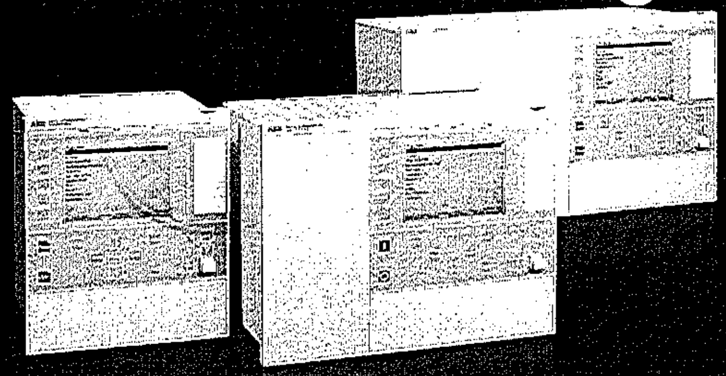
Приложение № 1.4 Заверено копие на каталог на Цифрови защити (ЦЗ ВКЕЛ 110 kV) за въводно поле „Драгалевци“ 110 kv: Основна цифрова надлъжна диференциална защита (комплект от две релета), Резервна цифрова максималнотокова защита на КЕЛ 110kV и комуникация на ЦЗ с RTU (ПС „ВИТОША“)



Relion® 670 series

Line differential protection RED670 2.1 IEC
Product guide

ДЗЗД „ЕИК ДРАГАЛЕВЦИ", Пловдив

ВЯРНО С ОРИГИНАЛА

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Power and productivity for a better world™ ABB

Contents

1. Application

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

Each MU has eight analogue channels, normally four currents and four voltages. Conventional and Merging Unit channels can be mixed freely in the application.

> If IEC 61850-9-2LE communication is interrupt, data from the merging units (MU) after the time for interruption will be incorrect. Both data stored in the IED and displayed on the local HMI will be corrupt. For this reason it is important to connect signal from respective MU units (SMPLLOST) to the disturbance recorder.

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

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

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

The logic is prepared with a graphical tool. The advanced logic capability 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.

Communication via optical connections ensures immunity against disturbances.

Four packages have been defined for following applications:

- Single-breaker (double or single bus) with three phase tripping (A31)
- Single-breaker (double or single bus) with single phase tripping (A32)
- Multi-breaker (one-and a half or ring) with three phase tripping (B31)
- Multi-breaker (one-and a half or ring) with single phase tripping (B32)

Optional functions are not configured but a maximum configuration with all optional functions are available as template in the graphical configuration tool. Analog inputs and binary input/output signals are pre-defined for basic use. Other signals may be required by each particular application.

Add binary I/O boards as required for the application when ordering.

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Description of configuration A31

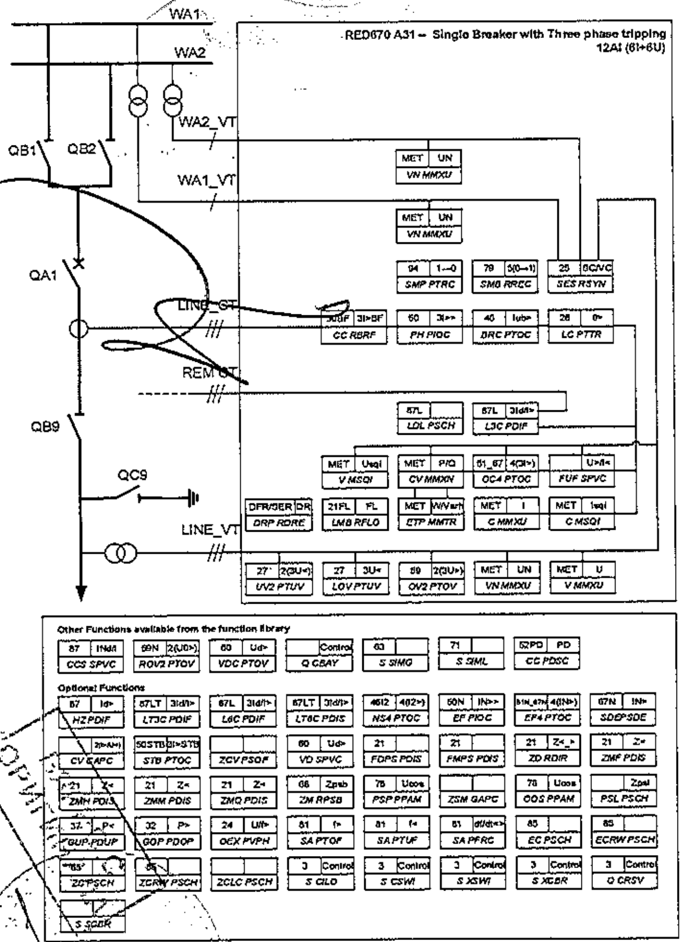

Figure 1. Configuration diagram for configuration A31

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Description of configuration A32

