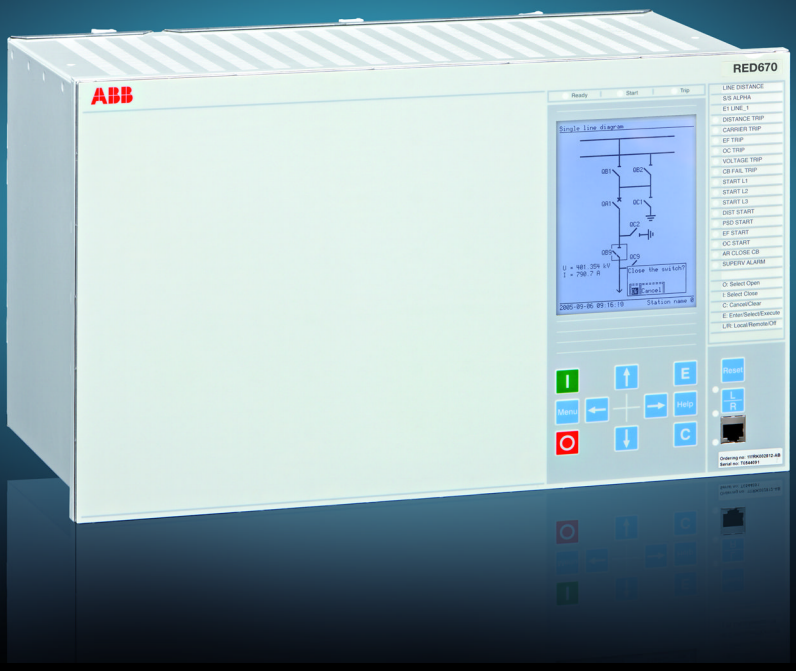

Relion® 670 series

Line differential protection RED670 Customized Product Guide

Power and productivity
for a better world™

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1. Application

RED670 is used for the protection, control and monitoring of overhead lines and cables in all types of networks. The IED can be used from distribution up to the highest voltage levels. It is suitable for the protection of heavily loaded lines and multi-terminal lines where the requirement for tripping is one-, two-, and/or three-phase. The IED is also suitable for protection of cable feeders to generator block transformers.

The phase segregated current differential protection provides an excellent sensitivity for high resistive faults and gives a secure phase selection. The availability of six stabilized current inputs per phase allows use on multi-breaker arrangements in three terminal applications or up to five terminal applications with single breaker arrangements. The communication between the IEDs involved in the differential scheme is based on the IEEE C37.94 standard and can be duplicated for important installations when required for redundancy reasons. Charging current compensation allows high sensitivity also on long overhead lines and cables. A full scheme distance protection is included to provide independent protection in parallel with the differential scheme in case of a communication channel failure for the differential scheme. The distance protection then provide protection for the entire line including the remote end back up capability either in case of a communications failure or via use of an independent communication channel to provide a fully redundant scheme of protection (that is a second main protection scheme). Eight channels for intertrip and other binary signals are available in the communication between the IEDs.

A high impedance differential protection can be used to protect T-feeders or line reactors.

The auto-reclose for single-, two- and/or three phase reclosing includes priority circuits for multi-breaker arrangements. It co-operates with the synchronism check function with high-speed or delayed reclosing.

High set instantaneous phase and earth overcurrent, four step directional or un-directional delayed phase and earth overcurrent, thermal overload and two step under- and overvoltage functions are examples of the available functions allowing the user to fulfill any application requirement.

The IED can also be provided with a full control and interlocking functionality including co-operation with the synchronism check function to allow integration of the main or back-up control.

Disturbance recording and fault locator are available to allow independent post-fault analysis after primary disturbances. The Disturbance recorder will also show remote station currents, as received to this IED, time compensated with measure communication time.

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 the 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 logics etc. The graphical configuration tool ensures simple and fast testing and commissioning.

A loop testing function allows complete testing including remote end IED when local IED is set in test mode.

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.

2. Available functions

Main protection functions

2 = number of basic instances
0-3 = option quantities

IEC 61850	ANSI	Function description	Line Differential
			RED670
Differential protection			
HZPDIF	87	1Ph high impedance differential protection	0-3
L3CPDIF	87L	Line differential protection, 3 CT sets, 2-3 line ends	1
L6CPDIF	87L	Line differential protection, 6 CT sets, 3-5 line ends	1
LT3CPDIF	87LT	Line differential protection, 3 CT sets, with inzone transformers, 2-3 line ends	1
LT6CPDIF	87LT	Line differential protection, 6 CT sets, with inzone transformers, 3-5 line ends	1
STSGGIO		Additional security logic for differential protection	0-1
Impedance protection			
ZMQPDIS, ZMQAPDIS	21	Distance protection zone, quadrilateral characteristic	0-5
ZDRDIR	21D	Directional impedance quadrilateral	0-2
ZMCPDIS, ZMCAPDIS	21	Distance characteristic for series compensated lines	0-5
ZDSRDIR	21D	Directional impedance quadrilateral, including series compensation	0-2
FDPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle	0-2
ZMHPDIS	21	Full-scheme distance protection, mho characteristic	0-5
ZMMPDIS, ZMMAPDIS	21	Full-scheme distance protection, quadrilaterial for earth faults	0-5
ZDMRDIR	21D	Directional impedance element for mho characteristic	0-2
ZDARDIR		Additional distance protection directional function for earth fault	0-2
ZSMGAPC		Mho impedance supervision logic	0-1
FMPSPDIS	21	Faulty phase identification with load enchroachment	0-2
ZMRPDIS, ZMRAPDIS	21	Distance protection zone, quadrilateral characteristic, separate settings	0-5
FRPSPDIS	21	Phase selection, quadrilateral characteristic with settable angle	0-2
ZMRPSB	78	Power swing detection	0-1
ZMRPSL		Power swing logic	0-1
PSPPPAM	78	Pole slip/out-of-step protection	0-1
ZCVPSOF		Automatic switch onto fault logic, voltage and current based	0-1
PPLPHIZ		Phase preference logic	0-1

Back-up protection functions

IEC 61850	ANSI	Function description	Line Differential
			RED670
Current protection			
PHPIOC	50	Instantaneous phase overcurrent protection	0-3
OC4PTOC	51_67	Four step phase overcurrent protection	0-1
EFPIOC	50N	Instantaneous residual overcurrent protection	0-1
EF4PTOC	51N_67N	Four step residual overcurrent protection	0-1
NS4PTOC	46I2	Four step directional negative phase sequence overcurrent protection	0-1
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0-1
LPPTR	26	Thermal overload protection, one time constant	0–2
CCRBRF	50BF	Breaker failure protection	0-2
STBPTOC	50STB	Stub protection	0-2
CCRPLD	52PD	Pole discordance protection	0-2
GUPPDUP	37	Directional underpower protection	0-2
GOPPDOP	32	Directional overpower protection	0-2
BRCPTOC	46	Broken conductor check	1
Voltage protection			
UV2PTUV	27	Two step undervoltage protection	0-2
OV2PTOV	59	Two step overvoltage protection	0-2
ROV2PTOV	59N	Two step residual overvoltage protection	0-2
OEXPVPH	24	Overexcitation protection	0-1
VDCPTOV	60	Voltage differential protection	0-2
LOVPTUV	27	Loss of voltage check	1
Frequency protection			
SAPTUF	81	Underfrequency protection	0-2
SAPTOF	81	Overfrequency protection	0-2
SAPFRC	81	Rate-of-change frequency protection	0-2
Multipurpose protection			
CVGAPC		General current and voltage protection	0-4

Control and monitoring functions

IEC 61850	ANSI	Function description	Line Differential RED670
Control			
SESRSYN	25	Synchrocheck, energizing check and synchronizing	0-2
SMBRREC	79	Autorecloser	0-4
APC8	3	Apparatus control for single bay, max 8 apparatuses (1CB) incl. interlocking	0-1
APC15	3	Apparatus control for single bay, max 15 apparatuses (2CBs) incl. interlocking	0-1
QCBAY		Apparatus control	1
LOCREM		Handling of LRswitch positions	1
LOCREMCTRL		LHMI control of PSTO	1
SLGGIO		Logic rotating switch for function selection and LHMI presentation	15
VSGGIO		Selector mini switch	20
DPGGIO		IEC61850 generic communication I/O functions	16
SPC8GGIO		Single pole generic control 8 signals	5
AutomationBits		AutomationBits, command function for DNP3.0	3
SingleCommand16Signals		Single command, 16 signals	4
Secondary system supervision			
CCSRDIF	87	Current circuit supervision	0-2
SDDRFUF		Fuse failure supervision	0-3
Logic			
SMPPTRC	94	Tripping logic	1-2
TMAGGIO		Trip matrix logic	12
		Configuration logic blocks	40-280
FixedSignals		Fixed signal function block	1
B16I		Boolean 16 to Integer conversion	16
B16IFCVI		Boolean 16 to Integer conversion with Logic Node representation	16
IB16		Integer to Boolean 16 conversion	16
IB16FCVB		Integer to Boolean 16 conversion with Logic Node representation	16
Monitoring			
CVMMXN		Measurements	6
EVENT		Event function	20
DRPRDRE		Disturbance report	1
SPGGIO		IEC61850 generic communication I/O functions	64
SP16GGIO		IEC61850 generic communication I/O functions 16 inputs	16
MVGGIO		IEC61850 generic communication I/O functions	24

IEC 61850	ANSI	Function description	Line Differential
			RED670
BSStatReport		Logical signal status report	3
RANGE_XP		Measured value expander block	66
LMBRFLO		Fault locator	1
Metering			
PCGGIO		Pulse-counter logic	16
ETPMMTR		Function for energy calculation and demand handling	6

Designed to communicate

IEC 61850	ANSI	Function description	Line Differential
			RED670
Station communication			
		SPA communication protocol	1
		LON communication protocol	1
		IEC60870-5-103 communication protocol	20/1
		Operation selection between SPA and IEC60870-5-103 for SLM	1
		DNP3.0 for TCP/IP and EIA-485 communication protocol	1
		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1
		Parameter setting function for IEC61850	1
IntlReceive		Horizontal communication via GOOSE for interlocking	59
		Goose binary receive	10
		Multiple command and transmit	60/10
		Ethernet configuration of links	1
		IEC 62439-3 Edition 1 parallel redundancy protocol	0-1
		IEC 62439-3 Edition 2 parallel redundancy protocol	0-1
Scheme communication			
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection	0-1
ZC1PPSCH	85	Phase segregated scheme communication logic for distance protection	0-1
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection	0-1
ZC1WPSCH		Current reversal and weak-end infeed logic for phase segregated communication	0-1
ZCLCPLAL		Local acceleration logic	0-1
ECPSCH	85	Scheme communication logic for residual overcurrent protection	0-1
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection	0-1
DTT		Direct transfer trip	0-1

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

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.

Line differential protection, 3 or 6 CT sets L3CPDIF, L6CPDIF

Line differential protection applies the Kirchhoff's law and compares the currents entering and leaving the protected multi-terminal circuit, consisting of overhead power lines, power transformers and cables. It offers phase-segregated true current differential protection with high sensitivity and provides phase selection information for single-pole tripping.

The three terminal version is used for conventional two-terminal lines with or without 1 1/2 circuit breaker arrangement in one end, as well as three terminal lines with single breaker arrangements at all terminals.

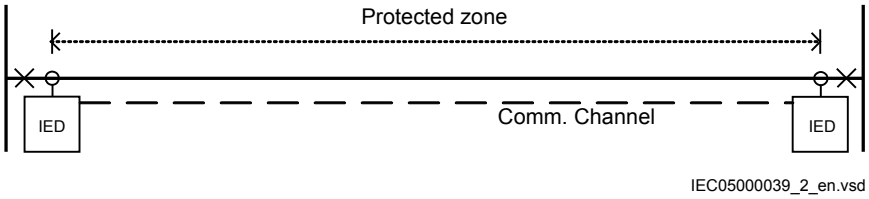


Figure 1. Example of application on a conventional two-terminal line

The six terminal versions are used for conventional two-terminal lines with 1 1/2 circuit breaker arrangements in both ends, as well as multi terminal lines with up to five terminals.

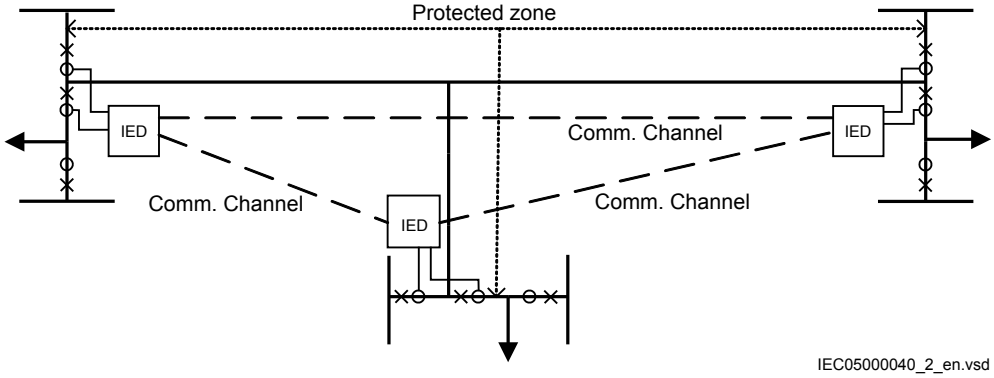


Figure 2. Example of application on a three-terminal line with 1 1/2 breaker arrangements

The current differential algorithm provides high sensitivity for internal faults, at the same time as it has excellent stability for external faults. Current samples from all CTs are exchanged between the IEDs in the line ends (master-master mode) or sent to one IED (master-slave mode) for evaluation.

