Relion® 670 series

Transformer protection RET670 Pre-configured Product Guide

Power and productivity
for a better world™

Contents

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1. Application

RET670 provides fast and selective protection, monitoring and control for two- and three-winding transformers, autotransformers, generator-transformer units and shunt reactors. The transformer 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.

A very fast differential protection function, with automatic CT ratio matching and vector group compensation, makes this IED the ideal solution even for the most demanding applications. Since RET670 has very low requirements on the main CTs, no interposing CTs are required.It is suitable for differential applications with multi-breaker arrangements with up to six restraint CT inputs. The differential protection function is provided with 2nd harmonic and wave-block restraint features to avoid tripping for magnetizing inrush current, and 5th harmonic restraint to avoid tripping for overexcitation.

The differential function offers a high sensitivity for low-level internal faults. The unique and innovative sensitive differential protection feature of the RET670 provides the best possible coverage for winding internal turn-to-turn faults, based on well-known theory of symmetrical components .

Low impedance restricted earth-fault protection functions are available as complimentary sensitive and fast main protection against winding earth faults. This function includes a directional zero-sequence current criterion for additional security.

Additionally a high impedance differential function is available. It can be used as restricted earth fault or, as three functions are included, also as differential protection on autotransformers, as differential protection for a tertiary connected reactor, as T-differential protection for the transformer feeder in a mesh-corner or ring arrangement, as tertiary bus protection and so on.

Tripping from Pressure relief/Buchholz and temperature devices can be done through the transformer IED where pulsing, lock-out contact output and so on, is performed. The binary inputs are heavily stabilized against disturbance to prevent incorrect operations at for example, dc system capacitive discharges or DC earth faults.

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

Versatile phase, earth, positive and zero sequence overcurrent functions, which can optionally be made directional and/or voltage controlled, provide further alternative backup protection. Thermal overload with two time-constants, volts per hertz, over/under voltage and over/under frequency protection functions are also available.

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

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

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

Out of Step function is available to separate power system sections close to electrical centre at occurring out of step.

The advanced logic capability, where user logic is prepared with a graphical tool, allows special applications such as automatic opening of disconnectors in multi-breaker arrangements, closing of breaker rings, load transfer logic and so on. The graphical configuration tool ensures simple and fast testing and commissioning.

Serial data communication is via optical connections to ensure immunity against disturbances.

The wide application flexibility makes this product an excellent choice for both new installations and the refurbishment of existing installations.

Six packages have been defined for the following applications:

- Transformer back-up protection (A10)
- Voltage control (A25)
- Two-winding transformer in single breaker arrangements (A30)

- Two-winding transformer in multi breaker arrangements (B30)
- Three-winding transformer in single breaker arrangements (A40)
- Three-winding transformer in multi breaker arrangements (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"

The applications are shown in figures 1, 2, 3and 4 for single resp. multi-breaker arrangement.

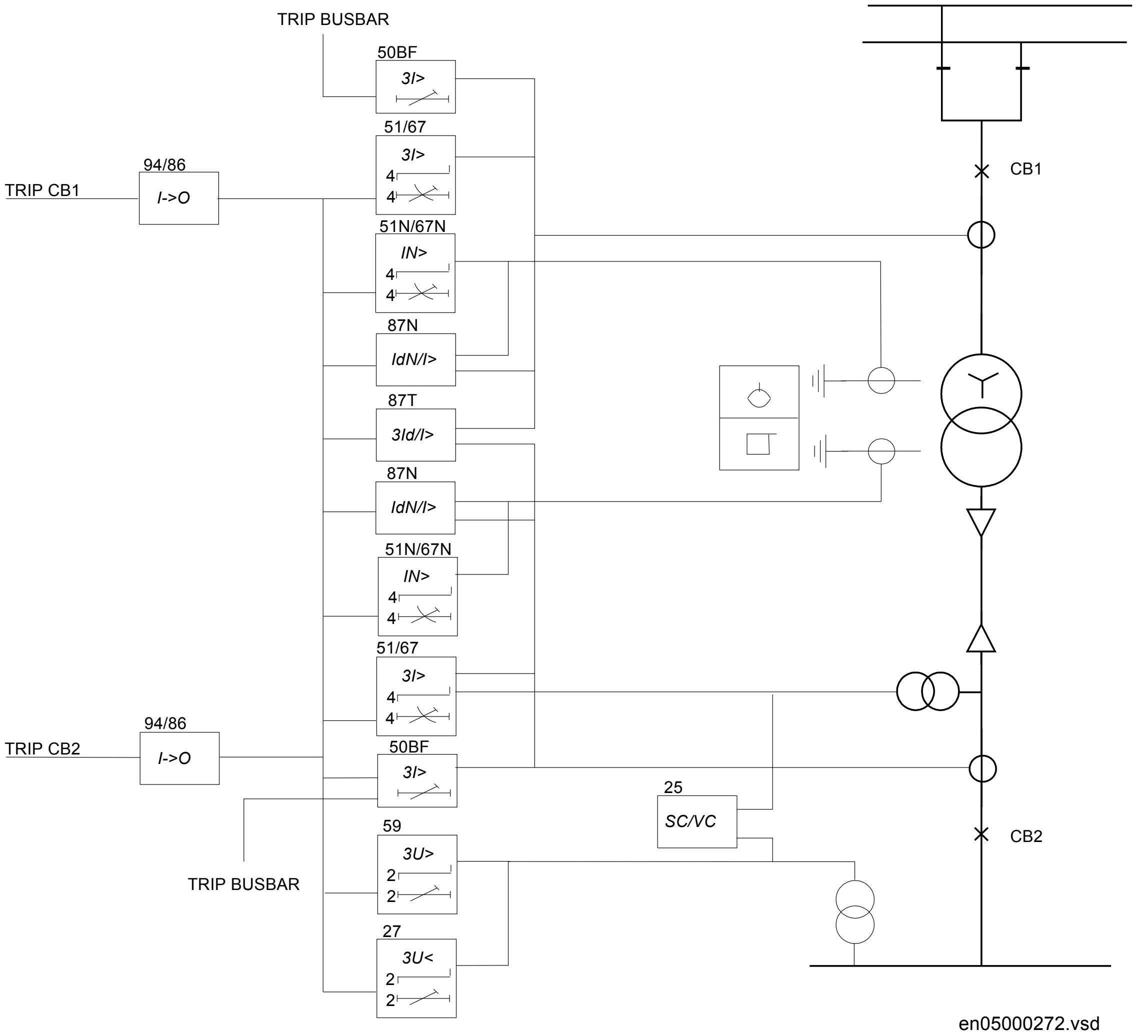


Figure 1. A typical protection application for a two winding transformer in single breaker arrangements is shown on the figure. The system earthing principle and connection group will vary which gives different detailed arrangements for each application.

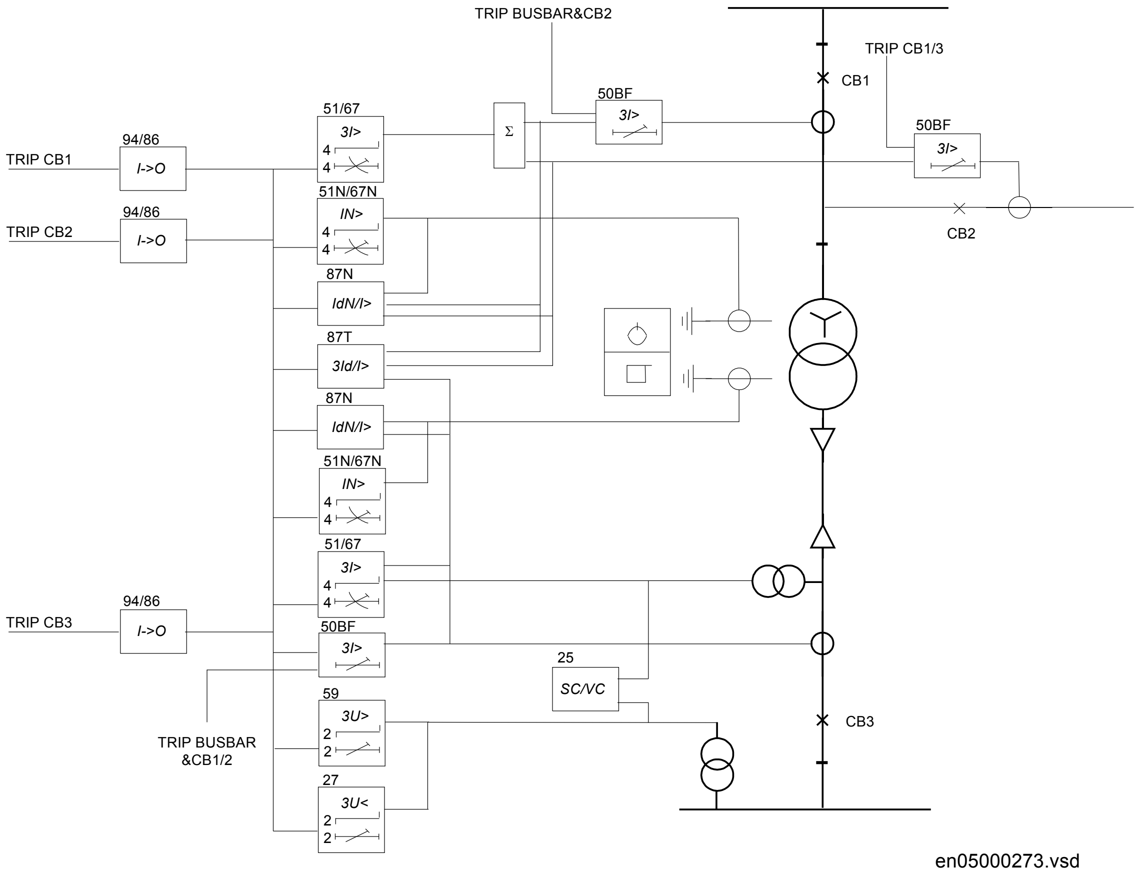


Figure 2. A typical protection application for a two winding transformer in multi breaker arrangements is shown on the figure. The system earthing principle and connection group will vary which gives different detailed arrangements for each application. Breaker failure function is here provided for each breaker.

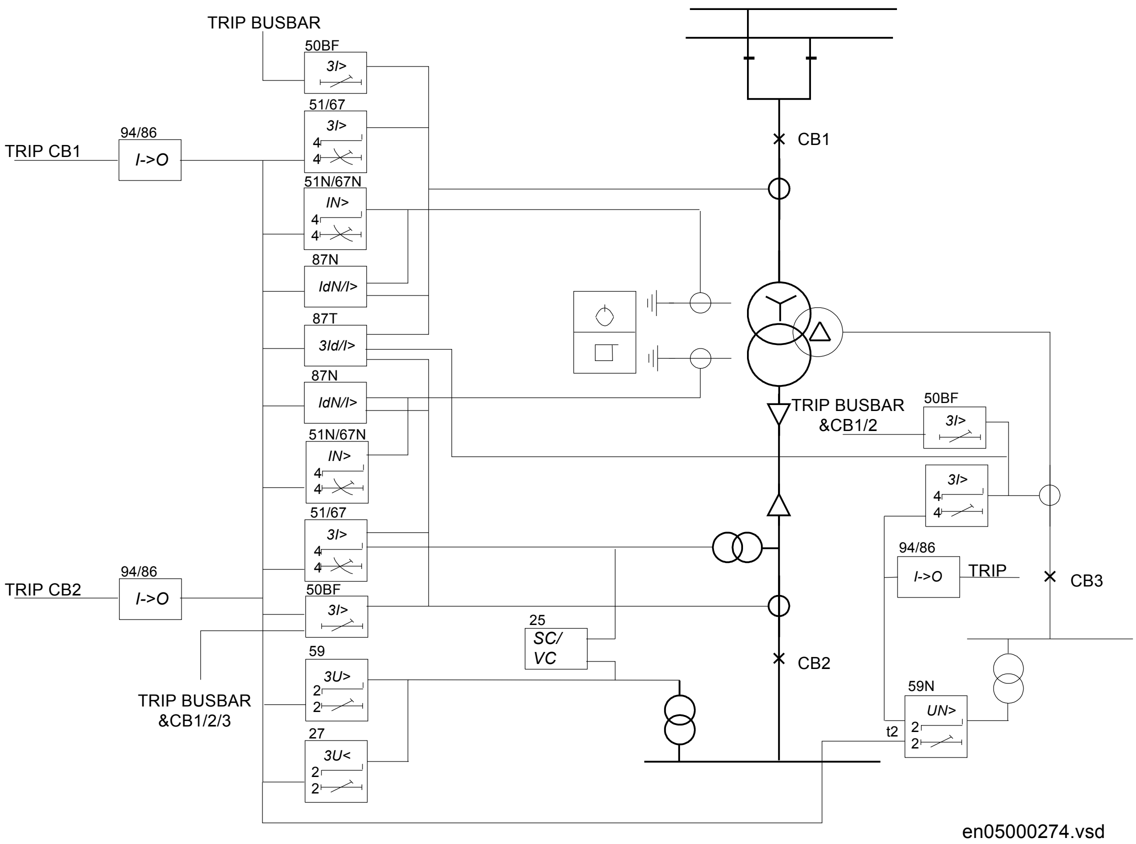


Figure 3. A typical protection application for a three winding transformer in single breaker arrangements is shown on the figure. The system earthing principle and connection group will vary which gives different detailed arrangements for each application.

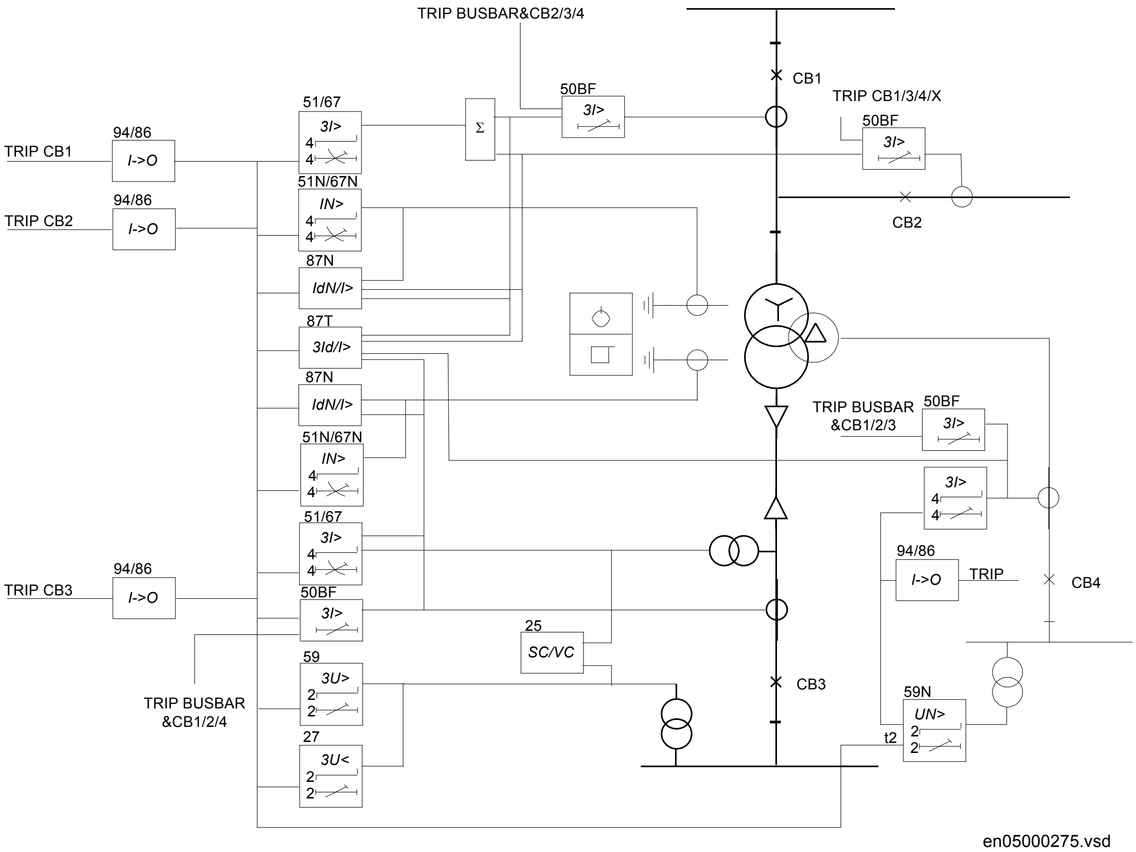


Figure 4. A typical protection application for a three winding transformer in multi breaker arrangements is shown on the figure. The system earthing principle and connection group will vary which gives different detailed arrangements for each application. Breaker failure function is here provided for each breaker.

