Relion 670 SERIES

Transformer protection RET670
Version 2.2
Product guide

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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.

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Section 1 Document revision history

Table 1: Document revision history

Document revision	Date	Product version	History
A	2017-07	2.2.0	First release for product version 2.2
B	2017-10	2.2.1	Ethernet ports with RJ45 connector added. enhancements/ updates made to ZMFPDIS and ZMFCPDIS.
C	2018-04	2.2.1	Document enhancements and corrections
D			Document not released
E	2018-07	2.2.2	LDCM galvanic X.21 added. Function PTRSTHR added. Ordering section updated.
F	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.
G			Document not released
H	2018-12	2.2.3	Functions PSTPDIF, CHMMHAI, VHMMHAI, DELVSPVC, DELSPVC and DELISPVC added. Updates/enhancements made to ZMFPDIS, ZMFCPDIS, CCRBRF, REALCOMP, PTRSTHR and FNKEYMDx. Ordering section updated.
J	2019-05	2.2.3	PTP enhancements and corrections
K			Document not released
L			Document not released
M			Document not released
N	2020-09	2.2.4	Functions ZMBURPSB, APPTEF, SCCFPVOC, SCUCPTOC, SCPDPTOV, SCUVPTOV, IEC 61850SIM, ALGOS and SMBRREC added. Updates/enhancements made to functions REFPDIF, ZMFPDIS, ZMFCPDIS, PPLPHIZ, PPL2PHIZ, ZCVPSOF, 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.
P	2021-06	2.2.5	Functions BRPTOC, FLTMMXU, LMBRFLO, 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, SAPTUF, STBPTOC, CHMMHAI, VHMMHAI, OC4PTOC, EF4PTOC, NS4PTOC, SCCFPVOC, DRPRDRE, SXSWI and SXCBR. Ordering section updated.
Q	2021-06	2.2.5	Added note to Disturbance report and IEC 60870-5-103 protocol
R	2022-07	2.2.5.4	Introduced RIA600, which is a software implementation of the IED LHMI panel.
Table continues on next page			

Document revision	Date	Product version	History
S			Document not released
T	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 LDRGFC, INTERRSIG, SETGRPS, TERMINALID, ZMFPDIS, ZMFCPDIS, PPLPHIZ, PPL2PHIZ, PSPPPAM, OC4PTOC, EF4PTOC, NS4PTOC, LCPTTR, LFPTTR, BRCPTOC, VRPVOC, APPTEF, OEXPVPH, VDCPTDV, SCCFPVOC, SCUCPTOC, SCPDPTDV, SCUVPTOV, 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.
U	2024-03	2.2.6.3	"Front with status LEDs, Ethernet port" option removed from ordering option Document enhancements and corrections

Section 2 New features

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

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

Section 3 Application

3.1 Application

The Intelligent Electronic Device (IED) provides fast and selective protection, monitoring and control for two- and three-winding transformers, autotransformers, step-up transformers and generator-transformer block units, phase shifting transformers, special railway transformers and shunt reactors. The IED is designed to operate correctly over a wide frequency range in order to accommodate power system frequency variations during disturbances and generator start-up and shut-down.

The IED has a fast, low-impedance differential protection function with very low requirements on the CTs. It is suitable for differential applications with multi-breaker arrangements with up to six restraint CT inputs. The differential protection function is provided with a 2nd harmonic and waveform-block restraint feature to avoid tripping for CT saturation and transformer inrush current, and 5th harmonic restraint to avoid tripping for transformer overexcitation.

The differential function offers a high sensitivity for low-level internal faults by using a sensitive differential protection feature based on an amplitude measurement and directional comparison of the negative sequence components.

Multiple low impedance restricted earth-fault protection functions are available as a sensitive and fast main protection against winding earth faults. This function includes a internal/external fault discriminator for additional security.

Additionally, a high impedance differential protection function is available. It can be used for different applications including restricted earth fault protection as winding protection, autotransformer differential protection, shunt reactor protection, T-feeder protection, busbar protection and generator differential protection.

Tripping and alarm signals from pressure relief, Buchholz and temperature devices can be sent directly to the IED via binary input channels for alarm and back-up purposes. The binary inputs are highly stabilized against disturbances to prevent incorrect operation due to, for example, DC system capacitive discharges or DC earth faults.

Distance protection functionality is available as back-up protection for faults within the transformer and in the connected power system.

Positive, negative and zero sequence overcurrent functions, which can optionally be made directional and/or voltage controlled, provide further alternative backup protection. Thermal overload, overexcitation, over/under voltage and over/under frequency protection functions are also available.

Breaker failure protection for each transformer breaker allows high speed back-up tripping of surrounding breakers.

A built-in disturbance and event recorder provides valuable data to the user about status and operation for post-fault disturbance analysis.

The IED can optionally be provided with full control and interlocking functionality including a synchrocheck function to allow integration of the main or local back-up control functionality.

A pole slip protection function is also available in the IED to detect, evaluate, and take the required action for pole slipping occurrences in the power system. The electrical system parts swinging to each other can be separated with the line(s) closest to the centre of the power swing, allowing the two systems to be stable when separated.

The IED 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.

Logic is prepared with a graphical tool. The advanced logic capability allows for special applications such as automatic opening of disconnectors in multi-breaker arrangements, closing of breaker rings and load transfer logic. Logic can be monitored and debugged online in real time for testing and commissioning.

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.

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

Communication via optical connections ensures immunity against disturbances.

Four packages have been defined for the following applications:

- Back-up (A10)
- Voltage and tap changer controll (A25)
- Single/Multi breaker, 2 winding differential (B30)
- Multi breaker, 3 winding differential (B40)

Optional functions are not configured but a maximum configuration with all optional functions are available as template in the graphical configuration tool. An alternative for Autotransformers is also available as a configuration template. Analog and tripping IO has been pre-defined for basic use on the, as standard supplied one binary input module and one binary output module. Add binary I/O as required for your application at ordering. Other signals need to be applied as required for each application.

For details on included basic functions, refer to chapter "Basic IED functions"

3.2 Description of configuration B30

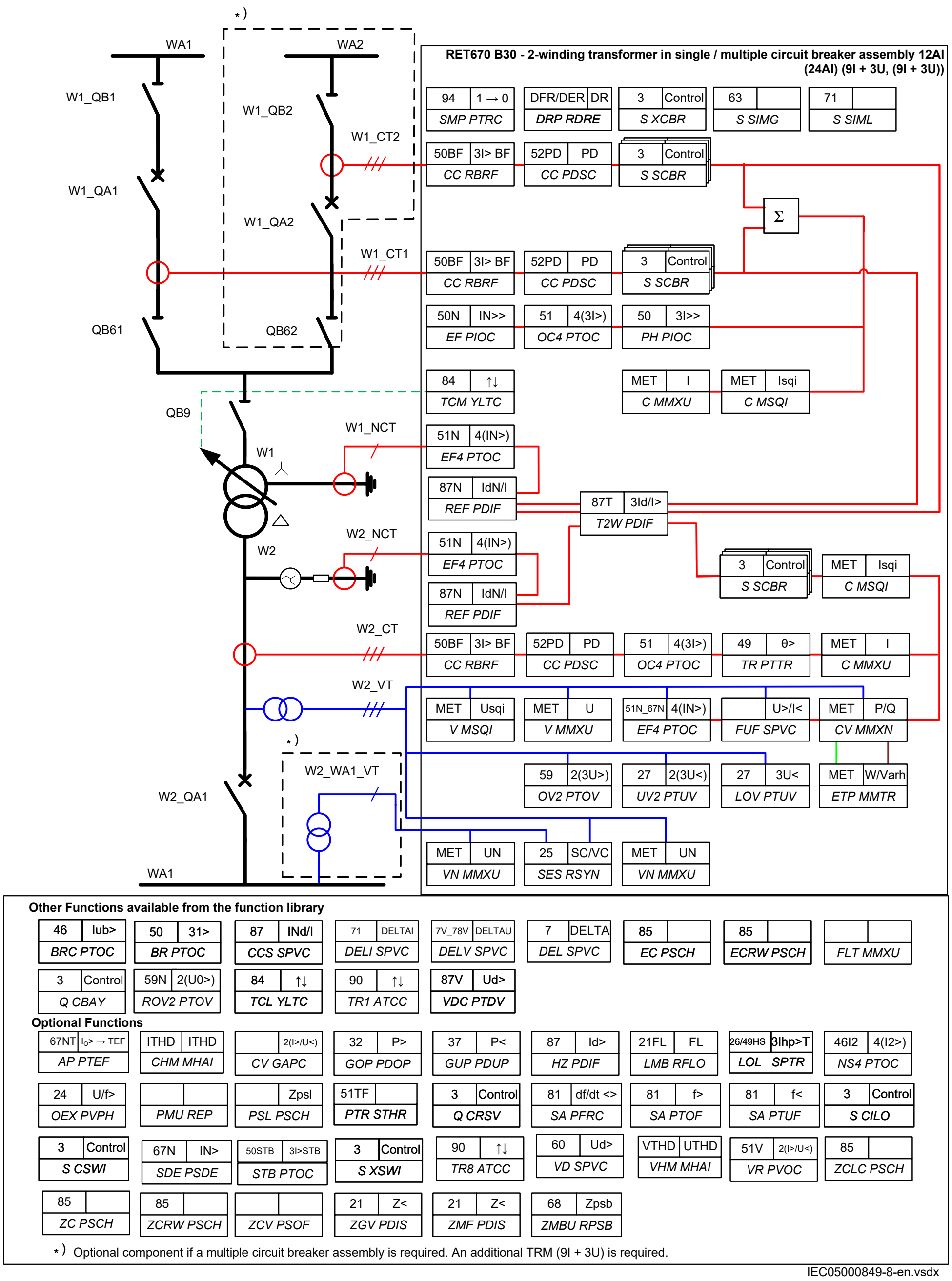


Figure 1: Block diagram for configuration B30

3.3 Description of configuration B40

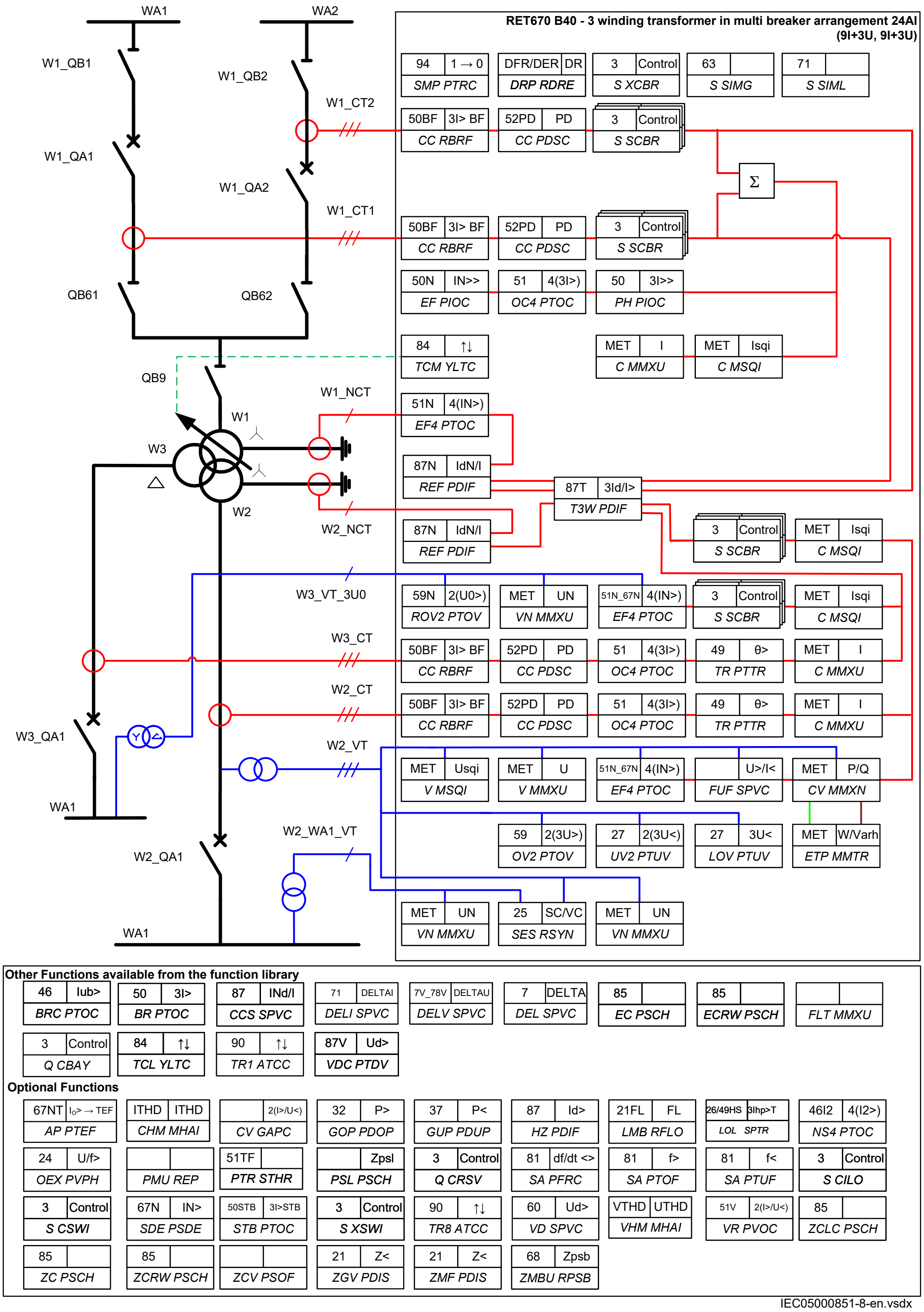


Figure 2: Configuration diagram for configuration B40

3.4 Description of configuration A10

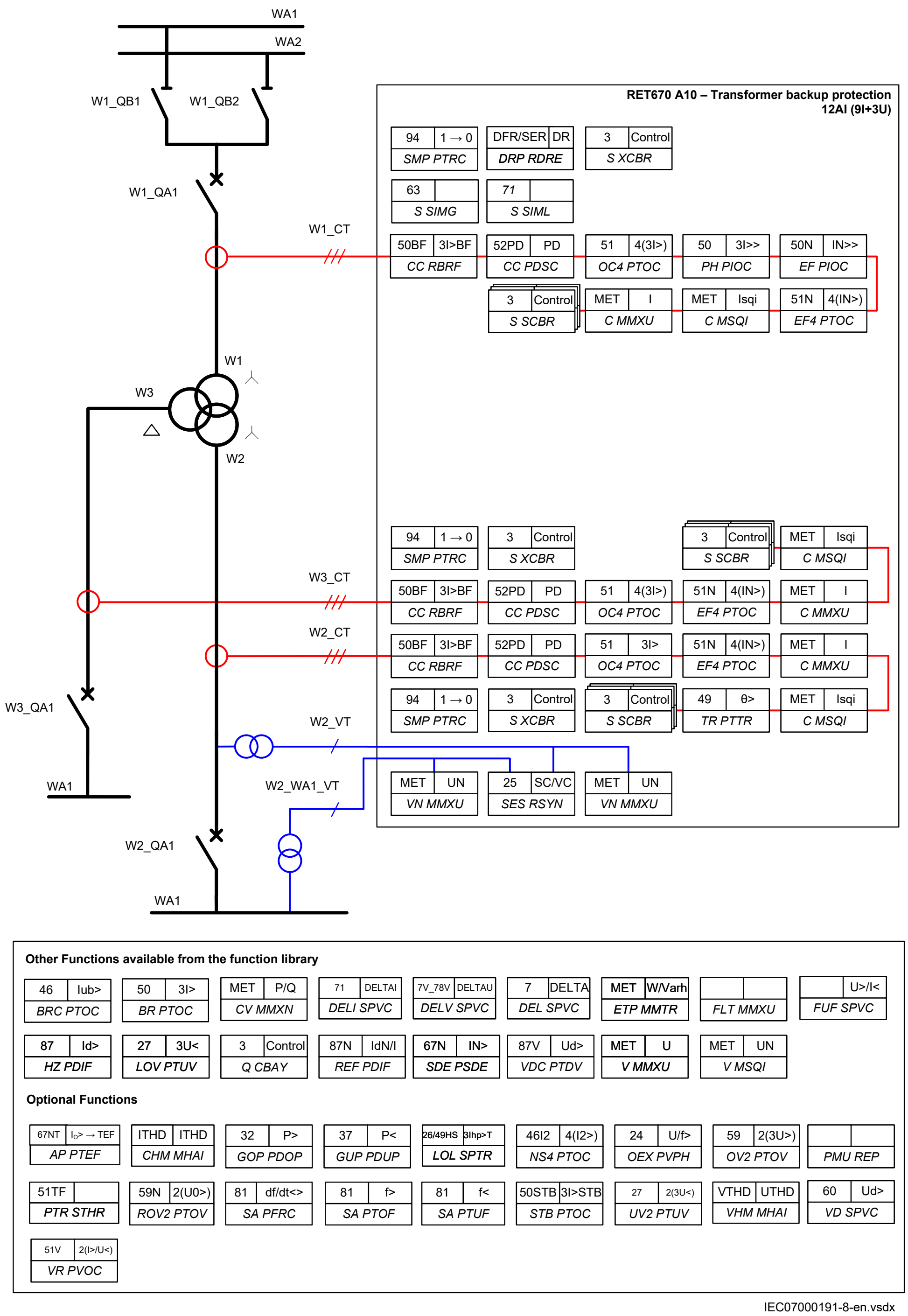


Figure 3: Block diagram for configuration A10

3.5 Description of configuration A25

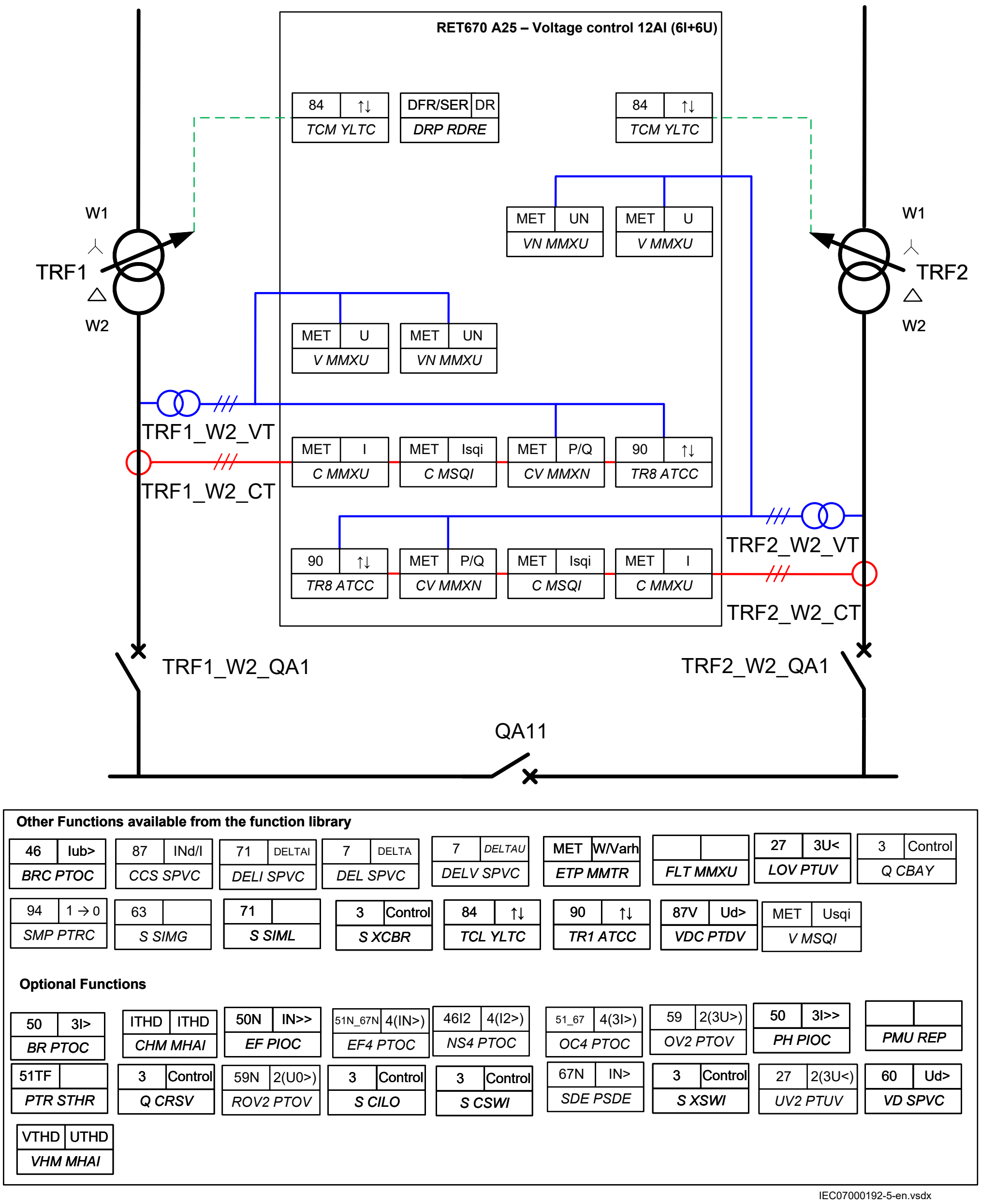


Figure 4: Block diagram for configuration A25

Section 4 Available functions

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

Table 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

4.1 Main protection functions

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
Differential protection							
T2WPDIF	87T	Transformer differential protection, two winding	1-3		1		
T3WPDIF	87T	Transformer differential protection, three winding	1-3			1	
HZPDIF	87	High impedance differential protection, single phase	0-6	1	3-A02	3-A02	
REFPDIF	87N	Restricted earth fault protection, low impedance	0-3	1	2	2B 1-A01	
LDRGFC	11REL	Additional security logic for differential protection	0-1				
PSTPDIF	87T	Self-adaptive differential protection for two-winding power transformers	1				
Impedance protection							
ZMQPDIS, ZMQAPDIS	21	Distance protection zone, quadrilateral characteristic	0-5				
ZDRDIR	21D	Directional impedance quadrilateral	0-2				
ZMCPDIS, ZMCAPDIS	21	Distance measuring zone, quadrilateral characteristic for series compensated lines	0-5				
ZDSRDIR	21D	Directional impedance quadrilateral, including series compensation	0-2				
FDPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle	0-2				
ZMHPDIS	21	Full-scheme distance protection, mho characteristic	0-5				
ZMMPDIS, ZMMAPDIS	21	Full-scheme distance protection, quadrilateral for earth faults	0-5				

