-time service temperature range	-40°C to +70°C (<16h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25°C to +55°C
Relative humidity	<93%, non-condensing

Table 29. Environmental conditions, continued

Description	Value
Atmospheric pressure	86 kPa to 106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40°C to +85°C

Table 30. Environmental tests

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

Table 31. CE compliance

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

Table 32. Mechanical tests

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

Injection equipment

Table 33. Electromagnetic compatibility tests

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
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 C37.90.3
Fast transient disturbance test	4 kV	IEC 60255-26, Zone A
Surge immunity test	1-2 kV, and 2-4 kV, 1.2/50 μs High energy	IEC 60255-26, Zone A
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-26, Zone A
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8
Radiated electromagnetic field disturbance test	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-26
Radiated electromagnetic field disturbance test	20 V/m, 80-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance test	10 V, 0.15-80 MHz	IEC 60255-26
Voltage dips and short interruptions	Dips: 40% /200 ms 70% /500 ms Interruptions: 0-50 ms: No restart 0… ∞ s: Correct behaviour at power down	IEC 60255-26
Radiated emission	30-1000 MHz	IEC 60255-26
Conducted emission	0.15-30 MHz	IEC 60255-26

Table 34. Insulation tests, REX060, REX062 and REG670

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min	IEC 60255-27
Impulse voltage test	5.0 kV, 1.2/50 μs, 0.5 J	IEC 60255-27
Insulation resistance	>100 MΩ at 500V DC	IEC 60255-27

Table 35. Insulation tests, REX061

Test	Type test values	Reference standard
Dielectric test	7.48 kV DC, 1min (connections to rotor) 2.8 kV DC, 1 min	IEEE 421.3 IEC 60255-27
Impulse voltage test	12.0 kV, 1.2/50 μs, 0.5 J (connections to rotor) 5.0 kV, 1.2/50 μs, 0.5 J	IEC 60664-1 IEC 60255-27
Insulation resistance	>100 MΩ at 500V DC	IEC 60255-27

Table 36. Mechanical tests

Test	Type test value	Reference standard
Vibration response test	Class 2	IEC 60255-21-1
Vibration endurance test REX060 REX061 and REX062	 Class 1 Class 2	IEC 60255-21-1
Shock response test REX060 REX061 and REX062	 Class 1 Class 2	IEC 60255-21-2
Shock withstand test REX060 REX061 and REX062	 Class 1 Class 2	IEC 60255-21-2
Bump test REX060 REX061 and REX062	 Class 1 Class 2	IEC 60255-21-2
Seismic test REG670 and REX060 REX061 and REX062	 Class 2 Class 2 extended	IEC 60255-21-3

Table 37. Environmental tests

Test	Type test value	Reference standard
Cold test operation storage	 16 h at -25°C 16 h at -40°C	IEC 60068-2-1
Dry heat test operation storage	 16 h at +70°C 16 h at +85°C	IEC 60068-2-2
Damp heat test steady state cyclic	 240 h at +40ºC humidity 93% 6 cycles at +25 to +55ºC humidity 93-95%	IEC 60068-2-78 IEC 60068-2-30

Table 38. Auxiliary DC supply voltage influence

Test	Type test values	Influence
Auxiliary voltage dependence, operate value	±20% of EL	0.01%/%
Ripple in DC auxiliary voltage, operate value	15% of EL	0.01%/%

Table 39. Temperature influence

Test	Type test values	Influence
Ambient temperature, operate value	-25°C to +55°C	0.02%/°C
Storage temperature	-40°C to +85°C	-

Table 40. Degree of protection

Description	Values
REX060 Front Panel mounted, front Rear, sides, top, bottom and connection terminals	 IP40 IP54 IP20
REX061 and REX062 Top Front, rear, sides and bottom	 IP41 IP20

Differential protection

Table 41. Generator differential protection GENPDIF

Function	Range or value	Accuracy
Operating Characteristic	Default Settings	IEC 60255-187-1 ±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Unrestrained differential current limit	(1-50)p.u. of *IBase* on terminal side	±1.0% of set value
Reset ratio	> 95%	-
Minimum pickup	(0.05–1.00)p.u. of *IBase*	±1.0% of I_r
Negative sequence current level	(0.02–0.20)p.u. of *IBase*	±1.0% of I_r
Operate time at 0 to 2 x IdMin restrained function	Min. = 25 ms Max. = 35 ms	-
Reset time at 2 x IdMin to 0 restrained function	Min. = 10 ms Max. = 25 ms	-
Operate time at 0 to 5 x IdUnre unrestrained function	Min. = 5 ms Max. = 15 ms	-
Reset time at 5 x IdUnre to 0 unrestrained function	Min. = 15 ms Max. = 30 ms	-
Critical impulse time, unrestrained function	2 ms typically at 0 to 5 x IdUnre	-
Impulse margin time unrestrained function	10 ms typically	-
Operate time at 0 to 5 x IMinNegSeq Negative sequence unrestrained function	Min. = 25 ms Max. = 35 ms	-
Reset time at 5 x IMinNegSeq to 0 Negative sequence unrestrained function	Min. = 30 ms Max. = 45 ms	-

Table 42. Transformer differential protection T2WPDIF/T3WPDIF

Function	Range or value	Accuracy
Operating characteristic	Default Settings	IEC 60255-187-1 ±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Reset ratio	> 90%	-
Unrestrained differential current limit	(100-5000)% of*IBase* on high voltage winding	±1.0% of set value
Minimum pickup	(10-60)% of IBase	±1.0% of I r
Second harmonic blocking	(5.0-100.0)% of fundamental differential current	±1.0% of I_r Note: fundamental magnitude = 100% of I_r
Fifth harmonic blocking	(5.0-100.0)% of fundamental differential current	±5.0% of I_r Note: fundamental magnitude = 100% of I_r
Connection type for each of the windings	Y or D	-
Phase displacement between high voltage winding, W1 and each of the windings, W2 and W3. Hour notation	0–11	-

Table 42. Transformer differential protection T2WPDIF/T3WPDIF , continued

Function	Range or value	Accuracy
*Operate time at 0 to 10 x IdMin, restrained function	Min. = 25 ms Max. = 35 ms	-
*Reset time at 10 x IdMin to 0, restrained function	Min. = 5 ms Max. = 15 ms	-
*Operate time at 0 to 10 x Idunre, unrestrained function	Min. = 5 ms Max. = 15 ms	-
*Reset time at 10 x Idunre to 0, unrestrained function	Min. = 15 ms Max. = 35 ms	-
**Operate time, unrestrained negative sequence function	Min. = 10 ms Max. = 20 ms	-
**Reset time, unrestrained negative sequence function	Min. = 10 ms Max. = 30 ms	-
Critical impulse time	2 ms typically at 0 to 5 x IdMin	-
*Note: Data obtained with single three-phase input current group. The operate and reset times for T2WPDIF/T3WPDIF are valid for an static output from SOM. **Note: Data obtained with two three-phase input current groups. The rated symmetrical currents are applied on both sides as pre- and after-fault currents. The fault is performed by increasing one phase current to double on one side and decreasing same phase current to zero on the other side.		

Table 43. Restricted earth-fault protection, low impedance REFPDIF

Function	Range or value	Accuracy
Operating characteristic	Default Settings	IEC 60255-187-1 ±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Minimum pickup, IdMin	(4.0-100.0)% of IBase	±1.0% of I_r
Directional characteristic	Fixed 180 degrees or ±60 to ±119 degrees	±2.0 degrees
Operate time, trip at 0 to 10 x IdMin	Min. = 15 ms Max. = 30 ms	-
Reset time, trip at 10 x IdMin to 0	Min. = 15 ms Max. = 30 ms	-
Second harmonic blocking	40.0% of fundamental	±1.0% of I_r

Table 44. High impedance differential protection, single phase HZPDIF

Function	Range or value	Accuracy
Operate voltage	(10-900) V I=U/R	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	>95% at (30-900) V	-
Maximum continuous power	See[1)]	-
Operate time at 0 to 10 x U_d	Min. = 5 ms Max. = 15 ms	
Reset time at 10 x U_d to 0	Min. = 75 ms Max. = 95 ms	

Table 44. High impedance differential protection, single phase HZPDIF , continued

Function	Range or value	Accuracy
Critical impulse time	2 ms typically at 0 to 10 x U_d	-
Operate time at 0 to 2 x U_d	Min. = 25 ms Max. = 35 ms	
Reset time at 2 x U_d to 0	Min. = 50 ms Max. = 70 ms	
Critical impulse time	15 ms typically at 0 to 2 x U_d	-

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

Impedance protection

Table 45. Full-scheme distance protection, Mho characteristic ZMHPDIS

<table>
<tr><th>Function</th><th>Range or value</th><th>Accuracy</th></tr>
<tr><td>Number of zones, Ph-E</td><td>Max 4 with selectable direction</td><td>-</td></tr>
<tr><td>Minimum operate current</td><td>(10–30)% of IBase</td><td>-</td></tr>
<tr><td>Positive sequence impedance, Ph-E loop</td><td>(0.005–3000.000) Ω/phase</td><td rowspan="5">±2.0% static accuracy
Conditions:
Voltage range: (0.1-1.1) x U_r
Current range: (0.5-30) x I_r
Angle: 85 degrees</td></tr>
<tr><td>Positive sequence impedance angle, Ph-E loop</td><td>(10–90) degrees</td></tr>
<tr><td>Reverse reach, Ph-E loop (Magnitude)</td><td>(0.005–3000.000) Ω/phase</td></tr>
<tr><td>Magnitude of earth return compensation factor KN</td><td>(0.00–3.00)</td></tr>
<tr><td>Angle for earth compensation factor KN</td><td>(-180–180) degrees</td></tr>
<tr><td>Dynamic overreach</td><td><5% at 85 degrees measured with CVT’s and 0.5<SIR<30</td><td>-</td></tr>
<tr><td>Definite time delay Ph-Ph and Ph-E operation</td><td>(0.000-60.000) s</td><td>±0.2% or ±60 ms whichever is greater</td></tr>
<tr><td>Operate time</td><td>22 ms typically</td><td>IEC 60255-121</td></tr>
<tr><td>Reset ratio</td><td>105% typically</td><td>-</td></tr>
<tr><td>Reset time at 0.5 x Zreach to 1.5 x Zreach</td><td>Min. = 30 ms
Max. = 50 ms</td><td>-</td></tr>
</table>

Table 46. High speed distance protection ZMFPDIS, ZMFCPDIS

<table>
<tr><th>Function</th><th>Range or value</th><th colspan="2">Accuracy</th></tr>
<tr><td>Number of zones</td><td>5 selectable directions, 2 fixed directions</td><td colspan="2">-</td></tr>
<tr><td>Minimum operate current, Ph-Ph and Ph-E</td><td>(5-6000)% of IBase</td><td colspan="2">±1.0% of I_r</td></tr>
<tr><td>Positive sequence reactance reach, Ph-E and Ph-Ph loop</td><td>(0.01 - 3000.00) ohm/p</td><td rowspan="5">Pseudo continuous ramp:
±2.0% of set value
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
IEC 60255-121 points A,B,C,D,E</td><td rowspan="5">Ramp of shots:
±2.0% of set value
Conditions:
IEC 60255-121 point B</td></tr>
<tr><td>Positive sequence resistance reach, Ph-E and Ph-Ph loop</td><td>(0.00 - 1000.00) ohm/p</td></tr>
<tr><td>Zero sequence reactance reach</td><td>(0.01 - 9000.00) ohm/p</td></tr>
<tr><td>Zero sequence resistive reach</td><td>(0.00 - 3000.00) ohm/p</td></tr>
<tr><td>Fault resistance reach, Ph-E and Ph-Ph</td><td>(0.01 -9000.00) ohm/l</td></tr>
<tr><td>Dynamic overreach</td><td>< 5% at 85 degrees measured with CVTs and 0.5 < SIR < 30, IEC 60255-121</td><td colspan="2">-</td></tr>
<tr><td>Reset ratio</td><td>105% typically</td><td colspan="2">-</td></tr>
</table>

Table 46. High speed distance protection ZMFPDIS, ZMFCPDIS, continued

Function	Range or value	Accuracy	
Directional blinders	Forward: -15 – 120 degrees Reverse: 165 – -60 degrees	**Pseudo continuous ramp:** ±2.0 degrees, IEC 60255-121	
Resistance determining the load impedance area - forward	(0.01 - 5000.00) ohm/p	**Pseudo continuous ramp:** ±2.0% of set value **Conditions:** Tested at ArgLd = 30 degrees	**Ramp of shots:** ±5.0% of set value **Conditions:** Tested at ArgLd = 30 degrees
Angle determining the load impedance area	5 - 70 degrees	**Pseudo continuous ramp:** ±2.0 degrees **Conditions:** Tested at RLdFw = 20 ohm/p	
Definite time delay to trip, Ph-E and Ph-Ph operation	(0.000-60.000) s	±0.2% of set value or ±35 ms whichever is greater	
Operate time	16 ms typically, IEC 60255-121	-	
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-	

Table 47. Pole slip protection PSPPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00 - 1000.00)% of Zbase	±2.0% of U_r/I_r
Zone 1 and Zone 2 trip counters	(1 - 20)	-