A restrained dual biased slope evaluation is made where the bias current is the highest phase current in any line end giving a secure through fault stability even with heavily saturated CTs. In addition to the restrained evaluation, an unrestrained high differential current setting can be used for fast tripping of internal faults with very high currents.

A special feature with this function is that applications with small power transformers (rated current less than 50 % of the differential current setting) connected as line taps (that is, as "shunt" power transformers), without measurements of currents in the tap, can be handled. The normal load current is here considered to be negligible, and special measures need only to be taken in the event of a short circuit on the LV side of the transformer. In this application, the tripping of the differential protection can be time delayed for low differential currents to achieve coordination with down stream over current IEDs.

A line charging current compensation provides increased sensitivity of Line differential protection.

Line differential protection 3 or 6 CT sets, with in-zone transformers LT3CPDIF, LT6CPDIF

Two two-winding power transformers, or one three-winding power transformer, can be included in the line differential protection zone. Both two- and three-winding transformers are correctly represented with vector group compensations made in the algorithm. The function includes 2nd and 5th harmonic restraint and zero-sequence current elimination.

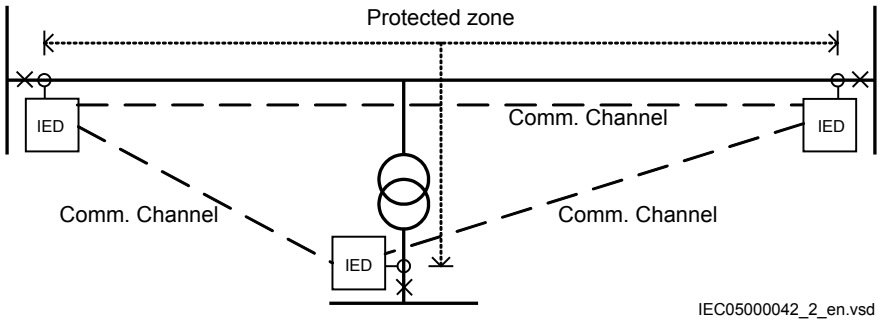


Figure 3. Example of application on a three-terminal line with a power transformer in the protection zone

Analog signal transfer for line differential protection

The line differential communication can be arranged as a master-master system or a master-slave system alternatively. In the former, current samples are exchanged between all IEDs, and an evaluation is made in each IED. This means that a 64 kbit/s communication channel is needed between every IED included in the same line differential protection zone. In the latter, current samples are sent from all slave IEDs to one master IED where the evaluation is made, and trip signals are sent to the remote ends when needed. In this system, a 64 kbit/s communication channel is only needed between the master, and each one of the slave IEDs.

It is recommended to use the same firmware version as well as hardware version for a specific RED670 scheme.

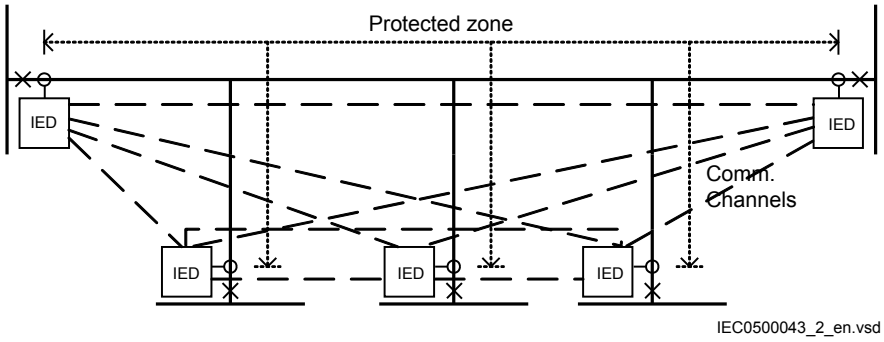


Figure 4. Five terminal lines with master-master system

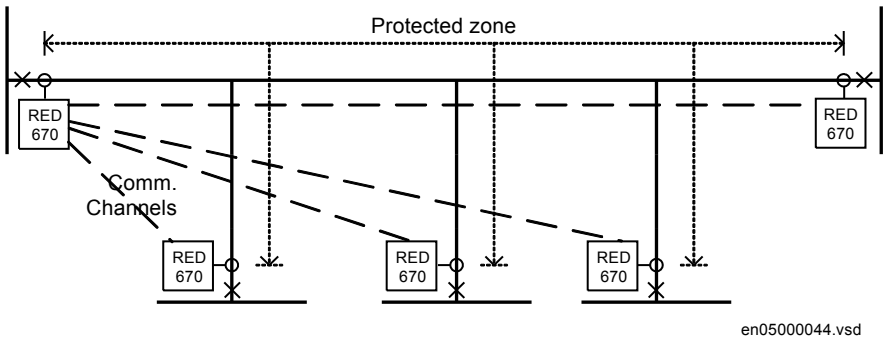


Figure 5. Five terminal line with master-slave system

Current samples from IEDs located geographically apart from each other, must be time coordinated so that the current differential algorithm can be executed correctly. In IED, it is possible to make this coordination in two different ways. The

echo method of time synchronizing is normally used whereas for applications where transmit and receive times can differ, the optional built in GPS receivers can be used.

Additional security logic for differential protection STSGGIO

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

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

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

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

The communication link is continuously monitored, and an automatic switchover to a standby link is possible after a preset time.

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

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

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

Features:

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

4. Impedance protection

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

The line distance protection is a five 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, as shown in figure6.

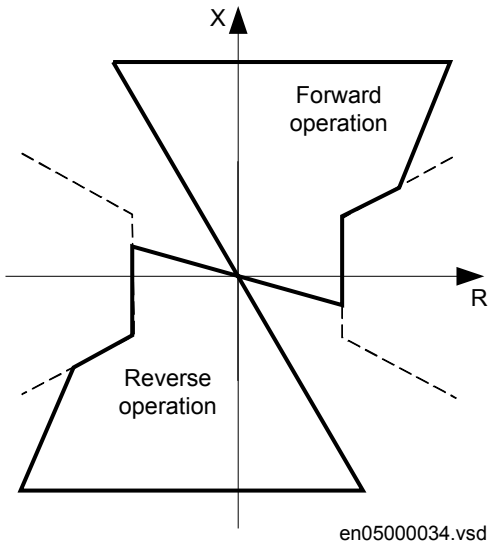


Figure 6. Typical quadrilateral distance protection zone with Phase selection with load encroachment function FDPSPDIS activated

The independent measurement of impedance for each fault loop together with a sensitive and reliable built-in phase

selection makes the function suitable in applications with single-phase autoreclosing.

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

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

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

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

Quadrilateral characteristic is available.

ZMCPDIS function has functionality for load encroachment which increases the possibility to detect high resistive faults on heavily loaded lines.

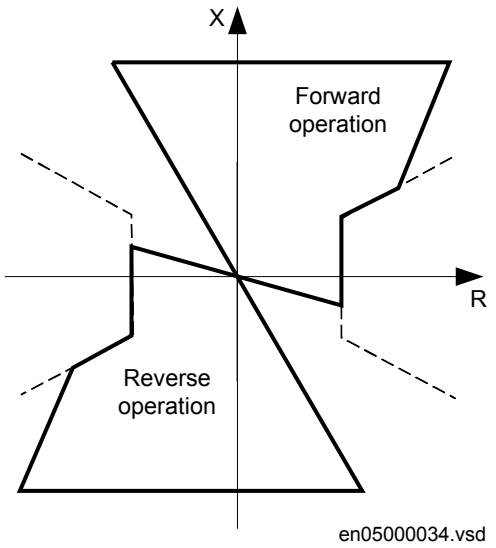


Figure 7. Typical quadrilateral distance protection zone with load encroachment function activated

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

Built-in adaptive load compensation algorithm for the quadrilateral function prevents overreaching of zone1 at load exporting end at phase to earth-faults on heavily loaded power lines.

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.

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 five zone full scheme protection for back-up detection of short circuit and earth faults. The full scheme technique provides back-up protection of power lines with high sensitivity and low requirement on remote end communication. The five zones have fully independent measuring and settings, which gives high flexibility for all types of lines.

The IED can be used up to the highest voltage levels. It is suitable for the protection of heavily loaded lines and multi-terminal lines where the requirement for tripping is one-, two- and/or three-pole.

The independent measurement of impedance for each fault loop together with a sensitive and reliable built in phase

selection makes the function suitable in applications with single phase autoreclosing.

Built-in adaptive load compensation algorithm prevents overreaching at phase-to-earth faults on heavily loaded power lines, see figure 8.

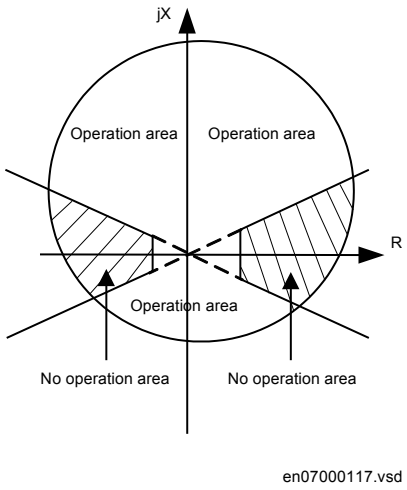


Figure 8. Load encroachment influence on the offset mho characteristic

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

The possibility to use the phase-to-earth quadrilateral impedance characteristic together with the mho characteristic increases the possibility to overcome eventual lack of sensitivity of the mho element due to the shaping of the curve at remote end faults.

The integrated control and monitoring functions offer effective solutions for operating and monitoring all types of transmission and sub-transmission lines.

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

The line distance protection is a five 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 , see figure 6.

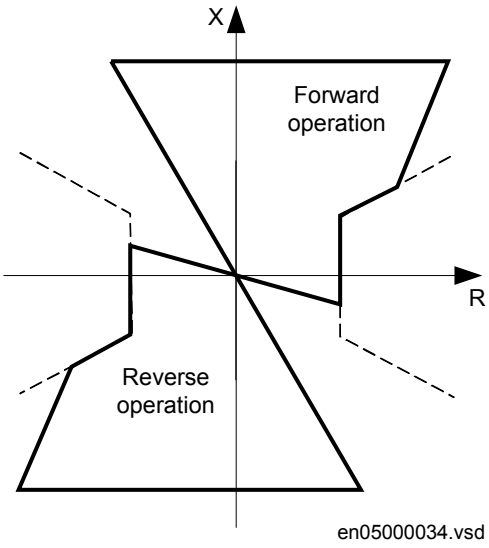


Figure 9. Typical quadrilateral distance protection zone with Phase selection, quadrilateral characteristic with settable angle function FRPSPDIS activated

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

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

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.

Distance protection zone, quadrilateral characteristic, separate settings ZMRPDIS, ZMRAPDIS

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

Mho alternative quadrilateral characteristic is available.

ZMRPDIS together with Phase selection, quadrilateral characteristic with settable angle FRPSPDIS has functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines, as shown in figure 6.

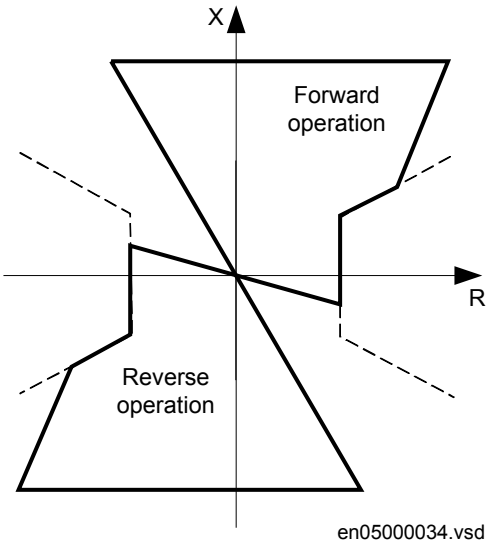


Figure 10. Typical quadrilateral distance protection zone with Phase selection, quadrilateral characteristic with settable angle function FRPSPDIS activated

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

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

The distance protection zones can operate, 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 and so on.

Phase selection, quadrilateral characteristic with settable angle FRPSPDIS

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

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

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

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

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.

Power swing logic ZMRPSL

Additional logic is available to secure tripping for faults during power swings and prevent tripping at power swings started by a fault in the network.

Pole slip protection PSPPPAM

Sudden events in an electrical power system such as large changes in load, fault occurrence or fault clearance, can cause power oscillations referred to as power swings. In a non-recoverable situation, the power swings become so severe that the synchronism is lost, a condition referred to as pole slipping. The main purpose of the pole slip protection (PSPPPAM) is to detect, evaluate, and take the required action for pole slipping occurrences in the power system. The electrical system parts swinging to each other can be separated with the line/s closest to the centre of the power swing allowing the two systems to be stable as separated islands.

Automatic switch onto fault logic, voltage and current based ZCVPSOF

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

Phase preference logic PPLPHIZ

The optional phase preference logic main purpose is to provide a selective tripping for cross-country faults in isolated or high impedance-earthed networks.

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.

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

Instantaneous residual overcurrent protection EFPIOC

The Instantaneous residual overcurrent protection EFPIOC has a low transient overreach and short tripping times to allow the use for instantaneous earth-fault protection, with the reach limited to less than the typical eighty percent of the line at minimum source impedance. EFPIOC 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 used as main protection for phase-to-earth faults.

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

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

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.

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

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

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

Sensitive directional residual overcurrent and power protection SDEPSDE

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

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

Thermal overload protection, one time constant LPTTR

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

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

The three-phase current measuring protection has an I^2t characteristic with settable time constant and a thermal memory..

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

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 inadvertent 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.

Stub protection STBPTOC

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

The stub protection STBPTOC covers the zone between the current transformers and the open disconnector. The three-phase instantaneous overcurrent function is released from a normally open, NO (b) auxiliary contact on the line disconnector.

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 a 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 also provided with undervoltage blocking.

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

Overfrequency protection SAPTOF

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

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

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

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

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.