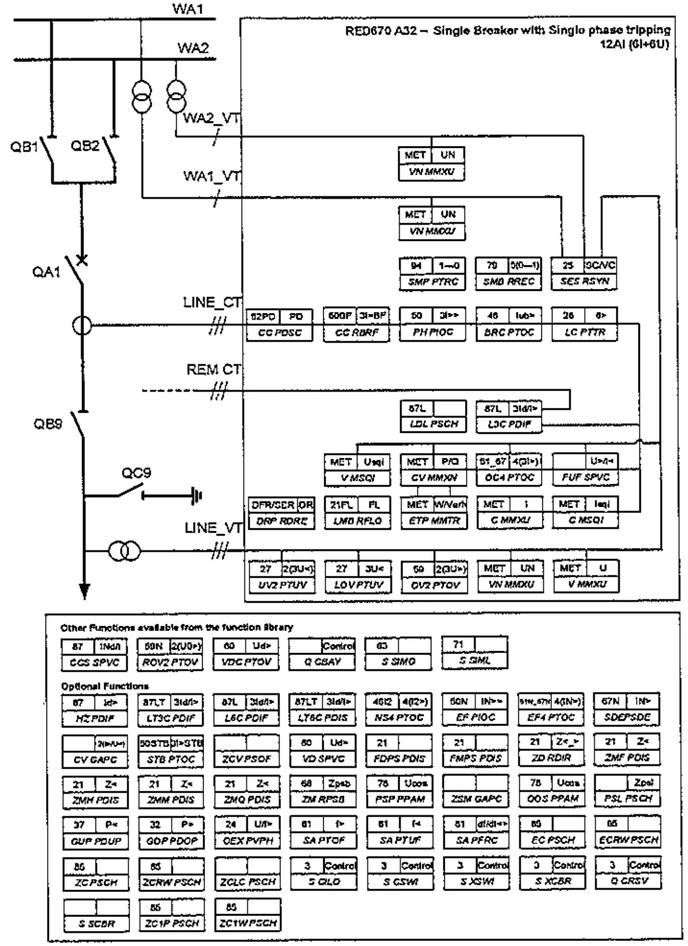

Figure 2. Configuration diagram for configuration A32

Description of configuration B31

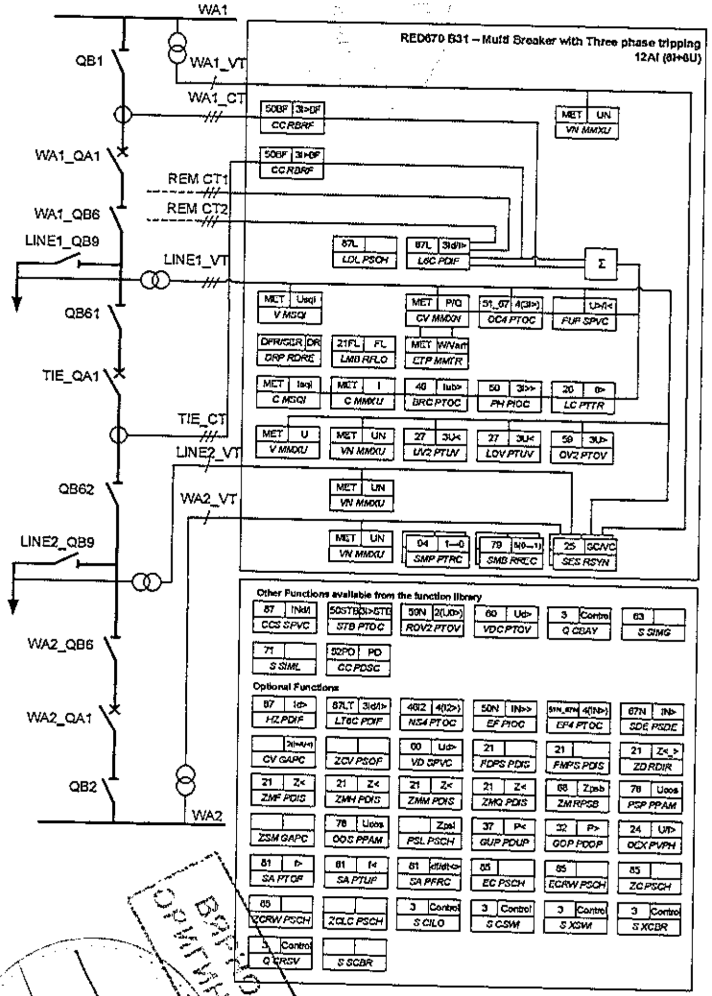

Figure 3. Configuration diagram for configuration B31

Description of configuration B32

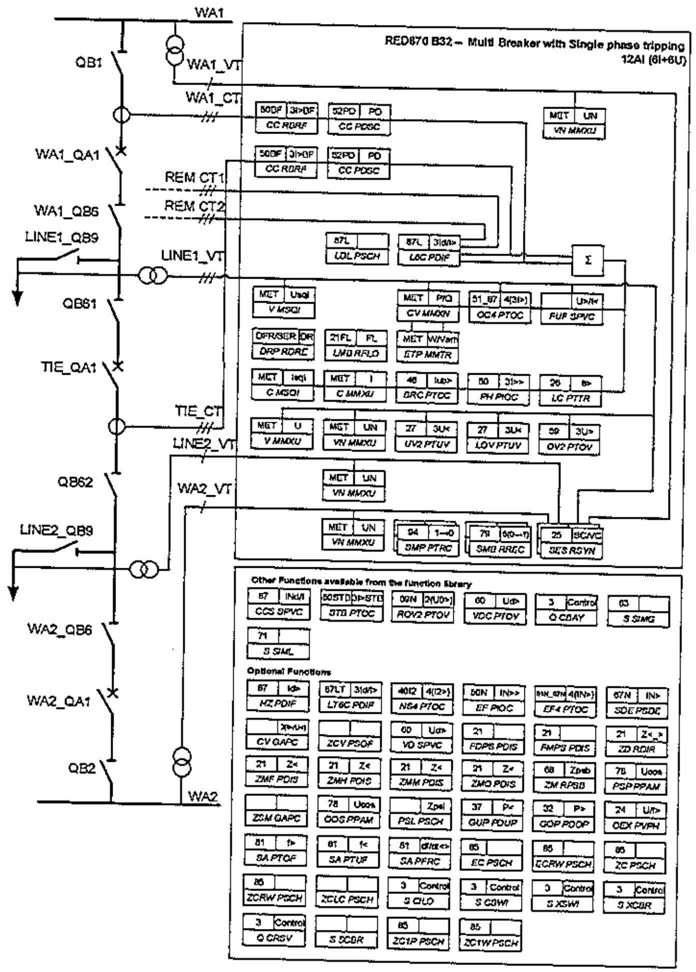

Figure 4. Configuration diagram for configuration B32

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2. Available functions

Main protection functions

Table 1. Example of quantities

2	= number of basic instances
0-3	= option quantities
3-A03	= optional function included in packages A03 (refer to ordering details)

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IEC 61850	ANSI	Function description	RED670 (Customized)	Line Differential RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Differential protection							
HZPDIF	87	1Ph high impedance differential protection	0-3	3-A02	3-A02	3-A02	3-A02
REFPDIF	87N	Restricted earth fault protection, low impedance	0–2				
L3CPDIF	87L	Line differential protection, 3 CT sets, 2–3 line ends	1	1		1	
L6CPDIF	87L	Line differential protection, 6 CT sets, 3–5 line ends	1	1-A04	1	1-A04	1
LT3CPDIF	87LT	Line differential protection, 3 CT sets, with inzone transformers, 2–3 line ends	1	1-A05		1-A05	
LT6CPDIF	87LT	Line differential protection, 6 CT sets, with inzone transformers, 3–5 line ends	1	1-A06	1-A06	1-A06	1-A06
LDLPSCH	87L	Line differential protection logic	1	1	1	1	1
LDRGFC	11REL	Additional security logic for differential protection	0-1				
Impedance protection							
ZMQPDIS, ZMQAPDIS	21	Distance protection zone, quadrilateral characteristic	0-5	1-B10 3-B11	1-B10 3-B11	1-B10 3-B11	1-B10 3-B11
ZDRDIR	21D	Directional impedance quadrilateral	0-2	1-B11	1-B11	1-B11	1-B11
ZMCPDIS, ZMCAPDIS	21	Distance measuring zone, quadrilateral characteristic for series compensated lines	0-5	3-B16	3-B16	3-B16	3-B16
ZDSRDIR	21D	Directional impedance quadrilateral, including series compensation	0-2	1-B16	1-B16	1-B16	1-B16
FDPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle	0-2	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
ZMHPDIS	21	Fullscheme distance protection, mho characteristic	0-5	4-B17	4-B17	4-B17	4-B17
ZMMPDIS, ZMMAPDIS	21	Fullscheme distance protection, quadrilateral for earth faults	0-5	4-B17	4-B17	4-B17	4-B17
ZDMRDIR	21D	Directional impedance element for mho characteristic	0-2	1-B17	1-B17	1-B17	1-B17
ZDARDIR		Additional distance protection directional function for earth faults	0-2	1-B17	1-B17	1-B17	1-B17
ZSMGAPC		Mho impedance supervision logic	0-1	1-B17	1-B17	1-B17	1-B17
FMPSPDIS	21	Faulty phase identification with load encroachment	0-2	2-B17	2-B17	2-B17	2-B17
ZMRPDIS, ZMRAPDIS	21	Distance protection zone, quadrilateral characteristic, separate settings	0-5				
FRPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle	0-2				
ZMFPDIS	21	High speed distance protection	0–1				
ZMFCPDIS	21	High speed distance protection for series compensated lines	0–1	1-B19	1-B19	1-B19	1-B19
ZMRPSB	68	Power swing detection	0-1	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
PSLPSCH		Power swing logic	0-1	1-B03	1-B03	1-B03	1-B03