2. Available functions

Main protection functions

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

IEC 61850	ANSI	Function description	Transformer					
			RET670 (A10)	RET670 (A30)	RET670 (B30)	RET670 (A40)	RET670 (B40)	RET670 (A25)
Differential protection								
T2WPDIF	87T	Transformer differential protection, two winding		1	1			
T3WPDIF	87T	Transformer differential protection, three winding				1	1	
HZPDIF	87	1Ph high impedance differential protection	1	3-A02	3-A02	3-A02	3-A02	
REFPDIF	87N	Restricted earth fault protection, low impedance	1	2	2	2-B/1-A01	2-B/1-A01	
Impedance protection								
ZMQPDIS, ZMQAPDIS	21	Distance protection zone, quadrilateral characteristic		4-B12	4-B12	4-B12	4-B12	
ZDRDIR	21D	Directional impedance quadrilateral		2-B12	2-B12	2-B12	2-B12	
FDPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle		2-B12	2-B12	2-B12	2-B12	
ZMHPDIS	21	Full-scheme distance protection, mho characteristic		4-B13	4-B13	4-B13	4-B13	
ZMMPDIS, ZMMAPDIS	21	Full-scheme distance protection, quadrilaterial for earth faults		4-B13	4-B13	4-B13	4-B13	
ZDMRDIR	21D	Directional impedance element for mho characteristic		2-B13	2-B13	2-B13	2-B13	
ZDARDIR		Additional distance protection directional function for earth fault		1-B13	1-B13	1-B13	1-B13	
ZSMGAPC		Mho impedance supervision logic		1-B13	1-B13	1-B13	1-B13	
FMPSPDIS	21	Faulty phase identification with load enchroachment		2-B13	2-B13	2-B13	2-B13	
ZMRPSB	78	Power swing detection		1-B12/-B13	1-B12/-B13	1-B12/-B13	1-B12/-B13	

Back-up protection functions

IEC 61850	ANSI	Function description	Transformer					
			RET670 (A10)	RET670 (A30)	RET670 (B30)	RET670 (A40)	RET670 (B40)	RET670 (A25)
Current protection								
PHPIOC	50	Instantaneous phase overcurrent protection	3	2	2	3	3	2-C19
OC4PTOC	51_67	Four step phase overcurrent protection	3	2	2	3	3	2-C19
EFPIOC	50N	Instantaneous residual overcurrent protection	3	2	2	3	3	2-C19
EF4PTOC	51N_67 N	Four step residual overcurrent protection	3	2	2	3	3	2-C19
NS4PTOC	46I2	Four step directional negative phase sequence overcurrent protection	2-C42	2-C42	2-C42	3-C43	3-C43	2-C19
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	1	1-C16	1-C16	1-C16	1-C16	1-C16
TRPTTR	49	Thermal overload protection, two time constant	1	1B, 1-C05	1B, 1-C05	2B, 1-C05	2B, 1-C05	
CCRBRF	50BF	Breaker failure protection	3	2	4	3	6	
CCRPLD	52PD	Pole discordance protection		1	2	1	2	
GUPPDUP	37	Directional underpower protection		1-C17	1-C17	1-C17	1-C17	
GOPPDOP	32	Directional overpower protection		1-C17	1-C17	1-C17	1-C17	
BRCPTOC	46	Broken conductor check	1	1	1	1	1	1
Voltage protection								
UV2PTUV	27	Two step undervoltage protection	1-D01	1B, 1-D01	1B, 1-D01	1B, 2-D02	1B, 2-D02	2-D02
OV2PTOV	59	Two step overvoltage protection	1-D01	1B, 1-D01	1B, 1-D01	1B, 2-D02	1B, 2-D02	2-D02
ROV2PTOV	59N	Two step residual overvoltage protection	1-D01	1B, 1-D01	1B, 1-D01	1B, 2-D02	1B, 2-D02	2-D02
OEXPVPH	24	Overexcitation protection		1-D03	1-D03	2-D04	2-D04	
VDCPTOV	60	Voltage differential protection	2	2	2	2	2	2
LOVPTUV	27	Loss of voltage check	1	1	1	1	1	1
Frequency protection								

IEC 61850	ANSI	Function description	Transformer					
			RET670 (A10)	RET670 (A30)	RET670 (B30)	RET670 (A40)	RET670 (B40)	RET670 (A25)
SAPTUF	81	Underfrequency protection	6-E01	6-E01	6-E01	6-E01	6-E01	
SAPTOF	81	Overfrequency protection	6-E01	6-E01	6-E01	6-E01	6-E01	
SAPFRC	81	Rate-of-change frequency protection	6-E01	6-E01	6-E01	6-E01	6-E01	
Multipurpose protection								
CVGAPC		General current and voltage protection		6-F02	6-F02	6-F02	6-F02	

Control and monitoring functions

IEC 61850	ANSI	Function description	Transformer					
			RET670 (A10)	RET670 (A30)	RET670 (B30)	RET670 (A40)	RET670 (B40)	RET670 (A25)
Control								
SESRSYN	25	Synchrocheck, energizing check and synchronizing	1	1	1-B, 2-H01	1-B, 3-H02	1-B, 4-H03	
APC30	3	Apparatus control for up to 6 bays, max 30 apparatuses (6CBs) incl. interlocking		1-H09	1-H09	1-H09	1-H09	1-H09
QCBAY		Apparatus control	1	1	1	1	1	1
Local Remote		Handling of LRswitch positions	1	1	1	1	1	1
LocRem Control		LHMI control of PSTO	1	1	1	1	1	1
TR1ATCC	90	Automatic voltage control for tap changer, single control		1-H11	1-H11	1-H11, 2-H16	1-H11, 2-H16	2B, 2-H16
TR8ATCC	90	Automatic voltage control for tap changer, parallel control		1-H15	1-H15	1-H15, 2-H18	1-H15,2-H18	2B, 2-H18
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs		4	4	4	4	4
TCLYLTC	84	Tap changer control and supervision, 32 binary inputs		4	4	4	4	4
SLGGIO		Logic rotating switch for function selection and LHMI presentation	15	15	15	15	15	15
VSGGIO		Selector mini switch	20	20	20	20	20	20
DPGGIO		IEC61850 generic communication I/O functions	16	16	16	16	16	16
SPC8GGIO		Single pole generic control 8 signals	5	5	5	5	5	5
AutomationBits		AutomationBits, command function for DNP3.0	3	3	3	3	3	3
		Single command, 16 signals	4	4	4	4	4	4
VCTRSend		Horizonal communication via GOOSE for VCTR	7	7	7	7	7	7
VCTR Receive		Horizontal communication via GOOSE for VCTR	1	1	1	1	1	1
Secondary system supervision								

IEC 61850	ANSI	Function description	Transformer					
			RET670 (A10)	RET670 (A30)	RET670 (B30)	RET670 (A40)	RET670 (B40)	RET670 (A25)
CCSRDIF	87	Current circuit supervision		2	3	3	5	4
SDDRFUF		Fuse failure supervision	1	3	3	3	3	
Logic								
SMPPTRC	94	Tripping logic	3	2	3	5	6	2
TMAGGIO		Trip matrix logic	12	12	12	12	12	12
		Configuration logic blocks	40-280	40-280	40-280	40-280	40-280	40-280
		Fixed signal function blocks	1	1	1	1	1	1
B16I		Boolean 16 to Integer conversion	16	16	16	16	16	16
B16IFCVI		Boolean 16 to Integer conversion with Logic Node representation	16	16	16	16	16	16
IB16		Integer to Boolean 16 conversion	16	16	16	16	16	16
IB16FVCB		Integer to Boolean 16 conversion with Logic Node representation	16	16	16	16	16	16
Monitoring								
CVMMXN		Measurements	6	6	6	6	6	6
CNTGGIO		Event counter	5	5	5	5	5	5
Event		Event function	20	20	20	20	20	20
DRPRDRE		Disturbance report	1	1	1	1	1	1
SPGGIO		IEC61850 generic communication I/O functions	64	64	64	64	64	64
SP16GGIO		IEC61850 generic communication I/O functions 16 inputs	16	16	16	16	16	16
MVGGIO		IEC61850 generic communication I/O functions	24	24	24	24	24	24
BSStart Report		Logical signal status report	3	3	3	3	3	3
RANGE_XP		Measured value expander block	66	66	66	66	66	66

IEC 61850	ANSI	Function description	Transformer					
			RET670 (A10)	RET670 (A30)	RET670 (B30)	RET670 (A40)	RET670 (B40)	RET670 (A25)
Metering								
PCGGIO		Pulse-counter logic	16	16	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	6	6	6	6	6	6

Designed to communicate

IEC 61850	ANSI	Function description	Transformer					
			RET670 (A10)	RET670 (A30)	RET670 (B30)	RET670 (A40)	RET670 (B40)	RET670 (A25)
Station communication								
		SPA communication protocol	1	1	1	1	1	1
		LON communication protocol	1	1	1	1	1	1
		IEC60870-5-103 communication protocol	20/1	20/1	20/1	20/1	20/1	20/1
		Operation selection between SPA and IEC60870-5-103 for SLM	1	1	1	1	1	1
		DNP3.0 for TCP/IP and EIA-485 communication protocol	1	1	1	1	1	1
		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1	1	1	1	1	1
		Parameter setting function for IEC61850	1	1	1	1	1	1
IntlReceive		Horizontal communication via GOOSE for interlocking	59	59	59	59	59	59
		Goose binary receive	10	10	10	10	10	10
		Multiple command and transmit	60/10	60/10	60/10	60/10	60/10	60/10
		Ethernet configuration of links	1	1	1	1	1	1
		IEC 62439-3 Edition 1 parallel redundancy protocol	1-P01	1-P01	1-P01	1-P01	1-P01	1-P01
		IEC 62439-3 Edition 2 parallel redundancy protocol	1-P02	1-P02	1-P02	1-P02	1-P02	1-P02
Remote communication								
		Binary signal transfer receive/transmit	6/36	6/36	6/36	6/36	6/36	6/36
		Transmission of analog data from LDCM	1	1	1	1	1	1
		Receive binary status from remote LDCM	6/3/3	6/3/3	6/3/3	6/3/3	6/3/3	6/3/3
Scheme communication								
ECPSCH	85	Scheme communication logic for residual overcurrent protection		1	1	1	1	
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection		1	1	1	1	

Basic IED functions

IEC 61850	Function description	
Basic functions included in all products		
IntErrorSig	Self supervision with internal event list	1
TIME	Time and synchronization error	1
TimeSynch	Time synchronization	1
ActiveGroup	Parameter setting groups	1
Test	Test mode functionality	1
ChangeLock	Change lock function	1
TerminalID	IED identifiers	1
Productinfo	Product information	1
MiscBaseCommon	Misc Base Common	1
IEDRuntimeComp	IED Runtime Comp	1
RatedFreq	Rated system frequency	1
SMBI	Signal Matrix for binary inputs	40
SMBO	Signal Matrix for binary outputs	40
SMMI	Signal Matrix for mA inputs	4
SMAI	Signal Matrix for analog inputs	36
Sum3Ph	Summation block 3 phase	18
LocalHMI	Parameter setting function for HMI in PCM600	1
LocalHMI	Local HMI signals	1
AuthStatus	Authority status	1
AuthorityCheck	Authority check	1
AccessFTP	FTP access with password	1
SPACommMap	SPA communication mapping	1
DOSFRNT	Denial of service, frame rate control for front port	1
DOSOEMAB	Denial of service, frame rate control for OEM port AB	1
DOSOEMCD	Denial of service, frame rate control for OEM port CD	1

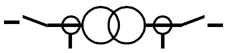
3. Differential protection

Transformer differential protection T2WPDIF/ T3WPDIF

The Transformer differential protection, two-winding (T2WPDIF) and Transformer differential protection, three-winding (T3WPDIF) are provided with internal CT ratio matching and vector group compensation and settable zero sequence current elimination.

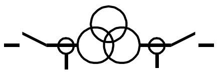
The function can be provided with up to three-phase sets of current inputs. All current inputs are provided with percentage bias restraint features, making the IED suitable for two- or three-winding transformer in multi-breaker station arrangements.

Two-winding applications



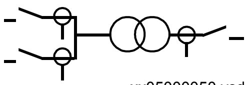
IEC05000048 V1 EN

two-winding power transformer



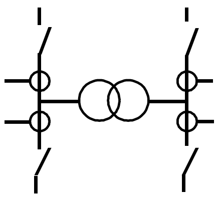
IEC05000049 V1 EN

two-winding power transformer with unconnected delta tertiary winding



IEC05000050 V1 EN

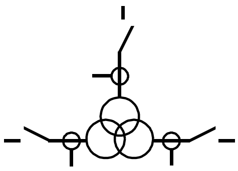
two-winding power transformer with two circuit breakers on one side



IEC05000051 V1 EN

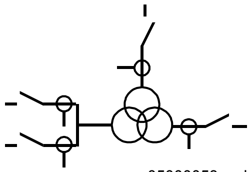
two-winding power transformer with two circuit breakers and two CT-sets on both sides

Three-winding applications



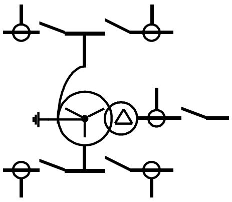
IEC05000052 V1 EN

three-winding power transformer with all three windings connected



IEC05000053 V1 EN

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



IEC05000057 V1 EN

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

Figure 5. CT group arrangement for differential protection and other protections

The setting facilities cover the applications of the differential protection to all types of power transformers and auto-transformers with or without load tap changer as well as for shunt reactors or and local feeders within the station. An adaptive stabilizing feature is included for heavy through-faults.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 level.

Stabilization is included for inrush currents as well as for overexcitation conditions. Adaptive stabilization is also included for system recovery inrush and CT saturation for external faults. A high set unrestrained differential current protection is included for a very high speed tripping at a high internal fault currents.

An innovative sensitive differential protection feature, based on the theory of symmetrical components, offers the best possible coverage for power transformer winding turn-to-turn faults.

1Ph High impedance differential protection HZPDIF

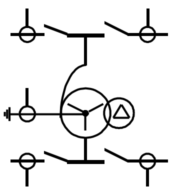
The 1Ph High impedance differential protection (HZPDIF) function can be used when the involved CT cores have the same turns ratio and similar magnetizing characteristics. It utilizes an external CT current summation by wiring, a series resistor, and a voltage dependent resistor which are mounted externally connected to the IED.

HZPDIF can be used to protect tee-feeders or busbars. Six single phase function blocks are available to allow application for two three-phase zones busbar protection.

Restricted earth fault protection, low impedance REFPDIF

Restricted earth-fault protection, low-impedance function (REFPDIF) can be used on all directly or low-impedance earthed windings. The REFPDIF function provides high sensitivity (down to 5%) and high speed tripping as it measures each winding individually and thus does not need inrush stabilization.

The low-impedance function is a percentage biased function with an additional zero sequence current directional comparison criterion. This gives excellent sensitivity and stability during through faults. The function allows the use of different CT ratios and magnetizing characteristics on the phase and neutral CT cores and mixing with other functions and protection IEDs on the same cores.



xx05000058.vsd

Figure 6. Autotransformer low impedance REFPDIF

4. Impedance protection

Distance measuring zone, quadrilateral characteristic ZMQPDIS, ZMQAPDIS (21)

The line distance protection is a four 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. 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.

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.

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

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.

Full-scheme distance measuring, Mho characteristic ZMHPDIS

The numerical mho line distance protection is a four zone full scheme protection for back-up detection of short circuit and earth faults. The four zones have fully independent measuring and settings, which gives high flexibility for all types of lines.

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

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

The distance protection is a four zone protection 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 faults functions ZMMDPIS and ZMMAPDIS have functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines .

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.

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).

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

Faulty phase identification with load encroachment FMPSPDIS

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 accurate and reliable classifying the different types of fault so that single phase tripping and autoreclosing can be used plays an important roll in this matter.

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.

Power swing detection ZMRPSB

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

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

5. Current protection

Instantaneous phase overcurrent protection PHPIOC

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

Four step phase overcurrent protection OC4PTOC

The four step phase overcurrent protection function OC4PTOC has an inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

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

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

A 2nd harmonic blocking can be set individually for each step.

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. EFPIOC can be blocked by activating the input BLOCK.

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

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

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

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

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

Second harmonic blocking can be set individually for each step.

EF4PTOC can be configured to measure the residual current from the three-phase current inputs or the current from a separate current input.

Four step negative sequence overcurrent protection NS4PTOC

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

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

The directional function is voltage polarized or dual polarized.