Autorecloser SMBRREC

The autorecloser SMBRREC function provides high-speed and/or delayed auto-reclosing for single or multi-breaker applications.

Up to five three-phase reclosing attempts can be included by parameter setting. The first attempt can be single-, two and/or three phase for single phase or multi-phase faults respectively.

Multiple autoreclosing functions are provided for multi-breaker arrangements. A priority circuit allows one circuit breaker to close first and the second will only close if the fault proved to be transient.

Each autoreclosing function is configured to co-operate with the synchrocheck 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.

Interlocking

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

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

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

Logic rotating switch for function selection and LHMI presentation SLGGIO

The logic rotating switch for function selection and LHMI presentation (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 distance or overcurrent protection ZCPSCH

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

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

Phase segregated communication is also available for correct operation at simultaneous faults when three distance protection communication channels are available between the line ends.

Phase segregated scheme communication logic for distance protection ZC1PPSCH

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

The main purpose of the Phase segregated scheme communication logic for distance protection (ZC1PPSCH) function is to supplement the distance protection function such that:

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

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

ZC1PPSCH can be completed with the current reversal and WEI logic for phase segregated communication, when found necessary in Blocking and Permissive overreaching schemes.

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

The current reversal function is used to prevent unwanted operations due to current reversal when using permissive overreach protection schemes in application with parallel lines when the overreach from the two ends overlap on the parallel line.

The weak-end infeed logic is used in cases where the apparent power behind the protection can be too low to activate the distance protection function. When activated, received carrier signal together with local undervoltage criteria and no reverse zone operation gives an instantaneous trip. The received signal is also echoed back during 200 ms to accelerate the sending end.

Three phase or phase segregated scheme logic is available.

Current reversal and weak-end infeed logic for phase segregated communication ZC1WPSCH

Current reversal and weak-end infeed logic for phase segregated communication (ZC1WPSCH) function is used to prevent unwanted operations due to current reversal when using permissive overreach protection schemes in application

with parallel lines when the overreach from the two ends overlaps on the parallel line.

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

Local acceleration logic ZCLCPLAL

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

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

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.

Direct transfer trip DTT

Low active power and power factor protection LAPPGAPC

Low active power and power factor protection (LAPPGAPC) function measures power flow. It can be used for protection and monitoring of:

- phase wise low active power
- phase wise low power factor
- phase wise reactive power and apparent power as service values

Following features are available:

- Definite time stage for low active power protection
- Definite time stage for low power factor protection
- Individual enabling of Low active power and Low power factor functions
- Low active power trip with 2 selection modes '1 out of 3' and '2 out of 3'
- Phase wise calculated values of apparent power, reactive power, active power and power factor are available as service values
- Insensitive to small variations in voltage and current

Compensated over and undervoltage protection COUVGAPC

Compensated over and undervoltage protection (COUVGAPC) function calculates the remote end voltage of the transmission line utilizing local measured voltage, current and with the help of transmission line parameters, that is, line resistance, reactance, capacitance and local shunt reactor. For protection of long transmission line for in zone faults, COUVGAPCcan be incorporated with local criteria within direct transfer trip logic to ensure tripping of the line only under abnormal conditions.

Sudden change in current variation SCCVPTOC

Sudden change in current variation (SCCVPTOC) function is a fast way of finding any abnormality in line currents. When there is a fault in the system, the current changes faster than the voltage. SCCVPTOC finds abnormal condition based on

phase-to-phase current variation. The main application is as a local criterion to increase security when transfer trips are used.

Carrier receive logic LCCRPTRC

In Direct transfer trip (DTT) scheme, the received CR signal gives the trip to the circuit breaker after checking certain local criteria functions in order to increase the security of the overall tripping functionality. Carrier receive logic (LCCRPTRC) function gives final trip output of the DTT scheme.

Features:

- Carrier redundancy to ensure security in DTT scheme
- Blocking function output on CR Channel Error
- Phase wise trip outputs

Negative sequence overvoltage protection LCNSPTOV

Negative sequence components are present in all types of fault condition. Negative sequence voltage and current get high values during unsymmetrical faults.

Zero sequence overvoltage protection LCZSPTOV

Zero sequence components are present in all abnormal conditions involving earth. They can reach considerably high values during earth faults.

Negative sequence overcurrent protection LCNSPTOC

Negative sequence components are present in all types of fault condition. They can reach considerably high values during abnormal operation.

Zero sequence overcurrent protection LCZSPTOC

Zero sequence components are present in all abnormal conditions involving earth. They have a considerably high value during earth faults.

Three phase overcurrent LCP3PTOC

Three phase overcurrent (LCP3PTOC) is designed for overcurrent conditions.

Features:

- Phase wise start and trip signals
- Overcurrent protection
- Phase wise RMS current is available as service values
- Single definite time stage trip function.

Three phase undercurrent LCPCPTUC

Three phase undercurrent function (LCP3PTUC) is designed for detecting loss of load conditions.

Features:

- Phase wise start and trip signals
- Phase wise RMS current is available as service values
- Single definite time stage trip function

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 a settable pulse prolongation to ensure a trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

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

Trip matrix logic 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
- Fault locator

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 (triggered).

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 signal to other systems or equipment in the substation. It can also be used inside the same IED, to attach a RANGE aspect to an analog value and to permit measurement supervision on that value.

Measured value expander block RANGE_XP

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

Fault locator LMBRFLO

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

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

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

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

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.

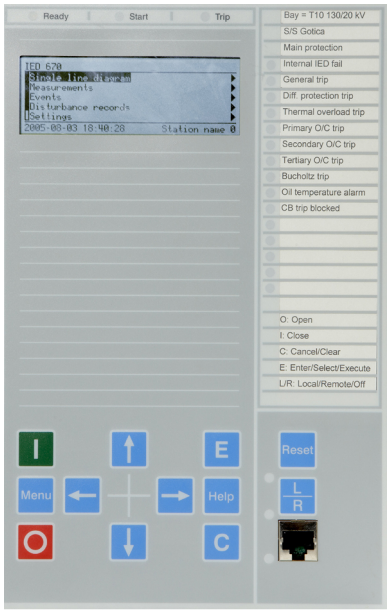
16. Human machine interface

Human machine interface

The local human machine interface is available in a small and a medium sized model. The difference between the two models is the size of the LCD. The small size LCD can display seven lines of text and the medium size LCD can display the single line diagram with up to 15 objects on each page. Up to 12 single line diagram pages can be defined, depending on the product capability.

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.



en05000055.jpg

Figure 11. Small, alpha numeric HMI

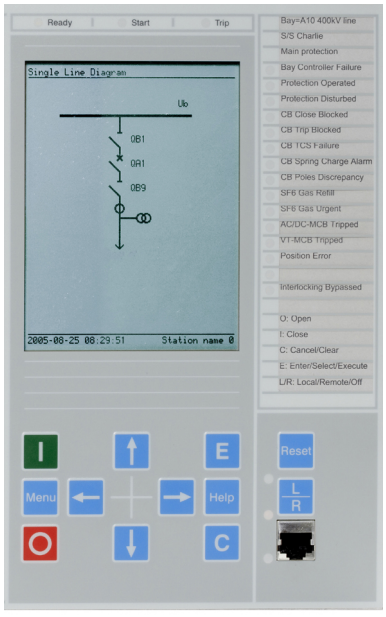


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Figure 12. Medium graphic HMI, 15 controllable objects

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, medium and long range LDCM

The line data communication module (LDCM) is used for communication between the IEDs situated at distances <110 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 X.21 line data communication module X.21-LDCM

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

Galvanic interface G.703 resp G.703E1

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

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 Long range (1550 nm single mode), Medium range (1310 nm single mode) and Short range (850 nm multi mode) are available.

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

The galvanic X.21 line data communication module is used for connection to telecommunication equipment, for example leased telephone lines. The module supports 64 kbit/s data communication between IEDs.

Examples of applications:

- Line differential protection
- Binary signal transfer

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.

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

Transformer input module TRM

The transformer input module is used to galvanically separate and 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

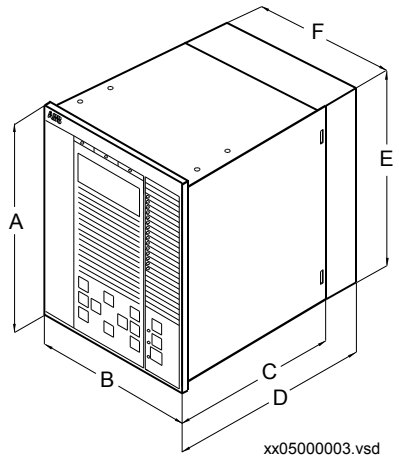


Figure 13. 1/2 x 19” case with rear cover

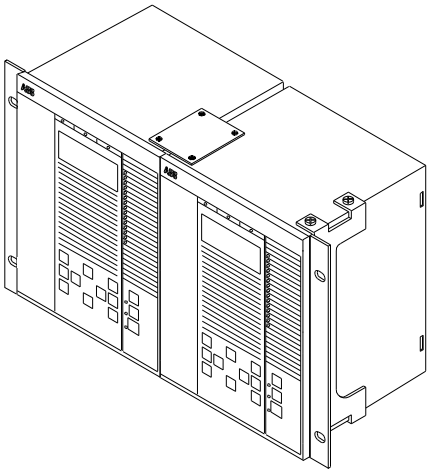


Figure 14. Side-by-side mounting

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)

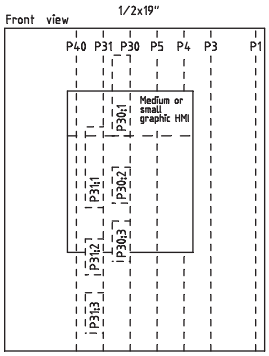
Mounting alternatives

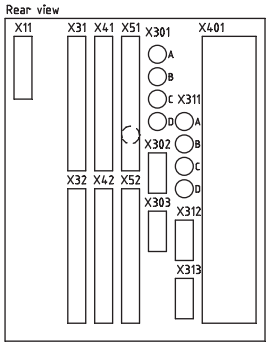
- 19” rack mounting kit
- Flush mounting kit with cut-out dimensions:
  - 1/2 case size (h) 254.3 mm (w) 210.1 mm
  - 3/4 case size (h) 254.3 mm (w) 322.4 mm
  - 1/1 case size (h) 254.3 mm (w) 434.7 mm
- Wall mounting kit

See ordering for details about available mounting alternatives.

20. Connection diagrams

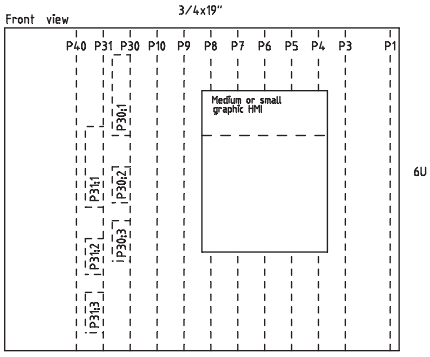
Table 1. Designations for 1/2 x 19” casing with 1 TRM slot

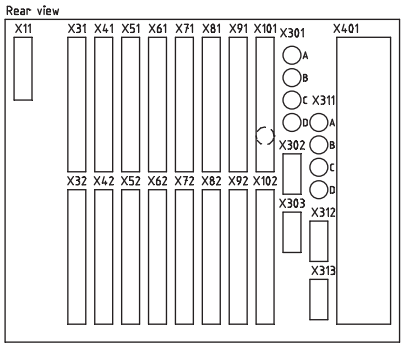




Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X51 and X52
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, 313
TRM	X401

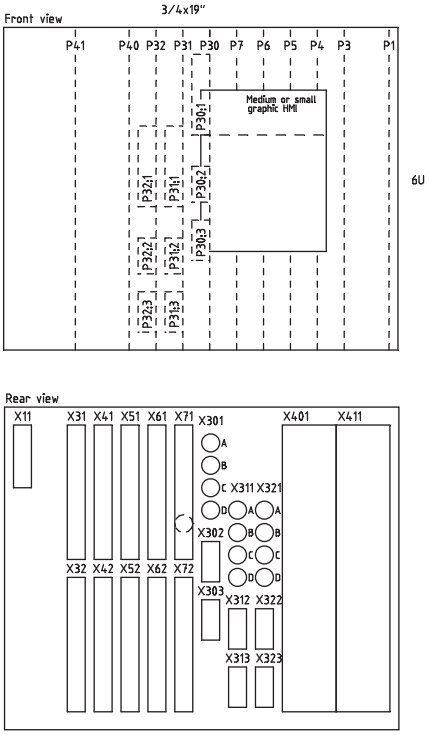
Table 2. Designations for 3/4 x 19” casing with 1 TRM slot





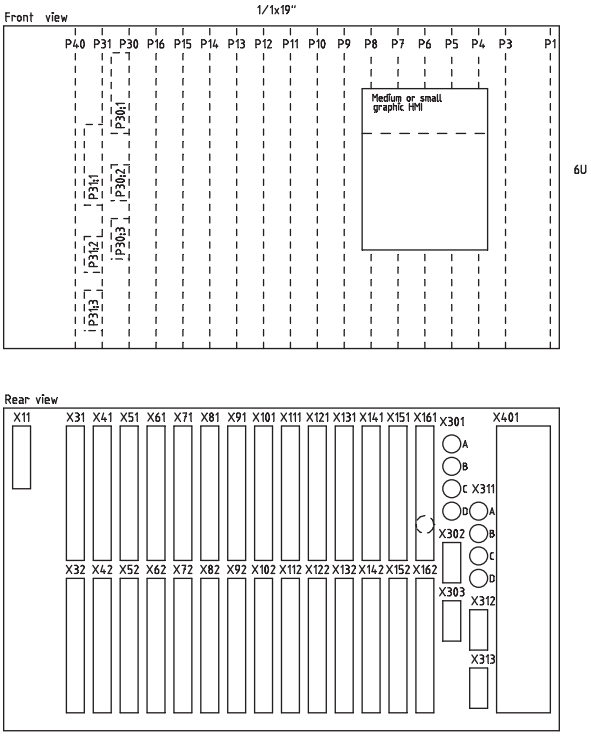
Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X101 and X102
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, X313
TRM	X401