Table 48. 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)	-

Table 49. Loss of excitation LEXPDIS

Function	Range or value	Accuracy
X offset of Mho top point for zone 1 and zone 2	(–100.0–100.0)% of Z_{Base}	±2.0% of $U_r/(\sqrt{3} \cdot I_r)$
Diameter of Mho circle for zone 1 and zone 2	(30.0–300.0)% of Z_{Base}	±2.0% of $U_r/(\sqrt{3} \cdot I_r)$
Independent time delay for zone 1 when impedance jumps from the outside the set circle to the center of the set circle	(0.00-60.00) s	±0.2% or ±60 ms whichever is greater
Independent time delay for zone 2 when impedance jumps from the outside the set circle to the center of the set circle	(0.00-60.00) s	±0.2% or ±60 ms whichever is greater
Operate time, start when impedance jumps from the outside the set circle to the center of the set circle	Min. = 35 ms Max. = 50 ms	-

Table 50. ROTIPHIZ technical data

Function	Range or value	Accuracy
Fault resistance sensitivity	Can be reached at steady state operating condition of the machine	500 kΩ
	Typically	50 kΩ
Injection frequency	(75.000 - 250.000) Hz	±0.1 Hz
Trip limit of fault resistance	(100 - 100000)Ω	5% of 1 kΩ at $R_f \leq 1$ kΩ 5% of set value at 1 kΩ < $R_f \leq 20$ kΩ 10% of set value at $R_f > 20$ kΩ
Alarm limit of fault resistance	(100 - 500000)Ω	5% of 1 kΩ at $R_f \leq 1$ kΩ 5% of 10 kΩ at 1 kΩ < $R_f \leq 20$ kΩ 10% of set value at 20 kΩ < $R_f \leq 200$ kΩ
Operate time, start at R_f ~ 0 Ω and filter length = 1 s	1.00 s typically	-
Operate time, trip at R_f ~ 0 Ω and filter length = 1 s	3.00 s typically	-
Alarm time delay at R_f ~ 0 Ω and filter length = 1 s	(0.00 - 600.00) s	±0.2% or ±2.00 s whichever is greater

Table 51. STTIPHIZ technical data

Function	Range or value	Accuracy
Fault resistance sensitivity	Can be reached at steady state operating condition of the machine	50 kΩ
	Typically	10 kΩ
Injection frequency	(50.000 - 250.000) Hz	±0.1 Hz
Injection voltage	240 V	
Trip limit of fault resistance	(100 - 10000) Ω	±5% of 1 kΩ at $R_f \leq 1$ kΩ ±10% of set value at $R_f > 1$ kΩ

Table 51. STTIPHIZ technical data, continued

Function	Range or value	Accuracy
Alarm limit of fault resistance	(100 - 50000) Ω	±5% of 1 kΩ at R_f ≤ 1 kΩ ±10% of 10 kΩ at 1 kΩ < R_f ≤ 10 kΩ ±50% of set value at R_f > 10 kΩ
Operate time, start at R_f ~ 0Ω and filter length = 1 s	1.00 s typically	-
Operate time, trip at R_f ~ 0Ω and filter length = 1 s	3.00 s typically	-
Alarm time delay at R_f ~ 0Ω and filter length = 1 s	(0.00 - 600.00) s	±0.2% or ± 2.00 s whichever is greater
Trip pulse length	(0.10-60.00) s	±0.2% or ±15 ms
Blocking time interval after reference impedance switch	(0-600) s	±0.2% or ±30 ms
Voltage amplitude for harmonic crossing block	(10-10000) V	±0.5% of U_r

Table 52. Underimpedance protection for generators and transformers ZGVPDIS

Function	Range or value	Accuracy
Number of zones	3	-
Forward reach	(3.0 - 200.0)% of Z_r where Z_r=UBase/√3*IBase	±5.0% of set impedance Conditions: Voltage range: (0.1 - 1.1) x U_r Current range: (0.5 - 30) x I_r
Reverse reach	(3.0 - 200.0)% of Z_r where Z_r=UBase/√3*IBase	±5.0% of set impedance Conditions: Voltage range: (0.1 - 1.1) x U_r Current range: (0.5 - 30) x I_r
Impedance angle	(5 - 90) degrees	-
Reset ratio	105% typically	-
Start time at 1.2 x set impedance to 0.8 x set impedance	Min. = 15 ms Max. = 35 ms	-
Independent time delay to operate at 1.2 x set impedance to 0.8 x set impedance	(0.000 – 60.000) s	±0.2% or ±40 ms whichever is greater

Wide area measurement system

Table 53. Protocol reporting via IEEE 1344 and IEC/IEEE 60255-118 (C37.118) PMUREPORT

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

Current protection

Table 54. Instantaneous phase overcurrent protection PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of IBase	-
Operate time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 15 ms	-
Reset time at 10 x I_{set} to 0	Min. = 25 ms Max. = 40 ms	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 55. Directional phase overcurrent protection, four steps OC4PTOC

Function	Range or value	Accuracy
Operate current, step 1-4	(5-2500)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Minimum operate current, step 1-4	(1-10000)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(40.0–65.0) degrees	±2.0 degrees
Relay operating angle (ROA)	(40.0–89.0) degrees	±2.0 degrees
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Independent time delay at 0 to 2 x I_{set}, step 1-4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves , step 1-4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see table 200, table 201 and table 202	16 curve types	See table 200, table 201 and table 202
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}	-

Table 55. Directional phase overcurrent protection, four steps OC4PTOC , continued

Function	Range or value	Accuracy
Impulse margin time	15 ms typically	-
Operate frequency, directional overcurrent	38-83 Hz	-
Operate frequency, non-directional overcurrent	10-90 Hz	-

Table 56. Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of lBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (50–2500)% of lBase	-
Operate time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time at 2 x I_{set} to 0	Min. = 15 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 15 ms	-
Reset time at 10 x I_{set} to 0	Min. = 25 ms Max. = 35 ms	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 57. Directional residual overcurrent protection, four steps EF4PTOC

Function	Range or value	Accuracy
Operate current, step 1-4	(1-2500)% of lBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (10-2500)% of lBase	-
Relay characteristic angle (RCA)	(-180 to 180) degrees	±2.0 degrees
Operate current for directional release	(1–100)% of lBase	For RCA ±60 degrees: ±2.5% of I_r at I ≤ I_r ±2.5% of I at I > I_r
Independent time delay at 0 to 2 x I_{set}, step 1-4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1-4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Definite Reset Time	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.8) x I_{set}	±0.2% or ±40 ms whichever is greater
Operate time for I_{set} = 1% (ANSI)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±10.0% or ±40 ms whichever is greater
Reset time for I_{set} = 1% (ANSI)	0.01 ≤ k ≤ 15.00, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±12.0% or ±160 ms whichever is greater.

Table 57. Directional residual overcurrent protection, four steps EF4PTOC , continued

Function	Range or value	Accuracy
Operate time for I_{set} = 1% (IEC)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±8.0% or ±100 ms whichever is greater
Reset time for I_{set} = 1% (IEC)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Operate time for I_{set} = 1% (RI&RD)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±2.0% or ±40 ms whichever is greater
Reset time for I_{set} = 1% (RI&RD)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Inverse time characteristics, see Table 200, Table 201 and Table 202	16 curve types	See Table 200, Table 201 and Table 202
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 58. Four step directional negative phase sequence overcurrent protection NS4PTOC

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

Table 58. Four step directional negative phase sequence overcurrent protection NS4PTOC , continued

Function	Range or value	Accuracy
Reset time for I_{set} = 1% (ANSI)	0.01 ≤ k ≤ 15.00, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±12.0% or ±160 ms whichever is greater.
Operate time for I_{set} = 1% (IEC)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±8.0% or ±100 ms whichever is greater
Reset time for I_{set} = 1% (IEC)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Operate time for I_{set} = 1% (RI&RD)	0.01 ≤ k ≤ 15.00, 0.0 x I_{set} to (2.0 - 20.0) x I_{set}	±2.0% or ±40 ms whichever is greater
Reset time for I_{set} = 1% (RI&RD)	0.000 ≤ tReset ≤ 60.000, 2.0 x I_{set} to (0 - 0.4) x I_{set}	±0.2% or ±50 ms whichever is greater
Inverse time characteristics, see table 200, table 201 and table 202	16 curve types	See table 200, table 201 and table 202
Minimum operate current, step 1 - 4	(1.00 - 10000.00)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±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 $I \leq I_r$ ±2.5% of I at $I > I_r$
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 59. 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 $I \leq I_r$ ±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 $S \leq S_r$ ±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 $\leq I_r$ ±1.0% of I at $I > I_r$

Table 59. Sensitive directional residual overcurrent and power protection SDEPSDE, continued

Function	Range or value	Accuracy
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 I_{set}	Min. = 40 ms Max. = 65 ms	
Reset time for non-directional residual overcurrent at 2 x I_{set} to 0	Min. = 40 ms Max. = 65 ms	
Operate time for directional residual overcurrent at 0 to 2 x I_{set}	Min. = 110 ms Max. = 160 ms	
Reset time for directional residual overcurrent at 2 x I_{set} to 0	Min. = 20 ms Max. = 60 ms	
Independent time delay for non-directional residual overvoltage at 0.8 x U_{set} to 1.2 x U_{set}	(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 I_{set}	(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 I_{set}	(0.000 – 60.000) s	±0.2% or ± 170 ms whichever is greater
Inverse time characteristics, see table 203, Table 204 and Table 205	16 curve types	See Table 203, Table 204 and Table 205
Relay characteristic angle (RCADir)	(-179 to 180) degrees	±2.0 degrees
Relay operate angle (ROADir)	(0 to 90) degrees	±2.0 degrees

Table 60. Thermal overload protection, two time constants TRPTTR

Function	Range or value	Accuracy
Base current 1 and 2	(30–250)% of *IBase*	±1.0% of I_r
Operate time: $$t = \tau \cdot ln\left(\frac{I^2 - I_p{}^2}{I^2 - I_{Trip}{}^2}\right)$$ (Equation 1) I = actual measured current Ip = load current before overload occurs ITrip = steady state operate current level in % of *IBasex*	Time constant τ = (0.10–500.00) minutes	IEC 60255-149, ±5.0% or 250 ms whichever is greater
Alarm level 1 and 2	(50–99)% of heat content operate value	±2.0% of heat content trip
Operate current	(50–250)% of *IBase*	±1.0% of I_r
Reset level temperature	(10–95)% of heat content trip	±2.0% of heat content trip

Table 61. Breaker failure protection CCRBRF

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

Table 62. Pole discordance protection CCPDSC

Function	Range or value	Accuracy
Operate current	(0–100)% of *IBase*	±1.0% of I_r
Independent time delay between trip condition and trip signal	(0.000-60.000) s	±0.2% or ± 30 ms whichever is greater

Table 63. 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 x S_r to 0.5 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 64. Directional overpower protection GOPPDOP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of SBase When measuring transformer inputs are used, the following accuracy can be obtained for low pickup settings which are typical for reverse power protection application:	±1.0% of S_r at $S \le S_r$ ±1.0% of S at $S > S_r$ Start value P=0.5% of S_r Pickup accuracy of ±0.20% of S_r*) Start value P=0.2% of S_r Pickup accuracy of ±0.15% of 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
Operate time, start at 0.5 x S_r to 2 x S_r and *k=0.000*	Min. =10 ms Max. = 25 ms	
Reset time, start at 2 x S_r to 0.5 x S_r and *k=0.000*	Min. = 35 ms Max. = 55 ms	
Independent time delay to operate for Step 1 and Step 2 at 0.5 x S_r to 2 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater
*) To achieve this accuracy for reverse power protection it is also recommended to apply settings *k=0.990* and *Mode=PosSeq*. These settings will help to minimize the overall measurement error ensuring the best accuracy for this application.		