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

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.

Thermal overload protection, two time constant TRPTTR

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

The thermal overload protection estimates the internal heat content of the transformer/generator (temperature) continuously. This estimation is made by using a thermal model of the transformer/

generator 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/generator.

Breaker failure protection CCRBRF

Breaker failure protection (CCRBRF) ensures fast back-up tripping of surrounding breakers in case the own breaker fails to open. CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Current check with extremely short reset time is used as check criterion to achieve high security against unnecessary operation.

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

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

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

Pole discordance protection CCRPLD

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 Polediscordance protection function CCRPLD operates based on information from auxiliary contacts of the circuit breaker for the three phases with additional criteria from unsymmetrical phase currents when required.

Directional over/underpower protection GOPPDOP/GUPPDUP

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

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

Each function has two steps with definite time delay. Reset times for both steps can be set as well.

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.

6. Voltage protection

Two step undervoltage protection UV2PTUV

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

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

Two step overvoltage protection OV2PTOV

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

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 an extremely high reset ratio to allow settings close to system service voltage.

Two step residual overvoltage protection ROV2PTOV

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

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

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

Reset delay ensures operation for intermittent earth faults.

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 not designed to carry flux and cause eddy currents to flow. The eddy currents can cause excessive heating and severe damage to insulation and adjacent parts in a relatively short time. The function has settable inverse operating curves and independent alarm stages.

Voltage differential protection VDCPTOV

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

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.

7. Frequency protection

Underfrequency protection SAPTUF

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

Underfrequency protection SAPTUF is used for load shedding systems, remedial action schemes, gas turbine startup and so on.

SAPTUF is provided with an undervoltage blocking.

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

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

SAPTOF is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring.

SAPTOF is provided with an undervoltage blocking.

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

Rate-of-change frequency protection SAPFRC

Rate-of-change frequency protection function (SAPFRC) gives an early indication of a main disturbance in the system. SAPFRC can be used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between positive or negative change of frequency.

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

8. Multipurpose protection

General current and voltage protection CVGAPC

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

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

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

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

9. Secondary system supervision

Current circuit supervision CCSRDIF

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.

It must be remembered that a blocking of protection functions at an occurrence of open CT circuit will mean that the situation will remain and extremely high voltages will stress the secondary circuit.

Current circuit supervision (CCSRDIF) 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 unwanted tripping.

Fuse failure supervision SDDRFUF

The aim of the fuse failure supervision function (SDDRFUF) is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid unwanted operations that otherwise might occur.

The fuse failure supervision function basically has three different algorithms, negative sequence and zero sequence based algorithms and an additional delta voltage and delta current algorithm.

The negative sequence detection algorithm is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence measuring quantities, a high value of voltage $3U_2$ without the presence of the negative-sequence current $3I_2$.

The zero sequence detection algorithm is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities, a high value of voltage $3U_0$ without the presence of the residual current $3I_0$.

For better adaptation to system requirements, an operation mode setting has been introduced which makes it possible to select the operating conditions for negative sequence and zero sequence based function. The selection of different operation modes makes it possible to choose different interaction possibilities between the negative sequence and zero sequence based algorithm.

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.

10. Control

Synchrocheck, energizing check, and synchronizing SESRSYN

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

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

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

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

For systems which are running asynchronous a synchronizing function is provided. The main purpose of the synchronizing function is to provide controlled closing of circuit breakers when two asynchronous systems are going to be connected. It is used for slip frequencies that are larger than those for synchrocheck and lower than a set maximum level for the synchronizing function.

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 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

In normal security, the command is processed and the resulting position is not supervised. However with enhanced security, the command is processed and the resulting position is supervised.

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 security with enhanced security is always terminated by a CommandTermination service primitive.

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

Voltage control TR1ATCC, TR8ATCC, TCMYLTC and TCLYLTC

The voltage control functions, Automatic voltage control for tap changer, single control TR1ATCC, Automatic voltage control for tap changer , parallel control TR8ATCC and Tap changer control and supervision, 6 binary inputs TCMYLTC as well as Tap changer control and supervision, 32 binary inputs TCLYLTC are used for control of power transformers with a motor driven 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 two former methods require exchange of information between the parallel transformers and this is provided for within IEC61850-8-1.

Voltage control includes many extra features such as possibility of 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.

Logic rotating switch for function selection and LHMI presentation SLGGIO

The logic rotating switch for function selection and LHMI presentation function (SLGGIO) (or the selector switch function block) is used to get a selector switch functionality similar 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 logic selector switches eliminate all these problems.

Selector mini switch VSGGIO

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

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

IEC 61850 generic communication I/O functions DPGGIO

The IEC 61850 generic communication I/O functions (DPGGIO) function block is used to send double indications to other systems or equipment in the substation. It is especially used in the interlocking and reservation station-wide logics.

Single point generic control 8 signals SPC8GGIO

The Single point generic control 8 signals (SPC8GGIO) function block is a collection of 8 single point commands, designed to bring in commands from REMOTE (SCADA) to those parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. Confirmation (status) of the result of the commands is supposed to be achieved by other means, such as binary inputs and SPGGIO function blocks. The commands can be pulsed or steady.

AutomationBits, command function for DNP3.0 AUTOBITS

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

Single command, 16 signals

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

11. Scheme communication

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 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.

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 communication channels.

The 670 series IEDs have for this reason available additions to 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.

12. Logic

Tripping logic SMPPTRC

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

The trip function block includes functionality for evolving faults and breaker lock-out.

Trip matrix logic TMAGGIO

Trip matrix logic TMAGGIO function is used to route trip signals and other logical output signals to different output contacts on the IED.

TMAGGIO output signals and the physical outputs allows the user to adapt the signals to the physical tripping outputs according to the specific application needs.

Fixed signal function block

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

13. Monitoring

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

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

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- primary and secondary phasors
- positive, negative and zero sequence currents and voltages
- mA, input currents
- pulse counters

Supervision of mA input signals

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

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

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

Event counter CNTGGIO
Event counter (CNTGGIO) has six counters which are used for storing the number of times each counter input has been activated.

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

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 96 binary signals.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Disturbance recorder DRPRDRE

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

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance report function (maximum 40 analog and 96 binary signals). The binary signals available are the same as for the event recorder function.

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

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

Event function

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

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

IEC61850 generic communication I/O function SPGGIO

IEC61850 generic communication I/O functions (SPGGIO) is used to send one single logical signal to other systems or equipment in the substation.

IEC61850 generic communication I/O functions MVGGIO

IEC61850 generic communication I/O functions (MVGGIO) function is used to send the instantaneous value of an analog output to other systems or equipment in the substation. It can also be used inside the same IED, to attach a RANGE aspect to an analog value and to permit measurement supervision on that value.

Measured value expander block RANGE_XP

The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGGIO) 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-high limit or above high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

14. Metering

Pulse counter logic PCGGIO

Pulse counter (PCGGIO) 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 function. A scaled service value is available over the station bus. The special Binary input module with enhanced pulse counting capabilities must be ordered to achieve this functionality.

Function for energy calculation and demand handling ETPMMTR

Outputs from the Measurements (CVMMXN) function can be used to calculate energy consumption. Active as well as reactive values are calculated in import and export direction. Values can be read or generated as pulses. Maximum demand power values are also calculated by the function.

15. Basic IED functions

Time synchronization

The time synchronization source selector is used to select a common source of absolute time for the IED when it is a part of a protection system. This makes it possible to compare event and disturbance data between all IEDs in a station automation system.

16. Human machine interface

Human machine interface

The local HMI is divided into zones with different functionality.

- Status indication LEDs.
- Alarm indication LEDs, which consist of 15 LEDs (6 red and 9 yellow) with user printable label. All LEDs are configurable from PCM600.
- Liquid crystal display (LCD).
- Keypad with push buttons for control and navigation purposes, switch for selection between local and remote control and reset.
- Isolated RJ45 communication port.

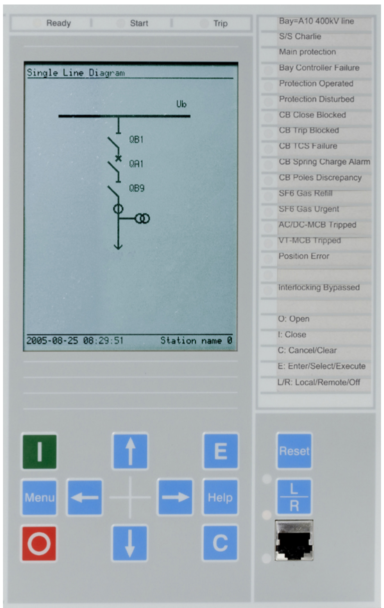


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Figure 7. Medium graphic HMI, 15 controllable objects

17. Station communication

Overview

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

Following communication protocols are available:

- IEC 61850-8-1 communication protocol
- LON communication protocol
- SPA or IEC 60870-5-103 communication protocol
- DNP3.0 communication protocol

Theoretically, several protocols can be combined in the same IED.

IEC 61850-8-1 communication protocol

The IED is equipped with single or double optical Ethernet rear ports (order dependent) for IEC 61850-8-1 station bus communication. The IEC 61850-8-1 communication is also possible from the optical Ethernet front port. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. Peer-to-peer communication according to GOOSE is part of the standard. Disturbance files uploading is provided.

Serial communication, LON

Existing stations with ABB station bus LON can be extended with use of the optical LON interface. This allows full SA functionality including peer-to-peer messaging and cooperation between existing ABB IED's and the new IED 670.

SPA communication protocol

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

IEC 60870-5-103 communication protocol

A single glass or plastic port is provided for the IEC60870-5-103 standard. This allows design of simple substation automation systems including equipment from different vendors. Disturbance files uploading is provided.

DNP3.0 communication protocol

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

Multiple command and transmit

When 670 IED's are used in Substation Automation systems with LON, SPA or IEC60870-5-103 communication protocols the Event and Multiple Command function blocks are used as the communication interface for vertical communication to station HMI and gateway and as interface for horizontal peer-to-peer communication (over LON only).

IEC 62439-3 Parallel Redundant Protocol

Redundant station bus communication according to IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2 are available as options in 670 series IEDs. IEC 62439-3 parallel redundant protocol is an optional quantity and the selection is made at ordering. Redundant station bus communication according to IEC 62439-3 uses both port AB and port CD on the OEM module.

Select IEC 62439-3 Edition 1 protocol at the time of ordering when an existing redundant station bus DuoDriver installation is extended.
Select IEC 62439-3 Edition 2 protocol at the time of ordering for new installations with redundant station bus.
IEC 62439-3 Edition 1 is NOT compatible with IEC 62439-3 Edition 2.

18. Remote communication

Analog and binary signal transfer to remote end

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

Binary signal transfer to remote end, 192 signals

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

Line data communication module, short and medium range LDCM

The line data communication module (LDCM) is used for communication between the IEDs situated at distances <60 km or from the IED to optical to electrical converter with G.703 or G.703E1 interface located on a distances <3 km away. The LDCM module sends and receives data, to and from another LDCM module. The IEEE/ANSI C37.94 standard format is used.

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.

19. Hardware description

Hardware modules

Power supply module PSM

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

Binary input module BIM

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

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

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

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

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

Optical ethernet module OEM
The optical fast-ethernet module is used to connect an IED to the communication buses (like the station bus) that use the IEC 61850-8-1 protocol (port A, B). The module has one or two optical ports with ST connectors.

Serial and LON communication module SLM, supports SPA/IEC 60870-5-103, LON and DNP 3.0
The serial and LON communication module (SLM) is used for SPA, IEC 60870-5-103, DNP3 and LON communication. The module has two optical communication ports for plastic/plastic, plastic/glass or glass/glass. One port is used for serial communication (SPA, IEC 60870-5-103 and DNP3 port or dedicated IEC 60870-5-103 port depending on ordered SLM module) and one port is dedicated for LON communication.

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

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

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

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

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

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

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

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

Layout and dimensions
Dimensions

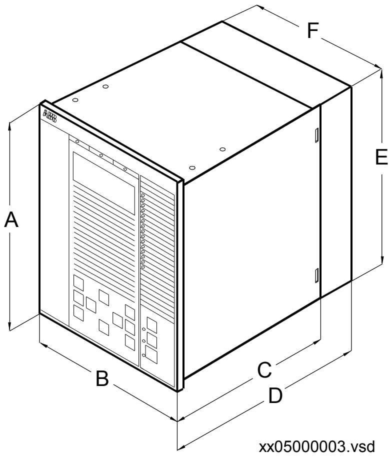


Figure 8. 1/2 x 19” case with rear cover

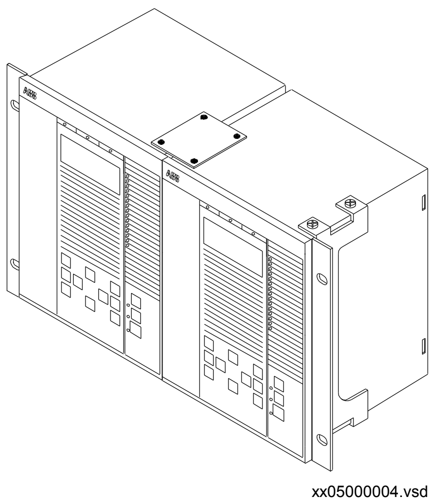


Figure 9. Side-by-side mounting

Case size	A	B	C	D	E	F
6U, 1/2 x 19”	265.9	223.7	201.1	242.1	252.9	205.7
6U, 3/4 x 19”	265.9	336.0	201.1	242.1	252.9	318.0
6U, 1/1 x 19”	265.9	448.1	201.1	242.1	252.9	430.3
						(mm)

Mounting alternatives

The following mounting alternatives are available (IP40 protection from the front):

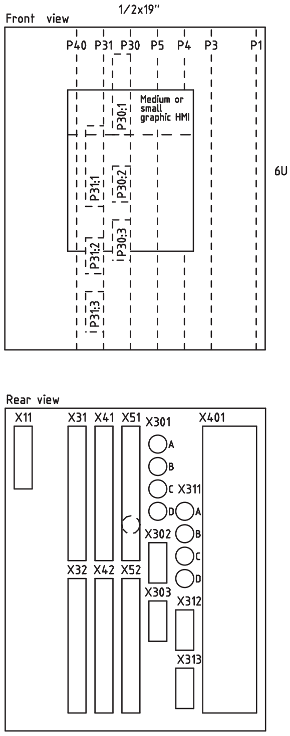
- 19” rack mounting kit
- Flush mounting kit with cut-out dimensions:

  - 1/2 case size (h) 254.3 mm (w) 210.1 mm
  - 3/4 case size (h) 254.3 mm (w) 322.4 mm
  - 1/1 case size (h) 254.3 mm (w) 434.7 mm
- Wall mounting kit

See ordering for details about available mounting alternatives.

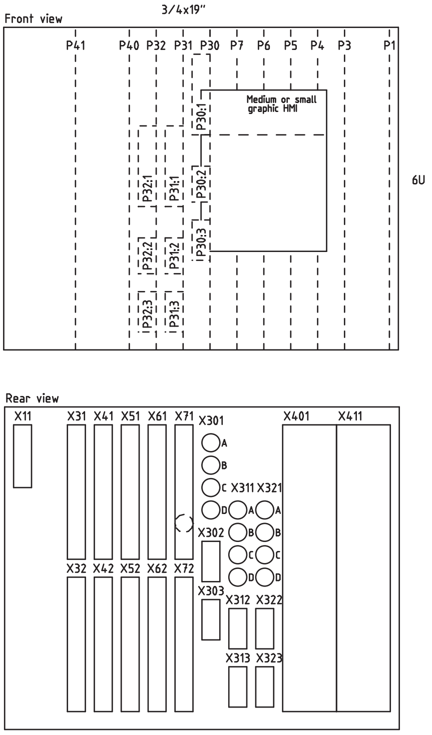
20. Connection diagrams

Table 1. Designations for 1/2 x 19” casing with 1 TRM slot



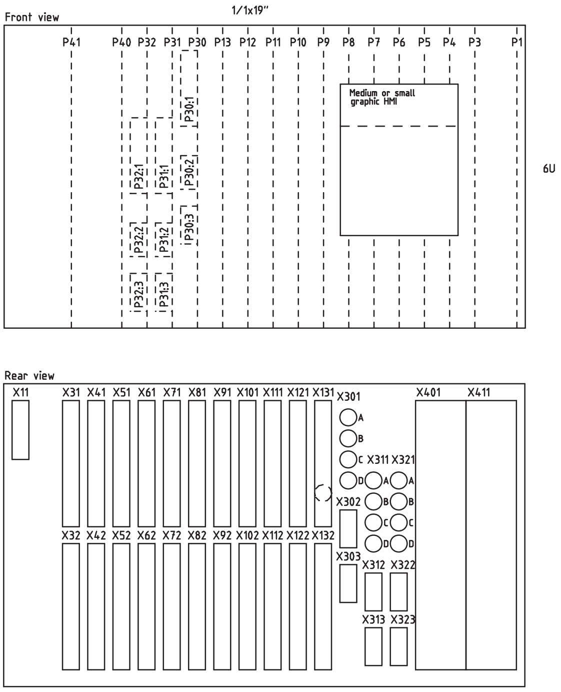
Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X51 and X52
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, 313
TRM	X401

Table 2. Designations for 3/4 x 19” casing with 2 TRM slot



Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X71 and X72
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, X313, X322, X323
TRM 1	X401
TRM 2	X411

Table 3. Designations for 1/1 x 19” casing with 2 TRM slots



Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X131 and X132
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, X313, X322, X323
TRM 1	X401
TRM 2	X411

SLM and LDCM ports shall not be used in RES670.