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



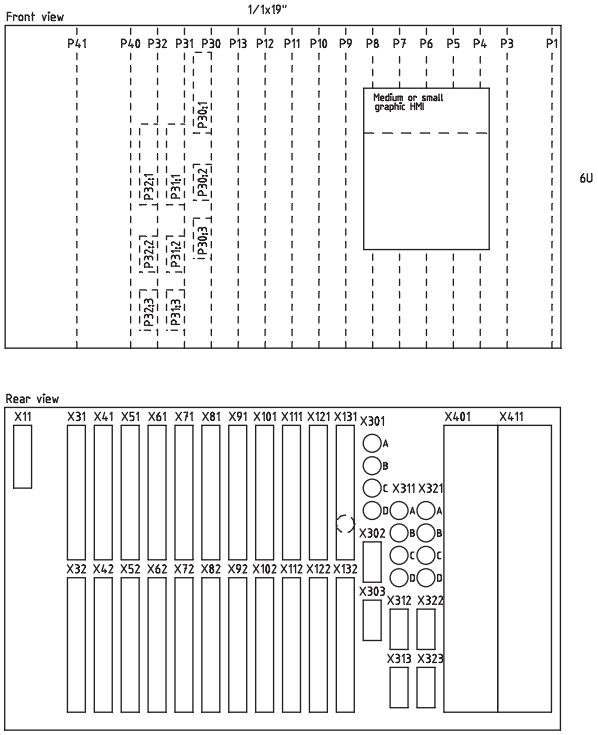
Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X71 and X72
SLM	X301:A, B, C, D
LDCM, IRIG-B or RS485	X302
LDCM or RS485	X303
OEM	X311:A, B, C, D
LDCM, RS485 or GTM	X312, X313, X322, X323
TRM 1	X401
TRM 2	X411

Table 4. Designations for 1/1 x 19” casing with 1 TRM slot



Module	Rear Positions
PSM	X11
BIM, BOM, SOM, IOM or MIM	X31 and X32 etc. to X161 and X162
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
TRM	X401

Table 5. 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

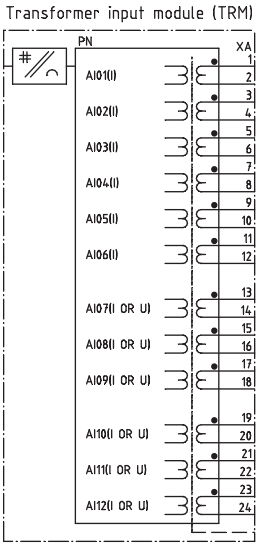


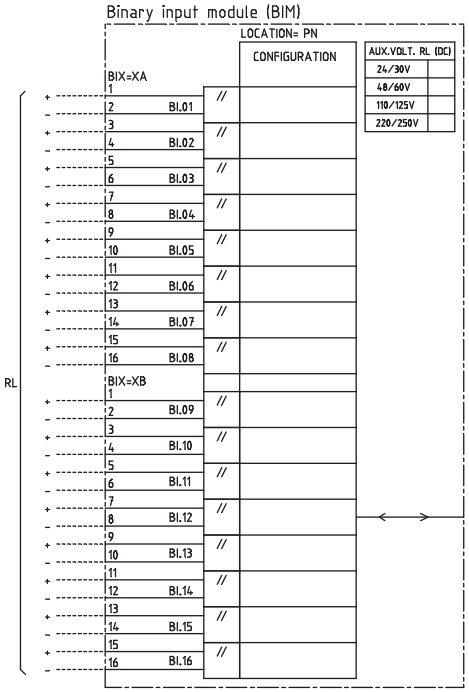
Figure 15. Transformer input module (TRM)

■ Indicates high polarity

Current/voltage configuration (50/60 Hz)	**CT/VT-input designation** according to figure 15											
	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, 5A+1I, 1A+5U	5A	5A	5A	5A	5A	5A	1A	110-220V	110-220V	110-220V	110-220V	110-220V
3I, 5A+4I, 1A+5U	5A	5A	5A	1A	1A	1A	1A	110-220V	110-220V	110-220V	110-220V	110-220V
3IM, 1A+4IP, 1A+5U	1AM *)	1AM *)	1AM *)	1A	1A	1A	1A	110-220V	110-220V	110-220V	110-220V	110-220V
3IM, 5A+4IP, 5A+5U	5AM *)	5AM *)	5AM *)	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
3I, 5A+3I, 1A+6U	5 A	5 A	5 A	1A	1A	1A	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.



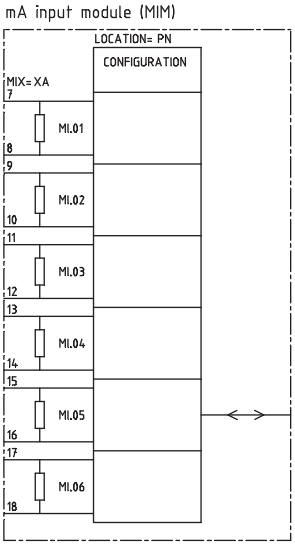
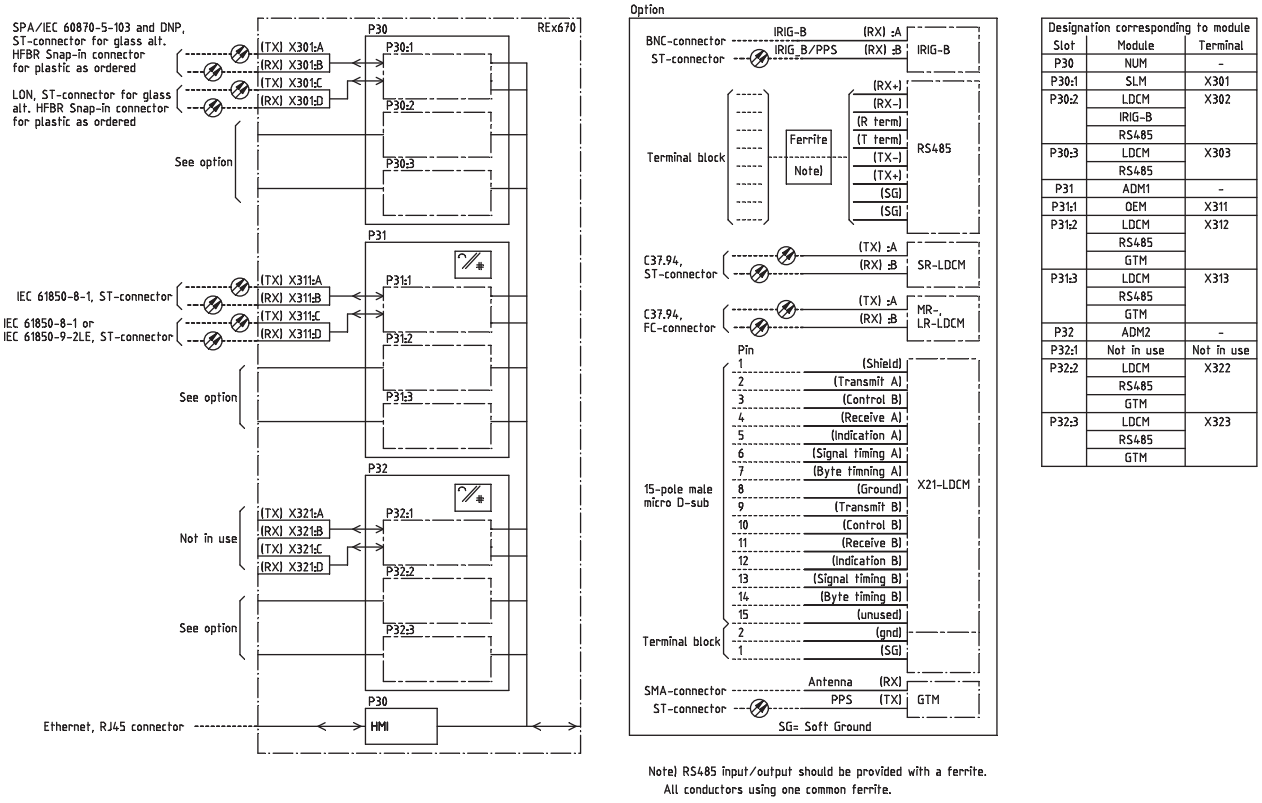


Figure 17. mA input module (MIM)

Figure 16. 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.



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 18. IED with basic functionality and communication interfaces

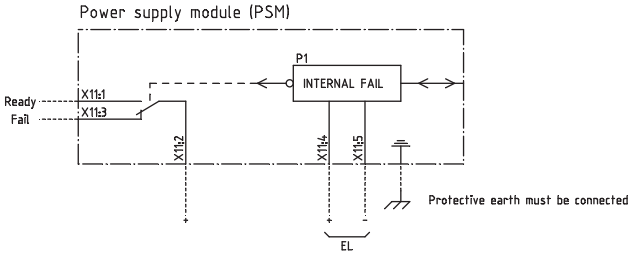


Figure 19. Power supply module (PSM)

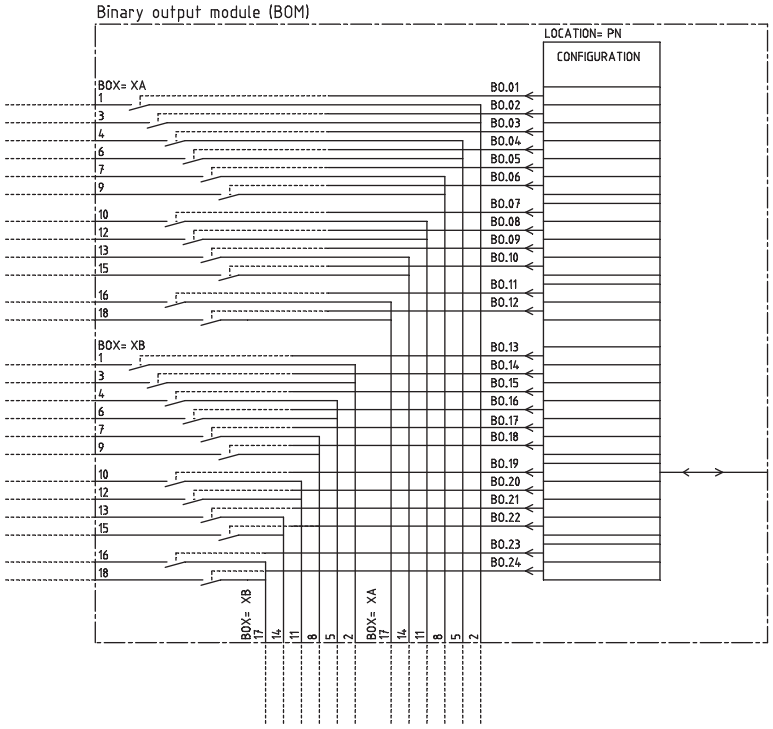


Figure 20. Binary output module (BOM). Output contacts named XA corresponds to rear position X31, X41, and so on, and output contacts named XB to rear position X32, X42, and so on.

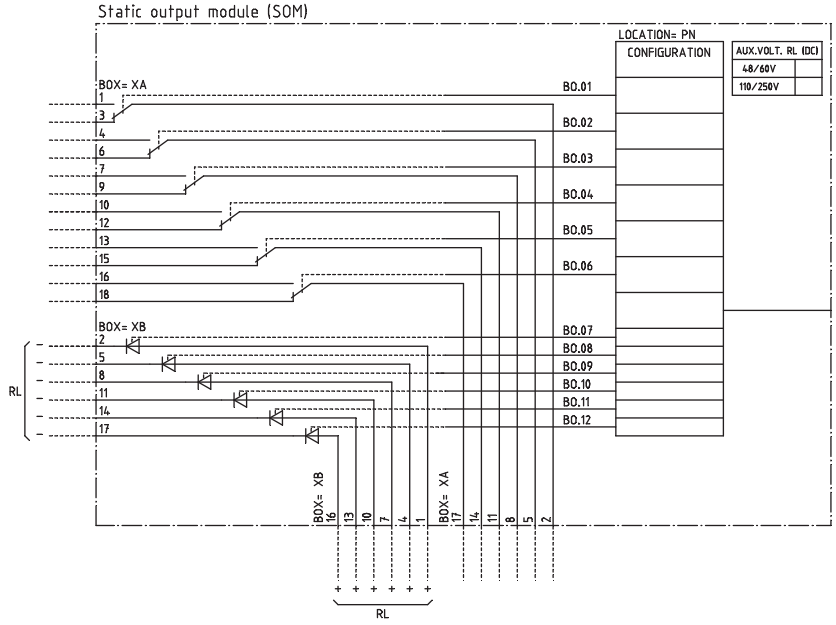


Figure 21. Static output module (SOM)

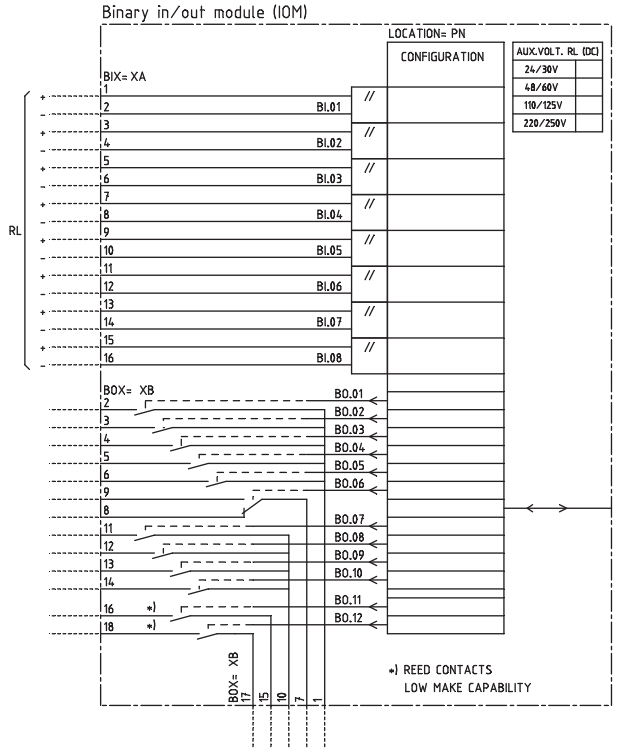


Figure 22. Binary in/out module (IOM). Input contacts named XA corresponds to rear position X31, X41, and so on, and output contacts named XB to rear position X32, X42, and so on.