IEC 61850	ANSI	Function description	Line Differential				
			RED670 (Customized)	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
PSPPPAM	78	Pole slip/out-of-step protection	0-1	1-B22	1-B22	1-B22	1-B22
OOSPPAM	78	Out-of-step protection	0-1	1-B22	1-B22	1-B22	1-B22
ZCVPSOF		Automatic switch onto fault logic, voltage and current based	0-1	1-B11 1-B16 1-B17	1-B11 1-B16 1-B17	1-B11 1-B16 1-B17	1-B11 1-B16 1-B17
PPLPHIZ		Phase preference logic	0-1	1-B04			

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Back-up protection functions

IEC 61850	ANSI	Function description	Line Differential				
			RED670 (Customized)	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Current protection							
PHPIOC	50	Instantaneous phase overcurrent protection	0-3	1	1	1	1
OC4PTOC	51_67[1]	Four step phase overcurrent protection	0-3	1	1	1	1
EFPIOC	50N	Instantaneous residual overcurrent protection	0-1	1-C24	1-C24	1-C24	1-C24
EF4PTOC	51N 67N[2]	Four step residual overcurrent protection	0-3	1-C24	1-C24	1-C24	1-C24
NS4PTOC	46I2	Four step directional negative phase sequence overcurrent protection	0-2	1-C24	1-C24	1-C24	1-C24
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0-1	1-C16	1-C16	1-C16	1-C16
LCPTTR	26	Thermal overload protection, one time constant, Celsius	0-2	1	1	1	1
LFPTTR	26	Thermal overload protection, one time constant, Fahrenheit	0-2	1	1	1	1
CCRBRF	50BF	Breaker failure protection	0-2	1	2	1	2
STBPTOC	50STB	Stub protection	0-2	1-B11	1B 1-B11	1-B11	1B 1-B11
CCPDSC	52PD	Pole discordance protection	0-2	1	2	1	2
GUPPDUP	37	Directional underpower protection	0-2	1-C17	1-C17	1-C17	1-C17
GOPPDOP	32	Directional overpower protection	0-2	1-C17	1-C17	1-C17	1-C17
BRCPTOC	46	Broken conductor check	1	1	1	1	1
VRPVOC	51V	Voltage restrained overcurrent protection	0-3				
Voltage protection							
UV2PTUV	27	Two step undervoltage protection	0-2	1	1	1	1
OV2PTOV	59	Two step overvoltage protection	0-2	1	1	1	1
ROV2PTOV	59N	Two step residual overvoltage protection	0-2	1	1	1	1
OEXPVPH	24	Overexcitation protection	0-1	1-D03	1-D03	1-D03	1-D03
VDCPTOV	60	Voltage differential protection	0-2	2	2	2	2
LOVPTUV	27	Loss of voltage check	1	1	1	1	1
PAPGAPC	27	Radial feeder protection	0-1				
Frequency protection							
SAPTUF	81	Underfrequency protection	0-6	2-E02	2-E02	2-E02	2-E02
SAPTOF	81	Overfrequency protection	0-6	2-E02	2-E02	2-E02	2-E02

IEC 61850	ANSI	Function description	Line Differential				
			RED670 (Customized)	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
SAPFRC	81	Rate-of-change frequency protection	0-2	2-E02	2-E02	2-E02	2-E02
Multipurpose protection							
CVGAPC		General current and voltage protection	0-4	4-F01	4-F01	4-F01	4-F01
General calculation							
SMAIHPAC		Multipurpose filter	0-6				

1) 67 requires voltage
2) 67N requires voltage

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Control and monitoring functions

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Control							
SESRSYN	25	Synchrocheck, energizing check and synchronizing	0-2	1	2	1	2
SMBRREC	79	Autorecloser	0-4	1 1-H04	2 2-H05	1 1-H04	2 2-H05
APC10	3	Apparatus control for single bay, max 10 apparatuses (1CB) incl. interlocking	0-1	1-H27		1-H27	
APC15	3	Apparatus control for single bay, max 15 apparatuses (2CBs) incl. interlocking	0-1		1-H08		1-H08
QCBAY		Apparatus control	1	1	1	1	1
LOCREM		Handling of LRswitch positions	1	1	1	1	1
LOCREMCTRL		LHMI control of PSTO	1	1	1	1	1
SLGAPC		Logic rotating switch for function selection and LHMI presentation	15	15	15	15	15
VSGAPC		Selector mini switch	20	20	20	20	20
DPGAPC		Generic communication function for Double Point indication	16	16	16	16	16
SPC8GAPC		Single point generic control 8 signals	5	5	5	5	5
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3	3	3
SINGLECMD		Single command, 16 signals	4	4	4	4	4
I103CMD		Function commands for IEC 60870-5-103	1	1	1	1	1
I103GENCMD		Function commands generic for IEC 60870-5-103	50	50	50	50	50
I103POSCMD		IED commands with position and select for IEC 60870-5-103	50	50	50	50	50
I103POSCMDV		IED direct commands with position for IEC 60870-5-103	10	10	10	10	10
I103IEDCMD		IED commands for IEC 60870-5-103	1	1	1	1	1
I103USRCMD		Function commands user defined for IEC 60870-5-103	1	1	1	1	1
Secondary system supervision							
CCSSPVC	87	Current circuit supervision	0-2	1	2	1	2
FUFSPVC		Fuse failure supervision	0-3	3	3	3	3
VDSPVC	60	Fuse failure supervision based on voltage difference	0-3	1-G03	1-G03	1-G03	1-G03
Logic							
SMPPTRC	94	Tripping logic	6	6	6	6	6
TMAGAPC		Trip matrix logic	12	12	12	12	12
ALMCALH		Logic for group alarm	5	5	5	5	5
WRNCALH		Logic for group warning	5	5	5	5	5
INDCALH		Logic for group indication	5	5	5	5	5

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SRMEMORY, TIMERSET, XOR		Basic configurable logic blocks (see Table 2)	40-280	40-280	40-280	40-280	40-280
ANDQT, INDCOMBSPQT, INDEXTSPQT, INVALIDQT, INVERTERQT, ORQT, PULSETIMERQT, RSMEMORYQT, SRMEMORYQT, TIMERSETQT, XORQT		Configurable logic blocks Q/T (see Table 3)	0–1				
AND, GATE, INV, LLD, OR, PULSETIMER, SLGAPC, SRMEMORY, TIMERSET, VSGAPC, XOR		Extension logic package (see Table 4)	0–1				
FXDSIGN		Fixed signal function block	1	1	1	1	1
B16I		Boolean 16 to Integer conversion	18	18	18	18	18
BTIGAPC		Boolean 16 to Integer conversion with Logic Node representation	16	16	16	16	16
IB16		Integer to Boolean 16 conversion	18	18	18	18	18
ITBGAPC		Integer to Boolean 16 conversion with Logic Node representation	16	16	16	16	16
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12	12
INTCOMP		Comparator for integer inputs	12	12	12	12	12
REALCOMP		Comparator for real inputs	12	12	12	12	12
Monitoring							
CVMMXN, VMMXU, CMSQI, VMSQI, VNMMXU		Measurements	6	6	6	6	6
CMMXU		Measurements	10	10	10	10	10
AISVBAS		Function block for service value presentation of secondary analog inputs	1	1	1	1	1
EVENT		Event function	20	20	20	20	20