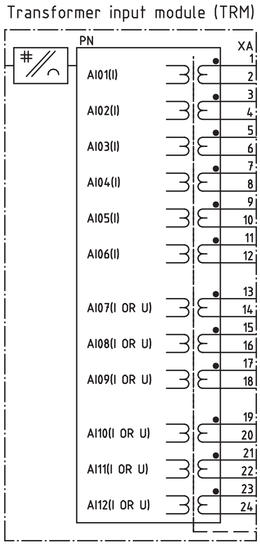


Figure 10. Transformer input module (TRM)

■ Indicates high polarity

	CT/VT-input designation according to figure 10											
Current/voltage configuration (50/60 Hz)	AI01	AI02	AI03	AI04	AI05	AI06	AI07	AI08	AI09	AI10	AI11	AI12
12I, 1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A
12I, 5A	5A	5A	5A	5A	5A	5A	5A	5A	5A	5A	5A	5A
9I+3U, 1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	110-220V	110-220V	110-220V
9I+3U, 5A	5A	5A	5A	5A	5A	5A	5A	5A	5A	110-220V	110-220V	110-220V
5I, 1A +4I, 5A +3U	1A	1A	1A	1A	1A	5A	5A	5A	5A	110-220V	110-220V	110-220V
7I+5U, 1A	1A	1A	1A	1A	1A	1A	1A	110-220V	110-220V	110-220V	110-220V	110-220V
7I+5U, 5A	5A	5A	5A	5A	5A	5A	5A	110-220V	110-220V	110-220V	110-220V	110-220V
6I+6U, 1A	1A	1A	1A	1A	1A	1A	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V
6I+6U, 5A	5A	5A	5A	5A	5A	5A	110-220V	110-220V	110-220V	110-220V	110-220V	110-220V
6I, 1A	1A	1A	1A	1A	1A	1A	-	-	-	-	-	-
6I, 5A	5A	5A	5A	5A	5A	5A	-	-	-	-	-	-

*) Metering

Note that internal polarity can be adjusted by setting of analog input CT neutral direction and/or on SMAI pre-processing function blocks.

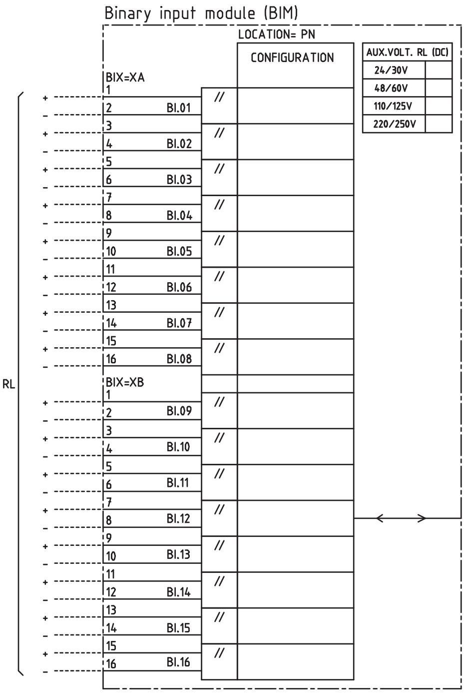


Figure 11. Binary input module (BIM). Input contacts named XA corresponds to rear position X31, X41, and so on, and input contacts named XB to rear position X32, X42, and so on.

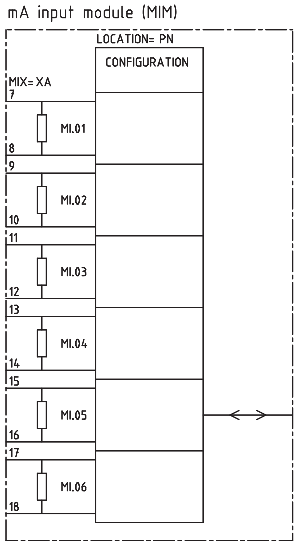
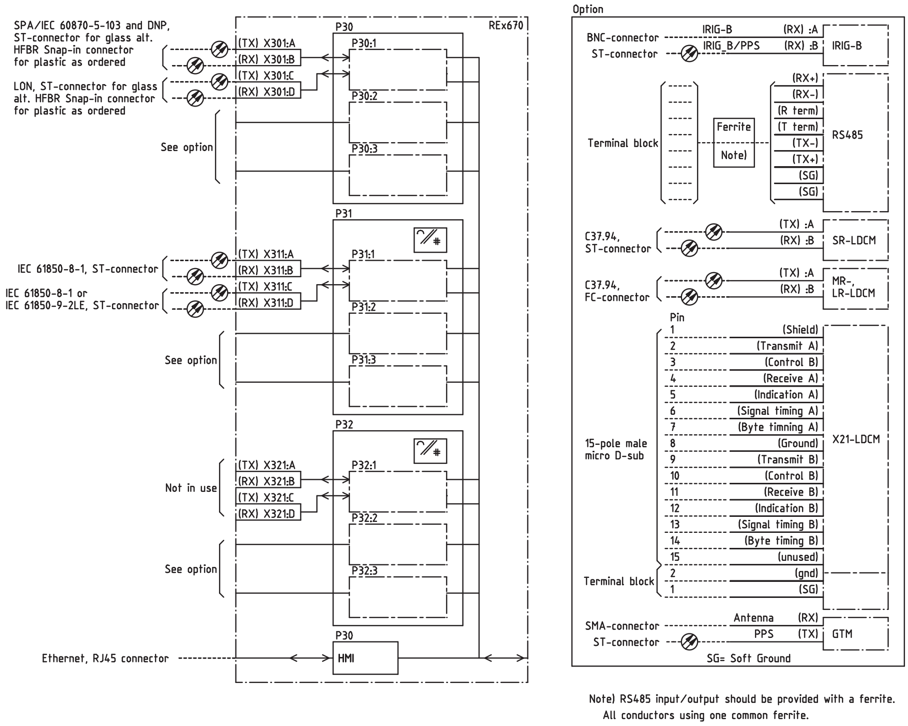


Figure 12. mA input module (MIM)



Designation corresponding to module		
Slot	Module	Terminal
P30	NUM	-
P30:1	SLM	X301
P30:2	LDCM	X302
	IRIG-B	
	RS485	
P30:3	LDCM	X303
	RS485	
P31	ADM1	-
P31:1	OEM	X311
P31:2	LDCM	X312
	RS485	
	GTM	
P31:3	LDCM	X313
	RS485	
	GTM	
P32	ADM2	-
P32:1	Not in use	Not in use
P32:2	LDCM	X322
	RS485	
	GTM	
P32:3	LDCM	X323
	RS485	
	GTM	

Figure 13. IED with basic functionality and communication interfaces

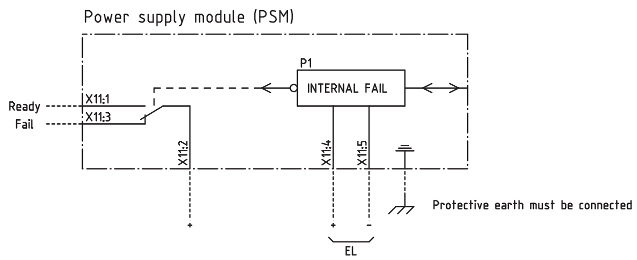


Figure 14. Power supply module (PSM)

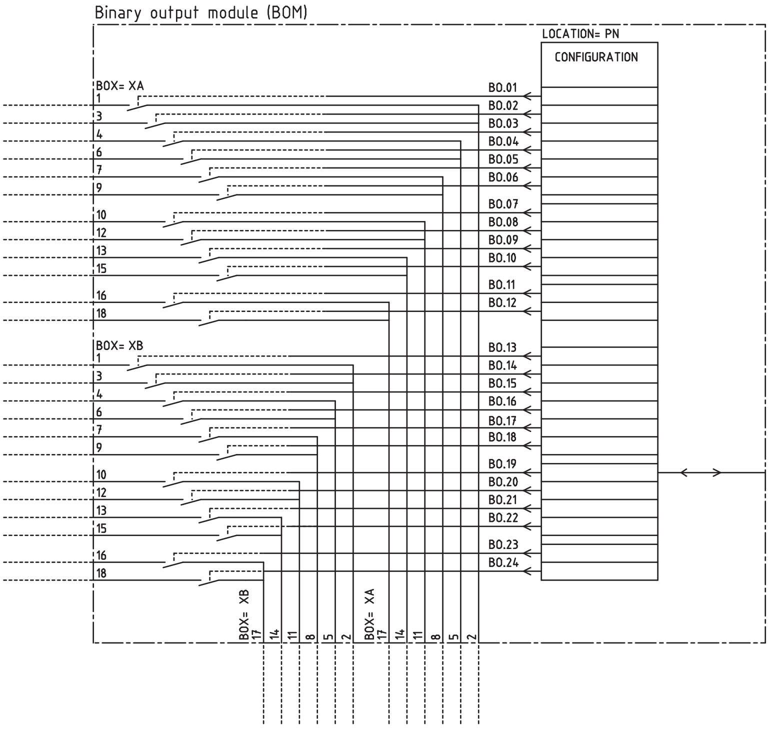


Figure 15. Binary output module (BOM). Output contacts named XA corresponds to rear position X31, X41, and so on, and output contacts named XB to rear position X32, X42, and so on.

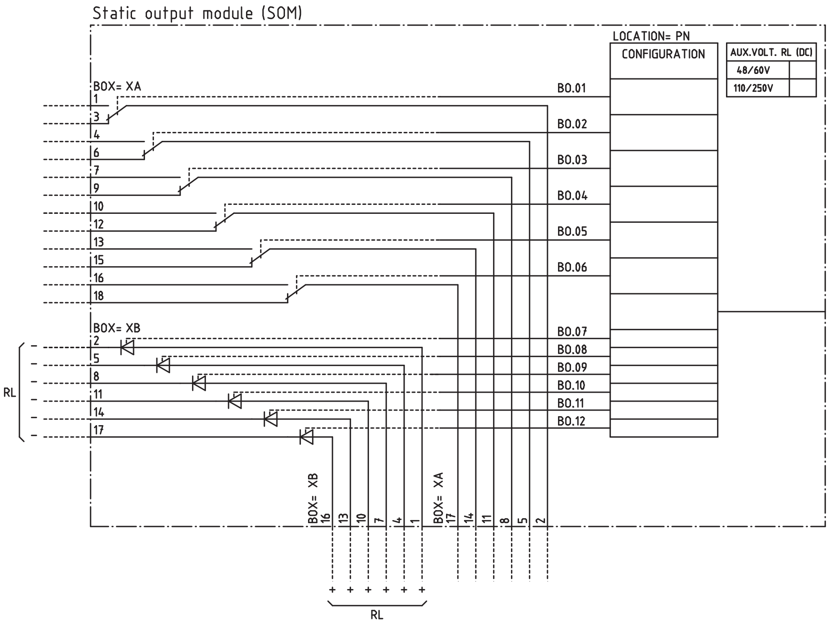


Figure 16. Static output module (SOM)

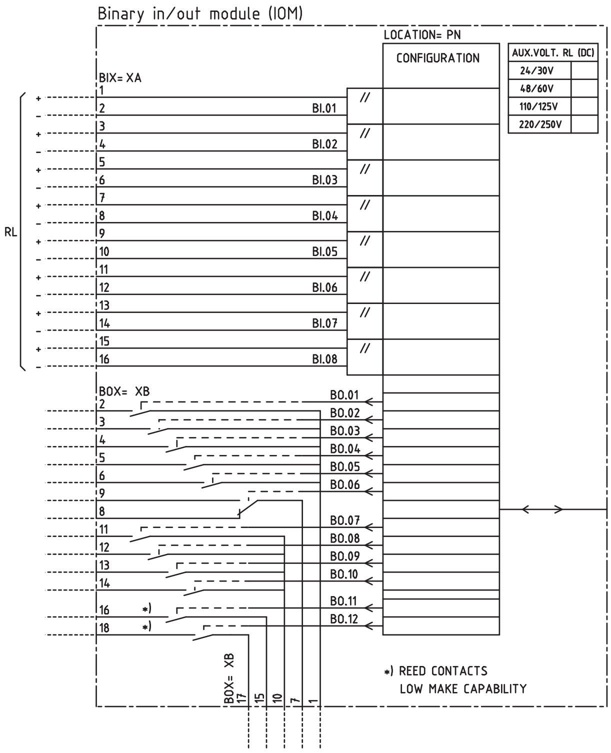


Figure 17. Binary in/out module (IOM). Input contacts named XA corresponds to rear position X31, X41, and so on, and output contacts named XB to rear position X32, X42, and so on.

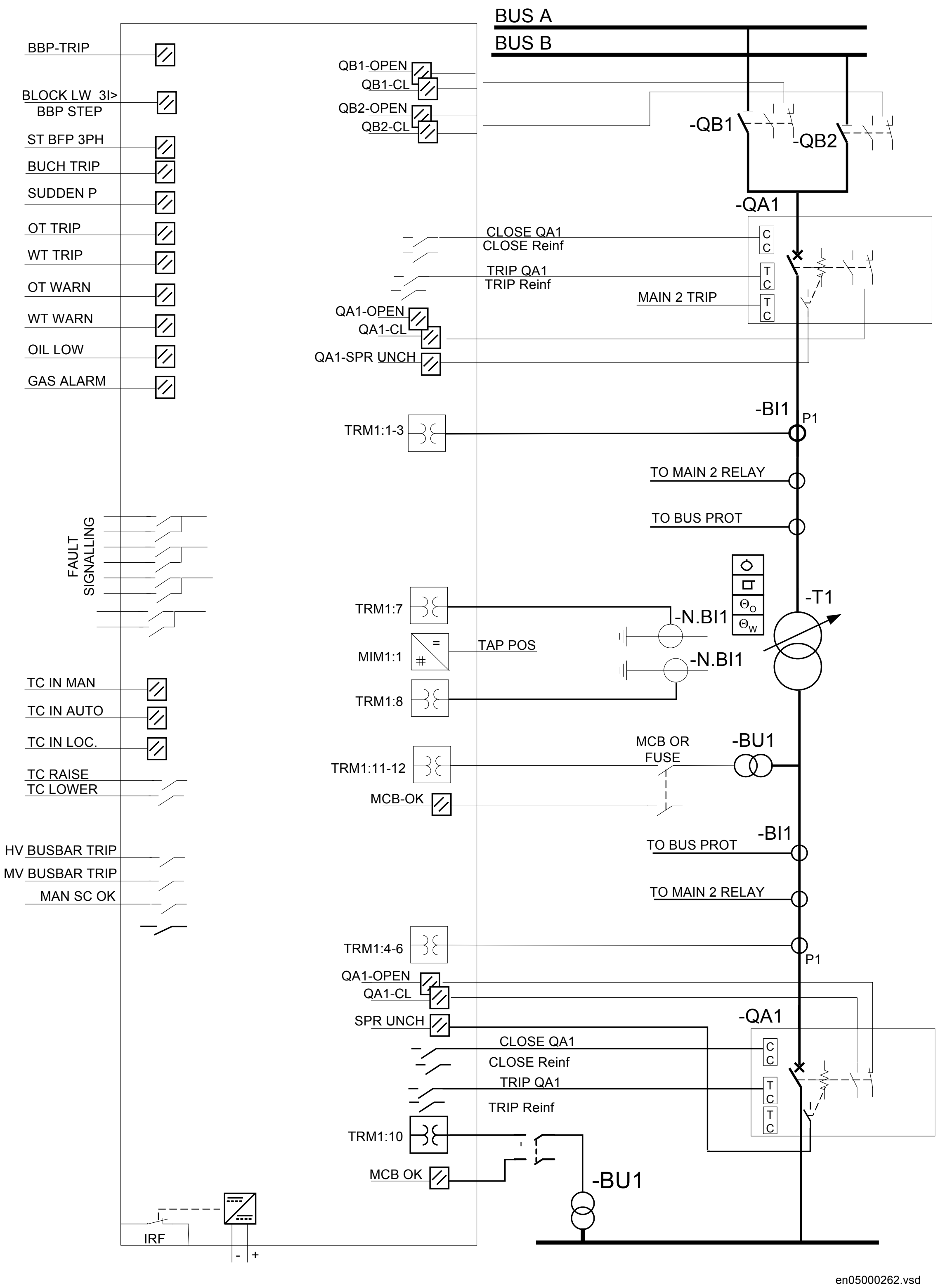


Figure 18. Typical connection diagram for two winding transformer in a single breaker arrangement. Note! Including IO for control option.