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 6. 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 7. 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 8. MIM - mA input module

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

Table 9. OEM - Optical ethernet module

Quantity	Rated value
Number of channels	1 or 2
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 10. PSM - Power supply module

Quantity	Rated value	Nominal range
Auxiliary dc voltage, EL (input)	EL = (24 - 60) V EL = (90 - 250) V	EL ± 20% EL ± 20%
Power consumption	50 W typically	-
Auxiliary DC power in-rush	< 5 A during 0.1 s	-

Binary inputs and outputs

Table 11. BIM - Binary input module

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

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

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

Quantity	Rated value	Nominal range
Binary inputs	16	-
DC voltage, RL	24/30 V 48/60 V 110/125 V 220/250 V	RL ± 20% RL ± 20% RL ± 20% RL ± 20%
Power consumption 24/30 V 48/60 V 110/125 V 220/250 V	 max. 0.05 W/input max. 0.1 W/input max. 0.2 W/input max. 0.4 W/input	-
Counter input frequency	10 pulses/s max	-
Balanced counter input frequency	40 pulses/s max	-
Oscillating signal discriminator	Blocking settable 1–40 Hz Release settable 1–30 Hz	

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

Table 13. IOM - Binary input/output module

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

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

Table 14. 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 DC
Test voltage across open contact, 1 min	1000 V rms	800 V DC
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A	 8 A 10 A 12 A
Making capacity at inductive load with L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	 220–250 V/0.4 A 110–125 V/0.4 A 48–60 V/0.2 A 24–30 V/0.1 A
Breaking capacity for AC, cos φ > 0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	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 15. IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-2)

Function or quantity	Trip and Signal relays	Fast signal relays (parallel reed relay)
Binary outputs	IOM: 10	IOM: 2
Max system voltage	250 V AC, DC	250 V DC
Test voltage across open contact, 1 min	250 V rms	250 V rms
Current carrying capacity Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 A	 8 A 10 A 12 A
Making capacity at inductive loadwith L/R>10 ms 0.2 s 1.0 s	 30 A 10 A	 0.4 A 0.4 A
Making capacity at resistive load 0.2 s 1.0 s	 30 A 10 A	 220–250 V/0.4 A 110–125 V/0.4 A 48–60 V/0.2 A 24–30 V/0.1 A
Breaking capacity for AC, cos φ>0.4	250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R < 40 ms	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A	48 V/1 A 110 V/0.4 A 220 V/0.2 A 250 V/0.15 A
Maximum capacitive load	-	10 nF

Table 16. 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 17. 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	8A
1.0s	10A
Making capacity at capacitive load with the maximum capacitance of 0.2 µF:	
0.2s	30A
1.0s	10A
Breaking capacity for DC with L/R ≤ 40ms	48V / 1A 110V / 0.4A 125V / 0.35A 220V / 0.2A 250V / 0.15A

Table 18. 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 Per relay, continuous Per relay, 1 s Per process connector pin, continuous	 8 A 10 A 12 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 19. 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 20. Auxiliary DC supply voltage influence on functionality during operation

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

Table 21. 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 22. 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 23. 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 24. 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 25. CE compliance

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

Table 26. 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 27. 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 power	U>Trip^2/SeriesResistor ≤200 W	-
Operate time	10 ms typically at 0 to 10 x U_d	-
Reset time	105 ms typically at 10 to 0 x U_d	-
Critical impulse time	2 ms typically at 0 to 10 x U_d	-

Table 28. Line differential protection L3CPDIF, L6CPDIF, LT3CPDIF, LT6CPDIF

Function	Range or value	Accuracy
Minimum operate current	(20-200)% of *IBase*	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I >I_r
SlopeSection2	(10.0-50.0)%	-
SlopeSection3	(30.0-100.0)%	-
EndSection 1	(20–150)% of *IBase*	-
EndSection 2	(100–1000)% of *IBase*	-
Unrestrained limit function	(100–5000)% of *IBase*	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I > I_r
Second harmonic blocking	(5.0–100.0)% of fundamental	± 2.0% of I_r
Fifth harmonic blocking	(5.0–100.0)% of fundamental	± 6.0% of I_r
Inverse characteristics, see table 124, 125 and table 126	19 curve types	See table 124 and table 125
Operate time	25 ms typically at 0 to 10 x I_d	-
Reset time	15 ms typically at 10 to 0 x I_d	-
Critical impulse time	2 ms typically at 0 to 10 x I_d	-
Charging current compensation	On/Off	-

Table 29. Additional security logic for differential protection STSGGIO

Function	Range or value	Accuracy
Operate current, zero sequence	(1-100)% of IBase	±1,0% of I_r
Operate current, low operation	(1-100)% of IBase	±1,0% of I_r
Operate voltage, phase to neutral	(1-100)% of UBase	± 0,5% of U_r
Operate voltage, phase to phase	(1-100)% of UBase	± 0,5% of U_r
Timers, general	(0.000-60.000) s	± 0.5% ± 10 ms
Critical impulse time	10 ms typically at 0.5 to.2 x Iset	-
Impulse margin time	20 ms typically	-
Transient overreach	< 2% at τ = 100 ms	-

Impedance protection

Table 30. Distance measuring zone, Quad ZMQPDIS

Function	Range or value	Accuracy
Number of zones	5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/phase	
Zero sequence reactance	(0.10-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
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. Distance measuring zone, quadrilateral characteristic for series compensated lines ZMCPDIS, ZMCAPDIS

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

Function	Range or value	Accuracy
Number of zones with selectable directions	5 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: 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 34. Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS

Function	Range or value	Accuracy
Number of zones	5 with selectable direction	-
Minimum operate current	(10-30)% of *IBase*	-
Positive sequence reactance	(0.50-3000.00) Ω/phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.50-9000.00) Ω/phase	
Zero sequence resistance	(0.50-3000.00) Ω/phase	
Fault resistance, Ph-E	(1.00-9000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CCVT's and 0.5<SIR<30	-
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 35. 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 36. Distance measuring zone, quadrilateral characteristic, separate settings ZMRPDIS, ZMRAPDIS

Function	Range or value	Accuracy
Number of zones	5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	± 2.0% static accuracy ± 2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/phase	
Zero sequence reactance	(0.10-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
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 37. Phase selection with load encroachment, quadrilateral characteristic FRPSPDIS

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 I_r Current range: (0.5-30) x IBase 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 38. 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

Table 39. Pole slip protection PSPPPAM

Function	Range or value	Accuracy
Impedance reach	(0.00–1000.00)% of Zbase	± 2.0% of Ur/Ir
Characteristic angle	(72.00–90.00) degrees	± 5.0 degrees
Start and trip angles	(0.0–180.0) degrees	± 5.0 degrees
Zone 1 and Zone 2 trip counters	(1-20)	-

Table 40. Phase preference logic PPLPHIZ

Function	Range or value	Accuracy
Operate value, phase-to-phase and phase-to-neutral undervoltage	(10.0 - 100.0)% of UBase	± 0,5% of U_r
Reset ratio, undervoltage	< 105%	-
Operate value, residual voltage	(5.0 - 70.0)% of UBase	± 0,5% of U_r
Reset ratio, residual voltage	> 95%	-
Operate value, residual current	(10 - 200)% of IBase	± 1,0% of I_r for I < I_r ± 1,0% of I for I > I_r
Reset ratio, residual current	> 95%	-
Timers	(0.000 - 60.000) s	± 0,5% ± 10 ms
Operating mode	No Filter, NoPref Cyclic: 1231c, 1321c Acyclic: 123a, 132a, 213a, 231a, 312a, 321a	

Table 41. Automatic switch onto fault logic, voltage and current based ZCVPSOF

Parameter	Range or value	Accuracy
Operate voltage, detection of dead line	(1–100)% of *UBase*	± 0.5% of U_r
Operate current, detection of dead line	(1–100)% of *IBase*	± 1.0% of I_r
Delay following dead line detection input before Automatic switch into fault logic function is automatically turned On	(0.000–60.000) s	± 0.5% ± 10 ms
Time period after circuit breaker closure in which Automatic switch into fault logic function is active	(0.000–60.000) s	± 0.5% ± 10 ms

Current protection

Table 42. Instantaneous phase overcurrent protection PHPIOC

Function	Range or value	Accuracy
Operate current	(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%	-
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 43. Four step phase overcurrent protection OC4PTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Min. operating current	(1-10000)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ±1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(40.0–65.0) degrees	± 2.0 degrees
Relay operating angle (ROA)	(40.0–89.0) degrees	± 2.0 degrees
2nd harmonic blocking	(5–100)% of fundamental	± 2.0% of I_r
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	± 0.2 % or ± 35 ms whichever is greater
Minimum operate time	(0.000-60.000) s	± 2.0 % or ± 40 ms whichever is greater
Inverse characteristics, see table 124, table 125 and table 126	16 curve types	See table 124, table 125 and table 126
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 44. Instantaneous residual overcurrent protection EFPIOC

Function	Range or value	Accuracy
Operate current	(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%	-
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 45. Four step residual overcurrent protection EF4PTOC

Function	Range or value	Accuracy
Operate current	(1-2500)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate current for directional comparison	(1–100)% of *IBase*	± 1.0% of I_r
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Inverse characteristics, see table 124, table 125 and table 126	18 curve types	See table 124, table 125 and table 126
Second harmonic restrain operation	(5–100)% of fundamental	± 2.0% 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	(1-30)% of *IBase*	±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 46. 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 124, table 125 and table 126	18 curve types	See table 124, table 125 and table 126
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 47. Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot \cos\varphi$ directional residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Operate level for $3I_0 \cdot 3U_0 \cdot \cos\varphi$ directional residual power	(0.25-200.00)% of *SBase*	± 1.0% of S_r at $S \leq S_r$ ± 1.0% of S at $S > S_r$ At low setting: (0.25-5.00)% of *SBase* ± 10% of set value
Operate level for $3I_0$ and φ residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $\leq I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Operate level for non-directional overcurrent	(1.00-400.00)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$ At low setting <5% of I_r: ±0.1% of I_r
Operate level for non-directional residual overvoltage	(1.00-200.00)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Residual release current for all directional modes	(0.25-200.00)% of *IBase*	± 1.0% of I_r at $I \leq I_r$ ± 1.0% of I at $I > I_r$ At low setting: (0.25-1.00)% of I_r: ±0.05% of I_r (1.00-5.00)% of I_r: ±0.1% of I_r
Residual release voltage for all directional modes	(0.01-200.00)% of *UBase*	± 0.5% of U_r at $U \leq U_r$ ± 0.5% of U at $U > U_r$
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±10 ms
Inverse characteristics, see table 124, table 125 and table 126	19 curve types	See table 124, table 125 and table 126
Relay characteristic angle RCA	(-179 to 180) degrees	± 2.0 degrees
Relay open angle ROA	(0-90) degrees	± 2.0 degrees
Operate time, non-directional residual over current	60 ms typically at 0 to 2 x I_{set}	-

Table 47. Sensitive directional residual overcurrent and power protection SDEPSDE, continued

Function	Range or value	Accuracy
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 48. Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(0-400)% of *IBase*	± 1.0% of I_r
Reference temperature	(0-400)°C, (0 - 600)°F	± 1.0°C, ±2°F
Operate time: $t = \tau \ln \left[\frac{I^2 - I_p^2}{I^2 - I_p^2 - \frac{T_{Trip} - T_{Amb}}{T_{ref}} \cdot I_{ref}^2} \right]$ (Equation 1) T_{Trip}= set operate temperature T_{Amb} = ambient temperature T_{ref} = temperature rise above ambient at I_{ref} I_{ref} = reference load current I = actual measured current I_p = load current before overload occurs	Time constant τ = (1–1000) minutes	IEC 60255-8, ±5.0% or ±200 ms whichever is greater
Alarm temperature	(0-200)°C, (0-400)°F	± 2.0% of heat content trip
Trip temperature	(0-400)°C, (0-600)°F	± 2.0% of heat content trip
Reset level temperature	(0-400)°C, (0-600)°F	± 2.0% of heat content trip

Table 49. 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 50. Stub protection STBPTOC

Function	Range or value	Accuracy
Operating current	(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%	-
Definite time	(0.000-60.000) s	± 0.5% ± 10 ms
Operate time, start function	20 ms typically at 0 to 2 x I_{set}	-
Reset time, startfunction	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 51. 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 52. 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 53. 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 54. 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 55. 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, step 1 and step 2	(1–100)% of *UBase*	± 0.5% of U_r
Inverse time characteristics for step 1 and step 2, see table 128	-	See table 128
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 10 ms
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 x U_{set} to 0	-
Reset time, start function	25 ms typically at 0 to 2 x U_{set}	-
Critical impulse time	10 ms typically at 2 x U_{set} to 0	-
Impulse margin time	15 ms typically	-