Table 65. Negative sequence time overcurrent protection for machines NS2PTOC

Function	Range or value	Accuracy
Operate current, step 1 - 2	(3-500)% of *IBase*	±1.0% of I_r
Reset ratio	>95%	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-

Table 65. Negative sequence time overcurrent protection for machines NS2PTOC , continued

Function	Range or value	Accuracy
Reset time, start at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Time characteristics	Definite or Inverse	-
Inverse time characteristic, step 1 - 2 $I_2^2 t = K$	K=1.0-99.0	±2.0% or ±40 ms whichever is greater
Reset time, inverse characteristic, step 1 - 2 $I_2^2 t = K$	Reset Multiplier = 0.01-20.00	±10.0% or ±40 ms whichever is greater
Minimum operate time for inverse time characteristic, step 1 - 2	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Maximum trip delay at 0.5 x I_{set} to 2 x I_{set}, step 1 - 2	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay at 0.5 x I_{set} to 2 x I_{set}, step 1 - 2	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay for Alarm at 0.5 x I_{set} to 2 x I_{set}	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater

Table 66. Accidental energizing protection for synchronous generators AEGPVOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-900)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio, overcurrent	>95% at (20–900)% of IBase	-
Transient overreach, overcurrent function	<10% at τ = 100 ms	-
Critical impulse time, overcurrent	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time, overcurrent	15 ms typically	-
Operate value, undervoltage	(2-150)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Critical impulse time, undervoltage	10 ms typically at 2 x U_{set} to 0	-
Impulse margin time, undervoltage	15 ms typically	-
Operate value, overvoltage	(2-200)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Definite time delay, overcurrent, at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Definite time delay, undervoltage, at 1.2 x U_{set} to 0.8 x U_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Definite time delay, overvoltage, at 0.8 x U_{set} to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater

Table 67. Generator stator overload protection GSPTTR

Function	Range or value	Accuracy
Current start level for overload protection	(105.0–900.0)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	>95%	
Start time at 0 to 2 x I_{set}	Min. = 50 ms Max. = 170 ms	
Thermal time characteristic	According to IEEE Std C50.13–2005	±1.5% or ±200 ms whichever is greater
Minimum operate time for thermal characteristic	(1.0–120.0) s	±1.5% or ±200 ms whichever is greater
Maximum operate time for thermal characteristic	(100.0–2000.0) s	±1.5% or ±200 ms whichever is greater

Table 68. Generator rotor overload protection GRPTTR

Function	Range or value	Accuracy
Overcurrent start level for overload protection	(105.0–900.0)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, overcurrent	>95%	—
Start time, overcurrent at 0 to 2 x I_{set}	Min = 50 ms Max = 170 ms	—
Thermal time characteristic	According to IEEE Std C50.13–2005	±1.5% or ±200 ms whichever is greater
Minimum operate time for thermal characteristic	(1.0–120.0) s	±1.5% or ±200 ms whichever is greater
Maximum operate time for thermal characteristic	(100.0–2000.0) s	±1.5% or ±200 ms whichever is greater
Undercurrent start level	(5.0–500.0)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Start time, undercurrent at 2 x I_{set} to 0	Min = 15 ms Max = 30 ms	—
Independent time delay for undercurrent function at 2 x I_{set} to 0	(0.0–600.0) s	±0.2% or ±45 ms whichever is greater

Table 69. Overcurrent protection with binary release BRPTOC

Function	Range or value	Accuracy
Operating current	(5-2500)% of *IBase*	*DFT*: ± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$ *Peak and Peak to peak*: ± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Reset ratio	> 95% at (25-2500)% of *IBase*	-

Table 69. Overcurrent protection with binary release BRPTOC , continued

Function	Range or value	Accuracy
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	*DFT*: ±0.2% or ±30 ms whichever is greater
		Peak to peak: ±0.2% or ±25 ms whichever is greater
		Peak: ±0.2% or ±20 ms whichever is greater
Operate time, start at 0 to 1.2 x I_{set}	*DFT*: Min.= 15 ms Max. = 30 ms	-
	Peak to peak: Min.= 10 ms Max. =25 ms	
	Peak: Min.= 5 ms Max. = 20 ms	
Reset time, start at 1.2 x I_{set} to 0	< 60 ms	-
Operate time, start at 0 to 2 x I_{set}	*DFT*: Min.= 10 ms Max. = 25 ms	-
	Peak to peak: Min.= 5 ms Max. =20 ms	
	Peak: Min.= 5 ms Max. = 15 ms	
Reset time, start at 2 x I_{set} to 0	< 60 ms	-
Operate time, start at 0 to 5 x I_{set}	*DFT*: Min.= 5 ms Max. = 20 ms	-
	Peak to peak: Min.= 5 ms Max. =15 ms	
	Peak: Min.= 5 ms Max. = 10 ms	
Reset time, start at 5 x I_{set} to 0	< 60 ms	-
Critical impulse time	*DFT:* 10 ms typically at 0 to 2 x I_{set}	-
	Peak to peak: 5 ms typically at 0 to 2 x I_{set}	
	Peak: 1 ms typically at 0 to 2 x I_{set}	

Table 70. Voltage-restrained time overcurrent protection VRPVOC

Function	Range or value	Accuracy
Start overcurrent	(20.0 - 5000.0)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio, overcurrent	> 95% at (100 - 1200)% of IBase > 80% at (20 - 99.9)% of IBase	-
Operate time, start overcurrent at 0 to 2 x I_{set}	Min. = 20 ms Max. = 30 ms	-
Reset time, start overcurrent at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start overcurrent at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start overcurrent at 10 x I_{set} to 0	Min. = 25 ms Max. = 35 ms	-
Independent time delay to operate, overcurrent at 0 to 2 x I_{set}	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see tables 200 and 201	13 curve types	See tables 200 and 201
Minimum operate time for inverse time characteristics	(0.00 - 60.00) s	±0.2% or ±35 ms whichever is greater
High voltage limit, voltage dependent operation	(30.0 - 100.0)% of UBase	±1.0% of U_r
Start undervoltage	(2.0 - 100.0)% of UBase	±0.5% of U_r
Reset ratio, undervoltage	< 105% at (10 - 100)% of UBase < 125% at (2 - 9.9)% of UBase	-
Operate time start undervoltage at 2 x U_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Reset time start undervoltage at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Independent time delay to operate, undervoltage at 2 x U_{set} to 0	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Internal low voltage blocking	(1.0 - 5.0)% of UBase	±0.3% of U_r
Overcurrent: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x I_{set} 20 ms typically	-
Undervoltage: Critical impulse time Impulse margin time	 10ms typically at 2 x U_{set} to 0 15 ms typically	-

Table 71. Average Power Transient Earth Fault Protection APPTEF

Function	Range or value	Accuracy
Minimum operate level for residual overvoltage 3Uo> start condition "UN>"	(5-80)% of UBase	±0.5% of Ur
Reset ratio for residual overvoltage 3Uo>	> 75%	-
Operate time for residual overvoltage 3Uo> at 0 to 2 x U_{set}	Min. = 5 ms Max. = 15 ms	-
Minimum threshold level for residual overcurrent start condition "IN>"	(3-100)% of IBase	±1.5% of Ir
Minimum operate level for integrated current to declare the forward direction "IMinForward”	(2.0-100.0)% of IBase	±1.5% of Ir
Minimum operate level for integrated current to declare the reverse direction "IMinReverse"	(2.0-100.0)% of IBase	±1.5% of Ir
Minimum time delay to declare EF direction "tStart"	(0.04-2.00) s	±0.2% or ±25 ms whichever is greater
Minimum trip time delay "tTrip"	(0.00-20.00) s	±0.2% or ±25 ms whichever is greater
Intermittent trip time delay "tTripInterm"	(0.00-20.00) s	±0.2% or ±25 ms whichever is greater
Minimum pulse length duration for trip and/or start outputs "tPulseMin"	(0.02-1.00) s	±0.2% or ±10 ms whichever is greater
Operate 3Io current level for cross country fault detection "CrossCntry_IN>"	(20-1000)% of IBase	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Time delay to activate cross country fault detection "tCC" at 0 to 2 x I_{set}	(0.02-1.00) s	±0.2% or ±25 ms whichever is greater
Drop off time delay to de-activate cross country fault detection at 2 x I_{set} to 0	Fixed 0.2 s	±0.2% or ±25 ms whichever is greater
Operate 3Io current level for circulating current detection "Circulate_IN>"	(2-200)% of IBase	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Time delay to activate circulating current detection "tCircIN" at 0 to 2 x I_{set}	(5.0-60.0) s	±0.2% or ±25 ms whichever is greater
Drop off time delay to de-activate circulating current detection at 2 x I_{set} to 0	Fixed 0.5 s	±0.2% or ±25 ms whichever is greater

Voltage protection

Table 72. 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 209	-	See table 209
Definite time delay, step 1 at 1.2 x U_{set} to 0	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 x U_{set} to 0	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000–60.000) s	±0.5% or ±40ms whichever is greater
Operate time, start at 2 x U_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 1.2 x U_{set} to 0	Min. = 5 ms Max. = 25 ms	-
Reset time, start at 0 to 1.2 x U_{set}	Min. = 15 ms Max. = 35 ms	-
Critical impulse time	5 ms typically at 1.2 x U_{set} to 0	-
Impulse margin time	15 ms typically	-

Table 73. 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 208	-	See table 208
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±45 ms whichever is greater
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Minimum operate time, Inverse characteristics	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 x U_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-

Table 73. Two step overvoltage protection OV2PTOV , continued

Function	Range or value	Accuracy
Reset time, start at 1.2 x U_{set} to 0	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 74. Residual overvoltage protection, two steps ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 - step 2	(1.0-200.0)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0.0–50.0)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Inverse time characteristics for low and high step, see table	-	See table 208
Definite time delay low step (step 1) at 0 to 1.2 x U_{set}	(0.00–6000.00) s	± 0.2% or ± 45 ms whichever is greater
Definite time delay high step (step 2) at 0 to 1.2 x U_{set}	(0.000–60.000) s	± 0.2% or ± 45 ms whichever is greater
Minimum operate time	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 x U_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 x U_{set} to 0	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 75. Overexcitation protection OEXPVPH

Function	Range or value	Accuracy
Operate value, start	(100–180)% of (*UBase*/f_{rated})	±0.5% of U
Operate value, alarm	(50–120)% of start level	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Operate value, high level	(100–200)% of (*UBase*/f_{rated})	±0.5% of U
Reset Ratio	> 99%	
Curve type	IEEE or customer defined $IEEE : t = \frac{(0.18 \cdot k)}{(M-1)^2}$ (Equation 2) where M = (E/f)/(Ur/fr)	±5.0 % or ±45 ms, whichever is greater

Table 75. Overexcitation protection OEXPVPH , continued

Function	Range or value	Accuracy
Minimum time delay for inverse function	(0.000–60.000) s	±1.0% or ±45 ms, whichever is greater
Maximum time delay for inverse function	(0.00–9000.00) s	±1.0% or ±45 ms, whichever is greater
Alarm time delay	(0.00–9000.00)	±1.0% or ±45 ms, whichever is greater

The healthy condition close to the rated values (that is, V/Hz below the set pickup value) must be applied first when the operate time of a function is tested. Otherwise, an additional delay of up to 50 ms should be added to stated operate times.

Table 76. Voltage differential protection VDCPTDV

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

Table 77. 100% Stator E/F 3rd harmonic STEFPHIZ

Function	Range or value	Accuracy
Fundamental frequency level UN (95% Stator EF)	(1.0–50.0)% of *UBase*	±0.25% of U_r
Third harmonic differential level	(0.5–10.0)% of *UBase*	±0.25% of U_r
Third harmonic differential block level	(0.1–10.0)% of *UBase*	±0.25% of U_r
Independent time delay to operate for fundamental UN > protection at 0 to 1.2 x UNFund>	(0.020–60.000) s	±0.2% or ±40 ms whichever is greater
Independent time delay to operate for 3rd harm-based protection at 0 to 5 x UN3rdH<	(0.020–60.000) s	±0.2% or ±40 ms whichever is greater
Filter characteristic: Fundamental Third harmonic	 Reject third harmonic by 1–40 Reject fundamental harmonic by 1–40	-

Frequency protection

Table 78. Underfrequency protection SAPTUF

Function	Range or Value			Accuracy
Operate value, start function, at symmetrical three phase voltage, *StartFrequency* 1)	(35.00 - 75.00) Hz			±2.0 mHz
Reset hysteresis	10.0 mHz fixed			±2.0 mHz
Operate time 1)	fr = 50 Hz	Start time measurement with sudden frequency change	Min. = 175 ms	-
			Max. = 195 ms	
		Start time measurement with frequency ramp	Min. = 70 ms	
			Max. = 90 ms	
	fr = 60 Hz	Start time measurement with sudden frequency change	Min. = 150 ms	-
			Max. = 165 ms	
		Start time measurement with frequency ramp	Min. = 60 ms	
			Max. = 75 ms	
Disengaging time 1)	fr = 50 Hz	Start time measurement with sudden frequency change	Min. = 170 ms	-
			Max. =195 ms	
		Start time measurement with frequency ramp	Min. = 75 ms	
			Max. = 100 ms	
	fr = 60 Hz	Start time measurement with sudden frequency change	Min. = 140 ms	-
			Max. =165 ms	
		Start time measurement with frequency ramp	Min. = 65 ms	
			Max. = 90 ms	
Operate time delay, *tDelay* 1)	fr = 50 Hz	(0.000-60.000)s		±0.2% or ±200 ms whichever is greater
	fr = 60 Hz			±0.2% or ±175 ms whichever is greater
Voltage dependent time delay	Settings: *UNom* = (50-150)% of UBase *UMin* = (50-150)% of UBase *Exponent* = 0.0-5.0 *tMax* = (0.010-60.000)s *tMin* = (0.010- 60.000)s $t = \left[\frac{U - UMin}{UNom - UMin} \right]^{Exponent} \cdot (tMax - tMin) + tMin$ $U = U_{measured}$			±1.0% or ±120 ms whichever is greater
Note: The stated accuracy is valid for the voltage range 50 V – 250 V secondary.				

1) The settings and test conditions are in accordance with IEC 60255-181 standard (section 6.2 – 6.7).

Table 79. Underfrequency protection SAPTOF

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

1) The settings and test conditions are in accordance with IEC 60255-181 standard (section 6.2 – 6.7).