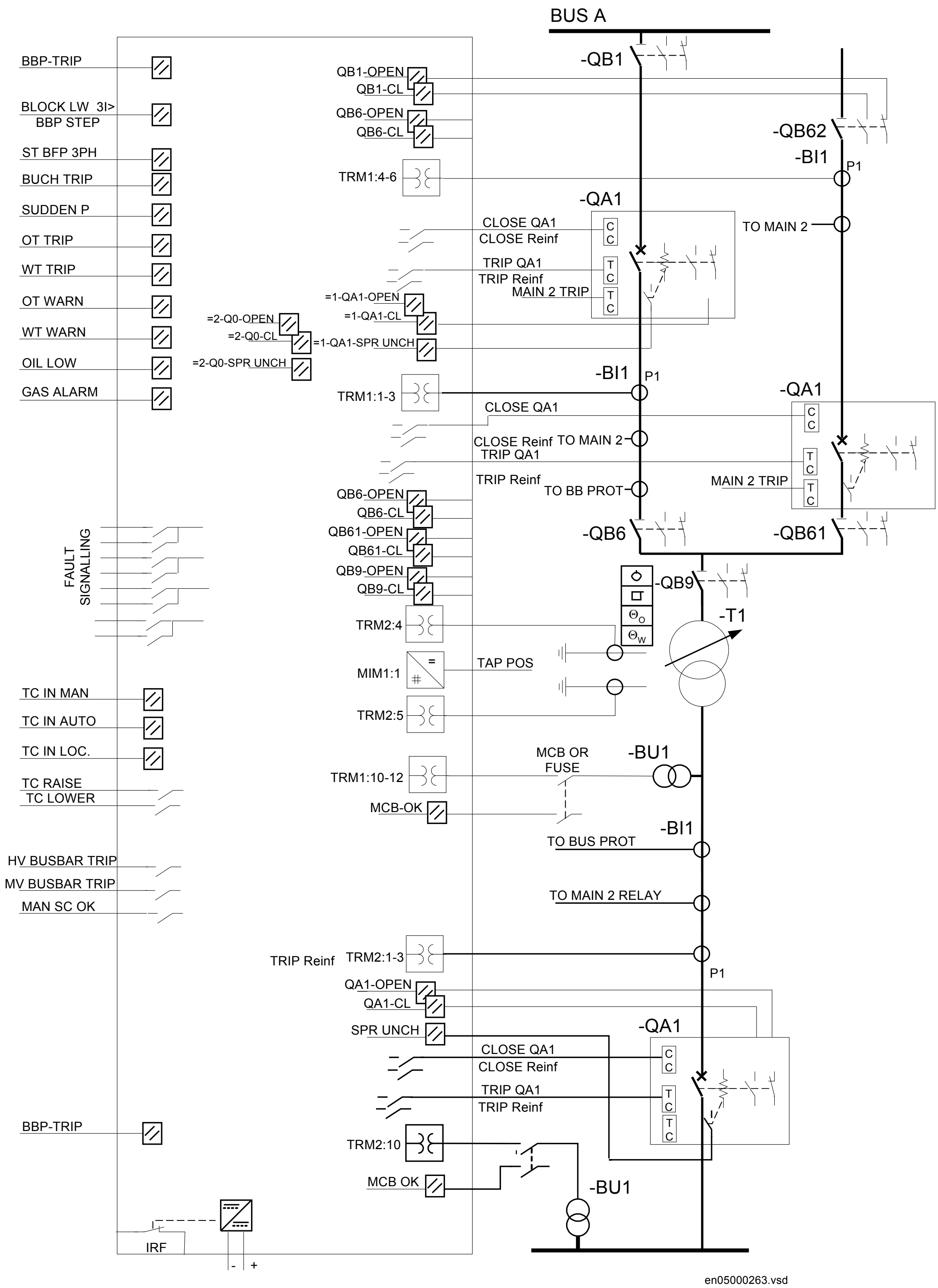


Figure 19. Typical connection diagram for two winding transformer in a multi breaker arrangement. Note! Including IO for control option.

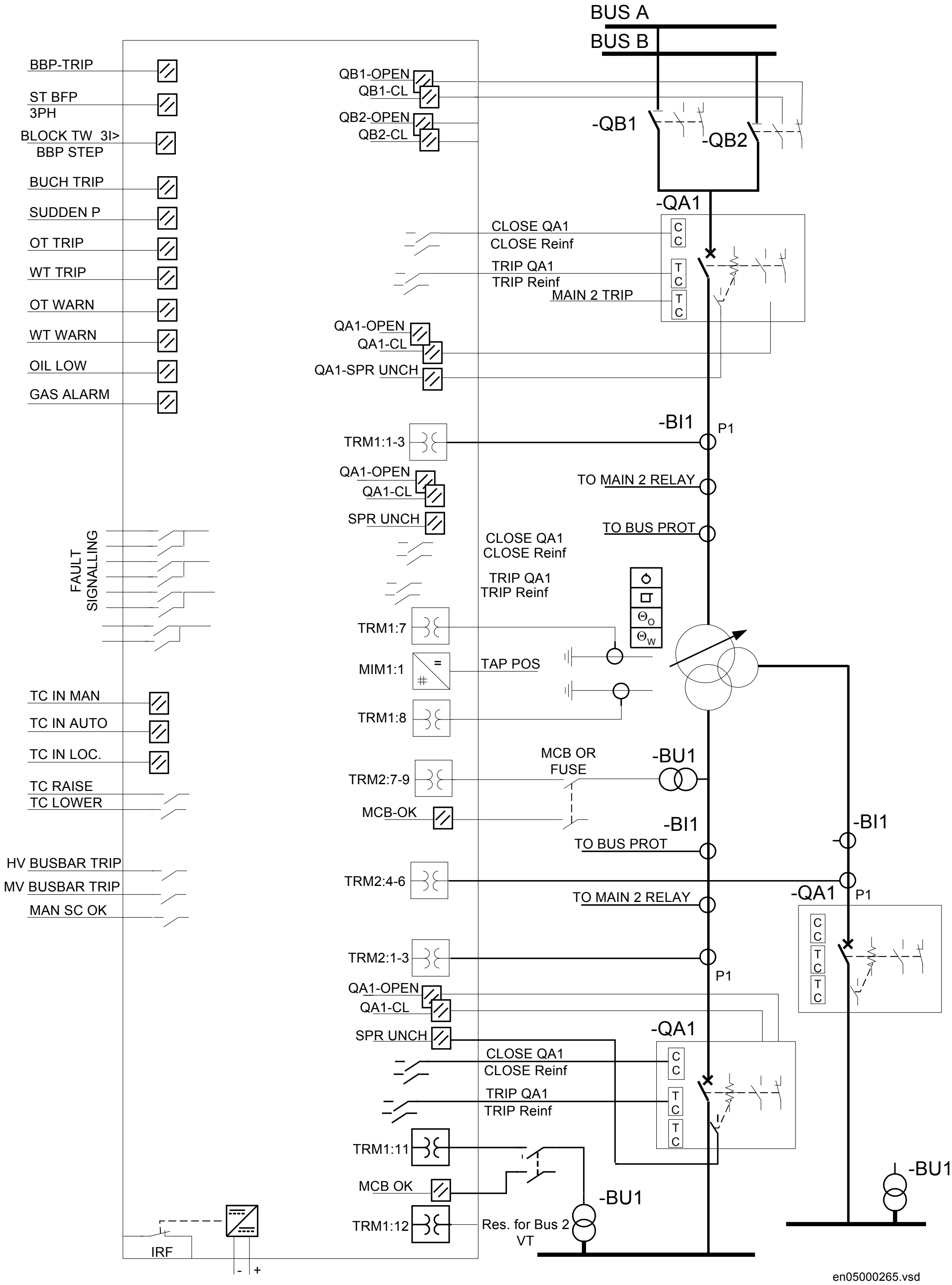


Figure 20. Typical connection diagram for three winding transformer in a single breaker arrangement. Note! Including IO for control option.

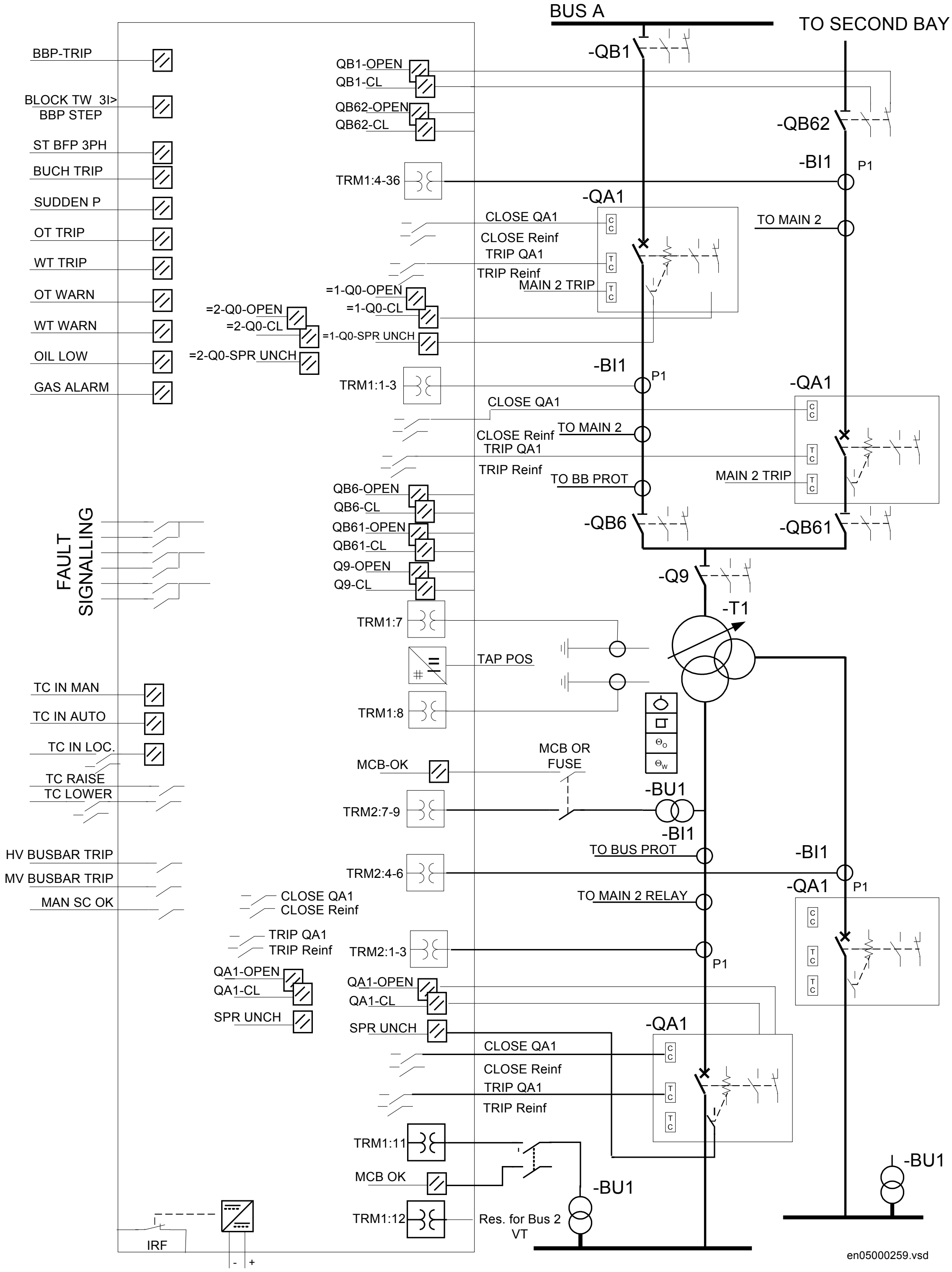


Figure 21. Typical connection diagram for three winding transformer in a multi breaker arrangement. Note! Including IO for control option.

21. Technical data

General

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

Energizing quantities, rated values and limits
Analog inputs

Table 4. TRM - Energizing quantities, rated values and limits for protection transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0.2-40) × I_r
Operative range	(0-100) x I_r	
Permissive overload	4 × I_r cont. 100 × I_r for 1 s *)	
Burden	< 150 mVA at I_r = 5 A < 20 mVA at I_r = 1 A	
Ac voltage	U_r = 110 V	0.5–288 V
Operative range	(0–340) V	
Permissive overload	420 V cont. 450 V 10 s	
Burden	< 20 mVA at 110 V	
Frequency	f_r = 50/60 Hz	± 5%

*) max. 350 A for 1 s when COMBITEST test switch is included.

Table 5. TRM - Energizing quantities, rated values and limits for measuring transformer modules

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0-1.8) × I_r at I_r = 1 A (0-1.6) × I_r at I_r = 5 A
Permissive overload	1.1 × I_r cont. 1.8 × I_r for 30 min at I_r = 1 A 1.6 × I_r for 30 min at I_r = 5 A	
Burden	< 350 mVA at I_r = 5 A < 200 mVA at I_r = 1 A	
Ac voltage	U_r = 110 V	0.5–288 V
Operative range	(0–340) V	
Permissive overload	420 V cont. 450 V 10 s	
Burden	< 20 mVA at 110 V	
Frequency	f_r = 50/60 Hz	± 5%

Table 6. MIM - mA input module

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

Table 7. OEM - Optical ethernet module

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

Auxiliary DC voltage

Table 8. 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	< 5 A during 0.1 s	-

Binary inputs and outputs

Table 9. 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 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	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	

Table 10. 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	

Table 11. 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 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	-

Table 12. IOM - Binary input/output module contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and signal relays	Fast signal relays (parallel reed relay)
Binary outputs	10	2
Max system voltage	250 V AC, DC	250 V AC, DC
Test voltage across open contact, 1 min	1000 V rms	800 V DC
Current carrying capacity Continuous 1 s	 8 A 10 A	 8 A 10 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

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

Function of quantity	Static binary output trip	
Rated voltage	48 - 60 VDC	110 - 250 VDC
Number of outputs	6	6
Impedance open state	~300 kΩ	~810 kΩ
Test voltage across open contact, 1 min	No galvanic separation	No galvanic separation
Current carrying capacity: Continuous 1.0s	 5A 10A	 5A 10A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF : 0.2s 1.0s	 30A 10A	 30A 10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 60V / 0,75A	110V / 0.4A 125V / 0.35A 220V / 0.2A 250V / 0.15A
Operating time	<1ms	<1ms

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

Function of quantity	Trip and signal relays
Max system voltage	250V AC/DC
Number of outputs	6
Test voltage across open contact, 1 min	1000V rms
Current carrying capacity: Continuous 1.0s	 8A 10A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF: 0.2s 1.0s	 30A 10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 110V / 0.4A 125V / 0,35A 220V / 0,2A 250V / 0.15A

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

Function or quantity	Trip and Signal relays
Binary outputs	24
Max system voltage	250 V AC, DC
Test voltage across open contact, 1 min	1000 V rms
Current carrying capacity Continuous 1 s	 8 A 10 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 125 V/0.35 A 220 V/0.2 A 250 V/0.15 A

Influencing factors

Table 16. Temperature and humidity influence

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

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

Dependence on	Reference value	Within nominal range	Influence
Ripple, in DC auxiliary voltage Operative range	max. 2% Full wave rectified	15% of EL	0.01% /%
Auxiliary voltage dependence, operate value		± 20% of EL	0.01% /%
Interrupted auxiliary DC voltage 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 <180 s