Table 56. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(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 steps 1 and 2, see table 127	-	See table 127
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 10 ms
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 57. Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and step 2	(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 129	-	See table 129
Definite time setting, step 1	(0.00–6000.00) s	± 0.5% ± 10 ms
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 58. 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 $IEEE: t = \frac{(0.18 \cdot k)}{(M-1)^2}$ (Equation 2) where M = (E/f)/(Ur/fr)	± 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	(0.00–9000.00)	± 0.5% ± 10 ms

Table 59. 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 60. 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 61. 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 $t = \left[\frac{U - UMin}{UNom - UMin}\right]^{Exponent} \cdot \left(tMax - tMin\right) + tMin$ (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	5% + 200 ms

Table 62. 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 63. 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 64. 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 124 and table 125	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 124 and table 125
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}	-
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	-

Table 64. General current and voltage protection CVGAPC , continued

Function	Range or value	Accuracy
Relay characteristic angle	(-180 to +180) degrees	± 2.0 degrees
Relay operate angle	(1 to 90) degrees	± 2.0 degrees
Reset ratio, overcurrent	> 95%	-
Reset ratio, undercurrent	< 105%	-
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent:		
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Undercurrent:		
Critical impulse time	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time	15 ms typically	-
Overvoltage:		
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-
Undervoltage:		
Critical impulse time	10 ms typically at 2 to 0 x U_{set}	-
Impulse margin time	15 ms typically	-

Secondary system supervision

Table 65. Current circuit supervision CCSRDIF

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

Table 66. 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, general start of function	25 ms typically at 1 to 0 of Ubase	-
Reset time, general start of function	35 ms typically at 0 to 1 of Ubase	-

Control

Table 67. 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}	0.500 - 2.000	-
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 for synchrocheck	(0.003-1.000) Hz	± 2.0 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	± 2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	(0.02-0.5) p.u	± 0.5% of U_r
Time delay output for synchrocheck	(0.000-60.000) s	± 0.5% ± 10 ms
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	± 2.0 mHz
Frequency difference maximum limit for synchronizing	(0.050-0.500) Hz	± 2.0 mHz
Maximum allowed frequency rate of change	(0.000-0.500) Hz/s	± 10.0 mHz/s
Closing time of the breaker	(0.000-60.000) s	± 0.5% ± 10 ms
Breaker closing pulse duration	(0.000-60.000) s	± 0.5% ± 10 ms
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-60.000) s	± 0.5% ± 10 ms
Minimum time to accept synchronizing conditions	(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 *UBaseBus and UBaseLine*	± 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 68. Autorecloser SMBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 1Ph shot 1 - t1 2Ph shot 1 - t1 3PhHS shot 1 - t1 3PhDld	(0.000-60.000) s	± 0.5% ± 10 ms
shot 2 - t2 shot 3 - t3 shot 4 - t4 shot 5 - t5	(0.00-6000.00) s	
Extended autorecloser open time	(0.000-60.000) s	
Autorecloser maximum wait time for sync	(0.00-6000.00) s	
Maximum trip pulse duration	(0.000-60.000) s	
Inhibit reset time	(0.000-60.000) s	
Reclaim time	(0.00-6000.00) s	
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	
Circuit breaker closing pulse length	(0.000-60.000) s	
CB check time before unsuccessful	(0.00-6000.00) s	
Wait for master release	(0.00-6000.00) s	
Wait time after close command before proceeding to next shot	(0.000-60.000) s	

Scheme communication

Table 69. Scheme communication logic for distance or overcurrent protection ZCPSCH

Function	Range or value	Accuracy
Scheme type	Intertrip Permissive Underreach Permissive Overreach Blocking	-
Co-ordination time for blocking communication scheme	(0.000-60.000) s	± 0.5% ± 10 ms
Minimum duration of a send signal	(0.000-60.000) s	± 0.5% ± 10 ms
Security timer for loss of guard signal detection	(0.000-60.000) s	± 0.5% ± 10 ms
Operation mode of unblocking logic	Off NoRestart Restart	-

Table 70. Phase segregated scheme communication logic for distance protection ZC1PPSCH

Function	Range or value	Accuracy
Scheme type	Intertrip Permissive UR Permissive OR Blocking	-
Co-ordination time for blocking communication scheme	(0.000-60.000) s	± 0.5% ± 10 ms
Minimum duration of a carrier send signal	(0.000-60.000) s	± 0.5% ± 10 ms
Security timer for loss of carrier guard detection	(0.000-60.000) s	± 0.5% ± 10 ms
Operation mode of unblocking logic	Off NoRestart Restart	-

Table 71. Current reversal and weak-end infeed logic for distance protection ZCRWPSCH

Function	Range or value	Accuracy
Detection levelphase-to-neutral voltage	(10-90)% of UBase	± 0.5% of U_r
Detection level phase-to-phase voltage	(10-90)% of UBase	± 0.5% of U_r
Reset ratio	<105%	-
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

Table 72. Current reversal and weak-end infeed logic for phase segregated communication ZC1WPSCH

Function	Range or value	Accuracy
Detection level phase to neutral voltage	(10-90)% of UBase	± 0.5% of U_r
Detection level phase to phase voltage	(10-90)% of UBase	± 0.5% of U_r
Reset ratio	<105%	-
Operate time for current reversal	(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

Table 73. 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 74. 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

Direct transfer trip

Table 75. Low active power and power factor protection LAPPGAPC

Function	Range or value	Accuracy
Operate value, low active power	(2.0-100.0)% of SBase	± 1,0% of S_r
Reset ratio, low active power	<105%	-
Transient overreach, low active power	<20 % at τ = 100 ms	-
Operate value, low power factor	0.00-1.00	± 1,0% of S_r
Reset ratio, low power factor	<105%	-
Transient overreach, low power factor	<20 % at τ = 100 ms	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms
Critical impulse time, low active power	10 ms typically at 1.2 to 0.8xP_{set}	-
Impulse margin time, low active power	10 ms typically	-

Table 76. Compensated over- and undervoltage protection COUVGAPC

Function	Range or value	Accuracy
Operate value, undervoltage	(1-100)% of UBase	± 0,5% of U_r
Reset ratio, undervoltage	<105%	-
Critical impulse time, undervoltage	5 ms typically at 1.2 to 0.8xU_{set}	-
Impulse margin time, undervoltage	15 ms typically	-
Operate value, overvoltage	(1-200)% of UBase	± 0.5% of U_r at U<U_r ± 0.5% of U at U>U_r
Reset ratio, overvoltage	>95%	-
Critical impulse time, overvoltage	2 ms typically at 0.8 to 1.2xU_{set}	-
Impulse margin time, overvoltage	10 ms typically	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 77. Sudden change in current variation SCCVPTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(0 - 100)% of IBase	± 1,0% of I_r
Reset ratio, overcurrent	>95%	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 78. Carrier receive logic LCCRPTRC

Function	Range or value	Accuracy
Operation mode	1 Out Of 2 2 Out Of 2	-
Timer	(0.000-60.000) s	± 0.5% ± 10 ms

Table 79. Negative sequence overvoltage protection LCNSPTOV

Function	Range or value	Accuracy
Operate value, negative sequence overvoltage	(1-200)% of UBase	± 0.5% of U_r at U<U_r ± 0.5% of U at U>U_r
Reset ratio, negative sequence overvoltage	>95%	-
Operate time, start	20 ms typically at 0 to 2xU_{set}	-
Reset time, start	25 ms typically at 2 to 0xU_{set}	-
Critical impulse time, negative sequence overvoltage	10 ms typically at 0 to 2xU_{set}	-
Impulse margin time, negative sequence overvoltage	15 ms typically	-
Timers	(0.000-120.000) s	± 0.5% ± 10 ms

Table 80. Zero sequence overvoltage protection LCZSPTOV

Function	Range or value	Accuracy
Operate value, zero sequence overvoltage	(1-200)% of UBase	± 0.5% of U_r at U<U_r ± 0.5% of U at U>U_r
Reset ratio, zero sequence overvoltage	>95%	-
Operate time, start	25 ms typically at 0 to 1.5xU_{set}	-
Reset time, start	25 ms typically at 1.5 to 0xU_{set}	-
Critical impulse time, zero sequence overvoltage	10 ms typically at 0 to 1.5xU_{set}	-
Timers	(0.000-120.000) s	± 0.5% ± 10 ms

Table 81. Negative sequence overcurrent protection LCNSPTOC

Function	Range or value	Accuracy
Operate value, negative sequence overcurrent	(1 - 2500)% of IBase	± 1.0% of Ir at I < I_r ± 1.0% of I at I > I_r
Reset ratio, negative sequence overcurrent	>95%	-
Operate time, start	20 ms typically at 0 to 2xI_{set} 15 ms typically at 0 to 10xI_{set}	-
Reset time, start	25 ms typically at 2 to 0xI_{set}	-
Critical impulse time, negative sequence overcurrent	10 ms typically at 0 to 2xI_{set} 2 ms typically at 0 to 10xI_{set}	-
Impulse margin time, negative sequence overcurrent	10 ms typically	-
Timer	(0.000-60.000) s	± 0.5% ± 10 ms
Transient overreach, start function	<5% at τ = 100 ms	-

Table 82. Zero sequence overcurrent protection LCZSPTOC

Function	Range or value	Accuracy
Operate value, zero sequence overcurrent	(1-2500)% of IBase	± 1.0% of I_r at $I<I_r$ ± 1.0% of I at $I>I_r$
Reset ratio, zero sequence overcurrent	>95%	-
Operate time, start	20 ms typically at 0 to $2xI_{set}$ 15 ms typically at 0 to $10xI_{set}$	-
Reset time, start	30 ms typically at 2 to $0xI_{set}$	-
Critical impulse time, zero sequence overcurrent	10 ms typically at 0 to $2xI_{set}$ 2 ms typically at 0 to $10xI_{set}$	-
Impulse margin time, zero sequence overcurrent	15 ms typically	-
Timer	(0.000-60.000) s	± 0.5% ± 10 ms

Table 83. Three phase overcurrent LCP3PTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-2500)% of IBase	± 1.0% of Ir at $I < I_r$ ± 1.0% of I at $I > I_r$
Reset ratio, overcurrent	>95%	-
Operate time, start	20 ms typically at 0 to $2xI_{set}$ 15 ms typically at 0 to $10xI_{set}$	-
Reset time, start	30 ms typically at 2 to $0xI_{set}$	-
Critical impulse time, overcurrent	5 ms typically at 0 to $2xI_{set}$ 2 ms typically at 0 to $10xI_{set}$	-
Impulse margin time, overcurrent	10 ms typically	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 84. Three phase undercurrent LCP3TUC

Function	Range or value	Accuracy
Operate value, undercurrent	(1.00-100.00)% of IBase	± 1.0% of I_r
Reset ratio, undercurrent	>105%	-
Operate time, start	20 ms typically at 2 to $0xI_{set}$	-
Reset time, start	30 ms typically at 0 to $2xI_{set}$	-
Critical impulse time, undercurrent	10 ms typically at 2 to $0xI_{set}$	-
Impulse margin time, undercurrent	10 ms typically	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Logic

Table 85. 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 86. 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 87. 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≤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 ≤ 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 ≤ 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 88. Phase current measurement CMMXU

Function	Range or value	Accuracy
Current	(0.1-4.0) × I_r	± 0.2% of I_r at I ≤ 0.5 × I_r ± 0.2% of I at I > 0.5 × I_r
Phase angle	(0.1–4.0) x I_r	± 0.5° at 0.2 × I_r < I < 0.5 × I_r ± 0.2° at 0.5 × I_r ≤ I < 4.0 × I_r

Table 89. Phase-phase voltage measurement VMMXU

Function	Range or value	Accuracy
Voltage	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Phase angle	(10 to 300) V	± 0.3° at U ≤ 50 V ± 0.2° at U > 50 V

Table 90. Phase-neutral voltage measurement VNMMXU

Function	Range or value	Accuracy
Voltage	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Phase angle	(10 to 300) V	± 0.3° at U ≤ 50 V ± 0.2° at U > 50 V

Table 91. Current sequence component measurement CMSQI

Function	Range or value	Accuracy
Current positive sequence, I1 Three phase settings	(0.1–4.0) × I_r	± 0.2% of I_r at I ≤ 0.5 × I_r ± 0.2% of I at I > 0.5 × I_r
Current zero sequence, 3I0 Three phase settings	(0.1–1.0) × I_r	± 0.2% of I_r at I ≤ 0.5 × I_r ± 0.2% of I at I > 0.5 × I_r
Current negative sequence, I2 Three phase settings	(0.1–1.0) × I_r	± 0.2% of I_r at I ≤ 0.5 × I_r ± 0.2% of I at I > 0.5 × I_r
Phase angle	(0.1–4.0) × I_r	± 0.5° at 0.2 × I_r < I < 0.5 × I_r ± 0.2° at 0.5 × I_r ≤ I < 4.0 × I_r

Table 92. Voltage sequence measurement VMSQI

Function	Range or value	Accuracy
Voltage positive sequence, U1	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Voltage zero sequence, 3U0	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Voltage negative sequence, U2	(10 to 300) V	± 0.3% of U at U ≤ 50 V ± 0.2% of U at U > 50 V
Phase angle	(10 to 300) V	± 0.3° at U ≤ 50 V ± 0.2° at U > 50 V

Table 93. 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 94. Event counter CNTGGIO

Function	Range or value	Accuracy
Counter value	0-100000	-
Max. count up speed	10 pulses/s (50% duty cycle)	-

Table 95. 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 120
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 96. Fault locator LMBRFLO

Function	Value or range	Accuracy
Reactive and resistive reach	(0.001-1500.000) 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
Phase selection	According to input signals	-
Maximum number of fault locations	100	-

Table 97. Event list

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

Table 98. Indications

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

Table 99. 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 100. Trip value recorder