Table 80. Rate-of-change frequency protection SAPFRC

Function	Range and value	Accuracy
Operate value, start function, at symmetrical three phase voltage *, *StartFreqGrad* or *Gs* per IEC 60255-181 standard	Positive gradient: from 0.05 to 10.00 Hz/s ** Negative gradient: from -0.05 to -10.00 Hz/s **	±10.0 mHz/s
Reset hysteresis *	< 15.0 mHz/s	
Operate value, restore enable frequency, at symmetrical three phase voltage, *RestoreFreq*	(45.00 - 65.00) Hz	±2.0 mHz

Table 80. Rate-of-change frequency protection SAPFRC , continued

Function	Range and value			Accuracy
Restore time delay, *tRestore*	fr = 50 Hz	(0.025 - 60.000) s		±0.2% or ±110 ms whichever is greater
Test conditions: Restore time delay measurement with sudden frequency change from *RestoreFreq* -0.02 Hz to *RestoreFreq* + 0.02 Hz	fr = 60 Hz			±0.2% or ±100 ms whichever is greater
Start time *	fr = 50 Hz	Gs: ±0.05 & ±0.50 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 110 ms	
			Max. = 290 ms	
		Gs: ±1.00 Hz/s Tested frequency slope: 1.2, 2.0, 5.0 x Gs	Min. = 180 ms	
			Max. = 300 ms	
		Gs: ±3.00, ±6.00 & ±10.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 300 ms	
			Max. = 390 ms	
	fr = 60 Hz	Gs: ±0.05 & ±0.50 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 90 ms	
			Max. = 220 ms	
		Gs: ±1.00 Hz/s Tested frequency slope: 1.2, 2.0, 5.0 x Gs	Min. = 140 ms	
			Max. = 240 ms	
		Gs: ±3.00, ±6.00 & ±10.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 180 ms	
			Max. = 300 ms	
Disengaging time *	fr = 50 Hz	Gs: ±0.05 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 130 ms	
			Max. = 270 ms	
		Gs: ±5.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 130 ms	
			Max. = 210 ms	
		Gs: ±10.00 Hz/s Tested frequency slope: 1.2 x Gs	Min. = 130 ms	
			Max. = 160 ms	
	fr = 60 Hz	Gs: ±0.05 Hz/s Tested frequency slope: 1.2, 2.0, 5.0, 10.0 x Gs	Min. = 100 ms	
			Max. = 210 ms	
		Gs: ±5.00 Hz/s Tested frequency slope: 1.2, 2.0 x Gs	Min. = 100 ms	
			Max. = 170 ms	
		Gs: ±10.00 Hz/s Tested frequency slope: 1.2 x Gs	Min. = 100 ms	
			Max. = 130 ms	
Operate time delay *, *tDelay* Test conditions: Gs: ± 0.2 Hz/s Frequency slope: 0.4 Hz/s Test points: 10%, 20%, 30%, 50% and 100% of the time delay setting range	fr = 50 Hz	(0.000-60.000) s		±0.2% or ±220 ms whichever is greater
	fr = 60 Hz			±0.2% or ±180 ms whichever is greater

Table 80. Rate-of-change frequency protection SAPFRC , continued

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

Table 81. 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 ±250 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 ±250 ms whichever is greater

Multipurpose protection

Table 82. General current and voltage protection CVGAPC

Function	Range or value	Accuracy
Measuring current input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Measuring voltage input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Start overcurrent, step 1 - 2	(2 - 5000)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Start undercurrent, step 1 - 2	(2 - 150)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Independent time delay, overcurrent at 0 to 2 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undercurrent at 2 x I_{set} to 0, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overcurrent (non-directional):		
Start time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Start time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Undercurrent:		
Start time at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Reset time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Overcurrent: Inverse time characteristics, see table 200, 201 and table 202	16 curve types	See table 200, 201 and table 202
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 $U > U_r$

Table 82. General current and voltage protection CVGAPC, continued

Function	Range or value	Accuracy
Start undervoltage, step 1 - 2	(2.0 - 150.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Independent time delay, overvoltage at 0.8 x U_{set} to 1.2 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undervoltage at 1.2 x U_{set} to 0.8 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overvoltage: Start time at 0.8 x U_{set} to 1.2 x U_{set} Reset time at 1.2 x U_{set} to 0.8 x U_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Undervoltage: Start time at 1.2 x U_{set} to 0.8 x U_{set} Reset time at 1.2 x U_{set} to 0.8 x U_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overvoltage: Inverse time characteristics, see table 208	 4 curve types	 See table 208
Undervoltage: Inverse time characteristics, see table 209	 3 curve types	 See table 209
High and low voltage limit, voltage dependent operation, step 1 - 2	(1.0 - 200.0)% of UBase	±1.0% of U_r at U ≤ U_r ±1.0% of U at U > U_r
Directional function	Settable: NonDir, forward and reverse	-
Relay characteristic angle	(-180 to +180) degrees	±2.0 degrees
Relay operate angle	(1 to 90) degrees	±2.0 degrees
Reset ratio, overcurrent	> 95% at (10 - 5000)% of IBase	-
Reset ratio, undercurrent	< 105% at (10 - 150)% of IBase	-
Reset ratio, overvoltage	> 98% at (10 - 200)% of UBase	-
Reset ratio, undervoltage	< 102% at (10 - 200)% of UBase	-
Operate frequency	10-90 Hz	-
Overcurrent: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x I_{set} 15 ms typically	 - -
Undercurrent: Critical impulse time Impulse margin time	 10 ms typically at 2 x I_{set} to 0 15 ms typically	 - -
Overvoltage: Critical impulse time	 10 ms typically at 0.8 x U_{set} to 1.2 x U_{set}	 -

Table 82. General current and voltage protection CVGAPC, continued

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

Table 83. Rotor earth fault protection based on General current and voltage protection (CVGAPC) and RXTTE4

Function	Range or value
For machines with:	
• rated field voltage up to	350 V DC
• additional requirement for static exciter: rated supply voltage up to The most restrictive condition shall be fulfilled.	700 V 50/60 Hz
Supply voltage 120 or 230 V	50/60 Hz
Operate earth fault resistance value	Approx. 1–20 kΩ
Influence of harmonics in the DC field voltage	Negligible influence of 50 V, 150 Hz or 50 V, 300 Hz
Permitted leakage capacitance	(1–5) μF
Permitted shaft earthing resistance	Maximum 200 Ω
Protective resistor	220 Ω, 100 W, plate (the height is 160 mm (6,2 inches) and width 135 mm (5,31 inches))

Secondary system supervision

Table 84. Current circuit supervision CCSSPVC

Function	Range or value	Accuracy
Operate current	(10-200)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio, Operate current	>90%	
Block current	(20-500)% of IBase	±5.0% of I_r at $I \le I_r$ ±5.0% of I at $I > I_r$
Reset ratio, Block current	>90% at (50-500)% of IBase	

Table 85. Fuse failure supervision FUFSPVC

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, zero sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage, negative sequence	(1-100)% of UBase	±0.5% of U_r
Operate current, negative sequence	(1–100)% of IBase	±0.5% of I_r
Operate voltage change level	(1-100)% of UBase	±10.0% of U_r
Operate current change level	(1–100)% of IBase	±10.0% of I_r
Operate phase voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase current	(1–100)% of IBase	±0.5% of I_r
Operate phase dead line voltage	(1-100)% of UBase	±0.5% of U_r
Operate phase dead line current	(1–100)% of IBase	±0.5% of I_r
Operate time, start, 1 ph, at 1 x U_r to 0	Min. = 10 ms Max. = 25 ms	-
Reset time, start, 1 ph, at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	-

Table 86. Fuse failure supervision VDSPVC

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

Table 86. Fuse failure supervision VDSPVC , continued

Function	Range or value	Accuracy
Operate time, alarm for pilot fuse failure at 1 x U_r to 0	Min. = 5 ms Max. = 15 ms	–
Reset time, alarm for pilot fuse failure at 0 to 1 x U_r	Min. = 15 ms Max. = 30 ms	–

Table 87. Voltage based delta supervision DELVSPVC

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

Table 88. Current based delta supervision DELISPVC

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

Control

Table 89. Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, φ_{line} - φ_{bus}	(-180 to 180) degrees	-
Voltage high limit for synchronizing and synchrocheck	(50.0-120.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line for synchrocheck	(0.003-1.000) Hz	±2.5 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	±2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	(0.02-0.5) p.u	±0.5% of U_r
Time delay output for synchrocheck when angle difference between bus and line jumps from “PhaseDiff” + 2 degrees to “PhaseDiff” - 2 degrees	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	±2.5 mHz
Frequency difference maximum limit for synchronizing	(0.050-1.000) Hz	±2.5 mHz
Maximum closing angle between bus and line for synchronizing	(15-30) degrees	±2.0 degrees
Breaker closing pulse duration	(0.050-1.000) s	±0.2% or ±15 ms whichever is greater
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-6000.00) s	±0.2% or ±35 ms whichever is greater
Minimum time to accept synchronizing conditions	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Voltage high limit for energizing check	(50.0-120.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Reset ratio, voltage high limit	> 95%	-
Voltage low limit for energizing check	(10.0-80.0)% of UBase	±0.5% of U_r
Reset ratio, voltage low limit	< 105%	-
Maximum voltage for energizing	(50.0-180.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Time delay for energizing check when voltage jumps from 0 to 90% of Urated	(0.000-60.000) s	±0.2% or ±100 ms whichever is greater
Operate time for synchrocheck function when angle difference between bus and line jumps from “PhaseDiff” + 2 degrees to “PhaseDiff” - 2 degrees	Min. = 15 ms Max. = 30 ms	–
Operate time for energizing function when voltage jumps from 0 to 90% of Urated	Min. = 70 ms Max. = 90 ms	–

Table 90. Tap changer control TCMYLTC/TCLYLTC

Function	Range or value	Accuracy
Tap position for lowest and highest voltage	(1–63)	-
mA for lowest and highest voltage tap position	(0.000–25.000) mA	-
Type of code conversion	BIN, BCD, GRAY, SINGLE, mA	-

Table 90. Tap changer control TCMYLTC/TCLYLTC , continued

Function	Range or value	Accuracy
Time after position change before the value is accepted *tStable*	(1–60) s	±0.2% or ±200 ms whichever is greater
Tap changer constant time-out	(1–120) s	±0.2% or ±200 ms whichever is greater
Raise/lower command output pulse duration	(0.5–10.0) s	±0.2% or ±200 ms whichever is greater

Logic

Table 91. Tripping logic common 3-phase output SMPPTRC

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

Table 92. Number of SMAGAPC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
SMAGAPC	12	-	-

Table 93. Number of STARTCOMB instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
STARTCOMB	32	-	-

Table 94. Number of TMAGAPC instances

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

Table 95. Number of ALMCALH instances

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

Table 96. Number of WRNCALH instances

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

Table 97. Number of INDCALH instances

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

Table 98. Number of AND instances

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

Table 99. Number of GATE instances

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

Table 100. Number of INV instances

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

Table 101. Number of LLD instances

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

Table 102. Number of OR instances

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

Table 103. 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 104. Number of RSMEMORY instances

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

Table 105. Number of SRMEMORY instances

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

Table 106. 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 107. Number of XOR instances

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

Table 108. Number of ANDQT instances

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

Table 109. Number of INDCOMBSPQT instances

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

Table 110. Number of INDEXTSPQT instances

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

Table 111. Number of INVALIDQT instances

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

Table 112. Number of INVERTERQT instances

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

Table 113. Number of ORQT instances

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

Table 114. 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 115. Number of RSMEMORYQT instances

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

Table 116. Number of SRMEMORYQT instances

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

Table 117. 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 118. Number of XORQT instances

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

Table 119. Number of instances in the extension logic package

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
SLGAPC	10	10	54
VSGAPC	10	10	100
AND	80	40	100
OR	80	40	100
PULSETIMER	20	20	49
GATE	—	—	49
TIMERSET	34	30	49
XOR	10	10	69
LLD	—	—	49
SRMEMORY	10	10	110
INV	80	40	100
RSMEMORY	10	10	20

Table 120. Number of B16I instances

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

Table 121. Number of BTIGAPC instances

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

Table 122. Number of IB16 instances

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

Table 123. Number of ITBGAPC instances

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

Table 124. Integrator TIGAPC

Function	Cycle time (ms)	Range of value	Accuracy
Time integration continuous active	3	0-999999.99 s	±0.2% or ±20 ms whichever is greater
Time integration continuous active	8	0-999999.99 s	± 0.2% or ±50 ms whichever is greater
Time integration continuous active	100	0-999999.99 s	±0.2% or ±250 ms whichever is greater

Table 125. Number of TIGAPC instances

Function	Quantity with cycle time		
	3 ms	8 ms	100 ms
TIGAPC	-	30	-

Table 126. 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 127. Number of TEIGAPC instances

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

Table 128. Number of INTCOMP instances

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

Table 129. Number of REALCOMP instances

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

Table 130. Number of HOLDMINMAX instances

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

Table 131. Number of INT_REAL instances

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

Table 132. Number of CONST_INT instances

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

Table 133. Number of INTSEL instances

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

Table 134. Number of LIMITER instances

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

Table 135. Number of ABS instances

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

Table 136. Number of POL_REC instances

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

Table 137. Number of RAD_DEG instances

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

Table 138. Number of CONST_REAL instances

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

Table 139. Number of REALSEL instances

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

Table 140. Number of STOREINT instances

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

Table 141. Number of STOREREAL instances

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

Table 142. Number of DEG_RAD instances

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

Monitoring

Table 143. Power system measurement CVMMXN

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

Table 144. 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 145. Voltage measurement phase-phase VMMXU

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

Table 146. Voltage measurement phase-earth VNMMXU

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

Table 147. Current sequence measurement CMSQI

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

Table 148. 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 149. 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 150. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Pre-fault time	(0.05–9.90) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–10.0) s	-
Maximum number of recordings	200, first in - first out	-
Time tagging resolution	1 ms	See table 195
Maximum number of analog inputs	40 + 30 (external + internally derived)	-
Maximum number of binary inputs	352	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	352	-
Maximum number of events in the Event recording per recording	1056	-
Maximum number of events in the Event list	5000, first in - first out	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 151. Insulation supervision for gas medium function SSIMG

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

Table 152. Insulation supervision for liquid medium function SSIML

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

Table 152. Insulation supervision for liquid medium function SSIML , continued

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

Table 153. Circuit breaker condition monitoring SSCBR

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

Table 154. Transformer loss of life LOLSPTR

Function	Range or value	Accuracy
Service value, hot spot temperature	–	±2.0% of expected value
Service value, top oil temperature	–	±2.0% of expected value
Service value, loss of life	–	±2.0% of expected value
Operate level , Warning level 1 and 2	(50 - 700)°C/°F of hot spot temperature	±2.0% of hot spot temperature
Operate time, Warning level 1 and 2	(50 - 700)°C/°F of hot spot temperature	±200 ms typically
Operate time, definite time function (ALARMx)	(0.0 - 6000.0) s	±250 ms typically

Table 155. Event list

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

Table 156. Indications

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

Table 157. Event recorder

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

Table 158. Trip value recorder

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

Table 159. Disturbance recorder

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

Relion® 670 series can store up to 10240 security events.