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
ZDMRDIR	21D	Directional impedance element for mho characteristic	0-2				
ZDARDIR		Additional distance protection directional function for earth faults	0-1				
ZSMGAPC		Mho impedance supervision logic	0-1				
FMPSPDIS	21	Faulty phase identification with load enchroachment	0-2				
ZMRPDIS, ZMRAPDIS	21	Distance measuring zone, quad characteristic separate Ph-Ph and Ph-E settings	0-5				
FRPSPDIS	21	Phase selection, quadrilateral characteristic with settable angle	0-2				
ZMFPDIS	21	High speed distance protection, quad and mho characteristic	0-2		1-B35	1-B35	
ZMFCPDIS	21	High speed distance protection for series comp. lines, quad and mho characteristic	0-2				
PPLPHIZ		Phase preference logic	0-1				
PPL2PHIZ		Phase preference logic	0-1				
ZMBURPSB	68	Power swing detection, blocking and unblocking	0-1		1-B35	1-B35	
PSLPSCH		Power swing logic	0-1		1-B35	1-B35	
PSPPPAM	78	Pole slip/out-of-step protection	0-1				
OOSPPAM	78	Out-of-step protection	0-1				
ZCVPSOF		Automatic switch onto fault logic, voltage and current based	0-2		1-B35	1-B35	
ZGVPDIS	21	Underimpedance protection for generators and transformers	0-2		1-B14	1-B14	

4.2 Back-up protection functions

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
Current protection							
PHPIOC	50	Instantaneous phase overcurrent protection	0-8	3	2	3	2-C19
OC4PTOC	51_67 1)	Directional phase overcurrent protection, four steps	0-8	3	2	3	2-C19
EFPIOC	50N	Instantaneous residual overcurrent protection	0-8	3	2	3	2-C19
EF4PTOC	51N_67N 2)	Directional residual overcurrent protection, four steps	0-8	3	3	3	2-C19
NS4PTOC	46I2	Directional negative phase sequence overcurrent protection, four steps	0-8	2-C42	2-C42	3-C43	2-C19
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0-3	1	1-C16	1-C16	1-C16
LCPTTR	26	Thermal overload protection, one time constant, Celsius	0-2				
LFPTTR	26	Thermal overload protection, one time constant, Fahrenheit	0-2				
TRPTTR	49	Thermal overload protection, two time constants	0-6	1	1B 1-C05	2B 1-C05	
CCRBRF	50BF	Breaker failure protection	0-6	3	4	6	
STBPTOC	50STB	Stub protection	0-3	3-B26	3-B26	3-B26	
CCPDSC	52PD	Pole discordance protection	0-6	3	4	6	
GUPPDUP	37	Directional underpower protection	0-2	1-C35	1-C35	1-C35	
GOPPDOP	32	Directional overpower protection	0-2	1-C35	1-C35	1-C35	
BRCPTOC	46	Broken conductor check	1	1	1	1	1
CBPGAPC		Capacitor bank protection	0-6				
NS2PTOC	46I2	Negative sequence time overcurrent protection for machines, two steps	0-2				
VRPVOC	51V	Voltage restrained overcurrent protection	0-3	1-C35	1-C35	1-C35	
APPTEF	67NT	Average power transient earth fault protection	0-2	1-C54	1-C54	1-C54	
BRPTOC	50	Overcurrent protection with binary release	0-8	3	2	3	2-C19
Voltage protection							
UV2PTUV	27	Two step undervoltage protection	0-3	1-D01	1B 1-D01	1B 2-D02	2-D02
OV2PTOV	59	Two step overvoltage protection	0-3	1-D01	1B 1-D01	1B 2-D02	2-D02

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
ROV2PTOV	59N	Residual overvoltage protection, two steps	0-4	1-D01	1B 1-D01	1B 2-D02	2-D02
OEXPVPH	24	Overexcitation protection	0-2	2-D04	1-D03	2-D04	
VDCPTDV	87V	Voltage differential protection	0-2	2	2	2	2
LOVPTUV	27	Loss of voltage check	1	1	1	1	1
Unbalance protection							
SCCFPVOC	51V	Cascading failure protection for shunt capacitor bank	0-3				
SCUCPTOC	60N	Current unbalance protection for shunt capacitor bank	0-3				
SCPDPTDV	87V	Phase voltage differential based capacitor bank unbalanced protection	0-3				
SCUVPTOV	60V	Voltage unbalance protection for shunt capacitor bank	0-3				
Frequency protection							
SAPTUF	81	Underfrequency protection	0-10	6-E01	6-E01	6-E01	
SAPTOF	81	Overfrequency protection	0-6	6-E01	6-E01	6-E01	
SAPFRC	81	Rate-of-change of frequency protection	0-6	6-E01	6-E01	6-E01	
Multipurpose protection							
CVGAPC		General current and voltage protection	0-9		6-F02	6-F02	
General calculation							
SMAIHPAC		Multipurpose filter	0-6				
Table Note: 1) 67 requires voltage 2) 67N requires voltage							

4.3 Control and monitoring functions

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
Control							
SESRSYN	25	Synchrocheck, energizing check and synchronizing	0-6	1	1B 2-H01	1B 4-H03	
SMBRREC	79	Autorecloser	1				
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

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
QCBAY		Bay control	1+5/APC30	1	1+5/APC30	1+5/APC30	1+5/APC30
LOCREM		Handling of local/remote switch positions	1+5/APC30	1	1+5/APC30	1+5/APC30	1+5/APC30
LOCREMCTRL		WebUI control of the permitted source to operate (PSTO)	1	1	1	1	1
SXCBR		Circuit breaker	18	12	18	18	18
TR1ATCC	90	Automatic voltage control for tapchanger, single control	0-4		1	2	2B 2-H16
TR8ATCC	90	Automatic voltage control for tapchanger, parallel control	0-4		1-H15	1-H15 2-H18	2B 2-H18
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs	0-4		4	4	4
TCLYLTC	84	Tap changer control and supervision, 32 binary inputs	0-4		4	4	4
SLGAPC		Logic rotating switch for function selection and WebUI presentation	15	15	15	15	15
VSGAPC		Selector mini switch	30	30	30	30	30
DPGAPC		Generic communication function for Double Point indication	32	32	32	32	32
SPC8GAPC		Single point generic control function, 8 signals	5	5	5	5	5
AUTOBITS		Automation bits, command function for DNP3.0	3	3	3	3	3
SINGLECMD		Single command, 16 inputs	8	8	8	8	8
I103CMD		Function commands for IEC 60870-5-103	1	1	1	1	1
I103GENCMD		Function commands for IEC 60870-5-103, generic	50	50	50	50	50
I103POSCMD		IED commands with position and select for IEC 60870-5-103	50	50	50	50	50
I103POSCMDV		IED direct commands with position for IEC 60870-5-103	50	50	50	50	50
I103IEDCMD		IED commands for IEC 60870-5-103	1	1	1	1	1
I103USRCMD		Function commands user defined for IEC 60870-5-103	4	4	4	4	4
Secondary system supervision							
CCSSPVC	87	Current circuit supervision	0-6		4	6	4
FUFSPVC		Fuse failure supervision	0-4	1	3	3	
VDSPVC	60	Fuse failure supervision based on voltage difference	0-2	1-G03	1-G03	1-G03	1-G03
DELVSPVC	7V_78V	Voltage delta supervision	4	4	4	4	4

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
DELISPVC	7I	Current delta supervision	4	4	4	4	4
DELSPVC	78	Real delta supervision, real	4	4	4	4	4
Logic							
SMPPTRC	94	Tripping logic	12	12	12	12	12
SMAGAPC		General start matrix block	12	12	12	12	12
STARTCOMB		Start combinator	32	32	32	32	32
TMAGAPC		Trip matrix logic	12	12	12	12	12
ALMCALH		Logic for group alarm	5	5	5	5	5
WRNCALH		Logic for group warning	5	5	5	5	5
INDCALH		Logic for group indication	5	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	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	1
B16I		Boolean to integer conversion, 16 bit	18	18	18	18	18
BTIGAPC		Boolean to integer conversion with logical node representation, 16 bit	16	16	16	16	16
IB16		Integer to Boolean 16 conversion	24	24	24	24	24
ITBGAPC		Integer to boolean conversion with logical node representation, 16 bit	16	16	16	16	16
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12	12
INTCOMP		Comparator for integer inputs	30	30	30	30	30
REALCOMP		Comparator for real inputs	30	30	30	30	30

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
HOLDMINMAX		Hold minimum and maximum of input	20	20	20	20	20
INT_REAL		Converter integer to real	20	20	20	20	20
CONST_INT		Definable constant for logic functions	10	10	10	10	10
INTSEL		Analog input selector for integer values	5	5	5	5	5
LIMITER		Definable limiter	20	20	20	20	20
ABS		Absolute value	20	20	20	20	20
POL_REC		Polar to rectangular converter	20	20	20	20	20
RAD_DEG		Radians to degree angle converter	20	20	20	20	20
CONST_REAL		Definable constant for logic functions	10	10	10	10	10
REALSEL		Analog input selctor for real values	5	5	5	5	5
STOREINT		Store value for integer inputs	10	10	10	10	10
STOREREAL		Store value for real inputs	10	10	10	10	10
DEG_RAD		Degree to radians angle converter	20	20	20	20	20
Monitoring							
CVMMXN		Power system measurement	6	6	6	6	6
CMMXU		Current measurement	10	10	10	10	10
VMMXU		Voltage measurement phase-phase	6	6	6	6	6
CMSQI		Current sequence measurement	6	6	6	6	6
VMSQI		Voltage sequence measurement	6	6	6	6	6
VNMMXU		Voltage measurement phase-earth	6	6	6	6	6
AISVBAS		General service value presentation of analog inputs	1	1	1	1	1
EVENT		Event function	20	20	20	20	20
DRPRDRE, A1RADR-A4RADR, B1RBDR-B22RBDR, C1RADR-C3RADR		Disturbance report	1	1	1	1	1
SPGAPC		Generic communication function for single point indication, 1 input	128	128	128	128	128
SP16GAPC		Generic communication function for single point indication, 16 inputs	16	16	16	16	16
Table continues on next page							

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
MVGAPC		Generic communication function for measured values	60	60	60	60	60
BINSTATREP		Logical signal status report	3	3	3	3	3
RANGE_XP		Measured value expander block	66	66	66	66	66
SSIMG	63	Insulation supervision for gas medium	21	21	21	21	21
SSIML	71	Insulation supervision for liquid medium	4	4	4	4	4
SSCBR		Circuit breaker condition monitoring	0-18	9	12	18	
LOLSPTR	26/49HS	Transformer insulation loss of life monitoring	0-4	4-M21	4-M21	4-M21	
I103MEAS		Measurands for IEC 60870-5-103	1	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC 60870-5-103	3	3	3	3	3
I103AR		Function status auto-recloser for IEC 60870-5-103	1	1	1	1	1
I103EF		Function status earth-fault for IEC 60870-5-103	1	1	1	1	1
I103FLTPROT		Function status fault protection for IEC 60870-5-103	1	1	1	1	1
I103IED		IED status for IEC 60870-5-103	1	1	1	1	1
I103SUPERV		Supervision status for IEC 60870-5-103	1	1	1	1	1
I103USRDEF		Status for user defined signals for IEC 60870-5-103	20	20	20	20	20
L4UFCNT		Event counter with limit supervision	30	30	30	30	30
TEILGAPC		Running hour meter	6	6	6	6	6
PTRSTHR	51TF	Through fault monitoring	0-2	2-M22	2-M22	2-M22	2-M22
CHMMHAI	ITHD	Current harmonic monitoring, 3 phase	0-3	3-M23	3-M23	3-M23	3-M23
VHMMHAI	VTHD	Voltage harmonic monitoring, 3 phase	0-3	3-M23	3-M23	3-M23	3-M23
FLTMMXU		Fault current and voltage monitoring	3	3	3	3	3
LMBRFLO		Fault locator	0-1		1-M01	1-M01	
Metering							
PCFCNT		Pulse-counter logic	16	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	6	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

Table continues on next page

Configurable logic blocks Q/T	Total number of instances
PULSETIMERQT	40
RSMEMORYQT	40
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

4.4 Communication

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
Station communication							
LONSPA, SPA		SPA communication protocol	1	1	1	1	1
ADE		LON communication protocol	1	1	1	1	1
HORZCOMM		Network variables via LON	1	1	1	1	1
PROTOCOL		Operation selection between SPA and IEC 60870-5-103 for SLM	1	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1	1
RS485GEN		RS485	1	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1	1
CHSERRS485		DNP3.0 for EIA-485 communication protocol	1	1	1	1	1
CH1TCP, CH2TCP, CH3TCP, CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1	1
CHSEROPT		DNP3.0 for TCP/IP and EIA-485 communication protocol	1	1	1	1	1
MSTSER		DNP3.0 serial master	1	1	1	1	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1	1

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1	1	1	1	1
IEC 61850-8-1		IEC 61850	1	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59	59
IEC 61850SIM		IEC 61850 simulation mode	1	1	1	1	1
GOOSEBINRCV		GOOSE binary receive	16	16	16	16	16
GOOSEDPRCV		GOOSE function block to receive a double point value	64	64	64	64	64
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	60	60	60	60	60
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64	64
VCTRSEND		Horizontal communication via GOOSE for VCTR	1	1	1	1	1
GOOSEVCTRRCV		Horizontal communication via GOOSE for VCTR	7	7	7	7	7
GOOSEVCTRCONF		GOOSE VCTR configuration for send and receive	1	1	1	1	1
ALGOS		Supervision of GOOSE subscription	100	100	100	100	100
MULTICMDRCV, MULTICMDSND		Multiple command receive and send	60/10	60/10	60/10	60/10	60/10
OPTICAL103		IEC 60870-5-103 Optical serial communication	1	1	1	1	1
RS485103		IEC 60870-5-103 serial communication for RS485	1	1	1	1	1
AGSAL		Generic security application component	1	1	1	1	1
LD0LLN0		IEC 61850 LD0 LLN0	1	1	1	1	1
SYSLLN0		IEC 61850 SYS LLN0	1	1	1	1	1
LPHD		Physical device information	1	1	1	1	1
PCMACCS		IED configuration protocol	1	1	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1	1
FSTACCSNA		Field service tool access via SPA protocol over Ethernet communication	1	1	1	1	1
FSTACCS		Field service tool access	1	1	1	1	1
GOOSEACRCV		GOOSE function block to receive a protection activation information	16	16	16	16	16
		IEC 61850-9-2 Process bus communication, 12 merging units	0-1	1-P30	1-P30	1-P30	1-P30
ACTIVLOG		Activity logging	1	1	1	1	1

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
ALTRK		Service tracking	1	1	1	1	1
PRP		IEC 62439-3 Parallel redundancy protocol	0-1	1-P23	1-P23	1-P23	1-P23
HSR		IEC 62439-3 High-availability seamless redundancy	0-1	1-P24	1-P24	1-P24	1-P24
RSTP		IEC 62439-3 Rapid spanning tree protocol	0-1	1-P25	1-P25	1-P25	1-P25
SNMPSERVERCONF		SNMPServerConfiguration	1	1	1	1	1
SNMPUSERCONF		SNMPUserConfiguration	2	2	2	2	2
PMUCONF, PMUREPORT, PHASORREPORT1, PHASORREPORT2, PHASORREPORT3, ANALOGREPORT1, BINARYREPORT1, SMAI1 - SMAI12, 3PHSUM, PMUSTATUS		Synchrophasor report, 24 phasors (see Table 7)	0-1	1-P33	1-P33	1-P33	1-P33
AP_1-AP_6		AccessPoint_ABS	1	1	1	1	1
AP_FRONT		Access point front	1	1	1	1	1
PTP		Precision time protocol	1	1	1	1	1
ROUTE_1-ROUTE_6		Route_ABS1-Route_ABS6	1	1	1	1	1
FRONTSTATUS		Access point diagnostic for front Ethernet port	1	1	1	1	1
SCHLCCH		Access point diagnostic for non-redundant Ethernet port	6	6	6	6	6
RCHLCCH		Access point diagnostic for redundant Ethernet ports	3	3	3	3	3
DHCP		DHCP configuration for front access point	1	1	1	1	1
QUALEXP		IEC 61850 quality expander	96	96	96	96	96
Remote communication							
BinSignRec1_1 BinSignRec1_2 BinSignReceive2		Binary signal transfer, receive	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6
BinSignTrans1_1 BinSignTrans1_2 BinSignTransm2		Binary signal transfer, transmit	3/3/6	3/3/6	3/3/6	3/3/6	3/3/6
BSR2M_305 BSR2M_312 BSR2M_322 BSR2M_306 BSR2M_313 BSR2M_323		Binary signal transfer, 2Mbit receive	1	1	1	1	1
BST2M_305 BST2M_312 BST2M_322 BST2M_306 BST2M_313 BST2M_323		Binary signal transfer, 2Mbit transmit	1	1	1	1	1
LDCMTRN		Transmission of analog data from LDCM	1	1	1	1	1

Table continues on next page

IEC 61850 or function name	ANSI	Function description	Transformer				
			RET670 (Customized)	RET670 (A10)	RET670 (B30)	RET670 (B40)	RET670 (A25)
LDCMTRN_2M_305 LDCMTRN_2M_306 LDCMTRN_2M_312 LDCMTRN_2M_313 LDCMTRN_2M_322 LDCMTRN_2M_323		Transmission of analog data from LDCM, 2Mbit	1	1	1	1	1
LDCMRecBinStat1 LDCMRecBinStat3		Receive binary status from remote LDCM	6/3	6/3	6/3	6/3	6/3
LDCMRecBinStat2		Receive binary status from LDCM	3	3	3	3	3
LDCM2M_305 LDCM2M_312 LDCM2M_322		Receive binary status from LDCM, 2Mbit	1	1	1	1	1
LDCM2M_306 LDCM2M_313 LDCM2M_323		Receive binary status from remote LDCM, 2Mbit	1	1	1	1	1
Scheme communication							
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection	0-2		1-B35 1-K01	1-B35 1-K01	
ZPCPSCH	85	Phase segregated scheme communication logic for distance protection	0-2				
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection	0-2		1-B35 1-K01	1-B35 1-K01	
ZPCWPSCH	85	Current reversal and weak-end infeed logic for phase segregated communication	0-2				
ZCLCPSCH		Local acceleration logic	0-1		1-B35 1-K01	1-B35 1-K01	
ECPSCH	85	Scheme communication logic for residual overcurrent protection	0-1		1	1	
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection	0-1		1	1	

Table 7: Number of function instances in Synchrophasor report, 24 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)	1
PHASORREPORT1	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 1-8	1
PHASORREPORT2	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 9-16	1
PHASORREPORT3	Protocol reporting of phasor data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), phasors 17-24	1
ANALOGREPORT1	Protocol reporting of analog data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), analogs 1-8	1

Table continues on next page

Function name	Function description	Total number of instances
BINARYREPORT1	Protocol reporting of binary data via IEEE 1344 and IEC/IEEE 60255-118 (C37.118), binary 1-8	1
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

Table 8: Number of function instances in Synchrophasor report, 32 phasors

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

4.5 Basic IED functions

Table 9: 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
Table continues on next page	

IEC 61850 or function name	Description
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
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 10: Local HMI functions

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

Section 5 Differential protection

5.1 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.