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

Table 101. 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 102. 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 103. 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 104. IEC 61850-8-1 communication protocol

Function	Value
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX
Protocol	IEC 608–5–103
Communication speed for the IEDs	9600 or 19200 Bd
Protocol	DNP3.0
Communication speed for the IEDs	300–19200 Bd
Protocol	TCP/IP, Ethernet
Communication speed for the IEDs	100 Mbit/s

Table 105. LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 106. SPA communication protocol

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

Table 107. IEC60870-5-103 communication protocol

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

Table 108. 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 109. 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 110. Galvanic X.21 line data communication module (X.21-LDCM)

Quantity	Range or value
Connector, X.21	Micro D-sub, 15-pole male, 1.27 mm (0.050") pitch
Connector, ground selection	2 pole screw terminal
Standard	CCITT X21
Communication speed	64 kbit/s
Insulation	1 kV
Maximum cable length	100 m

Table 111. 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 112. 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 113. 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 114. 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 115. Water and dust protection level according to IEC 60529

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

Table 116. 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 117. 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 118. 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 119. Self supervision with internal event list

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

Table 120. 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 121. 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 122. 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 123. 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 124. ANSI Inverse time characteristics

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

Table 125. IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{\left(I^{P} - 1 \right)} \right) \cdot k$ $I = I_{measured}/I_{set}$	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 60255-151, 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: $t = \left(\frac{A}{\left(I^{P} - C \right)} + B \right) \cdot k$ Reset characteristic: $t = \frac{TR}{\left(I^{PR} - CR \right)} \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01 A=(0.005-200.000) in steps of 0.001 B=(0.00-20.00) in steps of 0.01 C=(0.1-10.0) in steps of 0.1 P=(0.005-3.000) in steps of 0.001 TR=(0.005-100.000) in steps of 0.001 CR=(0.1-10.0) in steps of 0.1 PR=(0.005-3.000) in steps of 0.001	

Table 126. RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	IEC 60255-151, 5% + 40 ms
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot In \frac{I}{k} \right)$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	

Table 127. Inverse time characteristics for overvoltage protection

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

Table 128. Inverse time characteristics for undervoltage protection

Function	Range or value	Accuracy
Type A curve: $t = \frac{k}{\left(\frac{U < -U}{U <}\right)}$ U< = U_{set} U = $UV_{measured}$	k = (0.05-1.10) in steps of 0.01	5% +40 ms
Type B curve: $t = \frac{k \cdot 480}{\left(32 \cdot \frac{U < -U}{U <} - 0.5\right)^{2.0}} + 0.055$ U< = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01	
Programmable curve: $t = \left[\frac{k \cdot A}{\left(B \cdot \frac{U < -U}{U <} - C\right)^{P}}\right] + D$ U< = U_{set} U = $U_{measured}$	k = (0.05-1.10) in steps of 0.01 A = (0.005-200.000) in steps of 0.001 B = (0.50-100.00) in steps of 0.01 C = (0.0-1.0) in steps of 0.1 D = (0.000-60.000) in steps of 0.001 P = (0.000-3.000) in steps of 0.001	

Table 129. Inverse time characteristics for residual overvoltage protection

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

22. Ordering

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.

Product specification

Basic IED 670 platform and common functions housed in selected casing

RED670	Quantity:	☐	1MRK 002 810-AC

Default:

The IED connect CD contains configuration alternative. Use the PCM600 to create or modify the configuration. The PCM600 can also be used for adaptation of an included example configuration.

Option:

Customer specific configuration	On request

Connection type for Power supply modules and I/O modules

Rule: Same connection type for Power supply modules and I/O modules must be ordered

Compression terminals	☐	1MRK 002 960-AA
Ring lug terminals	☐	1MRK 002 960-BA

Power supply module

Rule: One Power supply module must be specified

Power supply module *(PSM)*	24-60 VDC	☐	1MRK 002 239-AB
	90-250 VDC	☐	1MRK 002 239-BB

Differential protection

Rule: One, and only one, Line differential protection must be ordered

Line differential protection, 3 CT sets, 2-3 line ends (L3CPDIF)	☐	1MRK 002 903-GB
Line differential protection, 6 CT sets, 3-5 line ends (L6CPDIF)	☐	1MRK 002 903-HB
Line differential protection 3 CT sets, with in-zone transformers, 2-3 line ends (LT3CPDIF)	☐	1MRK 002 903-KB
Line differential protection 6 CT sets, with in-zone transformers, 3-5 line ends (LT6CPDIF)	☐	1MRK 002 903-LB

Logic

Rule: One Tripping logic must be ordered

Tripping logic (SMPPTRC)	Qty:	1 ☐ 2 ☐	1MRK 002 917-AC

Optional functions

Differential protection

1Ph High impedance differential protection (HZPDIF)	Qty:	1 ☐ 2 ☐ 3 ☐	1MRK 002 901-HB
Additional security logic for differential protection (STSGGIO)	Qty:	☐	1MRK 002 903-PA

Impedance protection

Rule: One and only one of the alternatives (Alt. 1-4) can be ordered

Alternative 1:
Rule: Distance protection and Directional impedance must be ordered together
Note: Phase selection FDPSPDIS always included in this package)

Distance protection zones, quadrilateral characteristic (ZMQPDIS, ZMQAPDIS)	Qty:	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐	1MRK 002 904-XB
Directional impedance quadrilateral (ZDRDIR)	Qty:	1 2 ☐ ☐	1MRK 002 904-YB
Phase selection, quadrilateral characteristic with fixed angle (FDPSPDIS)	Qty:	1 2 ☐ ☐	1MRK 002 904-AD

Alternative 2:
Rule: All functions within the alternative must be ordered

Distance measuring zone, quadrilateral characteristic for series compensated lines (ZMCPDIS, ZMCAPDIS)	Qty:	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐	1MRK 002 925-AB
Directional impedance quadrilateral, including series compensation (ZDSRDIR, 21D)	Qty:	1 2 ☐ ☐	1MRK 002 925-CB
Phase selection, quadrilateral characteristic with fixed angle (FDPSPDIS)	Qty:	1 2 ☐ ☐	1MRK 002 904-AD

Alternative 3:
Rule: All functions within the alternative must be ordered

Full scheme distance protection, mho characteristic (ZMHPDIS)	Qty:	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐	1MRK 002 925-EB
Full scheme distance protection, quadrilateral for earth faults (ZMMPDIS, ZMMAPDIS)	Qty:	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐	1MRK 002 925-GB
Directional impedance element for mho characteristic (ZDMRDIR)	Qty:	1 2 ☐ ☐	1MRK 002 924-PA
Additional distance protection directional function for earth faults (ZDARDIR)	Qty:	1 2 ☐ ☐	1MRK 002 908-VA
Mho impedance supervision logic (ZSMGAPC)	Qty:	☐	1MRK 002 908-UB
Faulty phase identification with load enchroachment (FMPSPDIS)	Qty:	1 2 ☐ ☐	1MRK 002 925-BB

Alternative 4:
Rule: All functions within the alternative must be ordered

Distance protection zone, quadrilateral characteristic, separate settings (ZMRPDIS, ZMRAPDIS)	Qty:	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐	1MRK 002 925-VA
Phase selection, quadrilateral characteristic with settable angle (FRPSPDIS)	Qty:	1 2 ☐ ☐	1MRK 002 925-XA
Directional impedance quadrilateral (ZDRDIR)	Qty:	1 2 ☐ ☐	1MRK 002 904-YB

*Note: Optional with **alternative 1*** Directional impedance element for mho characteristic (ZDMRDIR)	Qty:	1 ☐ 2 ☐	1MRK 002 924-PA
*Note: Optional with **alternative 1, 2 and 4*** Faulty phase identification with load encroachment (FMPSPDIS)	Qty:	1 ☐ 2 ☐	1MRK 002 925-BB
*Note: Optional with **alternative 3*** Phase selection, quadrilateral characteristic with fixed angle (FDPSPDIS)	Qty:	1 ☐ 2 ☐	1MRK 002 904-AD
Power swing detection (ZMRPSB)	Qty:	☐	1MRK 002 904-NB
Power swing logic (ZMRPSL)	Qty:	☐	1MRK 002 924-RB
Pole slip/out-of-step protection (PSPPPAM)	Qty:	☐	1MRK 002 925-LB
Automatic switch onto fault logic, voltage and current based (ZCVPSOF)	Qty:	☐	1MRK 002 904-ZB
Phase preference logic (PPLPHIZ)	Qty:	☐	1MRK 002 908-LB

Current protection

Instantaneous phase overcurrent protection (PHPIOC)	Qty:	1 ☐ 2 ☐ 3 ☐	1MRK 002 906-AC
Four step phase overcurrent protection (OC4PTOC)	Qty:	☐	1MRK 002 906-BD
Instantaneous residual overcurrent protection (EFPIOC)	Qty:	☐	1MRK 002 906-CC
Four step residual overcurrent protection (EF4PTOC)	Qty:	☐	1MRK 002 906-DD
Four step directional negative phase sequence overcurrent protection (NS4PTOC)	Qty:	☐	1MRK 002 906-DM
Sensitive directional residual overcurrent and power protection (SDEPSDE)	Qty:	☐	1MRK 002 907-DC
Thermal overload protection, one time constant (LPTTR)	Qty:	1 ☐ 2 ☐	1MRK 002 906-LD
Breaker failure protection (CCRBRF)	Qty:	1 ☐ 2 ☐	1MRK 002 906-RC
Stub protection (STBPTOC)	Qty:	1 ☐ 2 ☐	1MRK 002 906-ZC
Pole discordance protection (CCRPLD)	Qty:	1 ☐ 2 ☐	1MRK 002 907-AC
Directional underpower protection (GUPPDUP)	Qty:	1 ☐ 2 ☐	1MRK 002 902-FB
Directional overpower protection (GOPPDUP)	Qty:	1 ☐ 2 ☐	1MRK 002 902-GB

Voltage protection

Two step undervoltage protection (UV2PTUV)	Qty:	1 2 ☐ ☐	1MRK 002 908-AC
Two step overvoltage protection (OV2PTOV)	Qty:	1 2 ☐ ☐	1MRK 002 908-DC
Two step residual overvoltage protection (ROV2PTOV)	Qty:	1 2 ☐ ☐	1MRK 002 908-GC
Overexcitation protection (OEXPVPH)	Qty:	☐	1MRK 002 908-MC
Voltage differential protection (VDCPTOV)	Qty:	1 2 ☐ ☐	1MRK 002 924-TB

Frequency protection

Underfrequency protection (SAPTUF)	Qty:	1 2 ☐ ☐	1MRK 002 908-NC
Overfrequency protection (SAPTOF)	Qty:	1 2 ☐ ☐	1MRK 002 908-RC
Rate-of-change frequency protection (SAPFRC)	Qty:	1 2 ☐ ☐	1MRK 002 908-SB

Multipurpose protection

General current and voltage protection (CVGAPC)	Qty:	1 2 3 4 ☐ ☐ ☐ ☐	1MRK 002 902-AB

Secondary system supervision

Current circuit supervision (CCSRDIF)	Qty:	1 2 ☐ ☐	1MRK 002 914-AB
Fuse failure supervision (SDDRFUF)	Qty:	1 2 3 ☐ ☐ ☐	1MRK 002 914-GC

Control

Synchrocheck, energizing check and synchronizing (SESRSYN)	Qty:	1 2 ☐ ☐	1MRK 002 916-AD
Autorecloser (SMBRREC)	Qty:	1 2 3 4 ☐ ☐ ☐ ☐	1MRK 002 916-EB

Rule: Only one of Apparatus control can be ordered

Apparatus control for single bay, max 8 apparatuses (1CB) incl. interlocking		☐	1MRK 002 916-GD
Apparatus control for single bay, max 15 apparatuses (2CBs) incl. interlocking		☐	1MRK 002 916-HD

Scheme communication

Rule: Only one of (ZCPSCH/ZC1PPSCH) can be ordered

Scheme communication logic for distance protection or overcurrent protection (ZCPSCH)	☐	1MRK 002 904-RA
Phase segregated Scheme communication logic for distance protection (ZC1PPSCH)	☐	1MRK 002 924-VA

Rule: Only one of (ZCRWPSCH/ZC1WPSCH) can be ordered

Current reversal and weak end infeed logic for distance protection (ZCRWPSCH)	☐	1MRK 002 904-SB
Current reversal and weak end infeed logic for phase segregated communication (ZC1WPSCH)	☐	1MRK 002 925-DB
Local acceleration logic (ZCLCPLAL)	☐	1MRK 002 904-VC
Scheme communication logic for residual overcurrent protection (ECPSCH)	☐	1MRK 002 906-GA
Current reversal and weak end infeed logic for residual overcurrent protection (ECRWPSCH)	☐	1MRK 002 906-HB

Direct transfer trip

Direct transfer trip (DTT)	Qty:	☐	1MRK 002 927-XA

Station communication

Note: Require 2-channel OEM

IEC 62439-3 Edition 1 parallel redundancy protocol	☐	1MRK 002 924-YR
IEC 62439-3 Edition 2 parallel redundancy protocol	☐	1MRK 002 924-YS

First local HMI user dialogue language

Rule: One must be ordered

HMI language, English IEC	☐	1MRK 002 930-AA
HMI language, English US	☐	1MRK 002 930-BA

Additional local HMI user dialogue language

Rule: Maximum one alternative

HMI language, German	☐	1MRK 002 920-AB
HMI language, Russian	☐	1MRK 002 920-BB
HMI language, French	☐	1MRK 002 920-DB
HMI language, Spanish	☐	1MRK 002 920-DB
HMI language, Polish	☐	1MRK 002 920-GB
HMI language, Hungarian	☐	1MRK 002 920-FB
HMI language, Czech	☐	1MRK 002 920-HB
HMI language, Swedish	☐	1MRK 002 920-KB

Optional hardware

Human machine hardware interface

Rule: One must be ordered.