IEC 61850	ANSI	Function description	Line Differential				
			RED670	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
DRPRDRE, A1RADR-A4RADR, B1RBDR-B8RBDR		Disturbance report	1	1	1	1	1
SPGAPC		Generic communication function for Single Point indication	64	64	64	64	64
SP16GAPC		Generic communication function for Single Point indication 16 inputs	16	16	16	16	16
MVGAPC		Generic communication function for Measured Value	24	24	24	24	24
BINSTATREP		Logical signal status report	3	3	3	3	3
RANGE_XP		Measured value expander block	66	66	66	66	66
SSIMG	63	Gas medium supervision	21	21	21	21	21
SSIML	71	Liquid medium supervision	3	3	3	3	3
SSCBR		Circuit breaker monitoring	0-6	3-M13	6-M15	3-M13	6-M15
LMBRFLO		Fault locator	1	1	1	1	1
I103MEAS		Measurands for IEC 60870-5-103	1	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC 60870-5-103	3	3	3	3	3
I103AR		Function status auto-recloser for IEC 60870-5-103	1	1	1	1	1
I103EF		Function status earth-fault for IEC 60870-5-103	1	1	1	1	1
I103FLTPROT		Function status fault protection for IEC 60870-5-103	1	1	1	1	1
I103IED		IED status for IEC 60870-5-103	1	1	1	1	1
I103SUPERV		Supervison status for IEC 60870-5-103	1	1	1	1	1
I103USRDEF		Status for user defined signals for IEC 60870-5-103	20	20	20	20	20
L4UFCNT		Event counter with limit supervision	30	30	30	30	30
TEILGAPC		Running hour-meter	9	9	9	9	9
Metering							
PCFCNT		Pulse-counter logic	16	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	6	6	6	6	6

Table 2. Total number of instances for basic configurable logic blocks

Basic configurable logic block	Total number of instances
AND	280
GATE	40
INV	420
LLD	40
OR	289
PULSETIMER	40
RSMEMORY	40
SRMEMORY	40
TIMERSET	60
XOR	40

Table 3. Total number of instances for configurable logic blocks Q/T

Configurable logic blocks Q/T	Total number of instances
ANDQT	120
INDCOMBSPQT	20
INDEXTSPQT	20
INVALIDQT	22
INVERTERQT	120
ORQT	120
PULSETIMERQT	40
RSMEMORYQT	40
SRMEMORYQT	40
TIMERSETQT	40
XORQT	40

Table 4. Total number of instances for extended logic package

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

Communication

IEC 61850	ANSI	Function description	Line Differential				
			RED670 (Customized)	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
Station communication							
LONSPA, SPA		SPA communication protocol	1	1	1	1	1
ADE		LON communication protocol	1	1	1	1	1
HORZCOMM		Network variables via LON	1	1	1	1	1
PROTOCOL		Operation selection between SPA and IEC 60870-5-103 for SLM	1	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1	1
RS485GEN		RS485	1	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1	1
DNPGENTCP		DNP3.0 communication general TCP protocol	1	1	1	1	1
CHSERRS485		DNP3.0 for EIA-485 communication protocol	1	1	1	1	1
CH1TCP, CH2TCP, CH3TCP, CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1	1
CHSEROPT		DNP3.0 for TCP/IP and EIA-485 communication protocol	1	1	1	1	1
MST1TCP, MST2TCP, MST3TCP, MST4TCP		DNP3.0 for serial communication protocol	1	1	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol	1	1	1	1	1
IEC 61850-8-1		Parameter setting function for IEC 61850	1	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59	59
GOOSEBINRCV		GOOSE binary receive	16	16	16	16	16
GOOSEDPRCV		GOOSE function block to receive a double point value	64	64	64	64	64
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	60	60	60	60	60
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64	64
MULTICMDRCV, MULTICMDSND		Multiple command and transmit	60/10	60/10	60/10	60/10	60/10
FRONT, LANABI, LANAB, LANCDI, LANCD		Ethernet configuration of links	1	1	1	1	1
GATEWAY		Ethernet configuration of link one	1	1	1	1	1

IEC 61850	ANSI	Function description	Line Differential				
			RED670 (Customized)	RED670 (A31)	RED670 (B31)	RED670 (A32)	RED670 (B32)
OPTICAL103		IEC 60870-5-103 Optical serial communication	1	1	1	1	1
RS485103		IEC 60870-5-103 serial communication for RS485	1	1	1	1	1
AGSAL		Generic security application component	1	1	1	1	1
LD0LLN0		IEC 61850 LD0 LLN0	1	1	1	1	1
SYSLLN0		IEC 61850 SYS LLN0	1	1	1	1	1
LPHD		Physical device information	1	1	1	1	1
PCMACCS		IED Configuration Protocol	1	1	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1	1
FSTACCS FSTACCSNA		Field service tool access via SPA protocol over ethernet communication	1	1	1	1	1
ACTIVLOG		Activity logging parameters	1	1	1	1	1
ALTRK		Service Tracking	1	1	1	1	1
SINGLELCCH		Single ethernet port link status	1	1	1	1	1
PRPSTATUS		Dual ethernet port link status	1	1	1	1	1
		Process bus communication IEC 61850-9-2 [1]					
PRP		IEC 62439-3 parallel redundancy protocol	0-1	1-P03	1-P03	1-P03	1-P03
Remote communication							
		Binary signal transfer receive/transmit	6/36	6/36	6/36	6/36	6/36
		Transmission of analog data from LDCM	1	1	1	1	1
		Receive binary status from remote LDCM	6/3/3	6/3/3	6/3/3	6/3/3	6/3/3
Scheme communication							
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection	0-1	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
ZC1PPSCH	85	Phase segregated scheme communication logic for distance protection	0-1			1-B05	1-B05
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection	0-1	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16	1-B11 1-B16
ZC1WPSCH	85	Current reversal and weak-end infeed logic for phase segregated communication	0-1			1-B05	1-B05
ZCLCPSCH		Local acceleration logic	0-1	1-B11	1-B11	1-B11	1-B11
ECPSCH	85	Scheme communication logic for residual overcurrent protection	0-1	1-C24	1-C24	1-C24	1-C24
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection	0-1	1-C24	1-C24	1-C24	1-C24
DTT		Direct transfer trip	0-1				

1) Only included for 9-2LE products

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Basic IED functions

Table 5. Basic IED functions

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

Table 5. Basic IED functions, continued

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

Table 6. Local HMI functions

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

3. Differential protection

1Ph High impedance differential protection HZPDIF
The 1Ph High impedance differential protection HZPDIF functions can be used when the involved CT cores have the same turns ratio and similar magnetizing characteristics. It utilizes an external CT secondary current summation by wiring. Actually all CT secondary circuits which are involved in the differential scheme are connected in parallel. External series resistor, and a voltage dependent resistor which are both mounted externally to the IED, are also required.

The external resistor unit shall be ordered under IED accessories in the Product Guide.

HZPDIF can be used to protect tee-feeders or busbars, reactors, motors, auto-transformers, capacitor banks and so on. One such function block is used for a high-impedance restricted earth fault protection. Three such function blocks are used to form three-phase, phase-segregated differential protection. Several function block instances (for example, six) can be available in a single IED.