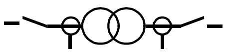
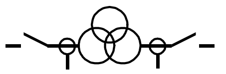
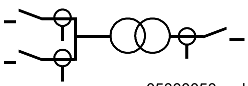
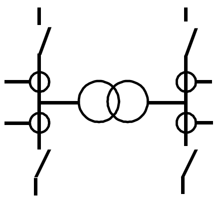
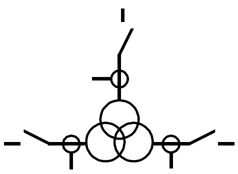
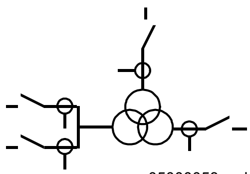
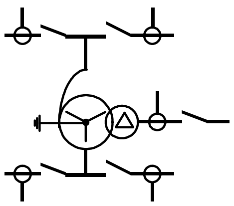
Two-winding applications	
 xx05000048.vsd	two-winding power transformer
 xx05000049.vsd	two-winding power transformer with unconnected delta tertiary winding
 xx05000050.vsd	two-winding power transformer with two circuit breakers and two CT-sets on one side
 xx05000051.vsd	two-winding power transformer with two circuit breakers and two CT-sets on both sides
Three-winding applications	
 xx05000052.vsd	three-winding power transformer with all three windings connected

Table continues on next page



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 5: 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.

5.2 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 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.

5.3 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 6.

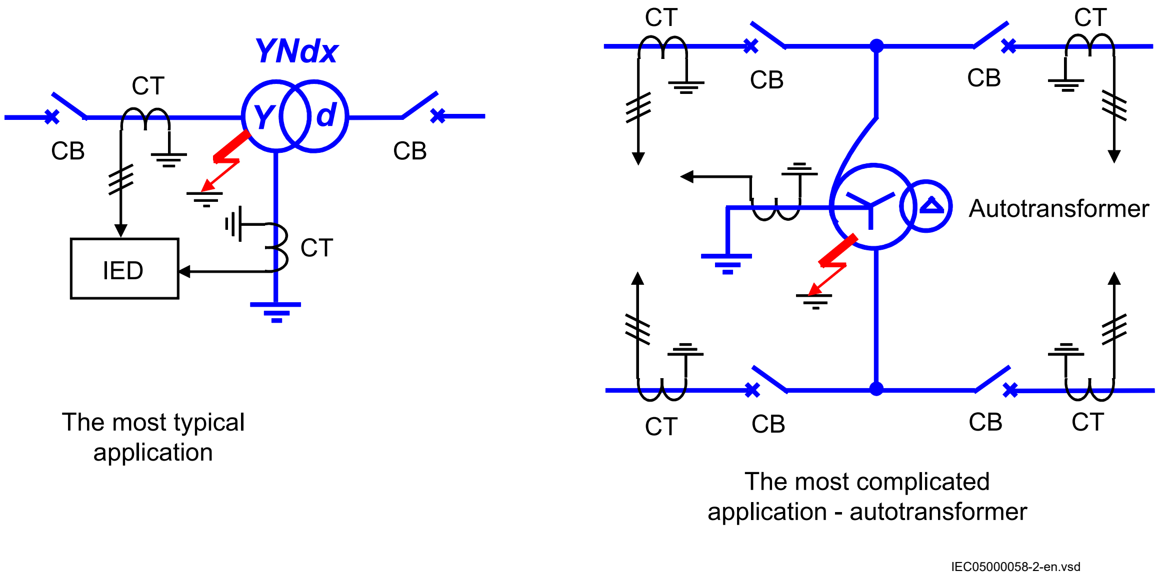


Figure 6: Examples of applications of the REFPDIF

5.4 Additional security logic for differential protection LDRGFC

Additional security logic for differential protection (LDRGFC) can help the security of the protection especially when the communication system is in abnormal status or for example when there is unspecified asymmetry in the communication link. It helps to reduce the probability for mal-operation of the protection. LDRGFC is more sensitive than the main protection logic to always release operation for all faults detected by the differential function. LDRGFC consists of four sub functions:

- Phase-to-phase current variation
- Zero sequence current criterion
- Low voltage criterion
- Low current criterion

Phase-to-phase current variation takes the current samples as input and it calculates the variation using the sampling value based algorithm. Phase-to-phase current variation function is a major one to fulfill the objectives of the startup element.

Zero sequence criterion takes the zero sequence current as input. It increases the security of protection during the high impedance fault conditions.

Low voltage criterion takes the phase voltages and phase-to-phase voltages as inputs. It increases the security of protection when the three-phase fault occurred on the weak end side.

Low current criterion takes the phase currents as inputs and it increases the dependability during the switch onto fault case of unloaded line.

The differential function can be allowed to trip as no load is fed through the line and protection is not working correctly.

Features:

- Startup element is sensitive enough to detect the abnormal status of the protected system
- Startup element does not influence the operation speed of main protection
- Startup element would detect the evolving faults, high impedance faults and three phase fault on weak side
- It is possible to block the each sub function of startup element
- Startup signal has a settable pulse time

5.5 Self-adaptive differential protection for two-winding power transformers PSTPDIF

The PSTPDIF function can be used as a differential protection for any two-winding three-phase power transformers. It is especially suitable for the differential protection of phase-shifting transformers (PST), which is also called phase-angle regulating transformers (PAR). This function is similar to the standard transformer differential protection function T2WPDIF (or 87T), but it can be applied to any type and construction of PST.

The differential protection is self-adaptive. It automatically learns and adopts to the actual transformation ratio and phase-angle shift across the protected transformer. Thus, any PST regardless of its construction principles (that is, symmetrical or asymmetrical) and design details (that is, single-core, double-core or even of complex design) can be entirely protected by using the PSTPDIF function.

The function is provided with two sets of three-phase current inputs (one from each side of the PST). Therefore, either the CTs located in bushings of the PST or in series with them shall be used. Both current inputs are provided with percentage bias restraint features. Note that two VT inputs, one from each side, shall also be connected to the function. Either single-phase or three-phase VT inputs can be used.

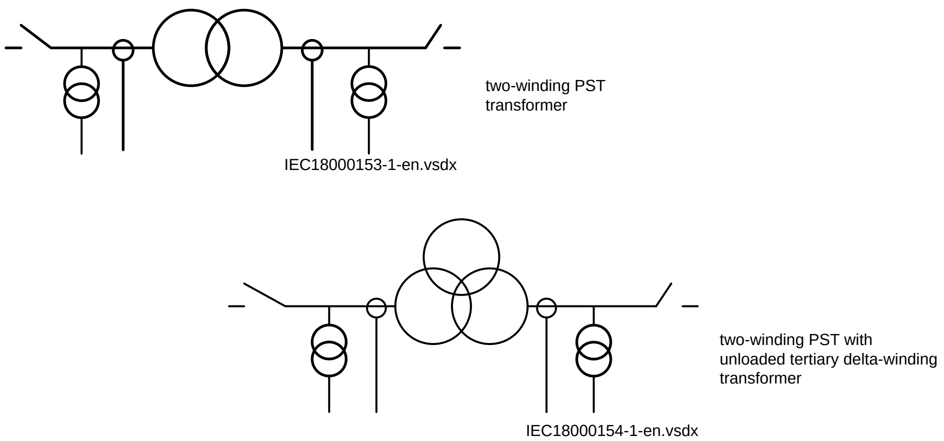


Figure 7: Possible arrangements for phase-shifting transformer differential protection

An adaptive stabilizing feature is included for heavy through-fault currents. As the false differential current is practically equal to zero during all operating conditions of the PST, the differential protection pick-up can be set to optimum sensitivity, thus covering internal faults with a low fault current level such as turn-to-turn faults.

Stabilization is included for inrush and over-excitation currents, and cross-blocking is also included. Adaptive stabilization is included for the system recovery inrush and CT saturation during external faults. A high set unrestrained differential current protection element is included for higher speed tripping at high internal fault currents.

A sensitive differential protection element based on the theory of negative-sequence current component is included. This element offers the best possible coverage of transformer winding(s) turn-to-turn faults.

Section 6 Impedance protection

6.1 Distance protection zone, quadrilateral characteristic ZMQPDIS, ZMQAPDIS

The line distance protection is an up to five (depending on product variant) zone full scheme protection function with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth faults for each of the independent zones. Individual settings for each zone in resistive and reactive reach gives flexibility for use as back-up protection for transformer connected to overhead lines and cables of different types and lengths.

Distance measuring zone, quadrilateral characteristic (ZMQPDIS) together with Phase selection with load encroachment (FDPSPDIS) has functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines, as shown in figure 8.

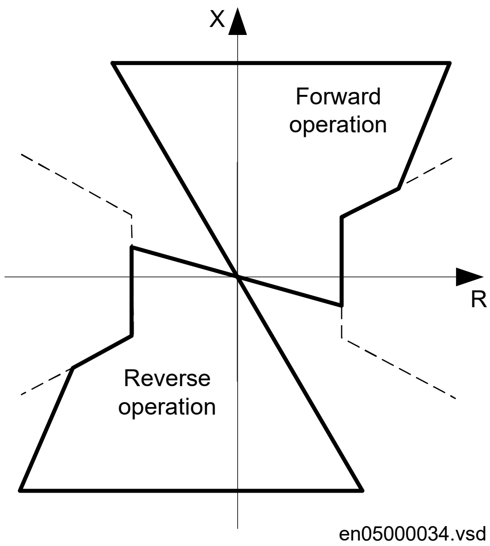


Figure 8: Typical quadrilateral distance protection zone with Phase selection with load encroachment function FDPSPDIS activated

The independent measurement of impedance for each fault loop together with a sensitive and reliable built-in phase selection makes the function suitable in applications with single-phase autoreclosing.

Built-in adaptive load compensation algorithm prevents overreaching of zone 1 at load exporting end at phase-to-earth faults on heavily loaded power lines.

The distance protection zones can operate independently of each other in directional (forward or reverse) or non-directional mode. This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines.

6.2 Distance measuring zone, quadrilateral characteristic for series compensated lines ZMCPDIS, ZMCAPDIS

The line distance protection is an up to five (depending on product variant) zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth fault for each of the independent zones. Individual settings for each zone resistive and reactive reach give flexibility for use on overhead lines and cables of different types and lengths.

Quadrilateral characteristic is available.

Distance measuring zone, quadrilateral characteristic for series compensated lines (ZMCPDIS) function has functionality for load encroachment which increases the possibility to detect high resistive faults on heavily loaded lines.

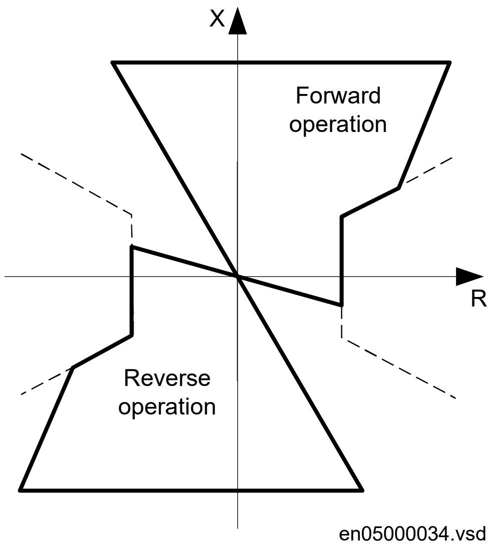


Figure 9: Typical quadrilateral distance protection zone with load encroachment function activated

The distance protection zones can operate, independent of each other, in directional (forward or reverse) or non-directional mode. This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines.

6.3 Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS

The operation of transmission networks today is in many cases close to the stability limit. Due to environmental considerations, the rate of expansion and reinforcement of the power system is reduced, for example, difficulties to get permission to build new power lines. The ability to accurately and reliably classify the different types of fault, so that single pole tripping and autoreclosing can be used plays an important role in this matter. Phase selection, quadrilateral characteristic with fixed angle (FDPSPDIS) is designed to accurately select the proper fault loop in the distance function dependent on the fault type.

The heavy load transfer that is common in many transmission networks may make fault resistance coverage difficult to achieve. Therefore, FDPSPDIS has a built-in algorithm for load encroachment, which gives the possibility to enlarge the resistive setting of both the phase selection and the measuring zones without interfering with the load.

The extensive output signals from the phase selection gives also important information about faulty phase(s), which can be used for fault analysis.

A current-based phase selection is also included. The measuring elements continuously measure three phase currents and the residual current and, compare them with the set values.

6.4 Full-scheme distance measuring, Mho characteristic ZMHPDIS

The numerical mho line distance protection is an up to five (depending on product variant) zone full scheme protection 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.

6.5 Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS, ZMMAPDIS

The line distance protection is an up to five (depending on product variant) zone full scheme protection function with three fault loops for phase-to-earth fault for each of the independent zones. Individual settings for each zone resistive and reactive reach give flexibility for use on overhead lines and cables of different types and lengths.

The Full-scheme distance protection, quadrilateral for earth fault functions have functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines , see Figure 10.

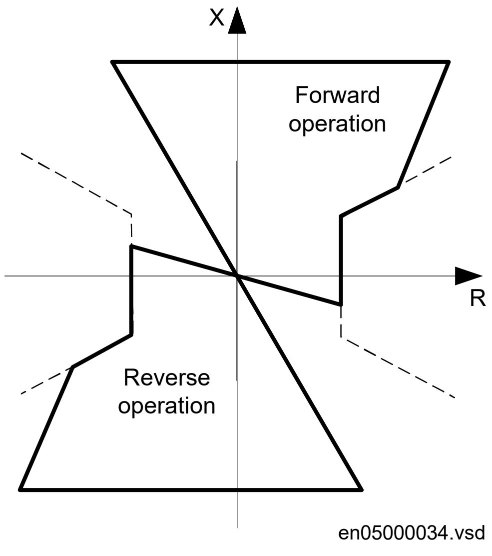


Figure 10: Typical quadrilateral distance protection zone with Phase selection, quadrilateral characteristic with settable angle function FRPSPDIS activated

The independent measurement of impedance for each fault loop together with a sensitive and reliable built in phase selection makes the function suitable in applications with single phase auto-reclosing.

The distance protection zones can operate, independent of each other, in directional (forward or reverse) or non-directional mode. This makes them suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as parallel lines, multi-terminal lines.

6.6 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).

6.7 Mho impedance supervision logic ZSMGAPC

The Mho impedance supervision logic (ZSMGAPC) includes features for fault inception detection and high SIR detection. It also includes the functionality for loss of potential logic as well as for the pilot channel blocking scheme.

ZSMGAPC can mainly be decomposed in two different parts:

1. A fault inception detection logic
2. High SIR detection logic

6.8 Faulty phase identification with load encroachment FMPSPDIS

The ability to accurately and reliably classify different types of fault so that single phase tripping and autoreclosing can be used plays an important roll in today's power systems.

The phase selection function is design to accurately select the proper fault loop(s) in the distance function dependent on the fault type.

The heavy load transfer that is common in many transmission networks may in some cases interfere with the distance protection zone reach and cause unwanted operation. Therefore the function has a built in algorithm for load encroachment, which gives the possibility to enlarge the resistive setting of the measuring zones without interfering with the load.

The output signals from the phase selection function produce important information about faulty phase(s), which can be used for fault analysis as well.

6.9 Distance measuring zone, quad characteristic separate Ph-Ph and Ph-E settings ZMRPDIS, ZMRAPDIS

The line distance protection is up to five zone full scheme protection with three fault loops for phase-to-phase faults and three fault loops for phase-to-earth fault for each of the independent zones. Individual settings for each zone in resistive and reactive reach gives flexibility for use as back-up protection for transformer connected to overhead lines and cables of different types and lengths.

Mho alternative quadrilateral characteristic is available.

Distance protection zone, quadrilateral characteristic (ZMRPDIS) together with Phase selection, quadrilateral characteristic with settable angle (FRPSPDIS) has functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines.

The distance protection zones can operate, independent of each other, in directional (forward or reverse) or non-directional mode.

6.10 Phase selection, quadrilateral characteristic with settable angle FRPSPDIS

The operation of transmission networks today is in many cases close to the stability limit. Due to environmental considerations, the rate of expansion and reinforcement of the power system is reduced for example, difficulties to get permission to build new power lines. The ability to accurately and reliably classify the different types of fault, so that single pole tripping and autoreclosing can be used plays an important role in this matter. The phase selection function is designed to accurately select the proper fault loop in the distance function dependent on the fault type.

The heavy load transfer that is common in many transmission networks may make fault resistance coverage difficult to achieve. Therefore, the function has a built in algorithm for load encroachment, which gives the possibility to enlarge the resistive setting of both the phase selection and the measuring zones without interfering with the load.

The extensive output signals from the phase selection gives also important information about faulty phase(s) which can be used for fault analysis.

A current-based phase selection is also included. The measuring elements continuously measure three phase currents and the residual current and, compare them with the set values.

6.11 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.

6.12 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.

6.13 Power swing detection, blocking and unblocking ZMBURPSB

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

Power swing detection, blocking and unblocking function (ZMBURPSB) is used to detect power swings and initiate blocking of all distance protection zones.

Also, fault identification and its classification for various types of fault occurrences during the power swing are available in the ZMBURPSB function. So, six measuring loops used in each distance protection zone, if blocked during power swing, can be unblocked/released for distance measurement depending upon the fault type and thereby, reliable fault clearance can be achieved for faults during power swing.

It is still possible to inhibit the ZMBURPSB function for earth-fault currents during a power swing without activating power swing unblocking functionality.

6.14 Power swing logic PSLPSCH

Power Swing Logic (PSLPSCH) provides possibility for selective tripping of faults on power lines during system oscillations (power swings or pole slips), when the distance protection function should normally be blocked. The complete logic consists of two different parts:

- Communication and tripping part: provides selective tripping on the basis of special distance protection zones and a scheme communication logic, which are not blocked during the system oscillations.
- Blocking part: blocks unwanted operation of instantaneous distance protection zone 1 for oscillations, which are initiated by faults and their clearing on the adjacent power lines and other primary elements.

6.15 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.

6.16 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.

6.17 Phase preference logic PPLPHIZ

The optional phase preference logic (PPLPHIZ) is used with the ZMQPDIS and FDPSPDIS distance protection. The main purpose of this function is to provide a selective tripping for cross-country faults in isolated or high impedance-earthed networks.

6.18 Phase preference logic PPL2PHIZ

The Phase preference logic function (PPL2PHIZ) is used with the high speed distance protection, quad and mho characteristic (ZMFPDIS). It is intended to be used in isolated or high impedance earthed networks where there is a requirement to operate on only one of the faulty lines during a cross-country fault. It can be used without preference to restrain operation for single earth faults with a delayed zero-sequence current release for cable networks earthed using a resistor.

For cross-country faults, the logic selects either the leading or lagging phase-to-earth loop for measurement. It initiates operation on the preferred phase based on the selected phase preference scheme. A number of different phase preference schemes are available.

PPL2PHIZ provides an additional phase selection criteria, namely under voltage criteria, suitable for phase selection during cross-country faults. In radial networks, where there is no fault current in the phase with the external fault, current or impedance based phase selection methods become ineffective.

Hence, only voltage can be used for phase selection. The phase selection result will be the same for all bays on a bus since the voltage is the same, which is an important condition for operating with phase preference.

In meshed and stronger networks, it may be difficult to find appropriate under-voltage settings for phase selection. Therefore an automatic phase selection logic is made available which works in parallel with a set under-voltage criterion in order to detect the two faulty phases even for complex networks. If for any reason the PPL2PHIZ is unable to detect the two faulty phases, then after a short time delay all three phase-to-earth loops of the distance protection will be released for operation. The final result might be that both faulty feeders are disconnected. In other words, protection operation is prioritized over strict adherence to preference.

During a cross-country fault, both fault locations are in front of the distance protection. The measured residual current magnitude can be quite small. The PPL2PHIZ function has built-in logic that can detect such a condition and properly release the preferred phase-to-earth loop.

6.19 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.

6.20 Automatic switch onto fault logic, voltage and current based ZCVPSOF

Automatic switch onto fault logic (ZCVPSOF) is a function that gives an instantaneous trip at closing of breaker onto a fault. A dead line detection check is provided to activate the function when the line is dead.

Section 7 Wide area measurement system

7.1 Synchrophasor report, 24 phasors

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

The IED supports the following IEEE synchrophasor standards:

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

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

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

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

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

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

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

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

Section 8 Current protection

8.1 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.

8.2 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.

8.3 Instantaneous residual overcurrent protection EFPIOC

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

8.4 Directional residual overcurrent protection, four steps EF4PTOC

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

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

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

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

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

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

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

8.5 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.

8.6 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.

8.7 Thermal overload protection, one time constant LCPTTR/ LFPTTR

The increasing utilization of the power system closer to the thermal limits has generated a need of a thermal overload protection for power lines.