Table 160. Event counter with limit supervision L4UFCNT

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

Table 161. Running hour-meter TEILGAPC

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

Table 162. Through fault monitoring PTRSTHR

Function	Range or value	Accuracy
Operate current	(50-1000)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50-1000)% of IBase	–

Table 163. Current harmonic monitoring CHMMHAI (50/60 Hz)

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

Table 164. Voltage harmonic monitoring VHMMHAI (50/60 Hz)

Function	Range or value		Accuracy
	Fundamental	Harmonic	
Frequency	(0.95 to 1.05) X f_r	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±2 mHz
True RMS	(10 to 150) V	No superimposed harmonics	±0.5% of U
	(10 to 150) V	2^{nd} order to 5^{th} order (0.1 - 0.5) X U_F	±2.0% of U
	(10 to 150) V	6^{th} order to 9^{th} order (0.1 - 0.5) X U_F	±5.0% of U
Fundamental	(10 to 150) V	No superimposed harmonics	±0.5% of U_F
	(10 to 150) V	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±0.5% of U_F
Crest Factor	(10 to 150) V	No superimposed harmonics	±2.0%

Table 164. Voltage harmonic monitoring VHMMHAI (50/60 Hz) , continued

Function	Range or value		Accuracy
	Fundamental	Harmonic	
Harmonic Amplitude	(10 to 150) V	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±4.0% of U_H
Total Harmonic Distortion (VTHD)	(10 to 150) V	2^{nd} order to 9^{th} order (0.1 - 0.5) X U_F	±3.0%
Note: The column header Fundamental gives the accuracy of fundamental measurement, which is also assessed in the presence of Harmonics. This is to check the accuracy of filters in detecting the fundamental component even in case of a distorted signal. U_F - Applied Voltage Fundamental U_H - Applied Voltage Harmonic (of respective harmonics) U - Actual Voltage = RMS (U_F and U_H)			

Table 165. Fault current and voltage monitoring FLTMMXU

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

Metering

Table 166. 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 167. Function for energy calculation and demand handling ETPMMTR

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

Station communication

Table 168. Communication protocols

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

Table 169. IEC 61850-9-2 communication protocol

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

Table 170. LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 171. SPA communication protocol

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

Table 172. IEC 60870-5-103 communication protocol

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

Table 173. SLM – LON port

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

Table 174. SLM – SPA/IEC 60870-5-103/DNP3 port

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

Table 175. 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 176. SFP - Optical ethernet port

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

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

Table 177. SFP - Galvanic RJ45

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

Table 178. Ethernet redundancy protocols, IEC 62439-3

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

Table 179. Rapid spanning tree protocol (RSTP)

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

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

Remote communication

Table 180. Line data communication module

Characteristic	Range or value		
Type of LDCM	**Short range (SR)**	**Medium range (MR)**	**Long range (LR)**
Type of fiber	Multi-mode fiber glass 62.5/125 µm Multi-mode fiber glass 50/125 µm	Single-mode fiber glass 9/125 µm	Single-mode fiber glass 9/125 µm
Peak Emission Wave length Nominal Maximum Minimum	 820 nm 865 nm 792 nm	 1310 nm 1330 nm 1290 nm	 1550 nm 1580 nm 1520 nm
Optical budget Multi-mode fiber glass 62.5/125 µm Multi-mode fiber glass 50/125 µm	18.8 dB (typical distance about 3 km/2 mile 1)) 11.8 dB (typical distance about 2 km/1 mile 1))	28.8 dB (typical distance 80 km/50 mile 1)) 30.8 dB 2)	28.7 dB (typical distance 120 km/75 mile 1))
Optical connector	Type ST	Type FC/PC	Type FC/PC
Protocol	C37.94	C37.94 implementation 3)	C37.94 implementation 3)
Data transmission	Synchronous	Synchronous	Synchronous
Transmission rate / Data rate	2 Mbit/s / 64 kbit/s	2 Mbit/s / 64 kbit/s	2 Mbit/s / 64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal	Internal or derived from received signal

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

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

Table 181. Galvanic X.21 line data communication module (X.21-LDCM)

Quantity	Range or value
Connector, X.21	Micro D-sub, 15-pole male, 1.27 mm (0.050") pitch
Connector, ground selection	2 pole screw terminal
Standard	CCITT X21
Communication speed	64 kbit/s
Insulation	1 kV
Maximum cable length	10 m

Hardware

IED

Table 182. Case

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

Table 183. Water and dust protection level according to IEC 60529

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

Table 184. Weight

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

Electrical safety

Table 185. 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 186. 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 187. 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 I/O modules. Please refer to the ordering particulars for details.

Table 188. NUM: Communication ports

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

Table 189. OEM: Number of Ethernet ports

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

Injection equipment hardware

Table 190. Injection unit REX060

Specifications	Values
Case size	6U, 1/2 19”; 223.7 x 245 x 267 mm (W x D x H)
Weight	8.0 kg
Burden, binary inputs	BI 220 V: burden 0.4 W BI 110 V: burden 0.2 W BI 48 V: burden 0.1 W
Burden, RIM injection	< 10 VA at 100 V external disturbance
Burden, SIM injection	< 10 VA at 12 V earth fault voltage 0 VA at > 10% of maximum earth fault voltage
Burden, SIM injection with REX062	< 1 VA at 24 V earth fault voltage
Burden, measuring transformer SIM	< 60 mVA at 24 V; 87 Hz
Burden, measuring transformer RIM	< 60 mVA at 50 V; 113 Hz
Installation category	III
Pollution degree	2

Table 191. Binary output contacts of SIM, RIM, and PSM in the REX060 Technical data

Function of quantity	Signal relay
Max system voltage	250 V DC
Min load voltage	24 V DC
Number of outputs in SIM and RIM	2
Number of outputs in PSM	1
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 4 A 8 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 20 A 8 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 20 A 8 A
Making capacity at resistive load 0.2 s 1.0 s	 20 A 8 A
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1)	48 V / 1 A 110 V / 0.4 A 125 V / 0.35 A 220 V / 0.2 A 250 V / 0.15 A
Breaking capacity for DC with L/R=100 ms	110 V / 0.3 A
Breaking capacity for DC with resistive load	4 A

Table 191. Binary output contacts of SIM, RIM, and PSM in the REX060 Technical data, continued

Function of quantity	Signal relay
Max operations with inductive load L/R ≤ 40 ms	1000
Max operations with resistive load	2000
Max operations with no load	10000

Table 192. Coupling capacitor unit REX061

Function	Range or values	Accuracy
For machines with:		
• rated field voltage up to	800 V DC	-
• additional requirement for static exciter: rated supply voltage up to	1600 V 50/60 Hz	-
The most restrictive condition between the rated field voltage and the additional requirement shall be fulfilled in case of the static exciter.		

Specifications	Values
Case size	218 x 150 x 243 mm (W x D x H)
Weight	4.8 kg
Assembling	6 x 5 mm screws (3 at bottom and 3 at top)
Rated rotor injection voltage	250 V
Burden, static excitation system X1:1 to X1:7	< 0.5 VA at 100 V external disturbance
Burden, static excitation system X1:1 or X1:7 to 0 V	< 1.0 VA at 100 V external disturbance
Burden, brushless excitation system X1:1 and X1:7 to 0 V	< 1.5 VA at 100 V external disturbance
Installation category	III
Pollution degree	2

Table 193. Shunt resistor unit REX062

Specifications	Values
Case size	218 x 150 x 243 mm (W x D x H)
Weight	4.5 kg
Assembling	6 x 5 mm screws (3 at bottom and 3 at top)
Rated stator injection voltage	240 V
Rated stator voltage	240 V
Burden, injection X1:2 and X1:4	< 25 VA at 12 V earth fault voltage < 100 VA at 24 V earth fault voltage
Installation category	III
Pollution degree	2

Basic IED functions

Table 194. Self supervision with internal event list

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

Table 195. Time synchronization, time tagging

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

Table 196. Time synchronization PTP: IEC/IEEE 61850-9-3

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

Table 197. 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 198. 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 199. 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 200. ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1 \right)} + B \right) \cdot k$$ Operate time for I_{set} = 10%, 195%, 400% of IBase (for all curves)	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	ANSI/IEEE C37.112 , ±7.0% or ±80 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	ANSI/IEEE C37.112 , ±3.0% or ±50 ms whichever is greater
Reset characteristic for ANSI curves: $$t = \frac{t_r}{\left(I^{2} - 1 \right)} \cdot k$$ I = $I_{measured}/I_{set}$ Reset time for I_{set} = 10%, 195%, 400% of IBase	0.01 ≤ k ≤ 15.00 0 x I_{set} - 0.8 x I_{set}	ANSI/IEEE C37.112 , ±8.0% or ±350 ms whichever is greater
Definite reset timer	(0.000 - 60.000) s 0 x I_{set} - 0.8 x I_{set}	ANSI/IEEE C37.112 , ±2.0% or ±40 ms whichever is greater
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	
ANSI Very inverse	A=19.61, B=0.491, P=2.0 , tr=21.6	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02, tr=4.85	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

Table 201. IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$$ Operate time for I_{set} = 10%, 195%, 400% of IBase (for all curves)	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±7.0% or ±80 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±3.0% or ±50 ms whichever is greater
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	

Table 201. IEC Inverse time characteristics, continued

Function	Range or value	Accuracy
Programmable characteristic Operate characteristic: $t = \left(\frac{A}{\left(I^{P} - C \right)} + B \right) \cdot k$ Operate time for I_{set} = 10%, 195%, 400% of IBase	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±7.0% or ±80 ms whichever is greater*
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±3.0% or ±50 ms whichever is greater*
Reset characteristic: $t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$ I = $I_{measured}/I_{set}$ Reset time for I_{set} = 10%, 195%, 400% of IBase	0.01 ≤ k ≤ 15.00 0 x I_{set} - 0.8 x I_{set}	IEC 60255-151, ±8.0% or ±350 ms whichever is greater*
	k = (0.01 - 999.00) in steps of 0.01 A = (0.005 - 200.000) in steps of 0.001 B = (0.00 - 20.00) in steps of 0.01 C = (0.1 - 10.0) in steps of 0.1 P = (0.005 - 3.000) in steps of 0.001 TR = (0.005 - 100.000) in steps of 0.001 CR = (0.1 - 10.0) in steps of 0.1 PR = (0.005 - 3.000) in steps of 0.001	*Data evaluated at default parameter values

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

Table 202. RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$ I = $I_{measured}/I_{set}$	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±2.0% or ±20 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±2.0% or ±20 ms whichever is greater
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k} \right)$ I = $I_{measured}/I_{set}$	0.01 ≤ k ≤ 15.00 1.2 x I_{set}	IEC 60255-151, ±2.0% or ±50 ms whichever is greater
	0.01 ≤ k ≤ 15.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}	IEC 60255-151, ±2.0% or ±40 ms whichever is greater

Table 203. ANSI Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1 \right)} + B \right) \cdot k$ Reset characteristic: $t = \frac{t_r}{\left(I^{2} - 1 \right)} \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \leq k \leq 2.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	ANSI/IEEE C37.112 , ±5.0% or ±160 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	
Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

Table 204. IEC Inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^P - 1 \right)} \right) \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \le k \le 2.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±5.0% or ±160 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 = (0.05-2.00) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	

Table 205. RI and RD type inverse time characteristics for Sensitive directional residual overcurrent and power protection

Function	Range or value	Accuracy
RI type inverse characteristic $t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	$0.05 \le k \le 2.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±5.0% or ±160 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 206. ANSI Inverse time characteristics for Voltage restrained time overcurrent protection

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 ≤ k ≤ 999.00	ANSI/IEEE C37.112 , ± 5.0% 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	
Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

Table 207. IEC Inverse time characteristics for Voltage restrained time overcurrent protection

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1\right)} \right) \cdot k$ $I = I_{measured}/I_{set}$	0.05 ≤ k ≤ 999.00	IEC 60255-151, ±5.0% 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	