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

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

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

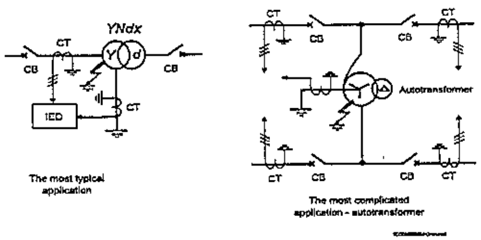

Figure 5. Examples of applications of the REFPDIF

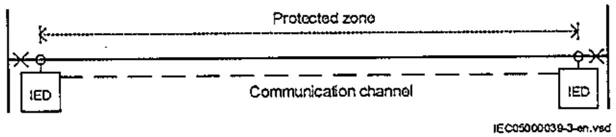

Figure 6. Example of application on a conventional two-terminal line

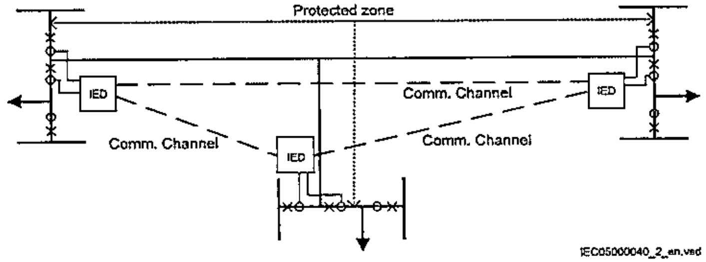

Figure 7. Example of application on a three-terminal line with 1½ breaker arrangements

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 and cables. Under the condition that there are no in-line or tap (shunt) power transformers within the zone of protection, it offers a phase segregated fundamental frequency current based 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 a 1½ circuit breaker arrangement in one end, as well as three-terminal lines with single breaker arrangements at all terminals.

The six-terminal versions are used for conventional two-terminal lines with 1½ circuit breaker arrangements in both ends, as well as multi-terminal lines with up to five terminals.

The current differential algorithm provides high sensitivity for internal faults and 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 (instantaneous) 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 *IdMin*) 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 considered to be negligible, and special measures must 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 downstream overcurrent IEDs. The local protection of the small tap power transformer is given the time needed to disconnect the faulty transformer.

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. In such application, the differential protection is based on the ampere turns balance between the transformer windings. 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. The phase-segregated differential protection with single-pole tripping is usually not possible in such applications.

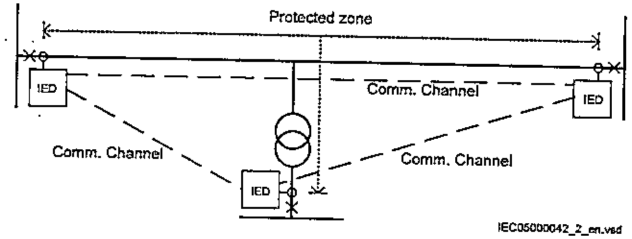

Figure 8. Example of application on a three-terminal line with an in-line power transformer in the protection zone

Analog signal transfer for line differential protection
The line differential protection function 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. The Master-Slave condition for the differential function appears automatically when the setting *Operation* for the differential function is set to *Off*.

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

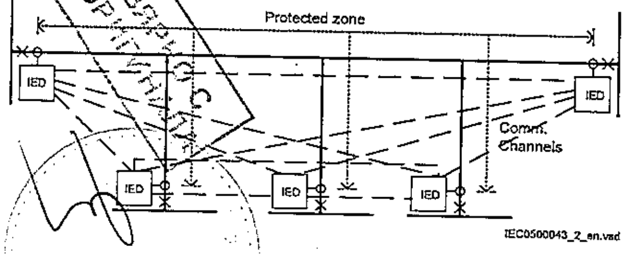

Figure 9. Five terminal lines with master-master system

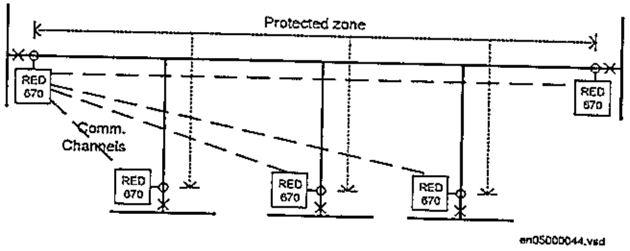

Figure 10. Five terminal line with master-slave system

Current samples from IEDs located geographically apart from each other, must be time coordinated so that the current differential algorithm can be executed correctly, this is done with the echo method.For applications where transmit and receive times can differ, the optional built in GPS receivers can be used

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

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

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

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

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

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

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

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

Features:

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

4. Impedance protection

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

ZMQPDIS together with Phase selection with load encroachment FDPSPDIS has functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines, as shown in figure 11.

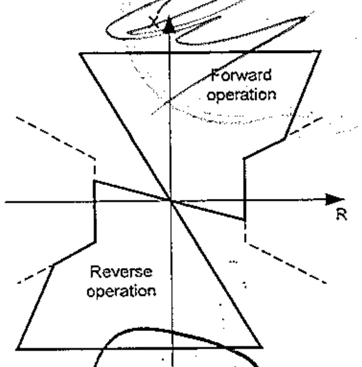

Figure 11. Typical quadrilateral distance protection zone with Phase selection with load encroachment function FDPSPDIS activated

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.

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

Quadrilateral characteristic is available.

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

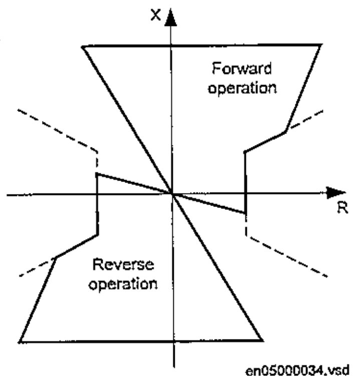

Figure 12. Typical quadrilateral distance protection zone with load encroachment function activated

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 an up to five (depending on product variant) zone full scheme protection of short circuit and earth faults.

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

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

Adaptive load compensation algorithm prevents overreaching at phase-to-earth faults on heavily loaded power lines, see Figure 13.

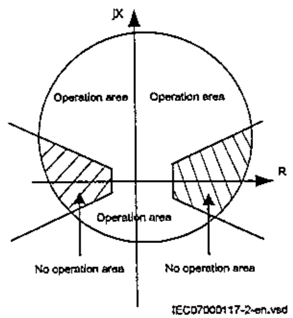

Figure 13. Load encroachment influence on the offset mho characteristic

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

The Full-scheme distance protection, quadrilateral for earth fault functions have functionality for load encroachment, which increases the possibility to detect high resistive faults on heavily loaded lines , see Figure 11.

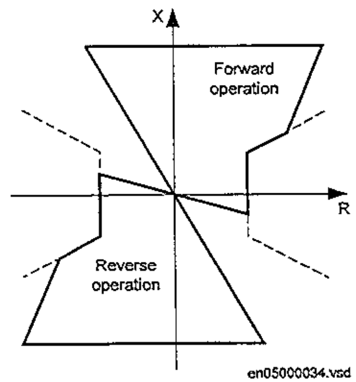

Figure 14. Typical quadrilateral distance protection zone with Phase selection, quadrilateral characteristic with settable angle function FRPSPDIS activated

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

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

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

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

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

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 11.

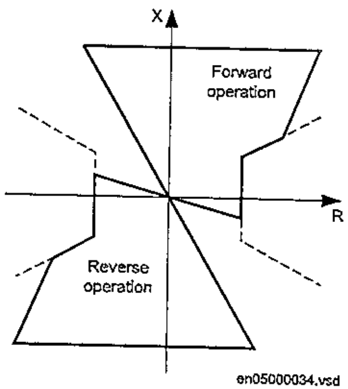

Figure 15. Typical quadrilateral distance protection zone with Phase selection, quadrilateral characteristic with settable angle function FRPSPDIS activated

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.