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

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

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

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

8.8 Thermal overload protection, two time constants TRPTTR

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

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

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

The estimated time to trip before operation is presented.

8.9 Breaker failure protection CCRBRF

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

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

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

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

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

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

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

8.10 Stub protection STBPTOC

When a power line is taken out of service for maintenance and the line disconnector is opened in multi-breaker arrangements the voltage transformers will mostly be outside on the disconnected part. The primary line distance protection will thus not be able to operate and must be blocked.

The stub protection (STBPTOC) covers the zone between the current transformers and the open disconnector. The three-phase instantaneous overcurrent function is released from a normally closed, NC (b) auxiliary contact on the line disconnector.

8.11 Overcurrent protection with binary release BRPTOC

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

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

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

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

8.12 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.

8.13 Directional over/underpower protection GOPPDOP/ GUPPDUP

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

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

Each function has two steps with definite time delay.

8.14 Broken conductor check BRCPTOC

The main purpose of the function Broken conductor check (BRCPTOC) is the detection of broken conductors on protected power lines and cables (series faults). Detection can be used to give alarm only or trip the line breaker.

8.15 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.

8.16 Capacitor bank protection CBPGAPC

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

8.17 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.

8.18 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.

Section 9 Voltage protection

9.1 Two-step undervoltage protection UV2PTUV

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

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

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

9.2 Two step overvoltage protection OV2PTOV

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

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

OV2PTOV has two voltage steps, each of them with inverse or definite time delayed.

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

9.3 Residual overvoltage protection, two steps ROV2PTOV

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

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

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

A reset delay ensures operation for intermittent earth faults.

9.4 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.

9.5 Voltage differential protection VDCPTDV

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

9.6 Loss of voltage check LOVPTUV

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

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

Section 10 Unbalance protection

10.1 Cascading failure protection for shunt capacitor bank SCCFPVOC

Cascading failures are series faults in shunt capacitor banks involving more than one capacitor unit (or even more than one rack). Cascading failures in shunt capacitor bank (SCCFPVOC) function provides protection against cascading faults and has the following protection modes to detect the unbalances.

- Two step, negative sequence based voltage restrained over-current protection
- Two step, zero sequence based voltage restrained over-current protection

10.2 Current unbalance protection for shunt capacitor bank SCUCPTOC

The current unbalance protection for shunt capacitor bank (SCUCPTOC) function is used to protect the shunt capacitor bank(SCB) from the unbalance due to internal faults in elements or units. It is applicable for protecting the following shunt capacitor bank configurations, only when CT's available to measure the unbalance current from the unbalance.

- Grounded and ungrounded double WYE
- Grounded and ungrounded single WYE with strings in each phase
- Grounded and ungrounded H bridge configurations

The main features of the function are,

- Remote command or binary trigger-based compensation for natural unbalance current
- Insensitive to system unbalances
- The function provides phase segregated warning, alarm and trip signals along with the general warning, alarm and trip signal based on independent set levels
- Two timer modes for trip signal-Definite time and programmable IDMT delay curve
- Unwanted operation of the function, for example, capacitor bank de-energization can be inhibited by activating a binary signal
- Secure operation of function against minimum phase currents

10.3 Phase voltage differential based capacitor bank unbalanced protection SCPDPTOV

The phase voltage differential based capacitor bank unbalanced protection (SCPDPTOV) function protects the shunt capacitor bank(SCB) from the unbalance due to internal faults in elements or units. The SCPDPTOV function can be applied to grounded and ungrounded capacitor bank configurations, where the three-phase bus and tap voltage measurements are available.

The main features of the function are,

- It can be applied for both single WYE and double WYE, grounded and ungrounded capacitor bank configurations.
- Continuous monitoring of voltage ratio to overcome the natural unbalance.
- The voltage ratio can be settable or can be triggered remotely to be updated it with continuously calculated values.
- Binary signal indication, when the percentage variation of calculated voltage and stored voltage ratios exceeds the settable limit.
- Function provides phase segregated warning, alarm and trip signals along with a general warning, alarm and trip signal based on independent set levels.
- Reliable warning and alarm signals are generated, stability of alarm and the warning signal is ensured with settable time delay.
- Two timer modes for trip signal-Definite time and programmable IDMT delay curve.
- Unwanted operation of the function, for example, capacitor bank de-energization can be inhibited by activating a binary signal.

10.4 Voltage unbalance protection for shunt capacitor bank SCUVPTOV

The voltage unbalance protection for shunt capacitor bank (SCUVPTOV) function is used to protect an ungrounded single and double WYE shunt capacitor bank with the single neutral voltage measurement. It operates when the differential voltage between measured neutral voltage and zero sequence voltage of the bus is larger than the set operate voltage.

The main features of the function are,

- It is insensitive to system unbalance
- Influence of any natural unbalance in the capacitor bank can be compensated
- Evaluation of the voltage unbalance compensation factor can be triggered by either binary input or over LHMI or MMS command
- Function operation can be blocked through binary input during unwanted operation, for example, SCB de-energization
- Minimum bus voltage check for secure operation
- Function has warning, alarm and trip levels
- Function trip signal can be delayed by definite timer or based on a programmable curve and warning and alarm have definite time delays

Section 11 Frequency protection

11.1 Underfrequency protection SAPTUF

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

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

SAPTUF is provided with undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected.

11.2 Overfrequency protection SAPTOF

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

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

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

SAPTOF is provided with an undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected.

11.3 Rate-of-change of frequency protection SAPFRC

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

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

Section 12 Multipurpose protection

12.1 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.

Section 13 General calculation

13.1 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.

Section 14 Secondary system supervision

14.1 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.

14.2 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.

14.3 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.

14.4 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.

14.5 Current based delta supervision DELISPVC

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

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

14.6 Delta supervision of real input DELSPVC

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

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

Section 15 Control

15.1 Synchrocheck, energizing check, and synchronizing SESRSYN

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

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

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

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

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

15.2 Autorecloser SMBRREC

The auto recloser (SMBRREC) function provides:

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

The auto recloser can be used for delayed busbar restoration.

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

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

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

15.3 Apparatus control APC

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

Apparatus control features:

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

Two types of command models can be used:

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

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

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

15.4 Interlocking

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

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

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

15.5 Switch controller SCSWI

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

15.6 Circuit breaker SXCBR

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

15.7 Circuit switch SXSWI

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

15.8 Reservation function QCRSV

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

15.9 Reservation input RESIN

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

15.10 Bay control QCBAY

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

15.11 Proxy for signals from switching device via GOOSE XLNPROXY

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

15.12 GOOSE function block to receive a switching device GOOSEXLNRCV

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

15.13 Local remote LOCREM/Local remote control LOCREMCTRL

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

15.14 Voltage control TR1ATCC/TR8ATCC , TCMYLTC/TCLYLTC

Automatic voltage control for tap changer, single control (TR1ATCC), Automatic voltage control for tap changer, parallel control (TR8ATCC), Tap changer control and supervision, 6 binary inputs (TCMYLTC) and Tap changer control and supervision, 32 binary inputs (TCLYLTC) are used for control of power transformers with an on-load tap changer. The functions provide automatic regulation of the voltage on the secondary side of transformers or alternatively on a load point further out in the network.

Control of a single transformer, as well as control of up to eight transformers in parallel is possible. For parallel control of power transformers, three alternative methods are available: the master-follower method, the circulating current method and the reverse reactance method. The first two methods require exchange of information between the parallel transformers and this is provided for within IEC 61850-8-1.

Voltage control includes many extra features such as the possibility to avoid simultaneous tapping of parallel transformers, hot stand by regulation of a transformer in a group which regulates it to a correct tap position even though the LV CB is open, compensation for a possible capacitor bank on the LV side bay of a transformer, extensive tap changer monitoring including contact wear and hunting detection, monitoring of the power flow in the transformer so that, for example, the voltage control can be blocked if the power reverses, etc.

15.15 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.

15.16 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.

15.17 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.

15.18 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.

15.19 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).

15.20 Single command, 16 inputs SINGLECMD

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

Section 16 Scheme communication

16.1 Scheme communication logic for distance or overcurrent protection ZCPSCH

To achieve instantaneous fault clearance for all line faults, scheme communication logic is provided. All types of communication schemes for permissive underreaching, permissive overreaching, blocking, delta based blocking, unblocking and intertrip are available.

The built-in communication module (LDCM) can be used for scheme communication signaling when included.

16.2 Phase segregated scheme communication logic for distance protection ZPCPSCH

Communication between line ends is used to achieve fault clearance for all faults on a power line. All possible types of communication schemes for example, permissive underreach, permissive overreach and blocking schemes are available. To manage problems with simultaneous faults on parallel power lines phase segregated communication is needed. This will then replace the standard Scheme communication logic for distance or Overcurrent protection (ZCPSCH) on important lines where three communication channels (in each subsystem) are available for the distance protection communication.

The main purpose of the Phase segregated scheme communication logic for distance protection (ZPCPSCH) function is to supplement the distance protection function such that:

- fast clearance of faults is also achieved at the line end for which the faults are on the part of the line not covered by its underreaching zone.
- correct phase selection can be maintained to support single-pole tripping for faults occurring anywhere on the entire length of a double circuit line.

To accomplish this, three separate communication channels, that is, one per phase, each capable of transmitting a signal in each direction is required.

ZPCPSCH can be completed with the current reversal and WEI logic for phase segregated communication, when found necessary in Blocking and Permissive overreaching schemes.

16.3 Current reversal and weak-end infeed logic for distance protection ZCRWPSCH

The ZCRWPSCH function provides the current reversal and weak end infeed logic functions that supplement the standard scheme communication logic. It is not suitable for standalone use as it requires inputs from the distance protection functions and the scheme communications function included within the terminal.

On detection of a current reversal, the current reversal logic provides an output to block the sending of the teleprotection signal to the remote end, and to block the permissive tripping at the local end. This blocking condition is maintained long enough to ensure that no unwanted operation will occur as a result of the current reversal.

On verification of a weak end infeed condition, the weak end infeed logic provides an output for sending the received teleprotection signal back to the remote sending end and other output(s) for local tripping. For terminals equipped for single- and two-pole tripping, outputs for the faulted phase(s) are provided. Undervoltage detectors are used to detect the faulted phase(s).

16.4 Current reversal and weak-end infeed logic for phase segregated communication ZPCWPSCH

Current reversal and weak-end infeed logic for phase segregated communication (ZPCWPSCH) function is used to prevent unwanted operations due to current reversal when using permissive overreach protection schemes in application with parallel lines where the overreach from the two ends overlaps on the parallel line.

The weak-end infeed logic is used in cases where the apparent power behind the protection can be too low to activate the distance protection function. When activated, received carrier signal together with local undervoltage criteria and no reverse zone operation gives an instantaneous trip. The received signal is also echoed back to accelerate the sending end.

16.5 Local acceleration logic ZCLCPSCH

To achieve fast clearing of faults on the whole line, when no communication channel is available, local acceleration logic (ZCLCPSCH) can be used. This logic enables fast fault clearing and re-closing during certain conditions, but naturally, it can not fully replace a communication channel.

The logic can be controlled either by the autorecloser (zone extension) or by the loss-of-load current (loss-of-load acceleration).

16.6 Scheme communication logic for residual overcurrent protection ECPSCH

To achieve fast fault clearance of earth faults on the part of the line not covered by the instantaneous step of the residual overcurrent protection, the directional residual overcurrent protection can be supported with a logic that uses communication channels.

In the directional scheme, information of the fault current direction must be transmitted to the other line end. With directional comparison, a short operate time of the protection including a channel transmission time, can be achieved. This short operate time enables rapid autoreclosing function after the fault clearance.

The communication logic module for directional residual current protection enables blocking as well as permissive under/overreaching, and unblocking schemes. The logic can also be supported by additional logic for weak-end infeed and current reversal, included in Current reversal and weak-end infeed logic for residual overcurrent protection (ECRWPSCH) function.

16.7 Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH

The Current reversal and weak-end infeed logic for residual overcurrent protection (ECRWPSCH) is a supplement to Scheme communication logic for residual overcurrent protection ECPSCH.

To achieve fast fault clearing for all earth faults on the line, the directional earth fault protection function can be supported with logic that uses tele-protection channels.

This is why the IEDs have available additions to the scheme communication logic.

If parallel lines are connected to common busbars at both terminals, overreaching permissive communication schemes can trip unselectively due to fault current reversal. This unwanted tripping affects the healthy line when a fault is cleared on the other line. This lack of security can result in a total loss of interconnection between the two buses. To avoid this type of disturbance, a fault current reversal logic (transient blocking logic) can be used.

Permissive communication schemes for residual overcurrent protection can basically operate only when the protection in the remote IED can detect the fault. The detection requires a sufficient minimum residual fault current, out from this IED. The fault current can be too low due to an opened breaker or high-positive and/or zero-sequence source impedance behind this IED. To overcome these conditions, weak-end infeed (WEI) echo logic is used. The weak-end infeed echo is limited to 200 ms to avoid channel lockup.

Section 17 Logic

17.1 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.

17.2 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.

17.3 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.

17.4 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.

17.5 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.

17.6 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.

17.7 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.

17.8 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.

17.9 Extension logic package

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

17.10 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.

17.11 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.

17.12 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.

17.13 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.

17.14 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.

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

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

17.16 Comparator for integer inputs INTCOMP

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

17.17 Comparator for real inputs REALCOMP

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

17.18 Hold Maximum and Minimum of Input HOLDMINMAX

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

17.19 Converter integer to real INT_REAL

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

17.20 Definable constant for logic function CONST_INT

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

17.21 Analog input selector for integer values INTSEL

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

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

17.22 Definable limiter LIMITER

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

17.23 Absolute value ABS

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

17.24 Polar to rectangular converter POL_REC

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

17.25 Radians to degree angle converter RAD_DEG

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

17.26 Definable constant for logic function CONST_REAL

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

17.27 Analog input selctor for real values REALSEL

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

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

17.28 Store value for integer inputs STOREINT

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

17.29 Store value for real inputs STOREREAL

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

17.30 Degree to radians angle converter DEG_RAD

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

Section 18 Monitoring

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

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

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

18.2 Supervision of mA input signals

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

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

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

18.3 Disturbance report DRPRDRE

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

Disturbance report (DRPRDRE), always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a maximum of 70 analog and 352 binary signals.

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

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder
- Fault locator
- 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.

18.4 Event list DRPRDRE

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

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

18.5 Indications DRPRDRE

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

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

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

18.6 Event recorder DRPRDRE

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

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

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

18.7 Trip value recorder DRPRDRE

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

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

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

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

18.8 Disturbance recorder DRPRDRE

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

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

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

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

18.9 Event function

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

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

18.10 Generic communication function for single point indication SPGAPC

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

18.11 Generic communication function for measured values MVGAPC

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

18.12 Measured values expander block RANGE_XP

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

18.13 Insulation supervision for gas medium function SSIMG

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

18.14 Insulation supervision for liquid medium SSIML

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

18.15 Circuit breaker condition monitoring SSCBR

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

18.16 Event counter with limit supervison L4UFCNT

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

Overflow indication is included for each up-counter.

18.17 Running hour-meter TEILGAPC

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

The main features of TEILGAPC are:

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

- Possibilities for blocking and reset
- Possibility for manual addition of accumulated time
- Reporting of the accumulated time

18.18 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.

18.19 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.

18.20 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.

18.21 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.

18.22 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

18.23 Fault locator LMBRFLO

The accurate fault locator is an essential component to minimize the outages after a persistent fault and/or to pin-point a weak spot on the line.

The fault locator is an impedance measuring function giving the distance to the fault in km, miles or % of line length. The main advantage is the high accuracy achieved by compensating for load current and for the mutual zero-sequence effect on double circuit lines.

The compensation includes setting of the remote and local sources and calculation of the distribution of fault currents from each side. This distribution of fault current, together with recorded load (pre-fault) currents, is used to exactly calculate the fault position. The fault can be recalculated with new source data at the actual fault to further increase the accuracy.

Especially on heavily loaded long lines, where the source voltage angles can be up to 35-40 degrees apart, the accuracy can be still maintained with the advanced compensation included in fault locator.

There are two phase selection inputs used to derive the fault loop information. The CALCDIST input need to be set in order to calculate the fault location. If the CALCDIST input is low, then the outputs are shown as default for the corresponding disturbance recorded.

Section 19 Metering

19.1 Pulse-counter logic PCFCNT

Pulse-counter logic (PCFCNT) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the binary input module and then read by the PCFCNT function. A scaled service value is available over the station bus. The special Binary input module with enhanced pulse counting capabilities must be ordered to achieve this functionality.

19.2 Function for energy calculation and demand handling ETPMMTR

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

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

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

Section 20 Human machine interface

20.1 Local HMI

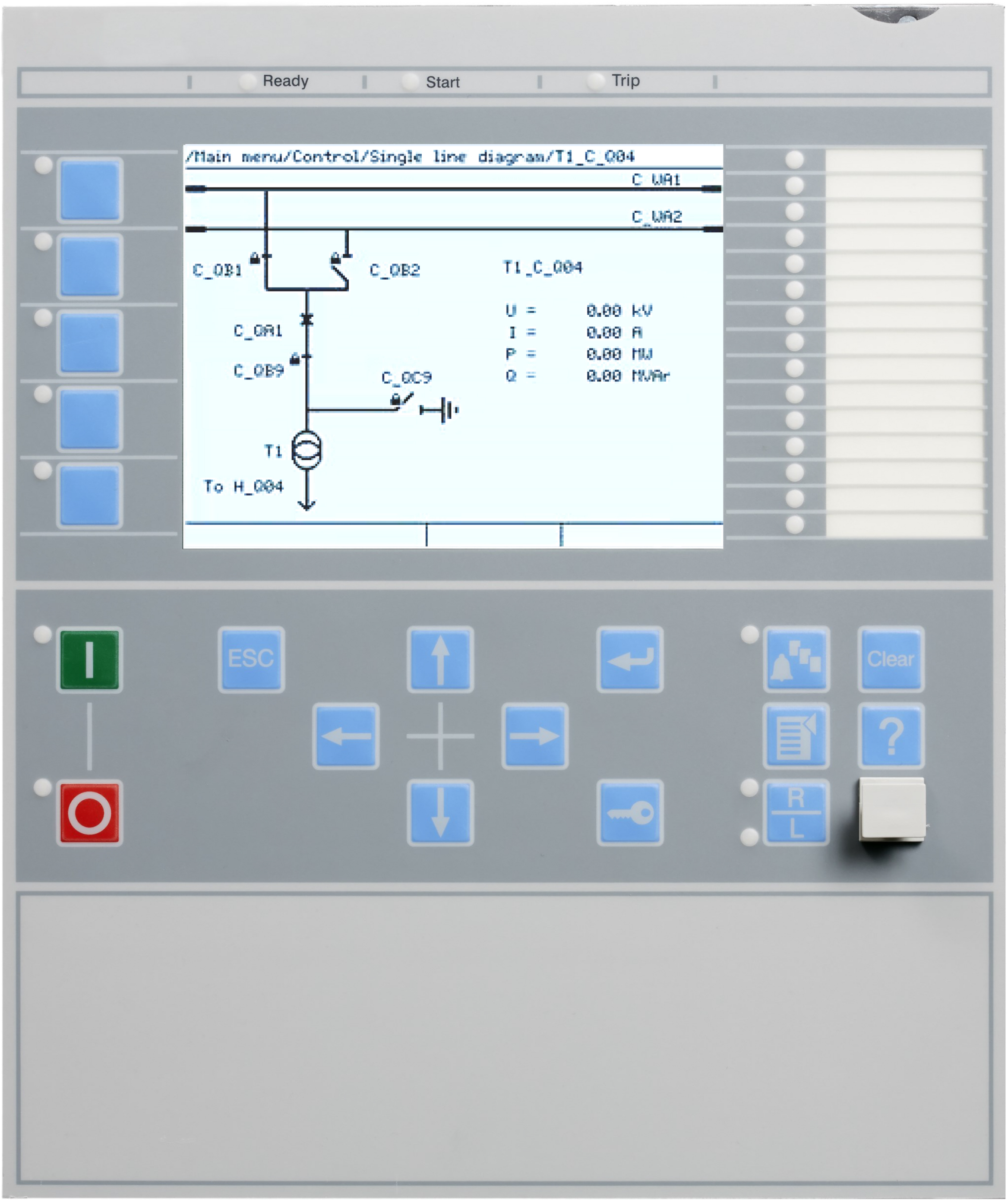


Figure 11: Local human-machine interface

The LHMI of the IED contains the following elements

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

The LHMI is used for setting, monitoring and controlling.

Section 21 Basic IED functions

21.1 Time synchronization

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

The IED supports SNTPv4 (RFC2030).