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

Dependence on	Within nominal range	Influence
Frequency dependence, operate value	f_r ± 2.5 Hz for 50 Hz f_r ± 3.0 Hz for 60 Hz	± 1.0% / Hz
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)	2nd, 3rd and 5th harmonic of f_r	± 1.0%
Harmonic frequency dependence for distance protection (10% content)	2nd, 3rd and 5th harmonic of f_r	± 6.0%
Harmonic frequency dependence for high impedance differential protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±5.0%

Type tests according to standards

Table 19. Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-22-1
100 kHz slow damped oscillatory wave immunity test	2.5 kV	IEC 61000-4-18, Class III
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Class IV
Surge withstand capability test	2.5 kV, oscillatory 4.0 kV, fast transient	IEEE/ANSI C37.90.1
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-22-2, Class IV IEC 61000-4-2, Class IV
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.1
Fast transient disturbance	4 kV	IEC 60255-22-4, Class A
Surge immunity test	1-2 kV, 1.2/50 μs high energy	IEC 60255-22-5
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-22-7, Class A
Conducted common mode immunity test	15 Hz-150 kHz	IEC 61000-4-16, Class IV
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8, Class V
Damped oscillatory magnetic field test	100 A/m	IEC 61000-4-10, Class V
Radiated electromagnetic field disturbance	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-22-3
Radiated electromagnetic field disturbance	35 V/m 26-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-22-6
Radiated emission	30-1000 MHz	IEC 60255-25
Conducted emission	0.15-30 MHz	IEC 60255-25

Table 20. Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kV AC, 1 min.	IEC 60255-5
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J	
Insulation resistance	>100 MΩ at 500 VDC	

Table 21. Environmental tests

Test	Type test value	Reference standard
Cold test	Test Ad for 16 h at -25°C	IEC 60068-2-1
Storage test	Test Ad for 16 h at -40°C	IEC 60068-2-1
Dry heat test	Test Bd for 16 h at +70°C	IEC 60068-2-2
Damp heat test, steady state	Test Ca for 4 days at +40 °C and humidity 93%	IEC 60068-2-78
Damp heat test, cyclic	Test Db for 6 cycles at +25 to +55 °C and humidity 93 to 95% (1 cycle = 24 hours)	IEC 60068-2-30

Table 22. CE compliance

Test	According to
Immunity	EN 50263
Emissivity	EN 50263
Low voltage directive	EN 50178

Table 23. Mechanical tests

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

Differential protection

Table 24. Transformer differential protection T2WPDIF, T3WPDIF

Function	Range or value	Accuracy
Operating characteristic	Adaptable	± 1.0% of Ir for I < Ir ± 1.0% of Ir for I > Ir
Reset ratio	>95%	-
Unrestrained differential current limit	(100-5000)% of *IBase* on high voltage winding	± 1.0% of set value
Base sensitivity function	(10-60)% of IBase	± 1.0% of Ir
Second harmonic blocking	(5.0-100.0)% of fundamental differential current	± 2.0% of Ir
Fifth harmonic blocking	(5.0-100.0)% of fundamental differential current	± 5.0% of Ir
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, restrained function	25 ms typically at 0 to 2 x Ib	-
Reset time, restrained function	20 ms typically at 2 to 0 x Ib	-
Operate time, unrestrained function	12 ms typically at 0 to 5 x Ib	-
Reset time, unrestrained function	25 ms typically at 5 to 0 x Ib	-
Critical impulse time	2 ms typically at 0 to 5 x Ib	-

Table 25. Restricted earth fault protection, low impedance REFPDIF

Function	Range or value	Accuracy
Operate characteristic	Adaptable	± 1.0% of I_r for I < IBase ± 1.0% of I for I > IBase
Reset ratio	>95%	-
Base sensitivity function	(4.0-100.0)% of *IBase*	± 1.0% of I_r
Directional characteristic	Fixed 180 degrees or ± 60 to ± 90 degrees	± 2.0 degree
Operate time, trip function	20 ms typically at 0 to 10 x IdMin	-
Reset time, trip function	25 ms typically at 10 to 0 x IdMin	-
Second harmonic blocking	(5.0-100.0)% of fundamental	± 2.0% of I_rBase

Table 26. 1Ph High impedance differential protection HZPDIF

Function	Range or value	Accuracy
Operate voltage	(20-400) V I=U/R	± 1.0% of I_r
Reset ratio	>95%	-
Maximum continuous voltage	U>Trip^2/series resistor ≤200 W	-
Operate time	10 ms typically at 0 to 10 x U_d	-
Reset time	90 ms typically at 10 to 0 x U_d	-
Critical impulse time	2 ms typically at 0 to 10 x U_d	-

Impedance protection

Table 27. Distance measuring zone, Quad ZMQPDIS

Function	Range or value	Accuracy
Number of zones	4 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	-
Impedance zone timers	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time	24 ms typically	-
Reset ratio	105% typically	-
Reset time	30 ms typically	-

Table 28. Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS

Function	Range or value	Accuracy
Minimum operate current	(5-500)% of *IBase*	-
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, 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 29. Full-scheme distance protection, Mho characteristic ZMHPDIS

Function	Range or value	Accuracy
Number of zones with selectable directions	4 with selectable direction	-
Minimum operate current	(10–30)% of I_{Base}	-
Positive sequence impedance, phase-to-earth 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: at 0 degrees and 85 degrees
Positive sequence impedance angle, phase-to-earth loop	(10–90) degrees	
Reverse reach, phase-to-earth 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	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time	20 ms typically (with static outputs)	-
Reset ratio	105% typically	-
Reset time	30 ms typically	-

Table 30. Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS

Function	Range or value	Accuracy
Number of zones	4 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	-
Impedance zone timers	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time	24 ms typically	-
Reset ratio	105% typically	-
Reset time	30 ms typically	-

Table 31. Faulty phase identification with load encroachment FMPSPDIS

Function	Range or value	Accuracy
Minimum operate current	(5-30)% of *IBase*	± 1.0% of I_r
Load encroachment criteria: Load resistance, forward and reverse	(0.5–3000) 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 32. Power swing detection ZMRPSB

Function	Range or value	Accuracy
Reactive reach	(0.10-3000.00) Ω/phase	± 2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Resistive reach	(0.10–1000.00)Ω/loop	
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Current protection

Table 33. Instantaneous phase overcurrent protection PHPIOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	25 ms typically at 0 to 2 x I_{set}	-
Reset time	25 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 10 x I_{set}	-
Reset time	35 ms typically at 10 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 34. Four step phase overcurrent protection OC4PTOC

Function	Setting range	Accuracy
Operate current	(1-2500)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Min. operating current	(1-100)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(-70.0– -50.0) degrees	± 2.0 degrees
Maximum forward angle	(40.0–70.0) degrees	± 2.0 degrees
Minimum forward angle	(75.0–90.0) degrees	± 2.0 degrees
2nd harmonic blocking	(5–100)% of fundamental	± 2.0% of I_r
Independent time delay	(0.000-60.000) s	± 0.5% ±10 ms
Minimum operate time	(0.000-60.000) s	± 0.5% ±10 ms
Inverse characteristics, see table 93, table 94 and table 95	19 curve types	See table 93, table 94 and table 95
Operate time, start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 35. Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of IBase	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	25 ms typically at 0 to 2 x I_{set}	-
Reset time	25 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Operate time	10 ms typically at 0 to 10 x I_{set}	-
Reset time	35 ms typically at 10 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 10 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 36. Four step residual overcurrent protection EF4PTOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of *IBase*	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison	(1–100)% of *IBase*	$\pm$ 1.0% of I_r
Timers	(0.000-60.000) s	$\pm$ 0.5% $\pm$10 ms
Inverse characteristics, see table 93, table 94 and table 95	18 curve types	See table 93, table 94 and table 95
Second harmonic restrain operation	(5–100)% of fundamental	$\pm$ 2.0% of I_r
Relay characteristic angle	(-180 to 180) degrees	$\pm$ 2.0 degrees
Minimum polarizing voltage	(1–100)% of *UBase*	$\pm$ 0.5% of U_r
Minimum polarizing current	(1-30)% of *IBase*	$\pm$0.25% 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 function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 37. Four step negative sequence overcurrent protection NS4PTOC

Function	Range or value	Accuracy
Operate value, negative sequence current, step 1-4	(1-2500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Inverse characteristics, see table 93, table 94 and table 95	18 curve types	See table 93, table 94 and table 95
Minimum operate current for step 1 - 4	(1.00 - 10000.00)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Operate value, negative current for directional release	(1–100)% of *IBase*	± 1.0% of I_r
Relay characteristic angle	(-180 to 180) degrees	± 2.0 degrees
Minimum polarizing voltage	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	±1.0% of I_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start function	25 ms typically at 0.5 to 2 x I_{set}	-
Reset time, start function	25 ms typically at 2 to 0.5 x I_{set}	-
Critical impulse time, start function	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time, start function	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 38. 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* At low setting: (2.5-10) mA (10-50) mA	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at $I > I_r$ $\pm$0.5 mA $\pm$1.0 mA
Operate level for $3I_0 \cdot 3U_0 \cdot \cos\varphi$ directional residual power	(0.25-200.00)% of *SBase* At low setting: (0.25-5.00)% of *SBase*	$\pm$ 1.0% of S_r at $S \leq S_r$ $\pm$ 1.0% of S at $S > S_r$ $\pm$ 10% of set value
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of *IBase* At low setting: (2.5-10) mA (10-50) mA	$\pm$ 1.0% of I_r at $\leq I_r$ $\pm$ 1.0% of I at $I > I_r$ $\pm$0.5 mA $\pm$1.0 mA
Operate level for non-directional overcurrent	(1.00-400.00)% of *IBase* At low setting: (10-50) mA	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at $I > I_r$ $\pm$ 1.0 mA
Operate level for non-directional residual overvoltage	(1.00-200.00)% of *UBase*	$\pm$ 0.5% of U_r at $U \leq U_r$ $\pm$ 0.5% of U at $U > U_r$
Residual release current for all directional modes	(0.25-200.00)% of *IBase* At low setting: (2.5-10) mA (10-50) mA	$\pm$ 1.0% of I_r at $I \leq I_r$ $\pm$ 1.0% of I at $I > I_r$ $\pm$0.5 mA $\pm$ 1.0 mA
Residual release voltage for all directional modes	(0.01-200.00)% of *UBase*	$\pm$ 0.5% of U_r at $U \leq U_r$ $\pm$ 0.5% of U at $U > U_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	$\pm$ 0.5% $\pm$10 ms
Inverse characteristics, see table 93, table 94 and table 95	19 curve types	See table 93, table 94 and table 95
Relay characteristic angle RCA	(-179 to 180) degrees	$\pm$ 2.0 degrees
Relay open angle ROA	(0-90) degrees	$\pm$ 2.0 degrees
Operate time, non-directional residual over current	60 ms typically at 0 to 2 x I_{set}	-
Reset time, non-directional residual over current	60 ms typically at 2 to 0 x I_{set}	-
Operate time, start function	150 ms typically at 0 to 2 x I_{set}	-
Reset time, start function	50 ms typically at 2 to 0 x I_{set}	-

Table 39. 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: $$t = \tau \cdot \ln\left(\frac{I^2 - I_p{}^2}{I^2 - I_b{}^2}\right)$$ EQUATION1356 V1 EN (Equation 1) $I = I_{measured}$	I_p = load current before overload occurs Time constant τ = (1–500) minutes	IEC 60255–8, class 5 + 200 ms
Alarm level 1 and 2	(50–99)% of heat content trip 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 40. Breaker failure protection CCRBRF

Function	Range or value	Accuracy
Operate phase current	(5-200)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 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 $I \le I_r$ ± 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 $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Operate time for current detection	10 ms typically	-
Reset time for current detection	15 ms maximum	-

Table 41. Pole discordance protection CCRPLD

Function	Range or value	Accuracy
Operate current	(0–100)% of *IBase*	± 1.0% of I_r
Time delay	(0.000-60.000) s	± 0.5% ± 10 ms

Table 42. Directional underpower protection GUPPDUP

Function	Range or value	Accuracy
Power level	(0.0–500.0)% of *SBase* At low setting: (0.5-2.0)% of *SBase* (2.0-10)% of *SBase*	± 1.0% of S_r at S < S_r ± 1.0% of S at S > S_r < ± 50% of set value < ± 20% of set value
Characteristic angle	(-180.0–180.0) degrees	2 degrees
Timers	(0.00-6000.00) s	± 0.5% ± 10 ms

Table 43. Directional overpower protection GOPPDOP

Function	Range or value	Accuracy
Power level	(0.0–500.0)% of S_{base} At low setting: (0.5-2.0)% of S_{base} (2.0-10)% of S_{base}	± 1.0% of S_r at S < S_r ± 1.0% of S at S > S_r < ± 50% of set value < ± 20% of set value
Characteristic angle	(-180.0–180.0) degrees	2 degrees
Timers	(0.00-6000.00) s	± 0.5% ± 10 ms

Table 44. Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of *IBase*	± 0.1% of I_r
Unbalance current operation	(0–100)% of maximum current	± 0.1% of I_r
Timer	(0.00-6000.00) s	± 0.5% ± 10 ms

Voltage protection

Table 45. Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1–100)% of *UBase*	± 0.5% of U_r
Absolute hysteresis	(0–100)% of *UBase*	± 0.5% of U_r
Internal blocking level, low and high step	(1–100)% of *UBase*	± 0.5% of U_r
Inverse time characteristics for low and high step, see table 97	-	See table 97
Definite time delays	(0.000-60.000) s	± 0.5% ±10 ms
Minimum operate time, inverse characteristics	(0.000–60.000) s	± 0.5% ± 10 ms
Operate time, start function	25 ms typically at 2 to 0 x U_{set}	-
Reset time, start function	25 ms typically at 0 to 2 x U_{set}	-
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 46. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1-200)% of *UBase*	± 0.5% of U_r at $U < U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0–100)% 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 96	-	See table 96
Definite time delays	(0.000-60.000) s	± 0.5% ± 10 ms
Minimum operate time, Inverse characteristics	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time, start function	25 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 47. Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1-200)% of *UBase*	± 0.5% of U_r at U < U_r ± 1.0% of U at U > U_r
Absolute hysteresis	(0–100)% of *UBase*	± 0.5% of U_r at U < U_r ± 1.0% of U at U > U_r
Inverse time characteristics for low and high step, see table 98	-	See table 98
Definite time setting	(0.000–60.000) s	± 0.5% ± 10 ms
Minimum operate time	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time, start function	25 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	25 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 48. 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
Curve type	IEEE or customer defined $IEEE : t = \frac{(0.18 \cdot k)}{(M-1)^2}$ EQUATION1319 V1 EN (Equation 2) where M = (E/f)/(Ur/fr)	Class 5 + 40 ms
Minimum time delay for inverse function	(0.000–60.000) s	± 0.5% ± 10 ms
Maximum time delay for inverse function	(0.00–9000.00) s	± 0.5% ± 10 ms
Alarm time delay	(0.000–60.000) s	± 0.5% ± 10 ms

Table 49. Voltage differential protection VDCPTOV

Function	Range or value	Accuracy
Voltage difference for alarm and trip	(0.0–100.0) % of *UBase*	± 0.5 % of U_r
Under voltage level	(0.0–100.0) % of *UBase*	± 0.5% of U_r
Timers	(0.000–60.000)s	± 0.5% ± 10 ms

Table 50. Loss of voltage check LOVPTUV

Function	Range or value	Accuracy
Operate voltage	(0–100)% of UBase	± 0.5% of U_r
Pulse timer	(0.050–60.000) s	± 0.5% ± 10 ms
Timers	(0.000–60.000) s	± 0.5% ± 10 ms

Frequency protection

Table 51. Underfrequency protection SAPTUF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz
Operate time, start function	100 ms typically	-
Reset time, start function	100 ms typically	-
Operate time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms
Reset time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms
Voltage dependent time delay $$t = \left[\frac{U - UMin}{UNom - UMin} \right]^{Exponent} \cdot (tMax - tMin) + tMin$$ EQUATION1182 V1 EN (Equation 3) $U = U_{measured}$	Settings: UNom=(50-150)% of U_{base} UMin=(50-150)% of U_{base} Exponent=0.0-5.0 tMax=(0.000-60.000)s tMin=(0.000-60.000)s	Class 5 + 200 ms

Table 52. Overfrequency protection SAPTOF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz at symmetrical three-phase voltage
Operate time, start function	100 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Reset time, start function	100 ms typically	-
Operate time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms
Reset time, definite time function	(0.000-60.000)s	± 0.5% ± 10 ms

Table 53. Rate-of-change frequency protection SAPFRC

Function	Range or value	Accuracy
Operate value, start function	(-10.00-10.00) Hz/s	± 10.0 mHz/s
Operate value, internal blocking level	(0-100)% of UBase	± 0.5% of U_r
Operate time, start function	100 ms typically	-