Display type	Keypad symbol	Case size		
Small, alpha numeric	IEC	1/2 19"	☐	1MRK 000 008-HB
Small, alpha numeric	IEC	3/4 19"	☐	1MRK 000 008-PB
Small, alpha numeric	IEC	1/1 19"	☐	1MRK 000 008-KB
Medium, graphic display	IEC	1/2 19"	☐	1MRK 000 008-LB
Medium, graphic display	IEC	1/1 19"	☐	1MRK 000 008-MB
Medium, graphic display	IEC	3/4 19"	☐	1MRK 000 008-NB
Medium, graphic display	ANSI	1/2 19"	☐	1MRK 000 008-LC
Medium, graphic display	ANSI	3/4 19"	☐	1MRK 000 008-NC
Medium, graphic display	ANSI	1/1 19"	☐	1MRK 000 008-MC

Analog system

Rule: One Transformer input module must be ordered
Note: The same type of connection terminals has to be ordered for both TRMs

Transformer input module, compression terminals	12I, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-CG
Transformer input module, compression terminals	12I, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-CH
Transformer input module, compression terminals	9I+3U, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-BG
Transformer input module, compression terminals	9I+3U, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-BH
Transformer input module, compression terminals	5I, 1A+4I, 5A+3U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-BK
Transformer input module, compression terminals	7I+5U, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AP
Transformer input module, compression terminals	7I+5U, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AR
Transformer input module, compression terminals	6I, 5A+1I, 1A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AU
Transformer input module, compression terminals	3I, 5A+4I, 1A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AV
Transformer input module, compression terminals	3IM, 1A+4IP, 1A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-EA
Transformer input module, compression terminals	3IM, 5A+4IP, 5A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-EB
Transformer input module, compression terminals	6I+6U, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AG
Transformer input module, compression terminals	6I+6U, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AH
Transformer input module, compression terminals	3I, 5A+3I, 1A+6U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AE
Transformer input module, compression terminals	6I, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-DH
Transformer input module, compression terminals	6I, 1A, 50/60 Hz	Qty:	1 ☐	1MRK 002 247-DG
Transformer input module, compression terminals	6I, 5A, 50/60 Hz	Qty:	1 ☐	1MRK 002 247-DH

Transformer input module, ring lug terminals	12I, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-CC
Transformer input module, ring lug terminals	12I, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-CD
Transformer input module, ring lug terminals	9I+3U, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-BC
Transformer input module, ring lug terminals	9I+3U, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-BD
Transformer input module, ring lug terminals	5I, 1A+4I, 5A+3U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-BF
Transformer input module, ring lug terminals	7I+5U, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AS
Transformer input module, ring lug terminals	7I+5U, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AT
Transformer input module, ring lug terminals	6I, 5A+1I, 1A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AX
Transformer input module, ring lug terminals	3I, 5A+4I, 1A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AY
Transformer input module, ring lug terminals	3IM, 1A+4IP, 1A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-EC
Transformer input module, ring lug terminals	3IM, 5A+4IP, 5A+5U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-ED
Transformer input module, ring lug terminals	6I+6U, 1A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AC
Transformer input module, ring lug terminals	6I+6U, 5A, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AD
Transformer input module, ring lug terminals	3I, 5A+3I, 1A+6U, 50/60 Hz	Qty:	1 ☐ 2 ☐	1MRK 002 247-AF
Transformer input module, ring lug terminals	6I, 1A, 50/60 Hz	Qty:	1 ☐	1MRK 002 247-DC
Transformer input module, ring lug terminals	6I, 5A, 50/60 Hz	Qty:	1 ☐	1MRK 002 247-DD

Note: One Analog digital conversion module, with time synchronization is always delivered with each Transformer input module.

Case size

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

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

Note: Maximum quantity of I/O modules depends on the type of connection terminals.

Maximum quantity of I/O modules

Case sizes	BIM	IOM	BOM/ SOM	MIM	Maximum in case	
1/1 x 19”, one (1) TRM	14	6	4	4	14 (max 4 BOM+SOM +MIM)	☐ 1MRK 000 151-NC
1/1 x 19”, two (2) TRM	11	6	4	4	11 (max 4 BOM+SOM +MIM)	☐ 1MRK 000 151-ND
3/4 x 19”, one (1) TRM	8	6	4	1	8 (max 4 BOM+SOM+1 MIM)	☐ 1MRK 000 151-NB
3/4 x 19”, two (2) TRM	5	5	4	1	5 (max 4 BOM+SOM+1 MIM)	☐ 1MRK 000 151-NE
1/2 x 19”, one (1) TRM	3	3	3	0	3	☐ 1MRK 000 151-NA

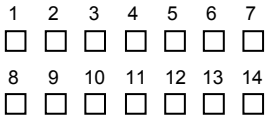
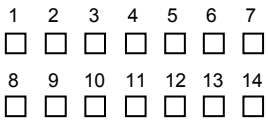
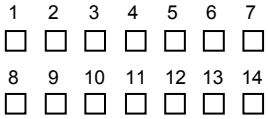
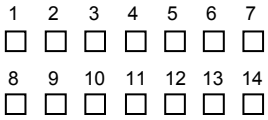
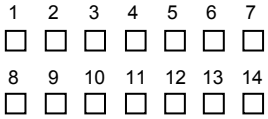
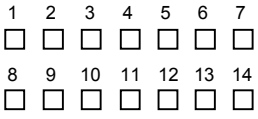
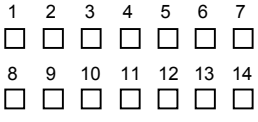
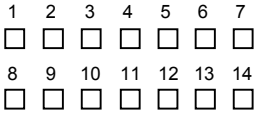
Maximum quantity of I/O modules, with ring lug terminals, module limits see above

Case sizes	Maximum in case	Possible locations for I/O modules with ringlugs	
1/1 x 19”, one (1) TRM	7	P3, P5, P7, P9, P11, P13, P15	☐ 1MRK 000 151-NC
1/1 x 19”, two (2) TRM	5	P3, P5, P7, P9, P11	☐ 1MRK 000 151-ND
3/4 x 19”, one (1) TRM	4	P3, P5, P7, P9	☐ 1MRK 000 151-NB
3/4 x 19”, two (2) TRM	2	P3, P5	☐ 1MRK 000 151-NE
1/2 x 19”, one (1) TRM	1	P3	☐ 1MRK 000 151-NA

Binary input/output modules

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.
For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used.

Binary input module (BIM) 16 inputs

RL 24-30 VDC, 30 mA	Qty:		1MRK 000 508-DB
RL 48-60 VDC, 30 mA	Qty:		1MRK 000 508-AB
RL 110-125 VDC, 30 mA	Qty:		1MRK 000 508-BB
RL 220-250 VDC, 30 mA	Qty:		1MRK 000 508-CB
RL 24-30 VDC, 50 mA	Qty:		1MRK 000 508-DD
RL 48-60 VDC, 50 mA	Qty:		1MRK 000 508-AD
RL 110-125 VDC, 50 mA	Qty:		1MRK 000 508-BD
RL 220-250 VDC, 50 mA	Qty:		1MRK 000 508-CD

Binary input module (BIM) with enhanced pulse counting capabilities, 16 inputs

RL 24-30 VDC Qty: 1 2 3 4 5 6 7 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 8 9 10 11 12 13 14 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1MRK 000 508-HA

RL 48-60 VDC Qty: 1 2 3 4 5 6 7 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 8 9 10 11 12 13 14 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1MRK 000 508-EA

RL 110-125 VDC Qty: 1 2 3 4 5 6 7 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 8 9 10 11 12 13 14 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1MRK 000 508-FA

RL 220-250 VDC Qty: 1 2 3 4 5 6 7 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 8 9 10 11 12 13 14 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1MRK 000 508-GA

Binary output module 24 output relays (BOM) Qty: 1 2 3 4 5 6 7 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 8 9 10 11 12 13 14 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1MRK 000 614-AB

Static binary output module (SOM)

RL 48-60 VDC Qty: 1 2 3 4 5 6 7 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 8 9 10 11 12 13 14 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1MRK 002 614-BA

RL 110-250 VDC Qty: 1 2 3 4 5 6 7 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 8 9 10 11 12 13 14 ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1MRK 002 614-CA

Make IOM with 50 mA inrush current the primary choice. IOM with 50 mA inrush current fulfill additional standards. As a consequence the EMC withstand capability is further increased.
IOM with 30 mA inrush current is still available.

Binary input/output module (IOM) 8 inputs, 10 outputs, 2 high-speed outputs

RL 24-30 VDC, 30 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-GB
RL 48-60 VDC, 30 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-AC
RL 110-125 VDC, 30 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-BC
RL 220-250 VDC, 30 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-CC
RL 24-30 VDC, 50 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-GD
RL 48-60 VDC, 50 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-AE
RL 110-125 VDC, 50 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-BE
RL 220-250 VDC, 50 mA	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-CE

Binary input/output module (IOM with MOV), 8 inputs, 10 outputs, 2 high-speed outputs

RL 24-30 VDC	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-GC
RL 48-60 VDC	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-AD
RL 110-125 VDC	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-BD
RL 220-250 VDC	Qty:	1 2 3 4 5 6 ☐ ☐ ☐ ☐ ☐ ☐	1MRK 000 173-CD

mA input module 6 channels (MIM)	Qty:	1 2 3 4 ☐ ☐ ☐ ☐	1MRK 000 284-AB

Station communication ports

Note: Optical ethernet module, 2 glass interfaces is not allowed together with SLM.

Optical ethernet module, 1 channel glass	☐	1MRK 002 266-AA
Optical ethernet module, 2 channel glass	☐	1MRK 002 266-BA
Serial and LON communication module, supports SPA/IEC 60870-5-103, LON and DNP 3.0		
Serial/LON plastic interface	☐	1MRK 001 608-AB
Serial plastic/LON glass interface	☐	1MRK 001 608-BB
Serial/LON glass interface	☐	1MRK 001 608-CB
Galvanic RS485 communication module for DNP 3.0	☐	1MRK 002 309-AA

Remote end serial communication for C37.94

Rule: One Line data communication module must be ordered. Generally max 4 LDCM in 3/4 and 1/1 case, but power dissipation may limit the quantity. Max one LDCM in 1/2 x 19" case.

Optical short range line data communication module *(SR LDCM)*	Qty:	1 ☐ 2 ☐ 3 ☐ 4 ☐	1MRK 002 122-AB
Optical medium range line data communication module (Single mode 1310 nm) *(MR LDCM)*	Qty:	1 ☐ 2 ☐ 3 ☐ 4 ☐	1MRK 002 311-AA
Optical long range line data communication module (Single mode 1550 nm) *(LR LDCM)*	Qty:	1 ☐ 2 ☐ 3 ☐ 4 ☐	1MRK 002 311-BA
Galvanic X21 line data communication module *(X21 LDCM)*	Qty:	1 ☐ 2 ☐ 3 ☐ 4 ☐	1MRK 002 307-AA

Time synchronization

Rule: Only one Time synchronization can be ordered.

GPS Time module (GTM)	☐	1MRK 002 282-AB
IRIG-B Time synchronization module	☐	1MRK 002 305-AA

Engineering facilities

19” rack mounting kit for 1/2 x 19” case or 2 x RHGS6 or RHGS12	Quantity:	☐	1MRK 002 420-BB
19” rack mounting kit for 3/4 x 19” case or 3 x RHGS6	Quantity:	☐	1MRK 002 420-BA
19” rack mounting kit for 1/1 x 19” case	Quantity:	☐	1MRK 002 420-CA
Note: Wall mounting not recommended with communication modules with fibre connection (SLM, OEM, LDCM) Wall mounting kit for terminal	Quantity:	☐	1MRK 002 420-DA

Flush mounting kit for terminal	Quantity:	☐	1MRK 000 020-Y
Flush mounting kit + IP54 sealing (factory mounted). Cannot be ordered separately thus must be specified when ordering a terminal.	Quantity:	☐	1MRK 002 420-EA

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 3 4 ☐ ☐ ☐ ☐	1MRK 002 245-AA
External interface converter from C37.94 to G703.E1	Quantity:	1 2 3 4 ☐ ☐ ☐ ☐	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 base on the available contacts arrangements shown in the reference documentation.

However our proposals for suitable variants are;

Single breaker/Single or Three Phase trip with internal neutral on current circuits (ordering number RK926 315-AK).

Single breaker/Single or Three Phase trip with external neutral on current circuits (ordering number RK926 315-AC).

Multi-breaker/Single or Three Phase trip with internal neutral on current circuits (ordering number RK926 315-BE).

Multi-breaker/Single or Three Phase trip with external neutral on current circuit (ordering number RK926 315-BV).

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 505 223-UEN
	ANSI	Quantity:	☐	1MRK 505 223-UUS
Technical reference manual	IEC	Quantity:	☐	1MRK 505 222-UEN
	ANSI	Quantity:	☐	1MRK 505 222-UUS
Installation and commissioning manual	IEC	Quantity:	☐	1MRK 505 224-UEN
	ANSI	Quantity:	☐	1MRK 505 224-UUS
Application manual	IEC	Quantity:	☐	1MRK 505 225-UEN
	ANSI	Quantity:	☐	1MRK 505 225-UUS
Engineering manual, 670 series		Quantity:	☐	1MRK 511 240-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 RED670	Identity number
Operator's manual	1MRK 505 223-UEN
Installation and commissioning manual	1MRK 505 224-UEN
Technical reference manual	1MRK 505 222-UEN
Application manual	1MRK 505 225-UEN
Product guide customized	1MRK 505 226-BEN
Product guide pre-configured	1MRK 505 228-BEN
Product guide IEC 61850-9-2	1MRK 505 204-BEN
Sample specification	SA2005-001281

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 511 240-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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