Precision time protocol PTP

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

Section 22 Ethernet

22.1 Access points

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

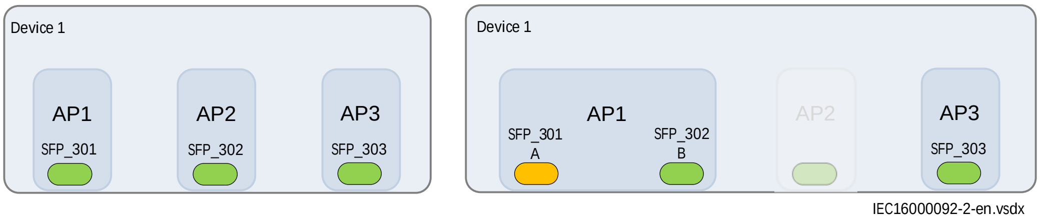


Figure 12: Access points, non redundant (left) and redundant communication (right)

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

22.2 Access points diagnostics

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

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

22.3 Redundant communication

PRP IEC 62439-3 redundant communication

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

HSR IEC 62439-3 High-availability seamless redundancy

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

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

Rapid spanning tree protocol RSTP

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

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

22.4 Routes

A route is a specified path for data to travel between the source device in a subnetwork to the destination device in a different subnetwork. A route consists of a destination address and the address of the gateway to be used when sending data to the destination device, see Figure 13.

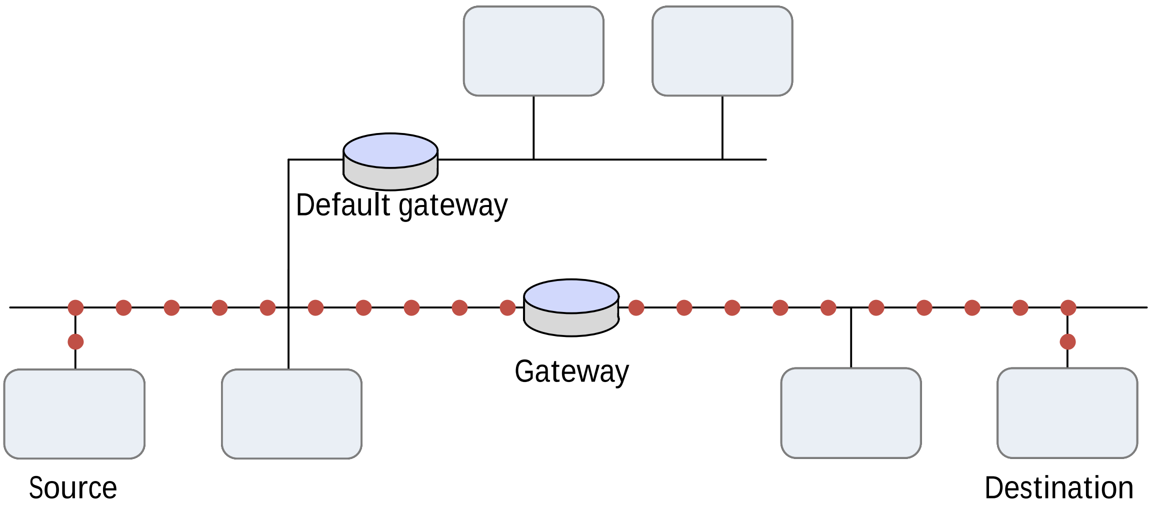


Figure 13: Route from source to destination through gateway

Section 23 Station communication

23.1 Communication protocols

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

Available communication protocols are:

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

Several protocols can be combined in the same IED.

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

23.2 Simple network management protocol SNMP

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

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

The SNMP agent supports the following,

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

23.3 IEC 61850-8-1 communication protocol

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

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

23.4 IEC 61850 quality expander QUALEXP

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

23.5 Supervision of GOOSE subscription (ALGOS)

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

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

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

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

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

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

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

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

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

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

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

23.8 LON communication protocol

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

23.9 SPA communication protocol

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

23.10 IEC 60870-5-103 communication protocol

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

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

23.11 Measurands for IEC 60870-5-103 I103MEAS

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

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

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

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

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

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

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

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

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

23.16 IED status for IEC 60870-5-103 I103IED

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

23.17 Supervison status for IEC 60870-5-103 I103SUPERV

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

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

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

23.19 Function commands for IEC 60870-5-103 I103CMD

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

23.20 IED commands for IEC 60870-5-103 I103IEDCMD

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

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

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

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

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

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

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

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

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

23.24 DNP3.0 communication protocol

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

23.25 Multiple command and transmit

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

Section 24 Remote communication

24.1 Analog and binary signal transfer to remote end

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

24.2 Binary signal transfer

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

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

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

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

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

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

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

24.5 Galvanic interface G.703 resp G.703E1

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

Section 25 Hardware description

25.1 Hardware modules

25.1.1 Numeric processing module NUM

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

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

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

25.1.2 Power supply module PSM

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

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

25.1.3 Binary input module BIM

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

25.1.4 Binary output module BOM

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

25.1.5 Static binary output module SOM

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

25.1.6 Binary input/output module IOM

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

25.1.7 mA input module MIM

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

25.1.8 Optical Ethernet module

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

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

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

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

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

25.1.10 Line data communication module LDCM

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

Alternative modules are:

Short range LDCM (820 nm multi mode fiber),

Medium range (1310 nm single mode fiber)

and Long range (1550 nm single mode fiber) .

25.1.11 Galvanic RS485 serial communication module

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

25.1.12 GPS time synchronization module GTM

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

25.1.13 IRIG-B Time synchronizing module

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

The Pulse Per Second (PPS) input is supported.

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

25.1.14 Transformer input module TRM

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

Ring lug or compression type connectors can be ordered.

25.1.15 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.

25.2 Layout and dimensions

25.2.1 Dimensions

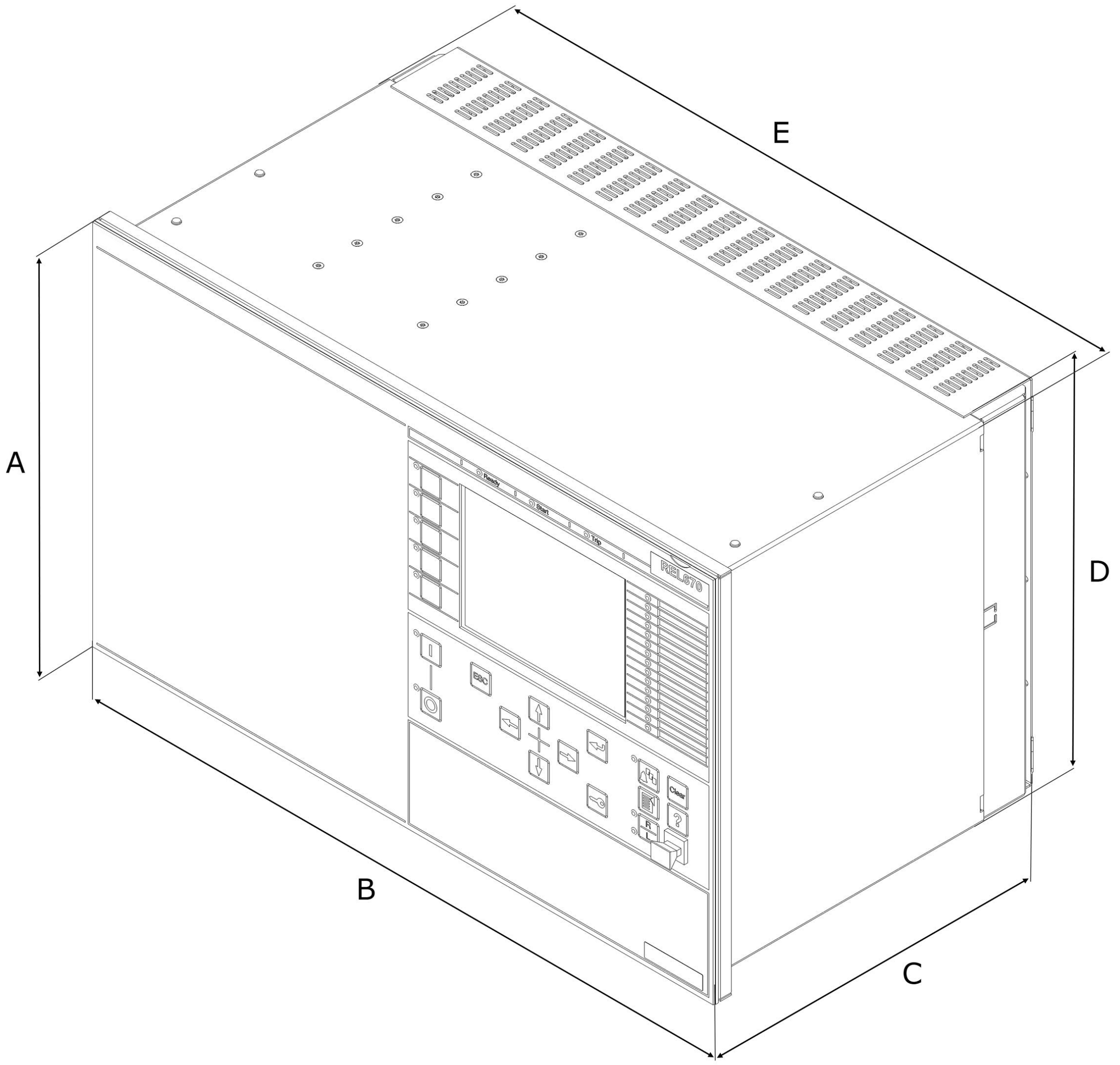


Figure 14: Case with rear cover

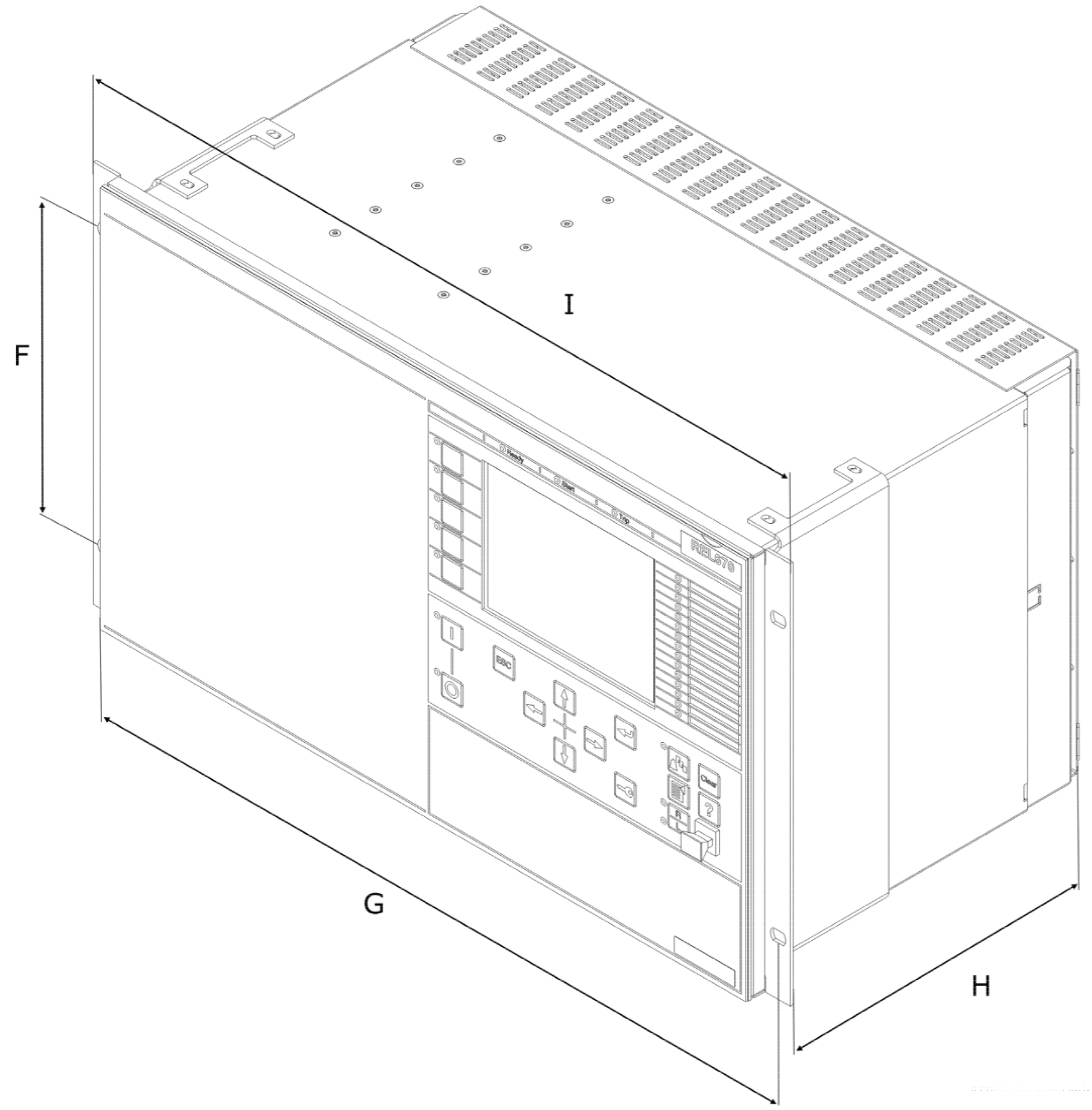


Figure 15: Case with rear cover and 19” rack mounting kit

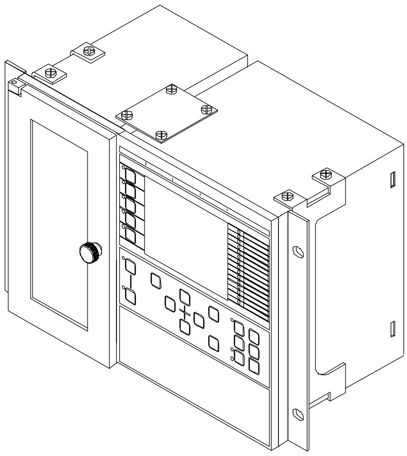


Figure 16: A 1/2 x 19” size IED side-by-side with RHGS6.

Table 11: 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.									

25.2.2 Mounting alternatives

- 19” rack mounting kit
- Flush mounting kit with cut-out dimensions:
  - 1/2 case size (h) 254.3 mm/10.01” (w) 210.1 mm/8.27”
  - 3/4 case size (h) 254.3 mm/10.01” (w) 322.4 mm/12.69”
  - 1/1 case size (h) 254.3 mm/10.01” (w) 434.7 mm/17.11”
- Wall mounting kit

See ordering for details about available mounting alternatives.

Section 26 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, RET670 2.2, A10X00 1MRK002807-TF

Connection diagram, RET670 2.2, B30X00 1MRK002807-TB

Connection diagram, RET670 2.2, B40X00 1MRK002807-TD

Connection diagram, RET670 2.2, A25X00 1MRK002807-TE

Connection diagrams for ANSI Customized products

Connection diagram, 670 series 2.2 1MRK002802-AG

Section 27 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.	

Section 28 Technical data

28.1 General

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

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

28.1.1 Presumptions for Technical Data

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

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

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

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

28.2 Energizing quantities, rated values and limits

28.2.1 Analog inputs

Table 12: 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 13: TRM - Energizing quantities, rated values and limits for measuring transformer

Description	Value	
Frequency		
Rated frequency f_r	50/60 Hz	
Operating range	f_r ± 10%	
Current inputs		
Rated current I_r	1A	5 A
Operating range	(0-1.8) × I_r	(0-1.6) × I_r

Table continues on next page

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

Table 14: 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	-

28.2.2 Auxiliary DC voltage

Table 15: 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	-

28.2.3 Binary inputs and outputs

Table 16: BIM - Binary input module

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ±20% RL ±20% RL ±20% RL ±20%
Power consumption 24/30 V, 50 mA 48/60 V, 50 mA 110/125 V, 50 mA 220/250 V, 50 mA 220/250 V, 110 mA	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input max. 0.5 W/input	-
Counter input frequency	10 pulses/s max	-
Table continues on next page		

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

Table 17: 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 18: IOM - Binary input/output module

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

Table 19: IOM - Binary input/output module contact data (reference standard: IEC 61810-1)

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

Table Note:

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

Table 20: IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-1)

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

Table continues on next page

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

Table 21: SOM - Static Output Module data (reference standard: IEC 61810-1): Heavy duty static binary outputs

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

Table continues on next page

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

Table 22: SOM - Static Output module data (reference standard: IEC 61810-1): Electromechanical relay outputs

Function of quantity	Trip and signal relays
Max system voltage	250 V AC/DC
Min load voltage	24 V DC
Number of outputs	6
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity: Continuous 1.0 s	 8 A 10 A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2 s 1.0 s	 30 A 10 A
Making capacity for DC with L/R > 10 ms: 0.2 s 1.0 s	 30 A 10 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos ϕ > 0.4	250 V / 8 A
Breaking capacity for DC with L/R ≤ 40 ms (According to IEC 61810-1)	48 V / 1 A 110 V / 0.4 A 125 V / 0.35 A 220 V / 0.2 A 250 V / 0.15 A
Max operations with inductive load L/R ≤ 40 ms	1 000
Breaking capacity for DC with L/R=100ms	110 V / 0.3 A
Breaking capacity for DC with resistive load	48 V / 2 A 110 V / 0.5 A 125 V / 0.45 A 220 V / 0.35 A 250 V / 0.3 A
Max operations with resistive load	2 000
Max operations with no load	30 million
Operating time	< 6 ms

Table 23: BOM - Binary output module contact data (reference standard: IEC 61810-1)

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

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

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

Table 24: IRF - Internal Fail relay output

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

Table continues on next page

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

28.2.4 Influencing factors

Table 25: 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 26: Auxiliary DC supply voltage influence on functionality during operation

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

Table 27: 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)	2^{nd}, 3^{rd} 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%

28.3 Type tests according to standards

Table 28: Electromagnetic compatibility

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

Table 29: 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 30: Environmental conditions

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

Table 31: 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 32: CE compliance

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

Table 33: 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

28.4 Differential protection

Table 34: 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	-
*Operate time at 0 to 10 x IdMin, restrained function	Min. = 25 ms Max. = 35 ms	-
Table continues on next page		

Function	Range or value	Accuracy
*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 35: 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 36: 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	
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	-
Table Note: 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.		

Table 37: Additional security logic for differential protection LDRGFC

Function	Range or value	Accuracy
Operate current, zero sequence current	(1-100)% of IBase	±1.0% of I_r
Operate current, low current operation	(1-100)% of IBase	±1.0% of I_r
Operate voltage, phase to neutral	(1-100)% of UBase	±0.5% of U_r
Operate voltage, phase to phase	(1-100)% of UBase	±0.5% of U_r
Independent time delay, zero sequence current at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Independent time delay, low current operation at 2 x I_{set} to 0	(0.000-60.000) s	±0.2% or ± 35 ms whichever is greater
Independent time delay, low voltage operation at 2 x U_{set} to 0	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Reset time delay for startup signal at 0 to 2 x U_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater

28.4.1 Technical data

Table 38: Self-adaptive differential protection for 2-winding power transformers PSTPDIF

Function	Range or value	Accuracy
Operating characteristic	Adaptable	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Reset ratio	> 90%	-
Unrestrained differential current limit *IdUnre*	(400-6000)% of IBase	±1.0% of set value
Minimum pickup, *IdMin*	(10-60)% of IBase	±1.0% of I r
Differential current alarm, *IDiffAlarm*	(2-50)% of IBase	±1.0% of I r
Time delay for differential current alarm, *tAlarmDelay*	(0.000-60.000) s	±0.2% or ±25 ms whichever is greater
Second harmonic blocking, *I2/I1Ratio*	(5.0-60.0)% of fundamental differential current	±1.0% of I_r Note: fundamental magnitude = 100% of I_r
Fifth harmonic blocking, *I5/I1Ratio*	(5.0-60.0)% of fundamental differential current	±5.0% of I_r Note: fundamental magnitude = 100% of I_r
Negative-sequence current limit, *IMinNegSeq*	(4-80)% of IBase	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Time delay for negative-sequence sensitive trip, *tTripNSSens*	(0.040-60.000) s	±0.2% or ±25 ms whichever is greater
Operate angle for negative-sequence fault discriminator, *NegSeqROA*	(30.0-120.0) degrees	±2.0 degrees
*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. = 5 ms Max. = 15 ms	-
*Operate time at 0 to 2 x IdUnre, unrestrained function	Min. = 10 ms Max. = 20 ms	-
*Reset time at 2 x IdUnre to 0, unrestrained function	Min. = 25 ms Max. = 35 ms	-

Table continues on next page

Function	Range or value	Accuracy
**Operate time, unrestrained negative sequence function	Min. = 10 ms Max. = 25 ms	-
**Reset time, unrestrained negative sequence function	Min. = 10 ms Max. = 30 ms	-
*Note: Data obtained with single input current group. **Note: Data obtained with two input current groups. The rated symmetrical currents are applied on both sides as pre- and post-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.		