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

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

The operation of the phase-selection is primarily based on a current change criteria (i.e. delta quantities), however there is also a phase selection criterion operating in parallel which bases its operation on voltage and current phasors exclusively. Additionally the directional element provides a fast and correct directional decision under difficult operating conditions, including close-in three-phase faults, simultaneous faults and faults with only zero-sequence in-feed.During phase-to-earth faults on heavily loaded power lines there is an adaptive load compensation algorithm that prevents overreaching of the distance zones in the load exporting end, improving the selectivity of the function. This also reduces underreach in the importing end.

Distance zones quad with high speed distance for series compensated networks ZMFCPDIS
The high speed distance protection (ZMFCPDIS) provides a sub-cycle, down towards a half-cycle operate time. Its six zone, full scheme protection concept is entirely suitable in applications with single-phase autoreclosing.

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

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

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

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

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

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

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

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

Pole slip protection PSPPPAM
The situation with pole slip of a generator can be caused by different reasons.

A short circuit may occur in the external power grid, close to the generator. If the fault clearing time is too long, the generator will accelerate so much, that the synchronism cannot be maintained.

Undamped oscillations occur in the power system, where generator groups at different locations, oscillate against each other. If the connection between the generators is too weak the magnitude of the oscillations will increase until the angular stability is lost.

The operation of a generator having pole slip will give risk of damages to the generator, shaft and turbine.

- At each pole slip there will be significant torque impact on the generator-turbine shaft.
- In asynchronous operation there will be induction of currents in parts of the generator normally not carrying current, thus resulting in increased heating. The consequence can be damages on insulation and stator/rotor iron.

The Pole slip protection (PSPPPAM) function shall detect pole slip conditions and trip the generator as fast as possible if the locus of the measured impedance is inside the generator-transformer block. If the centre of pole slip is outside in the power grid, the first action should be to split the network into two parts, after line protection action. If this fails there should be operation of the generator PSPPPAM in zone 2, to prevent further damages to the generator, shaft and turbine.

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

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

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

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

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

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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.

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.

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

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

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

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

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

Four step residual overcurrent protection, zero sequence and negative sequence direction EF4PTOC
The four step residual overcurrent protection EF4PTOC has an inverse or definite time delay independent for each step.

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

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

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

Second harmonic blocking can be set individually for each step.

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

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

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

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

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

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

The directional function is voltage polarized.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Each function has two steps with definite time delay.

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.

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

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

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

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.

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

Two step overvoltage protection OV2PTOV
Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, and open line ends on long lines.

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

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

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

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

Voltage differential protection 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.

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

Radial feeder protection PAPGAPC
The PAPGAPC function is used to provide protection of radial feeders having passive loads or weak end in-feed sources. It is possible to achieve fast tripping using communication system with remote end or delayed tripping not requiring communication or upon communication system failure. For fast tripping, scheme communication is required. Delayed tripping does not require scheme communication.

The PAPGAPC function performs phase selection using measured voltages. Each phase voltage is compared to the opposite phase-phase voltage. A phase is deemed to have a fault if its phase voltage drops below a settable percentage of the opposite phase-phase voltage. The phase - phase voltages include memory. This memory function has a settable time constant.

The voltage-based phase selection is used for both fast and delayed tripping. To achieve fast tripping, scheme communication is required. Delayed tripping does not require scheme communication. It is possible to permit delayed tripping only upon failure of the communications channel by blocking the delayed tripping logic with a communications channel healthy input signal.

On receipt of the communications signal, phase selective outputs for fast tripping are set based on the phase(s) in which the phase selection function has operated.

For delayed tripping, single pole and three pole delays are separately and independently settable. Furthermore, it is possible to enable or disable single pole and three pole delayed tripping. For single phase faults, it is possible to include a residual current check in the tripping logic. Three pole tripping is always selected for phase selection on more than one phase. Three pole tripping will also occur if the residual current exceeds the set level during fuse failure for a time longer than the three pole trip delay time.

7. Frequency protection

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

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

SAPTUF is provided with undervoltage blocking.

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

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

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

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

SAPTOF is provided with an undervoltage blocking.

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

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

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

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.

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

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

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

9. Secondary system supervision

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

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

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

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

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

The negative sequence detection algorithm is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence quantities.

The zero sequence detection is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities.

The selection of different operation modes is possible by a setting parameter in order to take into account the particular earthing of the network.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

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

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

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

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

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

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. The synchronizing function evaluates voltage difference, phase angle difference, slip frequency and frequency rate of change

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before issuing a controlled closing of the circuit breaker. Breaker closing time is a parameter setting.

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.

The autoreclosing function provides high-speed and/or delayed three pole autoreclosing.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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 permissive underreaching, permissive overreaching, blocking, delta based blocking, unblocking and intertrip are available.

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

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

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

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

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 where the overreach from the two ends overlaps on the parallel line.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The trip matrix logic function has 3 output signals and these outputs can be connected to physical tripping outputs according to the specific application needs for settable pulse or steady output.

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

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

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

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

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

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

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

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

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

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

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

One FXDSIGN function block is included in all IEDs.

Elapsed time integrator with limit transgression and overflow supervision (TEIGAPC)
The Elapsed time integrator function TEIGAPC is a function that accumulates the elapsed time when a given binary signal has been high.

The main features of TEIGAPC

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

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

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

BTIGAPC can receive remote values via IEC 61850 depending on the operator position input (PSTO).

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

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

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

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

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

13. Monitoring

Measurements CVMMXN, CMMXU, VNMMXU, VMMXU, CMSQI, VMSQI
The measurement functions are used to get on-line information from the IED. These service values make it possible to display on-line information on the local HMI and on the Substation automation system about:

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

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

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

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

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

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a, maximum of 40 analog and 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 AnRADR or BnRBDR function blocks, which are set to trigger the disturbance recorder. All connected signals from start of pre-fault time to the end of post-fault time will be included in the recording.

Every disturbance report recording is saved in the IED in the standard Comtrade format as a reader file HDR, a configuration file CFG, and a data file DAT. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance

report files may be uploaded to PCM600 for further analysis using the disturbance handling tool.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Measured value expander block RANGE_XP
The current and voltage measurements functions (CVMMXN, CMMXU, VMMXU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGAPC) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The

measure value expander block (RANGE_XP) has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

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

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

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

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

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

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

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

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

Overflow indication is included for each up-counter.

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

The main features of TEILGAPC are:

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

14. Metering

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

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

The values of active and reactive energies are calculated from the input power values by integrating them over a selected time *tEnergy*. The integration of active and reactive energy values will happen in both forward and reverse directions. These energy values are available as output signals and also as pulse outputs. Integration of energy values can be controlled by inputs

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(STARTACC and STOPACC) and *EnaAcc* setting and it can be reset to initial values with RSTACC input.

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

15. Human machine interface

Local HMI

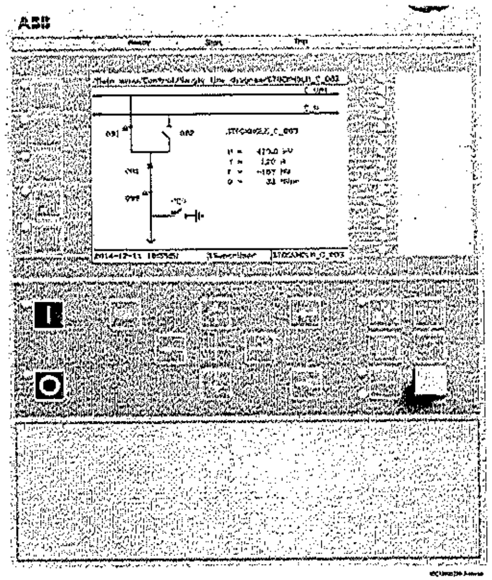

Figure 16. Local human-machine interface

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

The LHMI is used for setting, monitoring and controlling.