Table 208. Inverse time characteristics for overvoltage protection

Function	Range or value	Accuracy
Type A curve: $t = \dfrac{k}{\left(\dfrac{U - U>}{U>}\right)}$ 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: $t = \dfrac{k \cdot 480}{\left(32 \cdot \dfrac{U - U_n >}{U_n >} - 0.5\right)^{2.0}} + 0.035$	k = (0.05-1.10) in steps of 0.01	
Type C curve: $t = \dfrac{k \cdot 480}{\left(32 \cdot \dfrac{U - U_n >}{U >} - 0.5\right)^{3.0}} + 0.035$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $t = \dfrac{k \cdot A}{\left(B \cdot \dfrac{U - U >}{U >} - C\right)^{P}} + D$	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 209. Inverse time characteristics for undervoltage protection

Function	**Range or value**	**Accuracy**
Type A curve: $$t = \frac{k}{\left(\frac{U< - U}{U<}\right)}$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	±5.0% or ±45 ms whichever is greater
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< - U}{U<} - 0.5\right)^{2.0}} + 0.055$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $$t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U< - U}{U<} - C\right)^{P}}\right] + D$$ $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 210. Inverse time characteristics for residual overvoltage protection

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

27. Ordering for customized IED

Table 211. 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 212. 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: REG670*2.2 - F00X00 - A000220623000000000 - B00000402000001100000112112 - C460026220034000444002231114 - D22322100 - T0000 - E1066612 - F9 - S6 - G532 - H12000010044 - K00000000 - L1100000 - M12042220 - P1110000000000000110 - B1X0 - AC - CA - B - A3X0 - CD1D1ARGN1N1XXXXXXX - KKKXXHKKKAGXSX

Product definition					-	**Differential protection**																		-
REG670*	2.2	-	F00	X00	-	A	0	0	0						0	0	0	0	0	0	0	0	0	-

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

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

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

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

Scheme communication									-	**Logic**						-	**Monitoring**								-
K	0	0	0	0	0	0	0	0	-	L			00	0	00	-	M		0					0	-

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

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

Station communication, remote end serial communication and time synchronization													
K													

Table 213. Product definition

REG670*	2.2	F00	X00

Table 214. Product definition ordering codes

Product	REG670*
Product version	2.2
Configuration alternative	

Table 214. Product definition ordering codes, continued

REG670 Generator protection	F00
ACT configuration	
No ACT configuration downloaded	X00
Ordering number	
REG670 Generator protection	1MRK002826-AG

Table 215. Differential protection

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

Table 216. Differential functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Transformer differential protection, two winding	T2WPDIF	1MRK005904-FC	4	0-2		
Transformer differential protection, three winding	T3WPDIF	1MRK005904-GB	5	0-2		
High impedance differential protection, single phase	HZPDIF	1MRK005904-HB	6	00-06		
Generator differential protection	GENPDIF	1MRK005904-KB	7	0-2		
Restricted earth fault protection, low impedance	REFPDIF	1MRK005904-LD	8	0-3		

Table 217. Impedance protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
B	0	0	0	0	0		0		0	0	0	0	0			0	0	0	0	0						

Table 218. Impedance functions

Note: Only 1 alternative may be selected						
Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Alternative 3 Distance protection, mho (mho for phase - phase fault and mho in parallel with quad for earth fault)						
Full-scheme distance protection, mho characteristic	ZMHPDIS	1MRK005907-FA	6	0-4		
Directional impedance element for mho characteristic	ZDMRDIR	1MRK005907-HA	8	0-2		
Alternative 5 High speed distance protection, quadrilateral and mho						
High speed distance protection, quad and mho characteristic	ZMFPDIS	1MRK005907-SH	14	0-1		
Alternative 6 High speed distance protection for series compensated lines, quadrilateral and mho						
High speed distance protection for series comp. lines, quad and mho characteristic	ZMFCPDIS	1MRK005907-RH	15	0-1		
Optional with any alternative						
Poleslip/out-of-step protection	PSPPPAM	1MRK005908-CB	21	0-1		
Out-of-step protection	OOSPPAM	1MRK005908-GA	22	0-1		
Loss of excitation	LEXPDIS	1MRK005908-BB	23	0-2		
Sensitive rotor earth fault protection, injection based	ROTIPHIZ	1MRK005908-ED	24	0-1		
100% stator earth fault protection, injection based	STTIPHIZ	1MRK005908-FC	25	0-1		
Underimpedance protection for generators and transformers	ZGVPDIS	1MRK005907-TC	26	0-2		

Table 219. Current protection

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
C			00					0	0			00	0				0	0							

Table 220. Current functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Instantaneous phase overcurrent protection	PHPIOC	1MRK005910-AD	1	0-4		
Directional phase overcurrent protection, four steps	OC4PTOC	1MRK005910-BE	2	00-06		
Instantaneous residual overcurrent protection	EFPIOC	1MRK005910-DD	4	0-2		
Directional residual overcurrent protection, four steps	EF4PTOC	1MRK005910-EK	5	00-06		
Directional negative phase sequence overcurrent protection, four steps	NS4PTOC	1MRK005910-FE	6	00-02		
Sensitive directional residual overcurrent and power protection	SDEPSDE	1MRK005910-GA	7	0-2		
Thermal overload protection, two time constants	TRPTTR	1MRK005910-HC	10	0-3		
Breaker failure protection	CCRBRF	1MRK005910-LC	11	00-04		
Pole discordance protection	CCPDSC	1MRK005910-PA	14	0-4		
Directional underpower protection	GUPPDUP	1MRK005910-RA	15	0-4		
Directional overpower protection	GOPPDOP	1MRK005910-TA	16	0-4		
Negative sequence time overcurrent protection for machines, two steps	NS2PTOC	1MRK005910-VB	19	0-2		
Accidental energizing protection for synchronous generator	AEGPVOC	1MRK005910-WA	20	0-2		
Voltage restrained overcurrent protection	VRPVOC	1MRK005910-XE	21	0-3		
Stator overload protection	GSPTTR	1MRK005910-ZB	22	0-1		
Rotor overload protection	GRPTTR	1MRK005910-YB	23	0-1		
Average power transient earth fault protection	APPTEF	1MRK006940-LB	24	0-1		
Overcurrent protection with binary release	BRPTOC	1MRK005910-NG	25	00-04		

Table 221. Voltage protection

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

Table 222. Voltage functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Two step undervoltage protection	UV2PTUV	1MRK005912-AA	1	0-2		
Two step overvoltage protection	OV2PTOV	1MRK005912-BA	2	0-2		
Residual overvoltage protection, two steps	ROV2PTOV	1MRK005912-CE	3	0-3		
Overexcitation protection	OEXPVPH	1MRK005912-DB	4	0-2		
Voltage differential protection	VDCPTDV	1MRK005912-EC	5	0-2		
100% Stator earth fault protection, 3rd harmonic based	STEFPHIZ	1MRK005912-FB	6	0-1		

Table 223. Unbalance protection

Position	1	2	3	4
T	0	0	0	0

Table 224. Frequency protection

Position	1	2	3	4
E				

Table 225. Frequency functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Underfrequency protection	SAPTUF	1MRK005914-AC	1	00-10		
Overfrequency protection	SAPTOF	1MRK005914-BB	2	0-6		
Rate-of-change of frequency protection	SAPFRC	1MRK005914-CB	3	0-6		
Frequency time accumulation protection	FTAQFVR	1MRK005914-DB	4	00-12		

Table 226. Multipurpose protection

Position	1
F	

Table 227. Multipurpose functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
General current and voltage protection	CVGAPC	1MRK005915-AD	1	0-9		

Table 228. General calculation

Position	1
S	

Table 229. General calculation functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Multipurpose filter	SMAIHPAC	1MRK005915-KB	1	0-6		

Table 230. Secondary system supervision

Position	1	2	3
G			

Table 231. Secondary system supervision functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Current circuit supervision	CCSSPVC	1MRK005916-AC	1	0-5		
Fuse failure supervision	FUFSPVC	1MRK005916-BA	2	0-3		
Fuse failure supervision based on voltage difference	VDSPVC	1MRK005916-CA	3	0-2		

Table 232. Control

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

Table 233. Control functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Synchrocheck, energizing check and synchronizing	SESRSYN	1MRK005917-XD	2	0-2		
Control functionality for up to 6 bays, max 30 objects (6CBs), including interlocking	APC30	1MRK005917-MZ	7	0-1		
Tap changer control and supervision, 6 binary inputs	TCMYLTC	1MRK005917-DC	10	0-4		
Tap changer control and supervision, 32 binary inputs	TCLYLTC	1MRK005917-EB	11	0-4		

Table 234. Scheme communication

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

Table 235. Logic

Position	1	2	3	4	5
L			00	0	00

Table 236. Logic functions

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

Table 237. Monitoring

Position	1	2	3	4	5	6	7
M		0					0

Table 238. Monitoring functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Circuit breaker condition monitoring	SSCBR	1MRK005924-HC	1	00-12		
Transformer insulation loss of life monitoring	LOLSPTR	1MRK005924-NB	3	0-4		
Through fault monitoring	PTRSTHR	1MRK005924-TA	4	0–2		
Current harmonic monitoring, 3 phase	CHMMHAI	1MRK005924-QB	5	0–3		
Voltage harmonic monitoring, 3 phase	VHMMHAI	1MRK005924-SB	6	0–3		

Table 239. Station communication

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

Table 240. Station communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
IEC 61850-9-2 Process bus communication, 12 merging units		1MRK005933-HE	1	0-1		
IEC 62439-3 Parallel redundancy protocol	PRP	1MRK005932-FA	2	0-1		1)
IEC 62439-3 High-availability seamless redundancy	HSR	1MRK005932-NA	3	0-1		
Synchrophasor report, 16 phasors		1MRK005933-FB	17	0-1		2)
Rapid spanning tree protocol	RSTP	1MRK005933-SA	18	0-1		3)

1) PRP and HSR require two SFPs placed in pairs.
2) This functionality requires accurate time synchronization, therefore either ‘Precision Time Protocol (PTP) Time synch or GTM or IRIG-B will be required.
3) Option RSTP require 2 SFP placed in pairs

Table 241. Language selection

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

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

Table 242. Casing selection

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

Table 243. Mounting selection

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

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

Table 244. Power supply module selection

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

Table 245. Human machine interface selection

Human machine hardware interface	Case size	Ordering no	Selection	Notes and rules
Medium size - graphic display, IEC keypad symbols	1/2 x 19", IEC 3/4 x 19”, IEC 1/1 x 19”, IEC	1MRK000028-AA 1MRK000028-CA 1MRK000028-BA	B	
Medium size - graphic display, ANSI keypad symbols	1/2 x 19", ANSI 3/4 x 19”, ANSI 1/1 x 19”, ANSI	1MRK000028-AB 1MRK000028-CB 1MRK000028-BB	C	
Front with status LEDs, Ethernet port, IEC symbols	1/2 x 19", IEC 3/4 x 19”, IEC 1/1 x 19”, IEC	1MRK000031-AA 1MRK000031-CA 1MRK000031-BA	F	
Front with status LEDs, Ethernet port, ANSI symbols	1/2 x 19", ANSI 3/4 x 19”, ANSI 1/1 x 19”, ANSI	1MRK000031-AB 1MRK000031-CB 1MRK000031-BB	G	
		Selected		

Table 246. Analog system selection

Analog system	Ordering no	Selection		Notes and rules
When more than one TRM is selected, the connector type on both TRMs must be the same (A compression or B ring lug).				
Slot position (front view/rear view)		P40/X401	P41/X411	
No Transformer input module included		X0	X0	1)
TRM 12I 1A, 50/60Hz, compression terminals	1MRK002247-CG	A1	A1	
TRM 12I 5A, 50/60Hz, compression terminals	1MRK002247-CH	A2	A2	
TRM 9I 1A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BG	A3	A3	

Table 246. Analog system selection, continued

Analog system	Ordering no	Selection		Notes and rules
TRM 9I 5A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BH	A4	A4	
TRM 5I 1A + 4I 5A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BK	A5	A5	
TRM 6I 1A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AG	A6	A6	
TRM 6I 5A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AH	A7	A7	
TRM 7I 1A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AP	A12	A12	
TRM 7I 5A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AR	A13	A13	
TRM 6I 5A + 1I 1A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AU	A14	A14	
TRM 3I 5A + 4I 1A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AV	A15	A15	
TRM 3I 5A + 3I 1A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AE	A16	A16	
TRM 3IM 1A + 4IP 1A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-EA	A17	A17	
TRM 3IM 5A + 4IP 5A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-EB	A18	A18	
TRM 10I 1A + 2U 110/220V, 50/60Hz, compression terminals	1MRK002247-FA	A19	A19	
TRM 10I 5A + 2U 110/220V, 50/60Hz, compression terminals	1MRK002247-FB	A20	A20	
TRM 12I 1A, 50/60Hz, ring lug terminals	1MRK002247-CC	B1	B1	
TRM 12I 5A, 50/60Hz, ring lug terminals	1MRK002247-CD	B2	B2	
TRM 9I 1A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BC	B3	B3	
TRM 9I 5A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BD	B4	B4	
TRM 5I 1A + 4I 5A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BF	B5	B5	
TRM 6I 1A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AC	B6	B6	
TRM 6I 5A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AD	B7	B7	
TRM 7I 1A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AS	B12	B12	
TRM 7I 5A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AT	B13	B13	
TRM 6I 5A + 1I 1A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AX	B14	B14	
TRM 3I 5A + 4I 1A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AY	B15	B15	
TRM 3I 5A + 3I 1A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AF	B16	B16	
TRM 3IM 1A + 4IP 1A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-EC	B17	B17	
TRM 3IM 5A + 4IP 5A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-ED	B18	B18	
TRM 10I 1A + 2U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-FC	B19	B19	
TRM 10I 5A + 2U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-FD	B20	B20	
	Selected			

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

Table 247. Maximum quantity of I/O modules, with compression terminals

When ordering I/O modules, observe the maximum quantities according to the tables below.