28.5 Impedance protection

Table 39: Distance measuring zone, Quad ZMQPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/phase	
Zero sequence reactance	(0.10-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 x Zreach to 2 x Zreach	Min. = 20 ms Max. = 50 ms	-

Table 40: Distance measuring zone, quadrilateral characteristic for series compensated lines ZMCPDIS, ZMCAPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of *IBase*	-
Minimum operate current, Ph-Ph and Ph-E	(10-1000)% of *IBase*	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.01-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, Ph-E	(0.10-9000.00) Ω/loop	
Fault resistance, Ph-Ph	(0.10-3000.00) Ω/loop	

Table continues on next page

Function	Range or value	Accuracy
Dynamic overreach	<5% at 85 degrees measured with CCVT’s and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ± 35 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 x Zreach to 2 x Zreach	Min. = 20 ms Max. = 50 ms	-

Table 41: Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS

Function	Range or value	Accuracy
Minimum operate current	(5-500)% of *IBase*	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reactive reach, positive sequence	(0.50–3000.00) Ω/phase	±2.5% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach, positive sequence	(0.10–1000.00) Ω/phase	
Reactive reach, zero sequence	(0.50–9000.00) Ω/phase	
Resistive reach, zero sequence	(0.50–3000.00) Ω/phase	
Fault resistance, phase-to-earth faults, forward and reverse	(1.00–9000.00) Ω/loop	
Fault resistance, phase-to-phase faults, forward and reverse	(0.50–3000.00) Ω/loop	
Load encroachment criteria: Load resistance, forward and reverse Safety load impedance angle	(1.00–3000.00) Ω/phase (5-70) degrees	
Reset ratio	105% typically	-

Table 42: Full-scheme distance protection, Mho characteristic ZMHPDIS

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

Table 43: Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate current	(10-30)% of *IBase*	-
Positive sequence reactance	(0.50-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.50-9000.00) Ω/phase	
Zero sequence resistance	(0.50-3000.00) Ω/phase	
Fault resistance, Ph-E	(1.00-9000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CCVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 x Zreach to 2 x Zreach	Min. = 20 ms Max. = 50 ms	-

Table 44: Faulty phase identification with load encroachment FMPSPDIS

Function	Range or value	Accuracy
Load encroachment criteria: Load resistance, forward and reverse	(1.00–3000.00) Ω/ phase (5–70) degrees	±2.0% static accuracy Conditions: Voltage range: (0.1–1.1) x U_r Current range: (0.5–30) x I_r Angle: at 0 degrees and 85 degrees

Table 45: Distance measuring zone, quadrilateral characteristic, separate settings ZMRPDIS, ZMRAPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/ phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/ phase	
Zero sequence reactance	(0.10-9000.00) Ω/ phase	
Zero sequence resistance	(0.01-3000.00) Ω/ phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay phase-phase and phase-earth operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 x Zreach to 2 x Zreach	Min. = 20 ms Max. =50 ms	-

Table 46: Phase selection, quadrilateral characteristic with settable angle FRPSPDIS

Function	Range or value	Accuracy
Minimum operate current	(5-500)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Reactive reach, positive sequence	(0.50–3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach, positive sequence	(0.10–1000.00) Ω/phase	
Reactive reach, zero sequence	(0.50–9000.00) Ω/phase	
Resistive reach, zero sequence	(0.50–3000.00) Ω/phase	
Fault resistance, Ph-E faults, forward and reverse	(1.00–9000.00) Ω/loop	
Fault resistance, Ph-Ph faults, forward and reverse	(0.50–3000.00) Ω/loop	
Reset ratio	105% typically	-

Table 47: High speed distance protection ZMFPDIS, ZMFCPDIS

Function	Range or value	Accuracy	
Number of zones	5 selectable directions, 2 fixed directions	-	
Minimum operate current, Ph-Ph and Ph-E	(5-6000)% of IBase	±1.0% of I_r	
Positive sequence reactance reach, Ph-E and Ph-Ph loop	(0.01 - 3000.00) ohm/p	**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	**Ramp of shots:** ±2.0% of set value **Conditions:** IEC 60255-121 point B
Positive sequence resistance reach, Ph-E and Ph-Ph loop	(0.00 - 1000.00) ohm/p		
Zero sequence reactance reach	(0.01 - 9000.00) ohm/p		
Zero sequence resistive reach	(0.00 - 3000.00) ohm/p		
Fault resistance reach, Ph-E and Ph-Ph	(0.01 -9000.00) ohm/l		
Dynamic overreach	< 5% at 85 degrees measured with CVTs and 0.5 < SIR < 30, IEC 60255-121	-	
Reset ratio	105% typically	-	
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 48: Power swing detection, blocking and unblocking ZMBURPSB

Function	Range or value	Accuracy
Reactive reach	(0.10-3000.00) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach	(0.10–1000.00) Ω/loop	
Power swing detection operate time	(0.000-60.000) s	±0.2% or ±10 ms whichever is greater
Second swing reclaim operate time	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Minimum operate current, Ph-E	(5-1000)% of IBase	±1.0% of I_r

Table 49: Power swing logic PSLPSCH

Function	Range or value	Accuracy
Permitted maximum operating time difference between higher and lower zone	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Delay for operation of underreach zone with detected difference in operating time	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Conditional timer for sending the CS at power swings	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Conditional timer for tripping at power swings	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater
Timer for blocking the overreaching zones trip	(0.000 — 60.0000) s	±0,2% or ±15 ms whichever is greater

Table 50: 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 51: 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 52: Phase preference logic PPLPHIZ

Function	Range or value	Accuracy
Operate value, phase-to-phase and phase-to-neutral undervoltage, *UPN<* and *UPP<*	(10 - 90)% of UBase	±0.5% of U_r
Reset ratio, undervoltage	< 105%	-
Operate value, residual voltage, *3U0>*	(10 - 300)% of UBase	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio, residual voltage	> 95%	-
Operate value, residual current, *IN>*	(10 - 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%	-
Table continues on next page		

Function	Range or value	Accuracy
Independent time delay for residual current at 0 to 2 x I_{set}, *tIN*	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Independent time delay for residual voltage at 0.8 x U_{set} to 1.2 x U_{set}, *tUN*	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Independent dropoff-delay for residual voltage at 1.2 x U_{set} to 0.8 x U_{set}, *tOffUN*	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Operating mode	No Filter, NoPref Cyclic: 1231c, 1321c Acyclic: 123a, 132a, 213a, 231a, 312a, 321a	

Table 53: Phase preference logic PPL2PHIZ technical dataPhase preference logic PPLPHIZ technical data

Function	Range or value	Accuracy
Operate value of phase to earth undervoltage. Two phases shall start to detect cross-country fault, UPN<	(10 - 90)% of UBase/sqrt(3)	±0.5% of U_r
Operate value of phase to phase undervoltage to detect cross-country fault, UPP< <	(10 - 90)% of UBase/sqrt(3)	±0.5% of U_r
Reset ratio, undervoltage	< 105%	-
Operate value of residual voltage. For high impedance earthed system the maximum UN value will be 300%, *3U0>*	(10 - 300)% of UBase/sqrt(3)	±0.5% of U_r at $U \leq U_r$ ±0.5% of U at $U > U_r$
Reset ratio, residual voltage	> 95%	-
Stabilizing factor for residual over current characteristic. Magnitude of the residual current shall be bigger than this factor multiplied by magnitude of the maximum phase current, *kINStab*	(0.00-1.00)	-
Operate value of residual current to enable the cross-country fault detection, *IN*	(10 - 200)% of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
High operate value of residual to enable the cross-country fault detection without any time delay, *IN>>*	(10 - 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%	-
Required level of maximum phase current to detect cross-country fault without residual current start, *IPhMax>*	(50 - 500) % of IBase	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Required level of minimum phase to earth voltage to detect cross-country fault without residual current start, *UPhMin<*	(10 – 90) % of UBase/sqrt(3)	±0.5% of U_r
Required level of delta phase to phase voltage to detect cross-country fault without residual current start, *DeltaUPP.*	(5 – 50) % of UBase	±0.5% of U_r
Independent time delay for residual current at 0 to 2 x I_{set}, *tIN*	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Table continues on next page		

Function	Range or value	Accuracy
Independent time delay for residual voltage at 0.8 to 1.2 x U_{set}, *tUN*	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Independent dropoff-delay for residual voltage at 1.2 to 0.8 x U_{set}, *tOffUN*	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Operating mode	No Filter, NoPref Cyclic: 1231c, 1321c Acyclic: 123a, 132a, 213a, 231a, 312a, 321a	

Table 54: Automatic switch onto fault logic ZCVPSOF

Parameter	Range or value	Accuracy
Operate voltage, detection of dead line	(1–100)% of *UBase*	±0.5% of U_r
Operate current, detection of dead line	(1–100)% of *IBase*	±1.0% of I_r
Time delay to operate for the switch onto fault function	(0.03-120.00) s	±0.2% or ±30 ms whichever is greater
Time delay for UI detection	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Delay time for activation of dead line detection	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Drop-off delay time of switch onto fault function	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater

Table 55: 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

28.6 Wide area measurement system

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

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

Table 56: 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	

28.7 Current protection

Table 57: Instantaneous phase overcurrent protection PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (50–2500)% of IBase	-
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 58: Directional phase overcurrent protection, four steps OC4PTOC

Function	Range or value	Accuracy
Operate current, step 1-4	(5-2500)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Minimum operate current, step 1-4	(1-10000)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Relay characteristic angle (RCA)	(40.0–65.0) degrees	±2.0 degrees
Relay operating angle (ROA)	(40.0–89.0) degrees	±2.0 degrees
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Independent time delay at 0 to 2 x I_{set}, step 1-4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves , step 1-4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see table 209, table 210 and table 211	16 curve types	See table 209, table 210 and table 211
Table continues on next page		

Function	Range or value	Accuracy
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Operate frequency, directional overcurrent	38-83 Hz	-
Operate frequency, non-directional overcurrent	10-90 Hz	-

Table 59: Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (50–2500)% of IBase	-
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 60: Directional residual overcurrent protection, four steps EF4PTOC

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

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 209, Table 210 and Table 211	16 curve types	See Table 209, Table 210 and Table 211
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 61: Four step directional negative phase sequence overcurrent protection NS4PTOC

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

Table continues on next page

Function	Range or value	Accuracy
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 209, table 210 and table 211	16 curve types	See table 209, table 210 and table 211
Minimum operate current, step 1 - 4	(1.00 - 10000.00)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Relay characteristic angle (RCA)	(-180 to 180) degrees	±2.0 degrees
Operate current for directional release	(1–100)% of *IBase*	For RCA ±60 degrees: ±2.5% of I_r at I ≤ I_r ±2.5% of I at I > I_r
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 x I_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 x I_{set} to 0	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 62: 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 ≤ 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 ≤ 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 ≤ I_r ±1.0% of I at I > I_r
Operate level for non-directional overcurrent	(1.00-400.00)% of IBase	±1.0% of I_r at I ≤ 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 ≤ 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 ≤ 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 ≤ 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	
Table continues on next page		

Function	Range or value	Accuracy
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 212, Table 213 and Table 214	16 curve types	See Table 212, Table 213 and Table 214
Relay characteristic angle (RCADir)	(-179 to 180) degrees	±2.0 degrees
Relay operate angle (ROADir)	(0 to 90) degrees	±2.0 degrees

Table 63: Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(10-400)% of IBase	±1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	± 1.0°C, ±2.0°F
Operate time: $$t = \tau \ln \left[\frac{I^2 - I_p^2}{I^2 - \frac{T_{Trip} - T_{Amb}}{T_{ref}} \cdot I_{ref}^2} \right]$$ (Equation 1) T_{Trip} = set operate temperature T_{Amb} = ambient temperature T_{ref} = temperature rise above ambient at I_{ref} I_{ref} = reference load current I = actual measured current I_p = load current before overload occurs	Time constant τ = (1–1000) minutes	IEC 60255-149, ±5.0% or 250 ms whichever is greater
Alarm temperature	(0-200)°C, (0-400)°F	±2.0°C, ±4.0°F
Operate temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F
Reset level temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F

Table 64: 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 2) 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 65: 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 66: Stub protection STBPTOC

Function	Range or value	Accuracy
Operating 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*	
Independenttime delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Operate time, start at 0 to 2 x I_{set}	Min.= 10 ms Max.= 25 ms	
Reset time, start at 2 x I_{set} to 0	Min.= 10 ms Max.= 25 ms	
Operate time, start at 0 to 5 x I_{set}	Min.= 5 ms Max.= 20 ms	
Reset time, start at 5 x I_{set} to 0	Min.= 15 ms Max.= 30 ms	
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	
Impulse margin time	15 ms typically	

Table 67: 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 68: 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 69: Directional overpower protection GOPPDOP

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

Table 70: Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of *IBase*	±1.0% of I_r
Unbalance current operation	(50–90)% of maximum current	±1.0% of I_r
Independent operate time delay	(0.100-60.000) s	±0.2% or ±45 ms whichever is greater
Independent reset time delay	(0.010-60.000) s	±0.2% or ±30 ms whichever is greater
Start time at current change from I_r to 0	Min. = 80 ms Max. = 95 ms	-
Reset time at current change from 0 to I_r	Min. = 5 ms Max. = 20 ms	-

Table 71: Capacitor bank protection CBPGAPC

Function	Range or value	Accuracy
Operate value, overcurrent	(10-900)% of IBase	±2.0% of I_r at $I \le I_r$ ±2.0% of I at $I > I_r$
Reset ratio, overcurrent	>95% at (100-900)% of IBase	-
Start time, overcurrent, at 0.5 x Iset to 2 x Iset	Min. = 5 ms Max. = 20 ms	-
Reset time, overcurrent, at 2 x Iset to 0.5 x Iset	Min. = 25 ms Max. = 45 ms	-
Critical impulse time, overcurrent protection start	2 ms typically at 0.5 x Iset to 2 x Iset 1 ms typically at 0.5 x Iset to 10 x Iset	-
Impulse margin time, overcurrent protection start	10 ms typically	
Operate value, undercurrent	(5-100)% of IBase	±2.0% of I_r
Table continues on next page		

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

Table 72: 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	-
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 73: Overcurrent protection with binary release BRPTOC

Function	Range or value	Accuracy
Operating current	(5-2500)% of *IBase*	*DFT*: ± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
		Peak and Peak to peak: ± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Reset ratio	> 95% at (25-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	*DFT*: ±0.2% or ±30 ms whichever is greater
		Peak to peak: ±0.2% or ±25 ms whichever is greater
		Peak: ±0.2% or ±20 ms whichever is greater
Operate time, start at 0 to 1.2 x I_{set}	*DFT*: Min.= 15 ms Max. = 30 ms	-
	Peak to peak: Min.= 10 ms Max. =25 ms	
	Peak: Min.= 5 ms Max. = 20 ms	
Reset time, start at 1.2 x I_{set} to 0	< 60 ms	-
Operate time, start at 0 to 2 x I_{set}	*DFT*: Min.= 10 ms Max. = 25 ms	-
	Peak to peak: Min.= 5 ms Max. =20 ms	
	Peak: Min.= 5 ms Max. = 15 ms	
Reset time, start at 2 x I_{set} to 0	< 60 ms	-
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 74: 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 209 and 210	13 curve types	See tables 209 and 210
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 75: 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
Table continues on next page		

Function	Range or value	Accuracy
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

28.8 Voltage protection

Table 76: 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 218	-	See table 218
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 77: 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 ≤ 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 ≤ U_r ±0.5% of U at U > U_r
Inverse time characteristics for steps 1 and 2, see table 217	-	See table 217
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±45 ms whichever is greater
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Minimum operate time, Inverse characteristics	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 x U_{set} to 0	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 x U_{set} to 0	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 78: 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 ≤ 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 ≤ U_r ± 0.5% of U at U > U_r
Inverse time characteristics for low and high step, see table	-	See table 217
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 79: 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 ≤ 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 3) where M = (E/f)/(Ur/fr)	±5.0 % or ±45 ms, whichever is greater
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 80: 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 81: Loss of voltage check LOVPTUV

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

28.9 Unbalance protection

Table 82: Shunt Capacitor Cascading Failure Protection SCCFPVOC

Function	Range	Accuracy
Measuring current input	NegSeq, -3*ZeroSeq	-
Measuring voltage input	NegSeq, -3*ZeroSeq	-
Operating characteristics	Voltage restrained over-current	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Operate current, Step 1	(121-400)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Operate current, Step 2	(125-400)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	>95%	-
Operate time, START at 0 to 2 x Iset	Min. = 15 ms Max.= 30 ms	-
Reset time, START at 2 x Iset to 0	Min. = 15 ms Max. = 30 ms	-
Independent time delay at 0 to 2 x I**set**	(0.00-60.00) s	±0.2% or ±45 ms, whichever is greater
Second harmonic blocking	(10.0-50.0)% of fundamental	±1.0% of I_r
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 83: Current unbalance protection of shunt capacitor bank SCUCPTOC

Function	Range	Accuracy
Current unbalance level	(1.0 -1000.0)% of IBase2	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Reset ratio	>95% at (5.0 - 1000.0)% of IBase2 >75% at (1.0 - 5.0)% of IBase2	-
Minimum reference current	(5.0 - 100.0)% of IBase1	±1.0% of Ir
Independent time delay at 0 to 2 x I_{set}	(0.00-60.00) s	±0.2% or ±65 ms, whichever is greater
Reset time delay at to 2 x I_{set} to 0	(0.00 - 60.00) s	±0.2% or ±45 ms, whichever is greater
Inverse time characteristics	Programmable	±5.0% or ±65 ms, whichever is greater
Minimum operate time for inverse curve	(0.00 - 60.00) s	±0.2% or ±65 ms, whichever is greater
Operate time, START at 0 to 2 x I_{set}	Min = 30 ms Max = 60 ms	-
Reset time, START at 2 x I_{set} to 0	Min = 20 ms Max = 35 ms	-
Critical impulse time	10 ms typically at 0 to 10 x I_{set}	-
Impulse margin time	20 ms typically	-

Table 84: Phase voltage differential based capacitor bank unbalanced protection SCPDPTDV

Parameters	Range	Accuracy
Phase voltage differential level	(1.0-95.0) % of UBase	±0.5% of Ur
Reset Ratio	>90 % at (5.0 – 95.0)% of UBase >45% at (1.0 – 5.0)% of UBase	-
Minimum Bus Voltage	(5.0-100.0) % of UBase	±0.5% of Ur
Independent time delay at 0 to 2 x Uset	(0.00-60.00) s	±0.2% or ±70 ms whichever is greater
Reset time Delay at to 2 x Uset to 0	(0.00-60.00) s	±0.2% or ±45 ms whichever is greater
Table continues on next page		

Parameters	Range	Accuracy
Inverse time characteristics	Programmable	±5.0% or ±70 ms whichever is greater
Minimum Operate Time for Inverse Curve	(0.00-60.00) s	±0.2% or ±70 ms whichever is greater
Operate Time, START at 0 to 2 x Uset	Min = 30 ms Max = 60 ms	-
Reset Time, START at 2 x Uset to 0	Min = 15 ms Max = 35 ms	-
Critical impulse time	20 ms typically at 0 to 2 x Uset	-
Impulse margin time	20 ms typically	-

Table 85: Voltage unbalance protection of shunt capacitor bank SCUVPTOV

Function	Range	Accuracy
Neutral voltage unbalance level	(1.0-95.0) % of UBase	±0.5% of Ur
Reset ratio	>90% at (5.0 – 95.0)% of UBase >45% at (1.0 – 5.0)% of UBase	-
Minimum bus voltage	(5.0 - 100.0)% of UBase	±0.5% of Ur
Independent time delay at 0 to 2 x U_{set}	(0.00-60.00) s	±0.2% or ±65 ms, whichever is greater
Reset time delay at to 2 x U_{set} to 0	(0.00-60.00) s	±0.2% or ±45 ms, whichever is greater
Inverse time characteristics	Programmable	±5.0% or ±65 ms, whichever is greater
Minimum operate time for inverse curve	(0.00-60.00) s	±0.2% or ±65 ms, whichever is greater
Operate time, START at 0 to 2 x U_{set}	Min = 30 ms Max = 60 ms	-
Reset time, START at 2 x U_{set} to 0	Min = 15 ms Max = 35 ms	-
Critical impulse time	20 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	20 ms typically	-

28.10 Frequency protection

Table 86: Underfrequency protection SAPTUF

<table>
<tr><th>Function</th><th colspan="3">Range or Value</th><th>Accuracy</th></tr>
<tr><td>Operate value, start function, at symmetrical three phase voltage, StartFrequency 1)</td><td colspan="3">(35.00 - 75.00) Hz</td><td>±2.0 mHz</td></tr>
<tr><td>Reset hysteresis</td><td colspan="3">10.0 mHz fixed</td><td>±2.0 mHz</td></tr>
<tr><td rowspan="8">Operate time 1)</td><td rowspan="4">fr = 50 Hz</td><td rowspan="2">Start time measurement with sudden frequency change</td><td>Min. = 175 ms</td><td rowspan="4">-</td></tr>
<tr><td>Max. = 195 ms</td></tr>
<tr><td rowspan="2">Start time measurement with frequency ramp</td><td>Min. = 70 ms</td></tr>
<tr><td>Max. = 90 ms</td></tr>
<tr><td rowspan="4">fr = 60 Hz</td><td rowspan="2">Start time measurement with sudden frequency change</td><td>Min. = 150 ms</td><td rowspan="4">-</td></tr>
<tr><td>Max. = 165 ms</td></tr>
<tr><td rowspan="2">Start time measurement with frequency ramp</td><td>Min. = 60 ms</td></tr>
<tr><td>Max. = 75 ms</td></tr>
<tr><td colspan="5">Table continues on next page</td></tr>
</table>

Function	Range or Value			Accuracy
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.				
Table Note: 1) The settings and test conditions are in accordance with IEC 60255-181 standard (section 6.2 – 6.7).				