16. Basic IED functions

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

17. Station communication

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

Available communication protocols are:

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

Several protocols can be combined in the same IED.

IEC 61850-8-1 communication protocol
IEC 61850 Ed.1 or Ed.2 can be chosen by a setting in PCM600. The IED is equipped with 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 electrical Ethernet front port. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. IED-to-IED communication using GOOSE and client-server communication over MMS are supported. Disturbance recording file (COMTRADE) uploading can be done over MMS or FTP.

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

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

SPA communication protocol
A single glass or plastic port is provided for the ABB SPA protocol. This allows extensions of simple substation

automation systems but the main use is for Substation Monitoring Systems SMS.

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

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

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

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

18. Remote communication

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

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

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/68 miles or from the IED to optical to electrical converter with G.703 or G.703E1 interface located on a distances < 3 km/1.9 miles away. The LDCM module sends and receives data, to and from another LDCM module. The IEEE/ANSI C37.94 standard format is used.

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 IED and the battery system. An internal fail alarm output is available.

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

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

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

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

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

Optical ethernet module OEM
The optical fast-ethernet module is used for fast and interference-free communication of synchrophasor data over IEEE C37.118 and/or IEEE 1344 protocols. It is also used to connect an IED to the communication buses (like the station

bus) that use the IEC 61850-8-1 protocol (OEM rear port A, B). The process bus use the IEC 61850-9-2LE protocol (OEM rear port C, D). The module has one or two optical ports with ST connectors.

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

GPS time synchronization module GTM
This module includes a GPS receiver used for time synchronization. The 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.

The Pulse Per Second (PPS) input shall be used for synchronizing when IEC 61850-9-2LE is used.

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

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

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

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

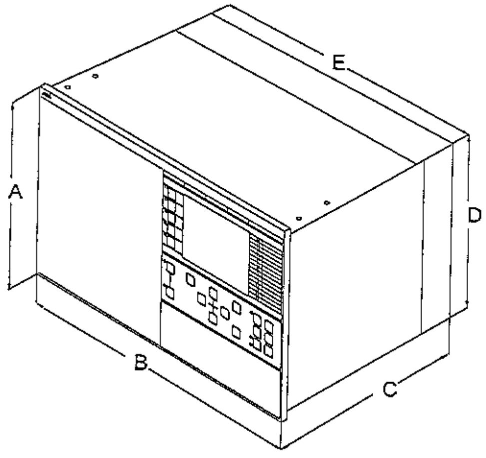

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Figure 17. Case with rear cover

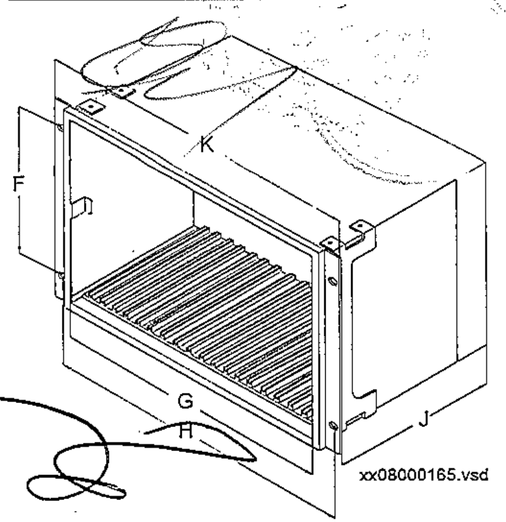

Figure 18. Case with rear cover and 19" rack mounting kit

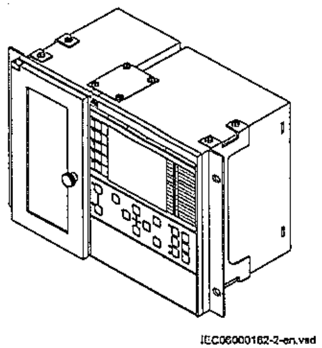

Figure 19. A 1/2 x 19" size IED side-by-side with RHGS6.

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

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

Mounting alternatives

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

See ordering for details about available mounting alternatives.

ДЗЗД „ЕИК ДРАГАЛЕВЦИ" ВЯРНО С ОРИГИНАЛА

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20. Connection diagrams

Connection diagrams

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

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

Connection diagrams for Customized products

Connection diagram, 670 series 2.1 1MRK002801-AF

Connection diagrams for Configured products

Connection diagram, RED670 2.1, A31 1MRK002803-HA

Connection diagram, RED670 2.1, B31 1MRK002803-HB

Connection diagram, RED670 2.1, A32 1MRK002803-HC

Connection diagram, RED670 2.1, B32 1MRK002803-HD

Connection diagrams for Customized products

Connection diagram, 670 series 2.1 1MRK002802-AF

21. Technical data

General

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

Energizing quantities, rated values and limits
Analog inputs

Table 7. 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 8. 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%

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Table 9. 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 10. OEM - Optical ethernet module

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

Auxiliary DC voltage

Table 11. PSM - Power supply module

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

Binary inputs and outputs

Table 12. 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 13. BIM - Binary input module with enhanced pulse counting capabilities

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

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

Table 14. 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 15. 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 16. 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 17. 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	5A	5A
1.0s	10A	10A
Making capacity at capacitive load with the maximum capacitance of 0.2 μF:		
0.2s	30A	30A
1.0s	10A	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

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Table 18. 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 19. SOM - 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 20. 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 21. 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 22. 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	±2.0%
Harmonic frequency dependence for distance protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±10.0%
Harmonic frequency dependence for high impedance differential protection (10% content)	2nd, 3rd and 5th harmonic of f_r	±10.0%
Harmonic frequency dependence for overcurrent protection	2nd, 3rd and 5th harmonic of f_r	±3.0% / Hz

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Type tests according to standards

Table 23. Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-26
100 kHz slow damped oscillatory wave immunity test	2.5 kV	IEC 61000-4-18, Class III
Ring wave immunity test, 100 kHz	2-4 kV	IEC 61000-4-12, Class IV
Surge withstand capability test	2.5 kV, oscillatory 4.0 kV, fast transient	IEEE/ANSI C37.90.1
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEC 60255-26 IEC 61000-4-2, Class IV
Electrostatic discharge Direct application Indirect application	15 kV air discharge 8 kV contact discharge 8 kV contact discharge	IEEE/ANSI C37.90.1
Fast transient disturbance	4 kV	IEC 60255-26, Zone A
Surge immunity test	2-4 kV, 1.2/50 µs high energy	IEC 60255-26, Zone A
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-26, Zone A
Conducted common mode immunity test	15 Hz-150 kHz	IEC 61000-4-16, Class IV
Power frequency magnetic field test	1000 A/m, 3 s 100 A/m, cont.	IEC 61000-4-8, Class V
Pulse magnetic field immunity test	1000 A/m	IEC 61000-4-9, Class V
Damped oscillatory magnetic field test	100 A/m	IEC 61000-4-10, Class V
Radiated electromagnetic field disturbance	20 V/m, 80-1000 MHz 1.4-2.7 GHz	IEC 60255-26
Radiated electromagnetic field disturbance	20 V/m 80-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEC 60255-26
Radiated emission	30-5000 MHz	IEEE/ANSI C63.4, FCC
Conducted emission	0.15-30 MHz	IEC 60255-26