Multipurpose protection

Table 54. 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	-
Base current	(1 - 99999) A	-
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	-
Base voltage	(0.05 - 2000.00) kV	-
Start overcurrent, step 1 and 2	(2 - 5000)% of IBase	± 1.0% of I_r for $I<I_r$ ± 1.0% of I for $I>I_r$
Start undercurrent, step 1 and 2	(2 - 150)% of IBase	± 1.0% of I_r for $I<I_r$ ± 1.0% of I for $I>I_r$
Definite time delay	(0.00 - 6000.00) s	± 0.5% ± 10 ms
Operate time start overcurrent	25 ms typically at 0 to 2 x I_{set}	-
Reset time start overcurrent	25 ms typically at 2 to 0 x I_{set}	-
Operate time start undercurrent	25 ms typically at 2 to 0 x I_{set}	-
Reset time start undercurrent	25 ms typically at 0 to 2 x I_{set}	-
See table 93 and table 94	Parameter ranges for customer defined characteristic no 17: k: 0.05 - 999.00 A: 0.0000 - 999.0000 B: 0.0000 - 99.0000 C: 0.0000 - 1.0000 P: 0.0001 - 10.0000 PR: 0.005 - 3.000 TR: 0.005 - 600.000 CR: 0.1 - 10.0	See table 93 and table 94
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	± 0.5% of U_r
Start overvoltage, step 1 and 2	(2.0 - 200.0)% of UBase	± 0.5% of U_r for $U<U_r$ ± 0.5% of U for $U>U_r$
Start undervoltage, step 1 and 2	(2.0 - 150.0)% of UBase	± 0.5% of U_r for $U<U_r$ ± 0.5% of U for $U>U_r$
Operate time, start overvoltage	25 ms typically at 0 to 2 x U_{set}	-
Reset time, start overvoltage	25 ms typically at 2 to 0 x U_{set}	-
Operate time start undervoltage	25 ms typically 2 to 0 x U_{set}	-

Table 54. General current and voltage protection CVGAPC , continued

Function	Range or value	Accuracy
Reset time start undervoltage	25 ms typically at 0 to 2 x U_{set}	-
High and low voltage limit, voltage dependent operation	(1.0 - 200.0)% of UBase	± 1.0% of U_r for $U<U_r$ ± 1.0% of U for $U>U_r$
Directional function	Settable: NonDir, forward and reverse	-
Relay characteristic angle	(-180 to +180) degrees	± 2.0 degrees
Relay operate angle	(1 to 90) degrees	± 2.0 degrees
Reset ratio, overcurrent	> 95%	-
Reset ratio, undercurrent	< 105%	-
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x I_{set} 15 ms typically	 - -
Undercurrent: Critical impulse time Impulse margin time	 10 ms typically at 2 to 0 x I_{set} 15 ms typically	 - -
Overvoltage: Critical impulse time Impulse margin time	 10 ms typically at 0 to 2 x U_{set} 15 ms typically	 - -
Undervoltage: Critical impulse time Impulse margin time	 10 ms typically at 2 to 0 x U_{set} 15 ms typically	 - -

Secondary system supervision

Table 55. Current circuit supervision CCSRDIF

Function	Range or value	Accuracy
Operate current	(5-200)% of I_r	± 10.0% of I_r at $I \le I_r$ ± 10.0% of I at $I > I_r$
Block current	(5-500)% of I_r	± 5.0% of I_r at $I \le I_r$ ± 5.0% of I at $I > I_r$

Table 56. Fuse failure supervision SDDRFUF

Function	Range or value	Accuracy
Operate voltage, zero sequence	(1-100)% of UBase	± 1.0% of U_r
Operate current, zero sequence	(1–100)% of IBase	± 1.0% of I_r
Operate voltage, negative sequence	(1–100)% of UBase	± 0.5% of U_r
Operate current, negative sequence	(1–100)% of IBase	± 1.0% of I_r
Operate voltage change level	(1–100)% of UBase	± 5.0% of U_r
Operate current change level	(1–100)% of IBase	± 5.0% of I_r
Operate phase voltage	(1-100)% of UBase	± 0.5% of U_r
Operate phase current	(1-100)% of IBase	± 1.0% 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	± 1.0% of I_r
Operate time, start function	25 ms typically at 1 to 0 Ubase	-
Reset time, start function	35 ms typically at 0 to 1 Ubase	-

Control

Table 57. Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, φ_{line} - φ_{bus}	(-180 to 180) degrees	-
Voltage ratio, U_{bus}/U_{line}	(0.40-25.000) % of *UBaseBus and UBaseLIne*	-
Voltage high limit for synchronizing and synchrocheck	(50.0-120.0)% of *UBaseBus and UBaseLIne*	± 0.5% of U_r at U ≤ U_r ± 0.5% of U at U >U_r
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line	(0.003-1.000) Hz	± 2.0 mHz
Phase angle difference limit between bus and line	(5.0-90.0) degrees	± 2.0 degrees
Voltage difference limit between bus and line	(0.02-0.5) p.u	± 0.5% of U_r
Time delay output for synchrocheck	(0.000-60.000) s	± 0.5% ± 10 ms
Voltage high limit for energizing check	(50.0-120.0)% of *UBaseBus and UBaseLIne*	± 0.5% of U_r at U ≤ U_r ± 0.5% of U at U >U_r
Reset ratio, voltage high limit	> 95%	-
Voltage low limit for energizing check	(10.0-80.0)% of *UBase*	± 0.5% of U_r
Reset ratio, voltage low limit	< 105%	-
Maximum voltage for energizing	(50.0-180.0)% of *UBaseBus and/ or UBaseLIne*	± 0.5% of U_r at U ≤ U_r ± 0.5% of U at U >U_r
Time delay for energizing check	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time for synchrocheck function	160 ms typically	-
Operate time for energizing function	80 ms typically	-

Table 58. Voltage control TR1ATCC, TR8ATCC, TCMYLTC and TLCYLTC

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 UB	±0.25% of U_r
Outer voltage deadband	(0.2–9.0)% of UB	-
Inner voltage deadband	(0.1–9.0)% of UB	-
Upper limit of busbar voltage	(80–180)% of UB	± 1.0% of U_r
Lower limit of busbar voltage	(70–120)% of UB	± 1.0% of U_r
Undervoltage block level	(0–120)% of UB	± 1.0% of U_r
Time delay (long) for automatic control commands	(3–1000) s	± 0.5% ± 10 ms
Time delay (short) for automatic control commands	(1–1000) s	± 0.5% ± 10 ms
Minimum operating time in inverse mode	(3–120) s	± 0.5% ± 10 ms
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 UB	-
Load voltage auto correction	(-20.0–20.0)% of UB	-
Duration time for the reverse action block signal	(30–6000) s	± 0.5% ± 10 ms
Current limit for reverse action block	(0–100)% of I1Base	-
Overcurrent block level	(0–250)% 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	(-9999.99–9999.99) MW	± 1.0% of S_r
Alarm level of reactive power in forward and reverse direction	(-9999.99–9999.99) MVAr	± 1.0% of S_r
Time delay for alarms from power supervision	(1–6000) s	± 0.5% ± 10 ms
Tap position for lowest and highest voltage	(1–63)	-
mA for lowest and highest voltage tap position	(0.000–25.000) mA	-

Table 58. Voltage control TR1ATCC, TR8ATCC, TCMYLTC and TLCYLTC, continued

Function	Range or value	Accuracy
Type of code conversion	BIN, BCD, GRAY, SINGLE, mA	-
Time after position change before the value is accepted	(1–60) s	± 0.5% ± 10 ms
Tap changer constant time-out	(1–120) s	± 0.5% ± 10 ms
Raise/lower command output pulse duration	(0.5–10.0) s	± 0.5% ± 10 ms

Scheme communication

Table 59. 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	± 0.5% ± 10 ms

Table 60. Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH

Function	Range or value	Accuracy
Operating mode of WEI logic	Off Echo Echo & Trip	-
Operate voltage $3U_o$ for WEI trip	(5-70)% of UBase	± 0.5% of U_r
Reset ratio	>95%	-
Operate time for current reversal logic	(0.000-60.000) s	± 0.5% ± 10 ms
Delay time for current reversal	(0.000-60.000) s	± 0.5% ± 10 ms
Coordination time for weak-end infeed logic	(0.000–60.000) s	± 0.5% ± 10 ms

Logic

Table 61. Tripping logic SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph, 1/3-ph, 1/2/3-ph	-
Minimum trip pulse length	(0.000-60.000) s	± 0.5% ± 10 ms
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 62. Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	fast	medium	normal		
LogicAND	60	60	160	-	-
LogicOR	60	60	160	-	-
LogicXOR	10	10	20	-	-
LogicInverter	30	30	80	-	-
LogicSRMemory	10	10	20	-	-
LogicRSMemory	10	10	20	-	-
LogicGate	10	10	20	-	-
LogicTimer	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicPulseTimer	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicTimerSet	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
LogicLoopDelay	10	10	20	(0.000–90000.000) s	± 0.5% ± 10 ms
Trip Matrix Logic	6	6	-	-	-
Boolean 16 to Integer	4	4	8	-	-
Boolean 16 to integer with Logic Node	4	4	8	-	-
Integer to Boolean 16	4	4	8	-	-
Integer to Boolean 16 with Logic Node	4	4	8	-	-

Monitoring

Table 63. Measurements CVMMXN

Function	Range or value	Accuracy
Frequency	(0.95-1.05) × f_r	± 2.0 mHz
Voltage	(0.1-1.5) ×U_r	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at U > U_r
Connected current	(0.2-4.0) × I_r	± 0.5% of I_r at $I \leq I_r$ ± 0.5% of I at I > I_r
Active power, P	0.1 x U_r< U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	± 1.0% of S_r at $S \leq S_r$ ± 1.0% of S at S > S_r Conditions: 0.8 x U_r < U < 1.2 U_r 0.2 x I_r < I < 1.2 I_r
Reactive power, Q	0.1 x U_r< U < 1.5 x U_r 0.2 x I_r < I < 4.0 x I_r	
Apparent power, S	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r< I < 4.0 x I_r	
Power factor, cos (φ)	0.1 x U_r < U < 1.5 x U_r 0.2 x I_r< I < 4.0 x I_r	± 0.02

Table 64. 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 65. Event counter CNTGGIO

Function	Range or value	Accuracy
Counter value	0-10000	-
Max. count up speed	10 pulses/s	-

Table 66. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Pre-fault time	(0.05–9.90) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–10.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See table 89
Maximum number of analog inputs	30 + 10 (external + internally derived)	-
Maximum number of binary inputs	96	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	96	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

Table 67. Event list

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

Table 68. Indications

Function		Value
Buffer capacity	Maximum number of indications presented for single disturbance	96
	Maximum number of recorded disturbances	100

Table 69. Event recorder

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

Table 70. Trip value recorder

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

Table 71. Disturbance recorder

Function		Value
Buffer capacity	Maximum number of analog inputs	40
	Maximum number of binary inputs	96
	Maximum number of disturbance reports	100
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)		340 seconds (100 recordings) at 50 Hz 280 seconds (80 recordings) at 60 Hz

Metering

Table 72. Pulse counter PCGGIO

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

Table 73. Energy metering ETPMMTR

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

Station communication

Table 74. IEC 61850-8-1 communication protocol

Function	Value
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX

Table 75. LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 76. SPA communication protocol

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

Table 77. IEC60870-5-103 communication protocol

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

Table 78. SLM – LON port

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

Table 79. SLM – SPA/IEC 60870-5-103/DNP3 port

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

Table 80. Galvanic RS485 communication module

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

Table 81. IEC 62439-3 Edition 1 and Edition 2 parallel redundancy protocol

Function	Value
Protocol	IEC 61850-8-1
Communication speed	100 Base-FX

Remote communication

Table 82. Line data communication module

Characteristic	Range or value		
Type of LDCM	**Short range (SR)**	**Medium range (MR)**	**Long range (LR)**
Type of fibre	Graded-index multimode 62.5/125 µm or 50/125 µm	Singlemode 9/125 µm	Singlemode 9/125 µm
Wave length	850 nm	1310 nm	1550 nm
Optical budget Graded-index multimode 62.5/125 µm, Graded-index multimode 50/125 µm	13 dB (typical distance about 3 km *) 9 dB (typical distance about 2 km *)	22 dB (typical distance 80 km *)	26 dB (typical distance 110 km *)
Optical connector	Type ST	Type FC/PC	Type FC/PC
Protocol	C37.94	C37.94 implementation **)	C37.94 implementation **)
Data transmission	Synchronous	Synchronous	Synchronous
Transmission rate / Data rate	2 Mb/s / 64 kbit/s	2 Mb/s / 64 kbit/s	2 Mb/s / 64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal	Internal or derived from received signal

*) depending on optical budget calculation
**) C37.94 originally defined just for multimode; using same header, configuration and data format as C37.94

Hardware

IED

Table 83. Case

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

Table 84. Water and dust protection level according to IEC 60529

Front	IP40 (IP54 with sealing strip)
Rear, sides, top and bottom	IP20

Table 85. Weight

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

Connection system

Table 86. CT and VT circuit connectors

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

Table 87. Binary I/O connection system

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

Basic IED functions

Table 88. Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	1000 events, first in-first out

Table 89. Time synchronization, time tagging

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

Table 90. 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 91. 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	+/-2μs

Table 92. IRIG-B

Quantity	Rated value
Number of channels IRIG-B	1
Number of channels PPS	1
Electrical connector:	
Electrical connector IRIG-B	BNC
Pulse-width modulated	5 Vpp
Amplitude modulated – low level – high level	 1-3 Vpp 3 x low level, max 9 Vpp
Supported formats	IRIG-B 00x, IRIG-B 12x
Accuracy	+/-10μs for IRIG-B 00x and +/-100μs for IRIG-B 12x
Input impedance	100 k ohm
Optical connector:	
Optical connector PPS and IRIG-B	Type ST
Type of fibre	62.5/125 μm multimode fibre
Supported formats	IRIG-B 00x, PPS
Accuracy	+/- 2μs

Inverse characteristic

Table 93. ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^P - 1\right)} + B \right) \cdot k$$ EQUATION1249-SMALL V1 EN Reset characteristic: $$t = \frac{t_r}{\left(I^2 - 1\right)} \cdot k$$ EQUATION1250-SMALL V1 EN $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 unless otherwise stated	-
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	ANSI/IEEE C37.112, class 5 + 40 ms
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	k=(0.05-999) in steps of 0.01 A=0.086, B=0.185, P=0.02, tr=4.6	

Table 94. IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $$t = \left(\frac{A}{\left(I^P - 1\right)} \right) \cdot k$$ EQUATION1251-SMALL V1 EN $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	-
Time delay to reset, IEC inverse time	(0.000-60.000) s	± 0.5% of set time ± 10 ms
IEC Normal Inverse	A=0.14, P=0.02	IEC 60255-3, class 5 + 40 ms
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: $$t = \left(\frac{A}{\left(I^P - C\right)} + B \right) \cdot k$$ EQUATION1370-SMALL V1 EN Reset characteristic: $$t = \frac{TR}{\left(I^{PR} - CR\right)} \cdot k$$ EQUATION1253-SMALL V1 EN $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	IEC 60255, class 5 + 40 ms

Table 95. RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$$ EQUATION1137-SMALL V1 EN $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	IEC 60255-3, class 5 + 40 ms
RD type logarithmic inverse characteristic $$t = 5.8 - \left(1.35 \cdot In\frac{I}{k}\right)$$ EQUATION1138-SMALL V1 EN $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	IEC 60255-3, class 5 + 40 ms

Table 96. Inverse time characteristics for overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ EQUATION1436-SMALL V1 EN $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$ EQUATION1437-SMALL V1 EN	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$ EQUATION1438-SMALL V1 EN	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	
Programmable curve: $$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$$ EQUATION1439-SMALL V1 EN	k = (0.05-1.10) in steps of 0.01 unless otherwise stated 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 97. Inverse time characteristics for undervoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U< - U}{U<}\right)}$$ EQUATION1431-SMALL V1 EN $U< = U_{set}$ $U = UV_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U< - U}{U<} - 0.5\right)^{2.0}} + 0.055$$ EQUATION1432-SMALL V1 EN $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated	
Programmable curve: $$t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U< - U}{U<} - C\right)^{P}}\right] + D$$ EQUATION1433-SMALL V1 EN $U< = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01 unless otherwise stated 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 98. Inverse time characteristics for residual overvoltage protection

Function	Range or value	Accuracy
Type A curve: $$t = \frac{k}{\left(\frac{U - U>}{U>}\right)}$$ EQUATION1436-SMALL V1 EN $U> = U_{set}$ $U = U_{measured}$	k = (0.05-1.10) in steps of 0.01	Class 5 +40 ms
Type B curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{2.0} - 0.035}$$ EQUATION1437-SMALL V1 EN	k = (0.05-1.10) in steps of 0.01	
Type C curve: $$t = \frac{k \cdot 480}{\left(32 \cdot \frac{U - U>}{U>} - 0.5\right)^{3.0} - 0.035}$$ EQUATION1438-SMALL V1 EN	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $$t = \frac{k \cdot A}{\left(B \cdot \frac{U - U>}{U>} - C\right)^{P}} + D$$ EQUATION1439-SMALL V1 EN	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

22. Ordering

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*1.2-A30-A01A02B12C05D01D03E01F02H09-B1-X0-C-B-KA-B3X0-A-ABC-X-XD. Using the code of each position #1-12 specified as RET670*1-2 2-3 3 3 3 3 3 3 3 3-4-5-6-7 7-8-9 9 9-10 10 10 10 10 10 10 10 10 10 10 10-11 11 11 11 11 11-12 12

#	1	-	2		-	3															-	4		-	5	6	-	7		-	8	-
RET670*		-			-																-			-			-			.		-

9			-	10											-	11						-	12	
			-												.							-		

	Position	
SOFTWARE	#1	Notes and Rules
Version number		
Version no	1.2	
Selection for position #1.		