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

Case sizes	BIM	IOM	BOM/ SOM	MIM	Maximum in case
1/1 x 19” rack casing, one (1) TRM	14	6	4	6	14 *)
1/1 x 19” rack casing, two (2) TRM	11	6	4	6	11 *)
3/4 x 19” rack casing, one (1) TRM	8	6	4	6	8 *)
3/4 x 19” rack casing, two (2) TRM	5	5	4	5	5 *)
1/2 x 19” rack casing, one (1) TRM	3	3	3	1	3 **)

*) Including a combination of maximum four modules of type BOM or SOM and six modules of type MIM.
**) Max 2 SOM possible

Table 248. Maximum quantity of I/O modules, with ringlug terminals

Note: Only every second slot can be used.

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

*) Including a combination of maximum four modules of type BOM or SOM and six modules of type MIM.

Table 249. Binary input/output module selection

Binary input/output modules	Ordering no	Selection															Notes and rules
Slot position (front view/rear view)			P3/X31	P4/X41	P5/X51	P6/X61	P7/X71	P8/X81	P9/X91	P10/X101	P11/X111	P12/X121	P13/X131	P14/X141	P15/X151	P16/X161	
1/2 case with 1 TRM			■	■	■												1)
3/4 case with 1 TRM			■	■	■	■	■	■	■	■							
3/4 case with 2 TRM			■	■	■	■	■										
1/1 case with 1 TRM			■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1/1 case with 2 TRM			■	■	■	■	■	■	■	■	■	■	■				
Compression terminals	1MRK002960-KA	C															
Ringlug terminals	1MRK002960-LA	R															2)
No board in slot			X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)	1MRK000614-AB		A	A	A	A	A	A	A	A	A	A	A	A	A	A	
BIM 16 inputs, RL24, 24-30VDC, 50mA	1MRK000508-DD		B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	
BIM 16 inputs, RL48, 48-60VDC, 50mA	1MRK000508-AD		C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110, 110-125VDC, 50mA	1MRK000508-BD		D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220, 220-250VDC, 50mA	1MRK000508-CD		E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, RL220, 220-250VDC, 120mA	1MRK000508-CE		E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIM 16 inputs, RL24, 24-30VDC, 50mA, enhanced pulse counting	1MRK000508-HA		F	F	F	F	F	F	F	F	F	F	F	F	F	F	

Table 249. Binary input/output module selection, continued

Binary input/output modules	Ordering no	Selection															Notes and rules
BIM 16 inputs, RL48, 48-60VDC, 50mA, enhanced pulse counting	1MRK000508-EA		G	G	G	G	G	G	G	G	G	G	G	G	G	G	
BIM 16 inputs, RL110, 110-125VDC, 50mA, enhanced pulse counting	1MRK000508-FA		H	H	H	H	H	H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220, 220-250VDC, 50mA, enhanced pulse counting	1MRK000508-GA		K	K	K	K	K	K	K	K	K	K	K	K	K	K	
IOM 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GD		L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AE		M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BE		N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CE		P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM 8 inputs, RL 220-250 VDC, 110mA, 10+2 output relays	1MRK000173-CF		P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GC		U	U	U	U	U	U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AD		V	V	V	V	V	V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BD		W	W	W	W	W	W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CD		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels	1MRK000284-AB		R	R	R	R	R	R	R	R	R	R	R	R	R	R	
SOM static output module, 6 heavy duty outputs, 250 VDC + 6 output relays	1MRK002614-CA		T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2	T2		3)
	Selected																

1) These black marks indicate the maximum number of modules per casing type and the slots that can be occupied.
2) Only every second slot can be used; see Table 248
3) SOM must not to be placed in the position nearest to NUM: 1/2 case slot P5, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 2 TRM slot P13, 1/1 case, 1 TRM slot P16.

Table 250. Station communication, remote end serial communication and time synchronization selection

Station communication, remote end serial communication and time synchronization	Ordering no	Selection														Notes and rules
Slot position (front view/rear view)		P30:1/X301	P30:2/X302	P30:3/X303	P30:4/X304	P30:5/X305	P30:6/X306	P30:6:1/X3061	P30:6:2/X3062	P31:1/X311	P31:2/X312	P31:3/X313	P32:2/X322	P32:3/X323	LDCM mode	1)
Available slots in 1/2, 3/4 and 1/1 case with 1 TRM		█	█	█	█	█	█	█	█	█	█	█			█	2)
Available slots in 3/4 and 1/1 case with 2 TRM		█	█	█	█	█	█	█	█	█	█	█	█	█	█	
No communication board included			X	X	X	X	X	X	X	X	X	X	X	X		
Ethernet SFP, optical LC connector, multi mode 2 km	1MRK005500-AA	K	K	K	K			K	K							3)
Ethernet SFP, RJ45 connector	1MRK005500-BA	P	P	P	P			P	P							
Ethernet SFP, optical LC connector, single mode 30 km	1MRK005500-DA	Q	Q	Q	Q			Q	Q							
Ethernet SFP, optical LC connector, single mode 60 km	1MRK005500-EA	R	R	R	R			R	R							
Ethernet SFP, optical LC connector, single mode 120 km	1MRK005500-FA	T	T	T	T			T	T							
Optical Ethernet module	1MRK002266-EA						H									
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	1MRK001608-AB									L						
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	1MRK001608-BB									M						
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	1MRK001608-CB									N						
Galvanic RS485 communication module	1MRK002309-AA											G	G	G		4)
Optical short range LDCM, 820nm	1MRK002122-AB					A	A				A	A	A	A		5)
Optical medium range LDCM, 1310 nm	1MRK002311-AA					B	B				B	B	B	B		
Optical long range LDCM, 1550 nm	1MRK002311-BA					C	C				C	C	C	C		
Galvanic X21 line data communication module	1MRK002307-AA										E	E	E	E		
Line data communication, default 64kbps mode	—														X	6)
Allow line data communication in 2Mbps mode	1MRK007002-AA														Y	
GPS time module	1MRK002282-AB										S	S	S	S		
IRIG-B time synchronization module, with PPS	1MRK002305-AA										F	F	F	F		
	Selected															

1) The maximum number and type of LDCM modules supported depend on the total amount of I/O and communication modules in the IED.
2) Max 2 LDCM in 1/2 case
3) Ethernet SFP is basic in P30:1. P30:6:1 and P30:6:2 require the Optical Ethernet module in P30:6.
4) RS485 not allowed in slot P31:2
5) Max 4 LDCMs can be ordered. Always place LDCM modules on the same board to support redundant communication: in P30:5 and P30:6, P31:2 and P31:3 or P32:2 and P32:3.
6) Default if no LDCM is selected

28. Ordering for pre-configured IED

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

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

Example code: REG670 *2.2-A20X00- A02H39-B1A12-AC-CA-B-A3X0-CDAB1RGN1N1XXXXXXX-KKKKXHKKLAGFSX. Using the code of each position #1-11 specified as REG670*1-2 2-3 3-4 4-5 6-7 7-8-9 9 9 9-10 10 10 10-11 11 11 11 11 11 11 11 11 11 11

	Product version		Configuration alternatives			Software options																		
#	1	-	2		-	3																		-
REG670*	2.2	-			-																			-

Language			Casing and Mounting			Power supply			HMI		Analog system		
4		-	5	6	-	7		-	8	-	9		-
		-			-			-		-			-

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

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

Configuration alternatives	Ordering no	#2		Notes and rules
Generator protection, Generator differential and back-up	1MRK004826-AG	A20		
Generator protection, Generator differential and generator/transformer back-up	1MRK004826-BG	B30		
Generator protection, Generator/transformer differential and back-up	1MRK004826-CG	C30		
ACT configuration				
Hitachi Energy standard configuration			X00	
Selection for position #2				

Software options	Ordering no	#3	Notes and rules
No option		X00	1)
Restricted earth fault protection, low impedance	1MRK004001-AA	A01	2)
High impedance differential protection - 3 blocks	1MRK004001-AB	A02	3)
Transformer differential protection - 2 winding	1MRK004001-AP	A31	4)
Transformer differential protection - 2 and 3 winding	1MRK004001-AR	A33	5)
Out-of-step protection	1MRK004001-BW	B22	
Rotor Fault Detection by Injection	1MRK004001-BV	B31	
Stator Fault Detection by Injection	1MRK004001-BX	B32	
Sensitive directional residual overcurrent and power protection	1MRK004001-CT	C16	
Voltage restrained overcurrent protection	1MRK004001-UN	C36	
Rotor overload protection	1MRK004001-UR	C38	
Four step directional negative phase sequence overcurrent protection - 1 block	1MRK004001-UH	C41	6)
Four step directional negative phase sequence overcurrent protection - 2 blocks	1MRK004001-UK	C42	7)
Average power transient earth fault protection	1MRK004001-UY	C54	
100% Stator E/F 3rd harmonic	1MRK004001-DE	D21	8)
Frequency time accumulation protection	1MRK004001-EC	E03	
Fuse failure supervision based on voltage difference	1MRK004001-HC	G03	
Control functionality for up to 30 objects	1MRK004001-GZ	H39	

Software options	Ordering no	#3	Notes and rules
Transformer insulation loss of life monitoring	1MRK004001-KM	M21	9)
Through fault monitoring	1MRK004001-KR	M22	
Harmonic monitoring	1MRK004001-KS	M23	
IEC 62439-3 Parallel redundancy protocol	1MRK004001-PP	P23	10)
IEC 62439-3 High-availability seamless redundancy	1MRK004001-PR	P24	
Rapid spanning tree protocol	1MRK004001-PY	P25	
IEC 61850-9-2 Process Bus communication, 12 merging units	1MRK004001-PT	P30	
Synchrophasor report, 16 phasors	1MRK004001-PX	P34	11)
	Selection for position #3		

1) All fields in the ordering form do not need to be filled in.
2) A01 only for B30
3) A02 only for A20
4) A31 only for A20
5) A33 only for B30
6) C41 only for A20
7) C42 only for B30/C30
8) D21 only for A20
9) M21 only for B30/C30
10) Options P23, P24 and P25 require two SFPs placed in pairs.
11) This functionality requires accurate time synchronization, therefore either ‘Precision Time Protocol (PTP) Time synch or GTM or IRIG-B will be required.

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

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

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

1) Only for A20
2) Only for B30/C30

Mounting details with IP40 of protection from the front	Ordering no	#6	Notes and rules
No mounting kit included		X	
19" rack mounting kit for 1/2 x 19" case or 2xRHGS6 or RHGS12	1MRK002420-BB	A	1)
19" rack mounting kit for 3/4x19" case or 3xRHGS6	1MRK002420-BA	B	
19" rack mounting kit for 1/1 x 19" case	1MRK002420-CA	C	
Wall mounting kit	1MRK002420-DA	D	2)
Flush mounting kit	1MRK002420-PA	E	
Flush mounting kit + IP54 mounting seal	1MRK002420-NA	F	
	Selection for position #6		

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

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

Human machine hardware interface	Case size	Ordering no	#8	Notes and rules
Medium size - graphic display, IEC keypad symbols	1/2 x 19", IEC	1MRK000028-AA	B	1)
	3/4 x 19", IEC	1MRK000028-CA		2)
	1/1 x 19", IEC	1MRK000028-BA		1)
Medium size - graphic display, ANSI keypad symbols	1/2 x 19", ANSI	1MRK000028-AB	C	
	3/4 x 19", ANSI	1MRK000028-CB		2)
	1/1 x 19", ANSI	1MRK000028-BB		
Front with status LEDs, Ethernet port, IEC symbols	1/2 x 19", IEC	1MRK000031-AA	F	
	3/4 x 19", IEC	1MRK000031-CA		
	1/1 x 19", IEC	1MRK000031-BA		
Front with status LEDs, Ethernet port, ANSI symbols	1/2 x 19", ANSI	1MRK000031-AB	G	
	3/4 x 19", ANSI	1MRK000031-CB		
	1/1 x 19", ANSI	1MRK000031-BB		
		Selection for position #8		

1) Only for A20
2) Only for B30/C30

Analog system	Ordering no	#9		Notes and rules
When more than one TRM is selected, the connector type on both TRMs must be the same (A compression or B ring lug).				
Slot position (front view/rear view)		P40/X401	P41/X411	
No Transformer input module included		X0	X0	1)
TRM 9I 1A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BG	A3	A3	2)
TRM 9I 5A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BH	A4	A4	
TRM 5I 1A + 4I 5A + 3U 110/220V, 50/60Hz, compression terminals	1MRK002247-BK	A5	A5	
TRM 6I 1A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AG		A6	3)
TRM 6I 5A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AH		A7	
TRM 7I 1A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AP	A12		4)
TRM 7I 5A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AR	A13		
TRM 6I 5A + 1I 1A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AU	A14		
TRM 3I 5A + 4I 1A + 5U 110/220V, 50/60Hz, compression terminals	1MRK002247-AV	A15		
TRM 9I 1A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BC	B3	B3	2)
TRM 9I 5A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BD	B4	B4	
TRM 5I 1A + 4I 5A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BF	B5	B5	
TRM 6I 1A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AC		B6	3)
TRM 6I 5A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AD		B7	
TRM 7I 1A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AS	B12		4)
TRM 7I 5A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AT	B13		
TRM 6I 5A + 1I 1A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AX	B14		
TRM 3I 5A + 4I 1A + 5U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AY	B15		
	Selection for position #9			