Table 87: 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	
Table continues on next page				

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

Table 88: Rate-of-change frequency protection SAPFRC

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

Function	Range and value			Accuracy
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
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.				

28.11 Multipurpose protection

Table 89: 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

Table continues on next page

Function	Range or value	Accuracy
Independent time delay, undercurrent at 2 x I_{set} to 0, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overcurrent (non-directional): Start time at 0 to 2 x I_{set} Reset time at 2 x I_{set} to 0 Start time at 0 to 10 x I_{set} Reset time at 10 x I_{set} to 0	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms Min. = 5 ms Max. = 20 ms Min. = 20 ms Max. = 35 ms	 - - - -
Undercurrent: Start time at 2 x I_{set} to 0 Reset time at 0 to 2 x I_{set}	 Min. = 15 ms Max. = 30 ms Min. = 15 ms Max. = 30 ms	 - -
Overcurrent: Inverse time characteristics, see table 209, 210 and table 211	16 curve types	See table 209, 210 and table 211
Overcurrent: Minimum operate time for inverse curves, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	±0.5% of U_r
Start overvoltage, step 1 - 2	(2.0 - 200.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Start undervoltage, step 1 - 2	(2.0 - 150.0)% of UBase	±0.5% of U_r at U ≤ U_r ±0.5% of U at U > U_r
Independent time delay, overvoltage at 0.8 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 217	4 curve types	See table 217
Undervoltage: Inverse time characteristics, see table 218	3 curve types	See table 218
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	-

Table continues on next page

Function	Range or value	Accuracy
Reset ratio, overvoltage	> 98% at (10 - 200)% of UBase	-
Reset ratio, undervoltage	< 102% at (10 - 200)% of UBase	-
Operate frequency	10-90 Hz	-
Overcurrent: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x I_{set} 15 ms typically	 - -
Undercurrent: Critical impulse time Impulse margin time	 10 ms typically at 2 x I_{set} to 0 15 ms typically	 - -
Overvoltage: Critical impulse time Impulse margin time	 10 ms typically at 0.8 x U_{set} to 1.2 x U_{set} 15 ms typically	 - -
Undervoltage: Critical impulse time Impulse margin time	 10 ms typically at 1.2 x U_{set} to 0.8 x U_{set} 15 ms typically	 - -

28.12 Secondary system supervision

Table 90: Current circuit supervision CCSSPVC

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

Table 91: 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 92: Fuse failure supervision VDSPVC

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

Table 93: 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 94: 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

28.13 Control

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

Table 96: Autorecloser SMBRREC

Function	Range or value	Accuracy
Dead time: shot 1 “t1 1Ph” shot 1 “t1 2Ph” shot 1 “t1 3Ph “ shot 1 “t1 3PhHS”	(0.000-120.000) s	±0.2% or ±35 ms whichever is greater
Dead time: shot 2 “t2 3Ph” shot 3 “t3 3Ph” shot 4 “t4 3Ph” shot 5 “t5 3Ph”	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Extend three-phase dead time duration “tExtended t1”	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum time that circuit breaker must be closed before new sequence is allowed “tCBClosedMin”	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Wait time for the slave to close when WAIT input has reset “tSlaveDeadTime”	(0.100-60.000) s	±0.2% or ±35 ms whichever is greater
Maximum allowed start pulse duration “tLongStartInh”	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Circuit breaker closing pulse duration “tPulse”	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Reclaim time ”tReclaim”	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Maximum wait time for release from master “tWaitForMaster”	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Reset time for reclosing inhibit “tInhibit”	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Wait time after close command before proceeding to next shot “tAutoContWait”	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Maximum wait time for fulfilled synchrocheck conditions “tSync”	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
Delay time before indicating successful reclosing “tSuccessful”	(0.000-60.000) s	±0.2% or ±50 ms whichever is greater
Maximum wait time for circuit breaker closing before indicating unsuccessful “tUnsucCl”	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater

Table 97: Voltage control TR1ATCC/TR8ATCC, TCMYLTC/TCLYLTC

Function	Range or value	Accuracy
Transformer reactance	(0.1–200.0) Ω, primary	-
Time delay for lower command when fast step down mode is activated	(1.0–100.0) s	-
Voltage control set voltage	(85.0–120.0)% of UBase	±0.25% of U_r
Outer voltage deadband	(0.2–9.0)% of UBase	-
Inner voltage deadband	(0.1–9.0)% of UBase	-
Upper limit of busbar voltage	(80–180)% of UBase	±0.5% of U_r
Lower limit of busbar voltage	(70–120)% of UBase	±0.5% of U_r
Undervoltage block level	(50–120)% of UBase	±0.5% of U_r
Time delay (long) for automatic control commands	(3–1000) s	±0.2% or ±600 ms whichever is greater
Time delay (short) for automatic control commands	(1–1000) s	±0.2% or ±600 ms whichever is greater
Minimum operating time in inverse mode	(3–120) s	±0.2% or ±600 ms whichever is greater
Table continues on next page		

Function	Range or value	Accuracy
Line resistance	(0.00–150.00) Ω, primary	-
Line reactance	(-150.00–150.00) Ω, primary	-
Load voltage adjustment constants	(-20.0–20.0)% of UBase	-
Load voltage auto correction	(-20.0–20.0)% of UBase	-
Duration time for the reverse action block signal	(30–6000) s	±0.2% or ±600 ms whichever is greater
Current limit for reverse action block	(0–100)% of I1Base	-
Overcurrent block level	(5–250)% of I1Base	±1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Level for number of counted raise/lower within one hour	(0–30) operations/hour	-
Level for number of counted raise/lower within 24 hours	(0–100) operations/day	-
Time window for hunting alarm	(1–120) minutes	-
Hunting detection alarm, max. operations/window	(3–30) operations/window	-
Alarm level of active power in forward and reverse direction at (10-200)% of S_r and (85-120)% of UBase	(-9999.99–9999.99) MW	±1.0% of S_r
Alarm level of reactive power in forward and reverse direction at (10-200)% of S_r and (85-120)% of UBase	(-9999.99–9999.99) MVAr	±1.0% of S_r
Time delay for alarms from power supervision	(1–6000) s	±0.2% or ±600 ms whichever is greater
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	-
Time after position change before the value is accepted	(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

28.14 Scheme communication

Table 98: Scheme communication logic for distance or overcurrent protection ZCPSCH

Function	Range or value	Accuracy
Scheme type	Off Intertrip Permissive UR Permissive OR Blocking DeltaBlocking	-
Operate voltage, Delta U	(0–100)% of UBase	±5.0% of ΔU
Operate current, Delta I	(0–200)% of IBase	±5.0% of ΔI
Operate zero sequence voltage, Delta 3U0	(0–100)% of UBase	±10.0% of Δ3U0
Operate zero sequence current, Delta 3I0	(0–200)% of IBase	±10.0% of Δ3I0
Co-ordination time for blocking communication scheme	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table continues on next page

Function	Range or value	Accuracy
Minimum duration of a carrier send signal	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Security timer for loss of guard signal detection	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Operation mode of unblocking logic	Off NoRestart Restart	-

Table 99: Phase segregated scheme communication logic for distance protection ZPCPSCH

Function	Range or value	Accuracy
Scheme type	Intertrip Permissive UR Permissive OR Blocking	-
Co-ordination time for blocking communication scheme	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Minimum duration of a carrier send signal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 100: Current reversal and weak-end infeed logic for distance protection ZCRWPSCH

Function	Range or value	Accuracy
Detection level phase-to-neutral voltage	(10-90)% of UBase	±0.5% of U_r
Detection level phase-to-phase voltage	(10-90)% of UBase	±0.5% of U_r
Operate time for current reversal logic	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 101: Current reversal and weak-end infeed logic for phase segregated communication ZPCWPSCH

Function	Range or value	Accuracy
Detection level phase to neutral voltage	(10-90)% of UBase	±0.5% of U_r
Detection level phase to phase voltage	(10-90)% of UBase	±0.5% of U_r
Reset ratio	<105% at (20-90)% of UBase	-
Operate time for current reversal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 102: Scheme communication logic for residual overcurrent protection ECPSCH

Function	Range or value	Accuracy
Scheme type	Permissive Underreaching Permissive Overreaching Blocking	-
Communication scheme coordination time	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater

Table 103: Local acceleration logic ZCLCPSCH

Function	Range or value	Accuracy
Operate current, LoadCurr	(1–100)% of IBase	±1.0% of I_r
Operate current, MinCurr	(1–100)% of IBase	±1.0% of I_r
Delay time on pick-up for current release	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater
Delay time on drop-off for current release	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater
Delay time on pick-up for MinCurr value	(0.000–60.000) s	±0.2% or ±35 ms whichever is greater

Table 104: Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH

Function	Range or value	Accuracy
Operate mode of WEI logic	Off Echo Echo & Trip	-
Operate voltage 3U0 for WEI trip	(5-70)% of UBase	±0.5% of U_r
Operate time for current reversal logic	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000–60.000) s	±0.2% or ±30 ms whichever is greater

28.15 Logic

Table 105: 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 106: Number of SMAGAPC instances

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

Table 107: Number of STARTCOMB instances

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

Table 108: Number of TMAGAPC instances

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

Table 109: Number of ALMCALH instances

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

Table 110: Number of WRNCALH instances

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

Table 111: Number of INDCALH instances

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

Table 112: Number of AND instances

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

Table 113: Number of GATE instances

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

Table 114: Number of INV instances

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

Table 115: Number of LLD instances

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

Table 116: Number of OR instances

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

Table 117: 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 118: Number of RSMEMORY instances

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

Table 119: Number of SRMEMORY instances

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

Table 120: 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 121: Number of XOR instances

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

Table 122: Number of ANDQT instances

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

Table 123: Number of INDCOMBSPQT instances

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

Table 124: Number of INDEXTSPQT instances

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

Table 125: Number of INVALIDQT instances

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

Table 126: Number of INVERTERQT instances

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

Table 127: Number of ORQT instances

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

Table 128: 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 129: Number of RSMEMORYQT instances

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

Table 130: Number of SRMEMORYQT instances

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

Table 131: 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 132: Number of XORQT instances

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

Table 133: 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 134: Number of B16I instances

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

Table 135: Number of BTIGAPC instances

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

Table 136: Number of IB16 instances

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

Table 137: Number of ITBGAPC instances

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

Table 138: 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 139: Number of TEIGAPC instances

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

Table 140: Number of INTCOMP instances

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

Table 141: Number of REALCOMP instances

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

Table 142: Number of HOLDMINMAX instances

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

Table 143: Number of INT_REAL instances

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

Table 144: Number of CONST_INT instances

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

Table 145: Number of INTSEL instances

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

Table 146: Number of LIMITER instances

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

Table 147: Number of ABS instances

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

Table 148: Number of POL_REC instances

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

Table 149: Number of RAD_DEG instances

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

Table 150: Number of CONST_REAL instances

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

Table 151: Number of REALSEL instances

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

Table 152: Number of STOREINT instances

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

Table 153: Number of STOREREAL instances

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

Table 154: Number of DEG_RAD instances

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

28.16 Monitoring

Table 155: Power system measurement CVMMXN

Function	Range or value	Accuracy
Frequency	(0.8-1.2) x f_r	±5.0 mHz for U at $0.2 \times U_r \leq U < 0.5 \times U_r$ ±3.0 mHz for U at $0.5 \times U_r \leq U < 1.0 \times U_r$ ±2.0 mHz for U at $U \geq U_r$
Voltage	(10 to 300) V	±0.3% of U at $U \leq 50$ V ±0.2% of U at $U > 50$ V
Current	(0.1-4.0) x I_r	±0.8% of I at $0.1 \times I_r < I < 0.2 \times I_r$ ± 0.5% of I at $0.2 \times I_r < I < 0.5 \times I_r$ ±0.2% of I at $0.5 \times I_r < I < 4.0 \times I_r$
Active power, P	(10 to 300) V (0.1-4.0) x I_r	±0.5% of S_r at $S \leq 0.5 \times S_r$ ±0.5% of S at $S > 0.5 \times S_r$
	(100 to 220) V (0.5-2.0) x I_r $\cos \varphi > 0.7$	±0.2% of P
Reactive power, Q	(10 to 300) V (0.1-4.0) x I_r	±0.5% of S_r at $S \leq 0.5 \times S_r$ ±0.5% of S at $S > 0.5 \times S_r$
	(100 to 220) V (0.5-2.0) x I_r $\cos \varphi < 0.7$	±0.2% of Q
Apparent power, S	(10 to 300) V (0.1-4.0) x I_r	±0.5% of S_r at $S \leq 0.5 \times S_r$ ±0.5% of S at $S > 0.5 \times S_r$
	(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 156: Current measurement CMMXU

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

Table 157: 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 158: 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 159: 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 160: 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 161: 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 162: 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 204
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	-
Table continues on next page		

Function	Range or value	Accuracy
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 163: 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 164: 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
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 165: 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
Table continues on next page		

Function	Range or value	Accuracy
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 166: 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 167: Event list

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

Table 168: Indications

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

Table 169: 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 170: Trip value recorder

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

Table 171: 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 172: 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 173: 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 174: 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 175: 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 $I > I_r$

Table continues on next page

Function	Range or value		Accuracy
	Fundamental	Harmonic	
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 176: Voltage harmonic monitoring VHMMHAI (50/60 Hz)

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

Table 177: Fault current and voltage monitoring FLTMMXU

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

Table 178: Fault locator LMBRFLO

Function	Value or range	Accuracy
Reactive and resistive reach	(0.001-1500.000) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r
Phase selection	According to input signals	-

28.17 Metering

Table 179: 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 180: 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

28.18 Station communication

Table 181: 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 182: IEC 61850-9-2 communication protocol

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

Table 183: LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 184: SPA communication protocol

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

Table 185: IEC 60870-5-103 communication protocol

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

Table 186: 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 187: 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 188: Galvanic RS485 communication module

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

Table 189: 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
Table continues on next page	

Quantity	Rated value
Wavelength and distance	1MRK005500-AA: 1310 nm, 1 m - 2 km 1MRK005500-DA: 1310 nm, 1 m - 10 km (OS1), 1 m - 30 km (OS2[1)]) 1MRK005500-EA: 1310 nm, 10 km - 60 km (OS2[1)]) 1MRK005500-FA: 1550 nm, 10 km - 120 km (OS2[1)]) (All are Class 1 laser safety)
Optical connector	Type LC
Communication speed	Fast Ethernet 100 Mbit/s

Table Note:

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

Table 190: 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 191: 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 192: 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.

28.19 Remote communication

Table 193: 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

Table Note:

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

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

Table 194: 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

28.20 Hardware

28.20.1 IED

Table 195: Case

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

Table 196: 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 197: 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

28.20.2 Electrical safety

Table 198: 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)

28.20.3 Connection system

Table 199: CT and VT circuit connectors

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

Table 200: Auxiliary power supply and binary I/O connectors

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

Table Note:

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

Table 201: 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 202: OEM: Number of Ethernet ports

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

28.21 Basic IED functions

Table 203: Self supervision with internal event list

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

Table 204: 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 205: Time synchronization PTP: IEC/IEEE 61850-9-3

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

Table 206: 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 207: 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 208: 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
Table continues on next page	

Quantity	Rated value
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

28.22 Inverse characteristic

Table 209: 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 210: 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	
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 211: RI and RD type inverse time characteristics

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

Table 212: 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 213: 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 ≤ k ≤ 2.00 1.5 x I_{set} ≤ I ≤ 20 x 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 214: 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 ≤ k ≤ 2.00 1.5 x I_{set} ≤ I ≤ 20 x 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 215: 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 216: 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 217: Inverse time characteristics for overvoltage protection

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

Table 218: 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 219: Inverse time characteristics for residual overvoltage protection

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

Section 29 Ordering for customized IED

Table 220: 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 221: 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: RET670* 2.2 - F00X00 - A00022403000000110 - B42251450002000200000000000 - C8800888322660036221620300028 - D33322020 - T3333 - E1066600 - F9 - S6 - G000 - H06100014044 - K02021110 - L1100000 - M18142330 - P1112220000000011010 - B1X0 - AC - CA - B - A3X0 - CD1D1ARGN1N1XXXXXXX - KKKXXHKKLAGXSX

Product definition					-	**Differential protection**																		-
RET670*	2.2	-	F00	X00	-	A	0	0	0				0		0	0	0	0	0	0			0	-

Impedance protection																											-
B																							0	0	0		-

Current protection																									-
C			00									00					1			0		0	0			-

Voltage protection									-	**Unbalance protection**					-	**Frequency protection**					-	**Multipurpose protection**		-	**General calculation**		-
D						0	1	0	-	T					-	E				00	-	F		-	S		-

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

Scheme communication									-	**Logic**						-	**Monitoring**								-
K								0	-	L			00	0	00	-	M							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 222: Product definition

RET670*	2.2	F00	X00

Table 223: Product definition ordering codes

Product	RET670*
Product version	2.2
Configuration alternative	
RET670 Transformer protection	F00
ACT configuration	
No ACT configuration downloaded	X00
Ordering number	
RET670 Transformer protection	1MRK002816-AG

Table 224: 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

Table 225: Differential functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Transformer differential protection, two winding	T2WPDIF	1MRK005904-FC	4	1-3		1) , 2)
Transformer differential protection, three winding	T3WPDIF	1MRK005904-GB	5	1-3		
High impedance differential protection, single phase	HZPDIF	1MRK005904-HB	6	00-06		
Restricted earth fault protection, low impedance	REFPDIF	1MRK005904-LD	8	0-3		
Additional security logic for differential protection	LDRGFC	1MRK005904-TB	15	0-1		
Self-adaptive differential protection for two-winding power transformers	PSTPDIF	1MRK005905-SA	16	1		1) , 2)

Table Note:

1) Qty of T2WPDIF +T3WPDIF + PSTPDIF = minimum 1 and maximum 3. If PSTPDIF is ordered then T2WPDIF/T3WPDIF cannot be combined in the same RET670.
2) When ordering multiple instances please consider sufficient TRM/MU channels are available.

Table 226: 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	

Table 227: Impedance functions, alternatives

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Note: One and only one of alternatives 1 - 6 can be selected. Selected qty is 0 for other functions in an unselected alternative.						
Alternative 1 Distance protection, quadrilateral						
Distance protection zone, quadrilateral characteristic	ZMQPDIS, ZMQAPDIS	1MRK005907-AA	1	0-5		
Directional impedance quadrilateral	ZDRDIR	1MRK005907-BA	2	0-2		
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Alternative 2 Distance protection for series compensated lines, quadrilateral						
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Distance measuring zone, quadrilateral characteristic for series compensated lines	ZMCPDIS, ZMCAPDIS	1MRK005907-DA	4	0-5		
Directional impedance quadrilateral, including series compensation	ZDSRDIR	1MRK005907-EA	5	0-2		
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	0-5		
Full-scheme distance protection, quadrilateral for earth faults	ZMMPDIS, ZMMAPDIS	1MRK005907-GA	7	0-5		
Directional impedance element for mho characteristic	ZDMRDIR	1MRK005907-HA	8	0-2		
Additional distance protection directional function for earth faults	ZDARDIR	1MRK005907-KA	9	0-1		
Mho impedance supervision logic	ZSMGAPC	1MRK005907-LB	10	0-1		
Faulty phase identification with load encroachment	FMPSPDIS	1MRK005907-MA	11	0-2		
Alternative 4 Distance protection, quadrilateral with separate settings for PP and PE						
Directional impedance quadrilateral	ZDRDIR	1MRK005907-BA	2	0-2		
Distance measuring zone, quad characteristic separate Ph-Ph and Ph-E settings	ZMRPDIS, ZMRAPDIS	1MRK005907-NA	12	0-5		
Phase selection, quadrilateral characteristic with settable angle	FRPSPDIS	1MRK005907-PA	13	0-2		
Alternative 5 High speed distance protection, quadrilateral and mho						
High speed distance protection, quad and mho characteristic	ZMFPDIS	1MRK005907-SH	14	0-2		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	0-2		1)
Optional with alternative 1						
Directional impedance element for mho characteristic	ZDMRDIR	1MRK005907-HA	8	0-2		
Optional with alternative 3						
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Optional with alternatives 1, 2 and 4						
Additional distance protection directional function for earth faults	ZDARDIR	1MRK005907-KA	9	0-1		
Faulty phase identification with load encroachment	FMPSPDIS	1MRK005907-MA	11	0-2		
Optional with alternatives 1, 2, 3 and 4						
Phase preference logic	PPLPHIZ	1MRK005908-DF	16	0-1		

Table continues on next page

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Optional with alternatives 5 and 6						
Phase preference logic	PPL2PHIZ	1MRK005908-DG	17	0-2		
Optional with any alternative						
Power swing detection, blocking and unblocking	ZMBURPSB	1MRK005907-UB	18	0-1		
Automatic switch onto fault logic, voltage and current based	ZCVPSOF	1MRK005908-AA	19	0-2		
Power swing logic	PSLPSCH	1MRK005907-VA	20	0-1		
PoleSlip/Out-of-step protection	PSPPPAM	1MRK005908-CB	21	0-1		
Out-of-step protection	OOSPPAM	1MRK005908-GA	22	0-1		
Underimpedance protection for generators and transformers	ZGVPDIS	1MRK005907-TC	26	0-2		

Table Note:

1) If qty ZMFPDIS > 1 then either IEC 61850 9-2 process bus communication with 8 MUs or LDCM can be ordered but not both.