Configuration alternatives	#2		Notes and Rules
Transformer back-up protection	A10		
Voltage control	A25		
Single breaker, 2 winding	A30		
Multi breaker, 2 winding	B30		
Single breaker, 3 winding	A40		
Multi breaker, 3 winding	B40		
ACT configuration			
ABB standard configuration		X00	
Selection for position #2.			

Software options	#3														Notes and Rules
No option	X 00														All fields in the ordering form do not need to be filled in
Restricted earth fault protection, low impedance	A 01														Note: A01 only for A40/ B40

Software options	#3															Notes and Rules
High impedance differential protection - 3 blocks		A 02														Note: A02, B12, B13, C05, C17, F02, H09, H11, H15 **not** in A25 and A10
Transformer distance protection, quadrilateral			B 12													
Transformer distance protection, mho			B 13													
Thermal overload protection				C 05												
Sensitive directional residual overcurrent and power protection					C 16											Note: C16 **not** in A10
Directional power protection						C 17										Note: C17 **not** in A10/ A25
Current protection VCTR						C 19										Note: Only for A25
Four step directional negative phase sequence overcurrent protection - 2 blocks							C 42									Note: Only for A10/A30/ B30
Four step directional negative phase sequence overcurrent protection - 3 blocks							C 43									Note: Only for A40/B40
Voltage protection, 1 bus								D 01								Note: Only one of Voltage protection can be ordered D01 only for A10/A30/ B30, D02 only for A25/ A40/B40
Voltage protection, 2 buses								D 02								
Overexcitation protection, 2 winding									D 03							Note: Only one of Overexcitation protection can be ordered Note: D03 only for A30/ B30, D04 only for A40/ B40
Overexcitation protection, 3 winding									D 04							
Frequency protection - station										E 01						Note: E01 **not** in A25
General current and voltage protection											F0 2					Note: F02 **not** in A10/A25
Synchrocheck - 2 circuit breakers												H 01				Note: Only for B30
Synchrocheck - 3 circuit breakers												H 02				Note: Only for A40
Synchrocheck - 4 circuit breakers												H 03				Note: Only for B40
Apparatus control 30 objects													H 09			Note: H09 **not** in A10
Voltage control, single transformer														H 11		Note: Only one of H11/ H15. H11/H15 **not** in A10/A25
Voltage control, parallel transformers														H 15		
Voltage control, single transformer, 2 control blocks														H 16		Note: H16, H18 only for A25/A40/B40
Voltage control, parallel transformers, 2 control blocks														H 18		
IEC 62439-3 Edition 1 parallel redundancy protocol															P 01	Note:Require 2-channel OEM
IEC 62439-3 Edition 2 parallel redundancy protocol															P 02	

Software options	#3															Notes and Rules
Selection for position #3																

First local HMI user dialogue language	#4		Notes and Rules
HMI language, English IEC	B1		
HMI language, English US	B2		
Additional local HMI user dialogue language			
HMI language, German		A1	
HMI language, Russian		A2	
HMI language, French		A3	
HMI language, Spanish		A4	
HMI language, Polish		A6	
HMI language, Hungarian		A7	
HMI language, Czech		A8	
HMI language, Swedish		A9	
Selection for position #4.			

Casing	#5	Notes and Rules
1/2 x 19" case	A	Note: Only for A10/A25/A30
3/4 x 19" case 2 TRM slots	C	Note: Not for A10
1/1 x 19" case 2 TRM slots	E	Note: Not for A10
Selection for position #5.		

Mounting details with IP40 of protection from the front	#6	Notes and Rules
No mounting kit included	X	
19" rack mounting kit for 1/2 x 19" case of 2xRHGS6 or RHGS12	A	Note: Only for A10/A25/A30
19" rack mounting kit for 3/4 x 19" case or 3xRGHS6	B	
19" rack mounting kit for 1/1 x 19" case	C	
Wall mounting kit	D	Note: Wall mounting not recommended with communication modules with fibre connection (SLM, OEM, LDCM)
Flush mounting kit	E	
Flush mounting kit + IP54 mounting seal	F	
Selection for position #6.		

Connection type for Power supply, Input/output and Communication modules	#7		Notes and Rules
Compression terminals	K		
Auxiliary power supply			
24-60 VDC		A	
90-250 VDC		B	
Selection for position #7.			

Human machine hardware interface	#8	Notes and Rules
Small size - text only, IEC keypad symbols	A	Note: Not for A25
Medium size - graphic display, IEC keypad symbols	B	Note: Required to give Raise/ Lower commands to OLTC from IED670 via Voltage control (VCTR) function
Medium size - graphic display, ANSI keypad symbols	C	
Selection for position #8.		

Connection type for Analog modules	#9			Notes and Rules
Compression terminals	A			
Ringlug terminals	B			
Analog system				
First TRM, 9I+3U 1A, 110/220V		3		Note: Not in A25
First TRM, 9I+3U 5A, 110/220V		4		Note: Not in A25
First TRM, 5I, 1A+4I, 5A+3U, 110/220V		5		Note: Not in A25
First TRM, 6I+6U 1A, 100/220V		6		Note: Only for A25
First TRM, 6I+6U 5A, 100/220V		7		Note: Only for A25
No second TRM included			X0	Note: A40/B30/B40 must include a second TRM
Second TRM, 12I, 1A, 100/220V			1	Note: Only for A30
Second TRM, 12I, 5A, 100/220V			2	Note: Only for A30
Second TRM, 9I+3U 1A, 110/220V			3	Note: Not in A25
Second TRM, 9I+3U 5A, 110/220V			4	Note: Not in A25
Second TRM, 5I, 1A+4I, 5A+3U, 110/220V			5	Note: Not in A25
Second TRM, 6I+6U 1A, 100/220V			6	Note: Only for A25/A30
Second TRM, 6I+6U 5A, 100/220V			7	Note: Only for A25/A30
Second TRM, 6I, 1A, 110/220V			8	Note: Only for A30
Second TRM, 6I, 5A, 5A, 110/220V			9	Note: Only for A30
Second TRM, 7I+5U 1A, 110/220V			12	Note: Only for A30
Second TRM, 7I+5U 5A, 110/220V			13	Note: Only for A30
Selection for position #9.				

Binary input/output module, mA and time synchronization boards. Note: 1BIM and 1 BOM included.	#10											Notes and Rules
Make BIM with 50 mA inrush current the primary choice. BIM with 50 mA inrush current fulfill additional standards. As a consequence the EMC withstand capability is further increased. BIM with 30 mA inrush current is still available. For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used.												
Slot position (rear view)	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	Note: Max 3 positions in 1/2 rack, 5 in 3/4 rack with 2 TRM and 11 in 1/1 rack with 2 TRM
1/2 Case with 1 TRM	■	■	■									Note: Only for A10/A25/A30
3/4 Case with 2 TRM	■	■	■	■	■							
1/1 Case with 2 TRM	■	■	■	■	■	■	■	■	■	■	■	
No board in slot			X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)		A	A	A	A	A	A	A	A	A	A	Note: Maximum 4 (BOM+SOM +MIM) boards.
BIM 16 inputs, RL24-30 VDC, 30 mA	B		B	B	B	B	B	B	B	B	B	Note: Only 1 BIM in A10
BIM 16 inputs, RL48-60 VDC, 30 mA	C		C	C	C	C	C	C	C	C	C	
BIM 16 inputs, RL110-125 VDC, 30 mA	D		D	D	D	D	D	D	D	D	D	
BIM 16 inputs, RL220-250 VDC, 30 mA	E		E	E	E	E	E	E	E	E	E	
BIM 16 inputs, RL24-30 VDC, 50 mA	B1		B1	B1	B1	B1	B1	B1	B1	B1	B1	
BIM 16 inputs, RL48-60 VDC, 50 mA	C1		C1	C1	C1	C1	C1	C1	C1	C1	C1	
BIM 16 inputs, RL110-125 VDC, 50 mA	D1		D1	D1	D1	D1	D1	D1	D1	D1	D1	
BIM 16 inputs, RL220-250 VDC, 50 mA	E1		E1	E1	E1	E1	E1	E1	E1	E1	E1	
BIM 16 inputs, RL24-30 VDC for pulse counting			F	F	F	F	F	F	F	F	F	
BIM 16 inputs, RL48-60 VDC for pulse counting			G	G	G	G	G	G	G	G	G	
BIM 16 inputs, RL110-125 VDC for pulse counting			H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220-250 VDC for pulse counting			K	K	K	K	K	K	K	K	K	
IOM 8 inputs, 10+2 output, RL24-30 VDC			L	L	L	L	L	L	L	L	L	
IOM 8 inputs, 10+2 output, RL48-60 VDC			M	M	M	M	M	M	M	M	M	
IOM 8 inputs, 10+2 output, RL110-125 VDC			N	N	N	N	N	N	N	N	N	
IOM 8 inputs, 10+2 output, RL220-250 VDC			P	P	P	P	P	P	P	P	P	
IOM 8 inputs, 10+2 output, RL24-30 VDC, 50 mA			L1	L1	L1	L1	L1	L1	L1	L1	L1	
IOM 8 inputs, 10+2 output, RL48-60 VDC, 50 mA			M1	M1	M1	M1	M1	M1	M1	M1	M1	
IOM 8 inputs, 10+2 output, RL110-125 VDC, 50 mA			N1	N1	N1	N1	N1	N1	N1	N1	N1	
IOM 8 inputs, 10+2 output, RL220-250 VDC, 50 mA			P1	P1	P1	P1	P1	P1	P1	P1	P1	
IOM with MOV 8 inputs, 10-2 output, 24-30 VDC			U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, 10-2 output, 48-60 VDC			V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, 10-2 output, 110-125 VDC			W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, 10-2 output, 220-250 VDC			Y	Y	Y	Y	Y	Y	Y	Y	Y	

Binary input/output module, mA and time synchronization boards. Note: 1BIM and 1 BOM included.	#10											Notes and Rules
Make BIM with 50 mA inrush current the primary choice. BIM with 50 mA inrush current fulfill additional standards. As a consequence the EMC withstand capability is further increased. BIM with 30 mA inrush current is still available. For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used.												
mA input module MIM 6 channels			R	R	R	R	R	R	R	R	R	Note: Max 4 (BOM+SOM+MIM) board in 1/1 case. Max 1 MIM+3 BOM in 3/4 case. No MIM board in 1/2 case
SOM Static output module, 12 outputs, 48-60 VDC			T1	T1	T1	T1	T1	T1	T1	T1	T1	
SOM static outputs module, 12 outputs, 110-250 VDC			T2	T2	T2	T2	T2	T2	T2	T2	T2	
Selection for position #10.												

Remote end communication, DNP serial comm. and time synchronization modules	#11						Notes and Rules
Slot position (rear view)	X312	X313	X302	X303	X322	X323	
Available slots in 1/2 case with 1TRM	■	■	■	■			Note: Only 1 LDCM.
Available slots in 3/4 & 1/1 case with 2 TRM	■	■	■	■	■	■	Note: Max 2 LDCM.
No remote communication board included	X	X	X	X	X	X	
Optical short range LDCM	A	A	A	A	A	A	Note: Not in A10/A25
Optical medium range, LDCM 1310 nm	B	B	B	B	B	B	Note: Not in A10/A25
GPS time module GTM	S	S			S	S	
IRIG-B Time synchronization module			F				
Galvanic RS485 communication module	G	G	G	G	G	G	
Selection for position #11.							

Serial communication unit for station communication	#12		Notes and Rules
Slot position (rear view)	X301	X311	
No first communication board included	X		
No second communication board included		X	
Serial and LON communication module (plastic)	A		Note: Optical ethernet module, 2 channel glass is not allowed together with SLM.
Serial (plastic) and LON (glass) communication module	B		
Serial and LON communication module (glass)	C		
Serial IEC 60870-5-103 plastic interface	F		
Serial IEC 60870-5-103 plastic/glass interface	G		
Serial IEC 60870-5-103 glass interface	H		
Optical ethernet module, 1 channel glass		D	
Optical ethernet module, 2 channel glass		E	
Selection for position #12.			

Guidelines

Carefully read and follow the set of rules to ensure problem-free order management. Be aware that certain functions can only be ordered in combination with other functions and that some functions require specific hardware selections.

Please refer to the available functions table for included application functions.

Accessories

GPS antenna and mounting details

GPS antenna, including mounting kits	Quantity:	☐	1MRK 001 640-AA
Cable for antenna, 20 m	Quantity:	☐	1MRK 001 665-AA
Cable for antenna, 40 m	Quantity:	☐	1MRK 001 665-BA

Interface converter (for remote end data communication)

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

Test switch

The test system COMBITEST intended for use with the IED 670 products is described in 1MRK 512 001-BEN and 1MRK 001024-CA. Please refer to the website: www.abb.com/substationautomation 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 215-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 215-BH).

Three winding transformer with internal neutral on current circuits (ordering number RK926 215-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 reference 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 reference to corresponding documents.

Protection cover

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

External resistor unit

High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity:	1 ☐ 2 ☐ 3 ☐	RK795101-MA
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 20-100V operating voltage	Quantity:	☐	RK795101-MB
High impedance resistor unit 1-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity:	1 ☐ 2 ☐ 3 ☐	RK795101-CB
High impedance resistor unit 3-ph with resistor and voltage dependent resistor for 100-400V operating voltage	Quantity:	☐	RK795101-DC

Combiflex

Key switch for settings

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

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

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

Configuration and monitoring tools

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

Manuals

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

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

User documentation

Rule: Specify the number of printed manuals requested Operator’s manual	IEC	Quantity:	☐	1MRK 504 114-UEN
	ANSI	Quantity:	☐	1MRK 504 114-UUS
Technical reference manual	IEC	Quantity:	☐	1MRK 504 113-UEN
	ANSI	Quantity:	☐	1MRK 504 113-UUS
Installation and commissioning manual	IEC	Quantity:	☐	1MRK 504 115-UEN
	ANSI	Quantity:	☐	1MRK 504 115-UUS
Application manual	IEC	Quantity:	☐	1MRK 504 116-UEN
	ANSI	Quantity:	☐	1MRK 504 116-UUS
Engineering guide IED 670 products		Quantity:	☐	1MRK 511 256-UEN

Reference information

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

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

Related documents

Documents related to RET670	Identity number
Operator's manual	1MRK 504 114-UEN
Installation and commissioning manual	1MRK 504 115-UEN
Technical reference manual	1MRK 504 113-UEN
Application manual	1MRK 504 116-UEN
Product guide customized	1MRK 504 117-BEN
Product guide pre-configured	1MRK 504 118-BEN
Product guide IEC 61850-9-2	1MRK 504 104-BEN
Sample specification	SA2005-001283
Connection and Installation components	1MRK 513 003-BEN
Test system, COMBITEST	1MRK 512 001-BEN
Accessories for 670 series IEDs	1MRK 514 012-BEN
670 series SPA and signal list	1MRK 500 092-WEN
IEC 61850 Data objects list for 670 series	1MRK 500 091-WEN
Engineering manual 670 series	1MRK 511 256-UEN
Communication set-up for Relion 670 series	1MRK 505 260-UEN

More information can be found on www.abb.com/substationautomation.

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