1) Only valid if IEC 61850-9-2 Process bus communication is selected. B30 must include a second TRM.
2) Only for B30/C30; Maximum qty = 1 for C30
3) Only for C30
4) Only for A20; Maximum qty = 1

Binary input/output modules	Ordering no	#10												Notes and rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM required in slots P3 and P4.														
Slot position (front/rear view)			P3/X31	P4/X41	P5/X51	P6/X61	P7/X71	P8/X81	P9/X91	P10/X101	P11/X111	P12/X121	P13/X131	1)
1/2 Case with 1 TRM			■	■	■									2)
3/4 Case with 2 TRM			■	■	■	■	■							3)
1/1 Case with 2 TRM			■	■	■	■	■	■	■	■	■	■	■	3)
Compression terminals	1MRK002960-KA	C												
No board in slot					X	X	X	X	X	X	X	X	X	

Binary input/output modules	Ordering no	#10												Notes and rules
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1BIM and 1 BOM required in slots P3 and P4.														
Binary output module 24 output relays (BOM)	1MRK000614-AB			A	A	A	A	A	A	A	A	A	A	4)
BIM 16 inputs, RL24, 24-30VDC, 50mA	1MRK000508-DD		B1		B1	B1	B1	B1	B1	B1	B1	B1	B1	
BIM 16 inputs, RL48, 48-60VDC, 50mA	1MRK000508-AD		C1		C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110, 110-125VDC, 50mA	1MRK000508-BD		D1		D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220, 220-250VDC, 50mA	1MRK000508-CD		E1		E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, RL220, 220-250VDC, 120mA	1MRK000508-CE		E2		E2	E2	E2	E2	E2	E2	E2	E2	E2	
BIM 16 inputs, RL24, 24-30VDC, 50mA, enhanced pulse counting	1MRK000508-HA				F	F	F	F	F	F	F	F	F	
BIM 16 inputs, RL48, 48-60VDC, 50mA, enhanced pulse counting	1MRK000508-EA				G	G	G	G	G	G	G	G	G	
BIM 16 inputs, RL110, 110-125VDC, 50mA, enhanced pulse counting	1MRK000508-FA				H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220, 220-250VDC, 50mA, enhanced pulse counting	1MRK000508-GA				K	K	K	K	K	K	K	K	K	
IOM 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GD				L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AE				M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BE				N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CE				P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM 8 inputs, RL 220-250 VDC, 110mA, 10+2 output relays	1MRK000173-CF				P2	P2	P2	P2	P2	P2	P2	P2	P2	
IOM with MOV 8 inputs, RL 24-30 VDC, 50mA, 10+2 output relays	1MRK000173-GC				U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, RL 48-60 VDC, 50mA, 10+2 output relays	1MRK000173-AD				V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, RL 110-125 VDC, 50mA, 10+2 output relays	1MRK000173-BD				W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, RL 220-250 VDC, 50mA, 10+2 output relays	1MRK000173-CD				Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels	1MRK000284-AB				R	R	R	R	R	R	R	R	R	5)
SOM static output module, 6 heavy duty static outputs, 250 VDC + 6 output relays	1MRK002614-CA				T2	T2	T2	T2	T2	T2	T2	T2		6)
	Selection for position #10	C												

1) These black marks indicate the maximum number of modules per casing type and the slots that can be occupied.
2) Only for A20
3) Only for B30/C30
4) Maximum 4 (BOM+SOM+MIM) boards.
5) MIM not in A20, Maximum 1 MIM board in 1/2 case.
6) SOM must not to be placed in the position nearest to NUM: 1/2 case slot P5, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 2 TRM slot P13, 1/1 case, 1 TRM slot P16.

Station communication, remote end serial communication and time synchronization	Ordering no	#11														Notes and rules
Slot position (front view/rear view)		P30:1/X301	P30:2/X302	P30:3/X303	P30:4/X304	P30:5/X305	P30:6/X306	P30:6:1/X3061	P30:6:2/X3062	P31:1/X311	P31:2/X312	P31:3/X313	P32:2/X322	P32:3/X323	LDCM mode	1)
Available slots in 1/2 with 1 TRM		■	■	■	■	■	■	■	■	■	■	■			■	
Available slots in 3/4 and 1/1 case with 2 TRM		■	■	■	■	■	■	■	■	■	■	■	■	■	■	
No communication board included			X	X	X	X	X	X	X	X	X	X	X	X		
Ethernet SFP, optical LC connector, multi mode 2 km	1MRK005500-AA	K	K	K	K			K	K							2)
Ethernet SFP, RJ45 connector	1MRK005500-BA	P	P	P	P			P	P							
Ethernet SFP, optical LC connector, single mode 30 km	1MRK005500-DA	Q	Q	Q	Q			Q	Q							
Ethernet SFP, optical LC connector, single mode 60 km	1MRK005500-EA	R	R	R	R			R	R							
Ethernet SFP, optical LC connector, single mode 120 km	1MRK005500-FA	T	T	T	T			T	T							
Optical Ethernet module	1MRK002266-EA						H									
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	1MRK001608-AB									L						
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	1MRK001608-BB									M						
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	1MRK001608-CB									N						
Galvanic RS485 communication module	1MRK002309-AA											G	G	G		
Optical short range LDCM, 820nm	1MRK002122-AB					A	A				A	A	A	A		3)
Optical medium range, LDCM 1310 nm	1MRK002311-AA					B	B				B	B	B	B		
Line data communication, default 64kbps mode	—														X	4)
Allow line data communication in 2Mbps mode	1MRK007002-AA														Y	
GPS time module	1MRK002282-AB										S	S	S	S		
IRIG-B Time synchronization module, with PPS	1MRK002305-AA										F	F	F	F		
	Selection for position #11															

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

29. Ordering for Accessories

Accessories

GPS antenna and mounting details

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

Interface converter (for remote end data communication)

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

Test switch

The test system COMBITEST intended for use with the IEDs is described in 1MRK512001-BEN and 1MRK001024-CA. Please refer to the website: www.hitachienergy.com/protection-control for detailed information.

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

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

However our proposals for suitable variants are:

Two winding transformer with internal neutral on current circuits. Two pcs can be used in applications for three winding transformers in single or multi-breaker arrangement (ordering number RK926 315-BD)

Two winding transformer with external neutral on current circuits. Two pcs can be used in applications for three winding transformers in single or multi-breaker arrangement (ordering number RK926 315-BH).

Three winding transformer with internal neutral on current circuits (ordering number RK926 315-BX).

The normally open "In test mode" contact 29-30 on the RTXP test switches should be connected to the input of the test function block to allow activation of functions individually during testing.

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

External resistor unit

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

Injection equipment

Rule: If injection equipment is ordered, ROTIPHIZ or STTIPHIZSensitive rotor earth fault protection, injection based (option B31) or 100% stator earth fault protection, injection based (option B32) is required in the IED.

Injection unit, REX060	Quantity:	☐	1MRK002500-AA

The REX060 injection unit requires a connection to a VT across the generator neutral point earthing resistor. The VT must have a rating of at least 100 VA and a rated secondary winding voltage of up to 120 V. It must adhere to IEC 61869-3:2011 section 5.5.301 Rated Output Values and the standard values specified according to burden range II.

Casing

1/2 x 19" rack casing	Basic
Backplane module (BPM)	Basic

Human machine interface

HMI and logic module (HLM)	Basic

Injection modules
Note: One of RIM and SIM have to be selected if REX060 is specified

Rule: Stator injection module (SIM) is required if 100% stator earth fault protection, injection based (option B32) (STTIPHIZ) is selected/active in REG670

Stator injection module (SIM)	☐	1MRK002544-AA

If the generator is earthed via a primary resistor connected between the generator neutral point and earth, a VT is placed across the primary resistor. SIM is then connected to the secondary side of the VT. The VT must have a rating of at least 100 VA and a rated secondary winding voltage of up to 120 V. It must adhere to IEC 61869-3:2011 section 5.5.301 Rated Output Values and the standard values specified according to burden range II.

Rule: Rotor injection module (RIM) is required if Sensitive rotor earth fault protection, injection based (option B31) (ROTIPHIZ) is selected/active in REG670

Rotor injection module (RIM)		☐	1MRK002544-BA
Power supply module			
Rule: One Power supply module must be specified			
Power supply module (PSM)	24-60 VDC	☐	1MRK002239-AB
	100-250 VDC	☐	1MRK002239-BB
Mounting details with IP40 of protection from the front			
19" rack mounting kit		☐	1MRK002420-BB
Wall mounting kit for terminal		☐	1MRK002420-DA
Flush mounting kit for terminal		☐	1MRK000020-Y
Extra IP54 mounting seal + flush mounting kit for terminal		☐	1MRK002420-EA

Rule: REX061 requires REX060 and that Rotor injection module (RIM) is selected in REX060 and that Sensitive rotor earth fault protection, injection based (option B31)(ROTIPHIZ) is selected/active in REG670.			
Coupling capacitor unit, REX061	Quantity:	☐	1MRK002550-AA
Rule: REX062 requires REX060 and that Stator injection module (SIM) is selected in REX060 and that 100% stator earth fault protection, injection based (option B32)(STTIPHIZ) is selected/ active in REG670.			
Shunt resistor unit, REX062	Quantity:	☐	1MRK002555-AA

Combiflex

Key switch for settings

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

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

Mounting kit			Ordering number
Side-by-side mounting kit	Quantity:	☐	1MRK000420-Z
Injection unit for Rotor earth fault protection (RXTTE 4) *Note: Requires additional COMBIFLEX terminal base RX4, 10A COMBIFLEX sockets and appropriate COMBIFLEX mounting accessories for proper operation*	Quantity:	☐	1MRK002108-BA
Protective resistor on plate	Quantity:	☐	RK795102-AD

Configuration and monitoring tools

Front connection cable between LHMI and PC	Quantity:	☐	1MRK001665-CA

LED Label special paper A4, 1 pc		Quantity:		1MRK002038-CA
LED Label special paper Letter, 1 pc		Quantity:		1MRK002038-DA

Manuals

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

Specify quantity of IED Connect USB flash drive requested.		Quantity:		1MRK002700-AA

User documentation

Specify the number of printed manuals requested

Application manual	IEC	Quantity:		1MRK502071-UEN
	ANSI	Quantity:		1MRK502071-UUS
Technical manual	IEC	Quantity:		1MRK502072-UEN
	ANSI	Quantity:		1MRK502072-UUS
Commissioning manual	IEC	Quantity:		1MRK502073-UEN
	ANSI	Quantity:		1MRK502073-UUS
Communication protocol manual, IEC 61850 Edition 1	IEC	Quantity:		1MRK511392-UEN
Communication protocol manual, IEC 61850 Edition 2 and Edition 2.1	IEC	Quantity:		1MRK511393-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity:		1MRK511394-UEN
Communication protocol manual, LON	IEC	Quantity:		1MRK511395-UEN
Communication protocol manual, SPA	IEC	Quantity:		1MRK511396-UEN
Communication protocol manual, DNP	ANSI	Quantity:		1MRK511391-UUS

Point list manual, DNP	ANSI	Quantity:	☐	1MRK511397-UUS
Operation manual	IEC	Quantity:	☐	1MRK500127-UEN
	ANSI	Quantity:	☐	1MRK500127-UUS
Installation manual	IEC	Quantity:	☐	1MRK514026-UEN
	ANSI	Quantity:	☐	1MRK514026-UUS
Engineering manual	IEC	Quantity:	☐	1MRK511398-UEN
	ANSI	Quantity:	☐	1MRK511398-UUS
Cyber security deployment guideline	IEC	Quantity:	☐	1MRK511399-UEN
Application guide, Communication set-up	IEC	Quantity:	☐	1MRK505382-UEN

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

Generator manufacturer:

Rated power: MVA

Type of prime mover: steam ☐, gas ☐, hydro ☐, pumpstorage ☐, nuclear ☐, other ______________________

Related documents

Documents related to REG670	Document numbers
Application manual	IEC: 1MRK502071-UEN ANSI: 1MRK502071-UUS
Commissioning manual	IEC: 1MRK502073-UEN ANSI: 1MRK502073-UUS
Product guide	1MRK502074-BEN
Technical manual	IEC: 1MRK502072-UEN ANSI: 1MRK502072-UUS
Type test certificate	IEC: 1MRK502074-TEN ANSI: 1MRK502074-TUS

670 series manuals	Document numbers
Operation manual	IEC: 1MRK500127-UEN ANSI: 1MRK500127-UUS
Engineering manual	IEC: 1MRK511398-UEN ANSI: 1MRK511398-UUS
Installation manual	IEC: 1MRK514026-UEN ANSI: 1MRK514026-UUS
Communication protocol manual, DNP3	1MRK511391-UUS
Communication protocol manual, IEC 60870-5-103	1MRK511394-UEN
Communication protocol manual, IEC 61850 Edition 1	1MRK511392-UEN

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

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