Table 228: 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									00					1			0		0	0		

Table 229: Current functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Instantaneous phase overcurrent protection	PHPIOC	1MRK005910-AD	1	0-8		
Directional phase overcurrent protection, four steps	OC4PTOC	1MRK005910-BE	2	00-08		
Instantaneous residual overcurrent protection	EFPIOC	1MRK005910-DD	4	0-8		
Directional residual overcurrent protection, four steps	EF4PTOC	1MRK005910-EK	5	00-08		
Directional negative phase sequence overcurrent protection, four steps	NS4PTOC	1MRK005910-FE	6	00-08		
Sensitive directional residual overcurrent and power protection	SDEPSDE	1MRK005910-GA	7	0-3		
Thermal overload protection, one time constant, Celsius	LCPTTR	1MRK005911-BD	8	0-2		
Thermal overload protection, one time constant, Fahrenheit	LFPTTR	1MRK005911-AB	9	0-2		
Thermal overload protection, two time constants	TRPTTR	1MRK005910-HC	10	0-6		
Breaker failure protection	CCRBRF	1MRK005910-LC	11	00-06		
Stub protection	STBPTOC	1MRK005910-NF	13	0-3		
Pole discordance protection	CCPDSC	1MRK005910-PA	14	0-6		
Directional underpower protection	GUPPDUP	1MRK005910-RA	15	0-2		
Directional overpower protection	GOPPDOP	1MRK005910-TA	16	0-2		
Broken conductor check	BRCPTOC	1MRK005910-SB	17	1		
Capacitor bank protection	CBPGAPC	1MRK005910-UB	18	0-6		
Negative sequence time overcurrent protection for machines, two steps	NS2PTOC	1MRK005910-VB	19	0-2		
Voltage restrained overcurrent protection	VRPVOC	1MRK005910-XE	21	0-3		
Average power transient earth fault protection	APPTEF	1MRK006940-LB	24	0-2		
Overcurrent protection with binary release	BRPTOC	1MRK005910-NG	25	00-08		

Table 230: Voltage protection

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

Table 231: Voltage functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Two step undervoltage protection	UV2PTUV	1MRK005912-AA	1	0-3		
Two step overvoltage protection	OV2PTOV	1MRK005912-BA	2	0-3		
Residual overvoltage protection, two steps	ROV2PTOV	1MRK005912-CE	3	0-4		
Overexcitation protection	OEXPVPH	1MRK005912-DB	4	0-2		
Voltage differential protection	VDCPTDV	1MRK005912-EC	5	0-2		
Loss of voltage check	LOVPTUV	1MRK005912-GA	7	1		

Table 232: Unbalance protection

Position	1	2	3	4
T				

Table 233: Unbalance functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Cascading failure protection for shunt capacitor bank	SCCFPVOC	1MRK006940-RC	1	0-3		
Current unbalance protection of shunt capacitor bank	SCUCPTOC	1MRK006940-AB	2	0-3		
Phase voltage differential based capacitor bank unbalanced protection	SCPDPTDV	1MRK006940-BB	3	0-3		
Voltage unbalance protection of shunt capacitor bank	SCUVPTOV	1MRK006940-KB	4	0-3		

Table 234: Frequency protection

Position	1	2	3	4
E				00

Table 235: Frequency functions

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

Table 236: Multipurpose protection

Position	1
F	

Table 237: 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 238: General calculation

Position	1
S	

Table 239: 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 240: Secondary system supervision

Position	1	2	3
G			

Table 241: Secondary system supervision functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Current circuit supervision	CCSSPVC	1MRK005916-AC	1	0-6		
Fuse failure supervision	FUFSPVC	1MRK005916-BA	2	0-4		
Fuse failure supervision based on voltage difference	VDSPVC	1MRK005916-CA	3	0-2		

Table 242: Control

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

Table 243: Control functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Synchrocheck, energizing check and synchronizing	SESRSYN	1MRK005917-XD	2	0-6		
Autorecloser	SMBRREC	1MRK005917-BC	3	0-1		
Control functionality for a single bay, max 10 objects (1CB), including interlocking	APC10	1MRK005917-KZ	5	0-1		
Control functionality for a single bay, max 15 objects (2CB), including interlocking	APC15	1MRK005917-LZ	6	0-1		
Control functionality for up to 6 bays, max 30 objects (6CBs), including interlocking	APC30	1MRK005917-MZ	7	0-1		
Automatic voltage control for tapchanger, single control	TR1ATCC	1MRK005917-NC	8	0-4		1) , 2)
Automatic voltage control for tapchanger, parallel control	TR8ATCC	1MRK005917-PC	9	0-4		
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 Note:

1) Only one ATCC may be selected.
2) If TR1ATCC or TR8ATCC is ordered then one of TCMYLTC or TCLYLTC must be ordered.

Table 244: Scheme communication

Position	1	2	3	4	5	6	7	8
K								0

Table 245: Scheme communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Scheme communication logic for distance or overcurrent protection	ZCPSCH	1MRK005920-AC	1	0-2		1)
Phase segregated scheme communication logic for distance protection	ZPCPSCH	1MRK005920-BB	2	0-2		
Current reversal and weak-end infeed logic for distance protection	ZCRWPSCH	1MRK005920-CA	3	0-2		2)
Current reversal and weak-end infeed logic for phase segregated communication	ZPCWPSCH	1MRK005920-DB	4	0-2		
Local acceleration logic	ZCLCPSCH	1MRK005920-EA	5	0-1		
Scheme communication logic for residual overcurrent protection	ECPSCH	1MRK005920-FB	6	0-1		
Current reversal and weak-end infeed logic for residual overcurrent protection	ECRWPSCH	1MRK005920-GA	7	0-1		

Table Note:

1) Only one of ZCPSCH/ZPCPSCH can be selected.
2) Only one of ZCRWPSCH/ZPCWPSCH can be selected.

Table 246: Logic

Position	1	2	3	4	5
L			00	0	00

Table 247: 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 248: Monitoring

Position	1	2	3	4	5	6	7
M							0

Table 249: Monitoring functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Circuit breaker condition monitoring	SSCBR	1MRK005924-HC	1	00-18		
Fault locator	LMBRFLO	1MRK005925-XF	2	0-1		
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 250: 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 251: 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, 24 phasors		1MRK005933-EB	16	0-1		2)
Rapid spanning tree protocol	RSTP	1MRK005933-SA	18	0-1		3)

Table Note:

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 252: Language selection

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

Table Note:

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

Table 253: 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 254: 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)

Table continues on next page

Mounting details with IP40 of protection from the front	Ordering no	Selection	Notes and rules
Flush mounting kit	1MRK002420-PA	E	
Flush mounting kit + IP54 mounting seal	1MRK002420-NA	F	
	Selected		

Table Note:

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

Table 255: 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 256: Human machine interface selection

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

Table 257: Analog system selection

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

Table continues on next page

Analog system	Ordering no	Selection		Notes and rules
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			

Table Note:

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

Table 258: 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 259: 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 260: 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			■	■	■	■	■										

Table continues on next page

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

Table continues on next page

Binary input/ output modules	Ordering no	Selection															Notes and rules
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																

Table Note:

1) These black marks indicate the maximum number of modules per casing type and the slots that can be occupied.
2) Only every second slot can be used; see Table 259
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 261: 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		■	■	■	■	■	■	■	■	■	■	■			■	
Available slots in 3/4 and 1/1 case with 2 TRM		■	■	■	■	■	■	■	■	■	■	■	■	■	■	

Table continues on next page

Station communication, remote end serial communication and time synchronization	Ordering no	Selection														Notes and rules
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		3)
Optical short range LDCM, 820nm	1MRK002122-AB					A	A				A	A	A	A		4)
Optical medium range LDCM, 1310 nm	1MRK002311-AA					B	B				B	B	B	B		
Optical long range LDCM, 1550 nm	1MRK002311-BA					C	C				C	C	C	C		
Galvanic X21 line data communication module	1MRK002307-AA										E	E	E	E		
Line data communication, default 64kbps mode	—														X	5)
Allow line data communication in 2Mbps mode	1MRK007002-AA														Y	
GPS time module	1MRK002282-AB										S	S	S	S		
IRIG-B time synchronization module, with PPS	1MRK002305-AA										F	F	F	F		
	Selected															

Table Note:

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

Section 30 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: RET670 *2.2-A10X00-A02H03-B1A12-AC-CA-B-A3X0-CDAB1RGN1N1XXXXXXX-KKKKXHKKLAGFSX. Using the code of each position #1-11 specified as RET670*1-2 2-3 3-4 4-5 6-7 7-8-9 9 9 9-10 10 10 10-11 11 11

	Product version		**Configuration alternatives**			**Software options**																													
#	1	-	2		-	3																													-
RET670*	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**
Transformer protection, Back-up	1MRK004816-FG	A10		
Transformer protection, Voltage and tap changer control	1MRK004816-EG	A25		
Transformer protection, Single/Multi breaker, 2 winding differential	1MRK004816-BG	B30		
Transformer protection, Multi breaker, 3 winding differential	1MRK004816-DG	B40		
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)
Underimpedance protection for generators and transformers	1MRK004001-UV	B14	3)
High speed distance protection, quad and mho characteristic	1MRK004001-XA	B35	
Stub protection	1MRK004001-VH	B26	4)
Thermal overload protection	1MRK004001-CE	C05	5)
Sensitive directional residual overcurrent and power protection	1MRK004001-CT	C16	6)
Current protection - VCTR	1MRK004001-XE	C19	7)
Directional power and voltage restrained overcurrent protection	1MRK004001-VL	C35	4)
Four step directional negative phase sequence overcurrent protection - 2 blocks	1MRK004001-UK	C42	8)
Four step directional negative phase sequence overcurrent protection - 3 blocks	1MRK004001-UL	C43	9)
Average power transient earth fault protection	1MRK004001-UY	C54	
Voltage protection - 1 bus	1MRK004001-DA	D01	10)
Voltage protection - 2 buses	1MRK004001-DB	D02	11)
Overexcitation protection - 2 winding	1MRK004001-DC	D03	12)
Overexcitation protection - 3 winding	1MRK004001-DD	D04	13)
Frequency protection - station	1MRK004001-EA	E01	4)
General current and voltage protection - transformer	1MRK004001-FB	F02	3)
Fuse failure supervision based on voltage difference	1MRK004001-HC	G03	
SynchroCheck - 2 circuit breakers	1MRK004001-GA	H01	14)

Table continues on next page

Software options	Ordering no	#3	Notes and rules
SynchroCheck - 4 circuit breakers	1MRK004001-GC	H03	15)
Voltage control, parallel transformers	1MRK004001-GM	H15	3)
Voltage control, single transformer - 2 control blocks	1MRK004001-GN	H16	16)
Voltage control, parallel transformers - 2 control blocks	1MRK004001-GP	H18	17)
Control functionality for up to 10 objects	1MRK004001-GW	H37	
Control functionality for up to 15 objects	1MRK004001-GY	H38	
Control functionality for up to 30 objects	1MRK004001-GZ	H39	6)
Scheme Communication	1MRK004001-KC	K01	3)
Fault Locator	1MRK004001-KA	M01	
Transformer insulation loss of life monitoring	1MRK004001-KM	M21	4)
Through fault monitoring	1MRK004001-KR	M22	
Harmonic monitoring	1MRK004001-KS	M23	
IEC 62439-3 Parallel redundancy protocol	1MRK004001-PP	P23	18)
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, 24 phasors	1MRK004001-PW	P33	19)
	Selection for position #3		

Table Note:

1) All fields in the ordering form do not need to be filled in.
2) Only for B40; 2 blocks already included for B40
3) Only for B30/B40
4) Only for B30/B40/A10
5) Only for B30/B40. 1 block already included in B30. 2 blocks already included in B40.
6) Only for B30/B40/A25
7) Only for A25
8) Only for A10/B30
9) Only for B40
10) Only for A10/B30; 1 block already included in B30
11) Only for A25/B40; 1 block already included in B40
12) Only for B30
13) Only for A10/B40
14) Only for B30
 1 block already included in B30
15) Only for B40; 1 block already included in B40
16) Only for A25; 2 blocks already included in A25
17) Only for B40/A25; 2 blocks already included in A25
18) Options P23, P24 and P25 require two SFPs placed in pairs.
19) 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		

Table Note:

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

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

Table Note:

1) Only for A10/A25/B30
2) Only for B30/B40/A25

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

Table Note:

1) Only for A10/A25/B30
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		
Medium size - graphic display, ANSI keypad symbols	1/2 x 19", ANSI	1MRK000028-AB	C	1)
	3/4 x 19", ANSI	1MRK000028-CB		2)
	1/1 x 19", ANSI	1MRK000028-BB		
		Selection for position #8		

Table Note:

1) Only for A10/A25/B30
2) Only for B30/B40/A25

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	A6	3)
TRM 6I 5A + 6U 110/220V, 50/60Hz, compression terminals	1MRK002247-AH	A7	A7	
TRM 9I 1A + 3U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-BC	B3	B3	4)
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	3)
TRM 6I 5A + 6U 110/220V, 50/60Hz, ring lug terminals	1MRK002247-AD	B7	B7	
	Selection for position #9			

Table Note:

1) Only valid if IEC 61850-9-2 Process bus communication is selected.
2) Only for A10/B30/B40. Maximum qty = 1 for A10. Second TRM is optional for B30, but required with multi-breaker application.
3) Only for A25. Second TRM is optional.
4) Only for A10/B30/B40. Maximum qty = 1 for A10. Second TRM is optional for B30, but required with multi-breaker application.

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 positions P3 and P4.														
Slot position (front view/rear view)			P3/X31	P4/X41	P5/X51	P6/X61	P7/X71	P8/X81	P9/X91	P10/X101	P11/X111	P12/X121	P13/X131	1)
1/2 case with 1 TRM			■	■	■									2)
3/4 case with 2 TRM			■	■	■	■	■							
1/1 case with 2 TRM			■	■	■	■	■	■	■	■	■	■	■	
Compression terminals	1MRK002960-KA	C												
No board in slot					X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)	1MRK000614-AB			A	A	A	A	A	A	A	A	A	A	3)
BIM 16 inputs, RL24, 24-30VDC, 50mA	1MRK000508-DD		B1		B1	B1	B1	B1	B1	B1	B1	B1	B1	4)
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	5)
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	6)
SOM static output module, 6 heavy duty outputs, 250 VDC + 6 output relays	1MRK002614-CA				T2	T2	T2	T2	T2	T2	T2	T2		7)
	Selection for position #10	C												

Table Note:

1) The black marks below indicate the maximum number of modules per casing type and the slots that can be occupied.
2) Only 2 slots for A10, 3 slots for A25
3) Maximum 4 (BOM+SOM+MIM) boards. Only 1 BOM in A10
4) Only 1 BIM in A10
5) Only for B30/B40/A25
6) MIM is not available in A10. Maximum 1 MIM board in 1/2 case
7) SOM is not available in A10. SOM must not to be placed in the position nearest to NUM: 1/2 case slot P5, 3/4 case 2 TRM slot P7, 1/1 case 2 TRM slot P13.

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 case with 1 TRM		■	■	■	■	■	■	■	■	■	■	■			■	
Available slots in 3/4 and 1/1 case with 2 TRM		■	■	■	■	■	■	■	■	■	■	■	■	■	■	
No communication board included			X	X	X	X	X	X	X	X	X	X	X	X		
Ethernet SFP, optical LC connector, multi mode 2 km	1MRK005500-AA	K	K	K	K			K	K							[2]
Ethernet SFP, RJ45 connector	1MRK005500-BA	P	P	P	P			P	P							
Ethernet SFP, optical LC connector, single mode 30 km	1MRK005500-DA	Q	Q	Q	Q			Q	Q							
Ethernet SFP, optical LC connector, single mode 60 km	1MRK005500-EA	R	R	R	R			R	R							
Ethernet SFP, optical LC connector, single mode 120 km	1MRK005500-FA	T	T	T	T			T	T							
Optical Ethernet module	1MRK002266-EA						H									[3]
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	1MRK001608-AB									L						
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	1MRK001608-BB									M						
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	1MRK001608-CB									N						
Galvanic RS485 communication module	1MRK002309-AA											G	G	G		
Optical short range LDCM, 820nm	1MRK002122-AB					A	A				A	A	A	A		[4] , [5]
Optical medium range, LDCM 1310 nm	1MRK002311-AA					B	B				B	B	B	B		
Line data communication, default 64kbps mode	—														X	[6] , [7]
Allow line data communication in 2Mbps mode	1MRK007002-AA														Y	261
GPS time module	1MRK002282-AB										S	S	S	S		
IRIG-B time synchronization module, with PPS	1MRK002305-AA										F	F	F	F		
	Selection for position #11															

Table Note:

1) The maximum number and type of LDCM modules supported depend on the total amount of I/O and communication modules in the IED.
2) Ethernet SFP is basic in P30:1. P30:6:1 and P30:6:2 require the Optical Ethernet module in P30:6.
3) OEM in slot P30:6 requires LDCM in slot P31:2 (only for B30/B40).
4) Only in B30/B40
5) 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.
6) Default if no LDCM is selected
7) LDCM is not applicable in A10/A25.

Section 31 Ordering for Accessories

31.1 Accessories

31.1.1 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

31.1.2 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

31.1.3 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.

31.1.4 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

31.1.5 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

31.1.6 Combiflex

31.1.6.1 Key switch for settings

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

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

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

31.1.7 Configuration and monitoring tools

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

31.2 Manuals

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

Specify quantity of IED Connect USB flash drive requested.		Quantity:		1MRK002700-AA
User documentation				
Specify the number of printed manuals requested				
Application manual	IEC	Quantity:		1MRK504163-UEN
	ANSI	Quantity:		1MRK504163-UUS
Technical manual	IEC	Quantity:		1MRK504164-UEN
	ANSI	Quantity:		1MRK504164-UUS
Commissioning manual	IEC	Quantity:		1MRK504165-UEN
	ANSI	Quantity:		1MRK504165-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

Table continues on next page

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

31.3 Reference information

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

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

31.4 Related documents

Documents related to RET670	Document numbers
Application manual	IEC: 1MRK504163-UEN ANSI: 1MRK504163-UUS
Commissioning manual	IEC: 1MRK504165-UEN ANSI: 1MRK504165-UUS
Product guide	1MRK504166-BEN
Technical manual	IEC: 1MRK504164-UEN ANSI: 1MRK504164-UUS
Type test certificate	IEC: 1MRK504166-TEN ANSI: 1MRK504166-TUS

670 series manuals	Document numbers
Operation manual	IEC: 1MRK500127-UEN ANSI: 1MRK500127-UUS
Engineering manual	IEC: 1MRK511398-UEN ANSI: 1MRK511398-UUS
Installation manual	IEC: 1MRK514026-UEN ANSI: 1MRK514026-UUS
Communication protocol manual, DNP3	1MRK511391-UUS
Communication protocol manual, IEC 60870-5-103	1MRK511394-UEN
Communication protocol manual, IEC 61850 Edition 1	1MRK511392-UEN
Communication protocol manual, IEC 61850 Edition 2 and Edition 2.1	1MRK511393-UEN
Communication protocol manual, LON	1MRK511395-UEN
Communication protocol manual, SPA	1MRK511396-UEN

Table continues on next page

670 series manuals	Document numbers
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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https://hitachienergy.com/protection-control

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1MRK504166-BEN