Table 24. Insulation

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

Table 25. Environmental tests

Test	Type test value	Reference standard
Cold operation test	Test Ad for 16 h at -25°C	IEC 60068-2-1
Cold storage test	Test Ab for 16 h at -40°C	IEC 60068-2-1
Dry heat operation test	Test Bd for 16 h at +70°C	IEC 60068-2-2
Dry heat storage test	Test Bb for 16 h at +85°C	IEC 60068-2-2
Change of temperature test	Test Nb for 5 cycles at -25°C to +70°C	IEC 60068-2-14
Damp heat test, steady state	Test Ca for 10 days at +40°C and humidity 93%	IEC 60068-2-78
Damp heat test, cyclic	Test Db for 6 cycles at +25 to +55°C and humidity 93 to 95% (1 cycle = 24 hours)	IEC 60068-2-30

Table 26. CE compliance

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

Table 27. Mechanical tests

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

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Differential protection

Table 28. Restricted earth-fault protection, low impedance REFPDIF

Function	Range or value	Accuracy
Operating characteristic	Adaptable	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	>95%	-
Minimum pickup, IdMin	(4.0-100.0)% of IBase	±1.0% of I_r
Directional characteristic	Fixed 180 degrees or ±60 to ±90 degrees	±2.0 degrees
Operate time, trip at 0 to 10 x IdMin	Min. = 15 ms Max. = 30 ms	-
Reset time, trip at 10 to 0 x IdMin	Min. = 15 ms Max. = 30 ms	-
Second harmonic blocking	60.0% of fundamental (hidden setting)	±1.0% of I_r

Table 29. 1Ph High impedance differential protection HZPDIF

Function	Range or value	Accuracy
Operate voltage	(10-900) V I=U/R	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	>95% at (30-900) V	-
Maximum continuous power	$U>Trip^2$/SeriesResistor ≤200 W	-
Operate time at 0 to 10 x U_d	Min. = 5 ms Max. = 15 ms	
Reset time at 10 to 0 x U_d	Min. = 75 ms Max. = 95 ms	
Critical impulse time	2 ms typically at 0 to 10 x U_d	-
Operate time at 0 to 2 x U_d	Min. = 25 ms Max. = 35 ms	
Reset time at 2 to 0 x U_d	Min. = 50 ms Max. = 70 ms	
Critical impulse time	15 ms typically at 0 to 2 x U_d	-

Table 30. 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 $I \le I_r$ ±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 $I \le I_r$ ±1.0% of I at $I > I_r$
*Second harmonic blocking	(5.0–100.0)% of fundamental	±1.0% of I_r Note: fundamental magnitude = 100% of I_r
*Fifth harmonic blocking	(5.0–100.0)% of fundamental	±2.0% of I_r Note: fundamental magnitude = 100% of I_r
*Inverse characteristics, see table 172, 173 and table 173	16 curve types	See table 172, 173 and table 174
Critical impulse time	2ms typically at 0 to 10 x I_d	-
Charging current compensation	On/Off	-
LT3CPDIF and LT6CPDIF:		
*Operate time, restrained function at 0 to 10 x I_d	Min. = 25 ms Max. = 35 ms	-
*Reset time, restrained function at 10 to 0 x I_d	Min. = 5 ms Max. = 15 ms	-
*Operate time, unrestrained function at 0 to 10 x I_d	Min. = 5 ms Max. = 15 ms	-
*Reset time, unrestrained function at 10 to 0 x I_d	Min. = 15 ms Max. = 25 ms	-
L3CPDIF and L6CPDIF:		
*Operate time, restrained function at 0 to 10 x I_d	Min. = 10 ms Max. = 25 ms	-
*Reset time, restrained function at 10 to 0 x I_d	Min. = 15 ms Max. = 25 ms	-
*Operate time, unrestrained function at 0 to 10 x I_d	Min. = 5 ms Max. = 15 ms	-
*Reset time, unrestrained function at 10 to 0 x I_d	Min. = 15 ms Max. = 25 ms	-

Note: Data valid for a single IED with two local current input groups

Table 31. Additional security logic for differential protection LDRGFC

Function	Range or value	Accuracy
Operate current, zero sequence current	(1-100)% of IBase	±1.0% of I_r
Operate current, low current operation	(1-100)% of IBase	±1.0% of I_r
Operate voltage, phase to neutral	(1-100)% of UBase	±0.5% of U_r
Operate voltage, phase to phase	(1-100)% of UBase	±0.5% of U_r
Independent time delay, zero sequence current at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Independent time delay, low current operation at 2 x I_{set} to 0	(0.000-60.000) s	±0.2% or ± 40 ms whichever is greater
Independent time delay, low voltage operation at 2 x U_{set} to 0	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Reset time delay for startup signal at 0 to 2 x U_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater

Impedance protection

Table 32. Distance measuring zone, Quad ZMQPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/phase	
Zero sequence reactance	(0.10-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-

Table 33. Distance measuring zone, quadrilateral characteristic for series compensated lines ZMCPDIS, ZMCAPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of *IBase*	-
Minimum operate current, Ph-Ph and Ph-E	(10-1000)% of *IBase*	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.01-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, Ph-E	(0.10-9000.00) Ω/loop	
Fault resistance, Ph-Ph	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CCVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ± 35 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-

Table 34. Phase selection, quadrilateral characteristic with fixed angle FDPSPDIS

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

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Table 35. Full-scheme distance protection, Mho characteristic ZMHPDIS

Function	Range or value	Accuracy
Number of zones, Ph-E	Max 5 with selectable direction	-
Minimum operate current	(10–30)% of IBase	-
Positive sequence impedance, Ph-E loop	(0.005–3000.000) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: 85 degrees
Positive sequence impedance angle, Ph-E loop	(10–90) degrees	
Reverse reach, Ph-E loop (Magnitude)	(0.005–3000.000) Ω/phase	
Magnitude of earth return compensation factor KN	(0.00–3.00)	
Angle for earth compensation factor KN	(-180–180) degrees	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±60 ms whichever is greater
Operate time	22 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.5 to 1.5 x Zreach	Min. = 30 ms Max. = 45 ms	-

Table 36. Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate current	(10-30)% of *IBase*	-
Positive sequence reactance	(0.50-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.10-1000.00) Ω/phase	
Zero sequence reactance	(0.50-9000.00) Ω/phase	
Zero sequence resistance	(0.50-3000.00) Ω/phase	
Fault resistance, Ph-E	(1.00-9000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CCVT's and 0.5<SIR<30	-
Definite time delay Ph-Ph and Ph-E operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	

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Table 37. Faulty phase identification with load encroachment FMPSPDIS

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

Table 38. Distance measuring zone, quadrilateral characteristic, separate settings ZMRPDIS, ZMRAPDIS

Function	Range or value	Accuracy
Number of zones	Max 5 with selectable direction	-
Minimum operate residual current, zone 1	(5-1000)% of IBase	-
Minimum operate current, phase-to-phase and phase-to-earth	(10-1000)% of IBase	-
Positive sequence reactance	(0.10-3000.00) Ω/phase	±2.0% static accuracy ±2.0 degrees static angular accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r Angle: at 0 degrees and 85 degrees
Positive sequence resistance	(0.01-1000.00) Ω/phase	
Zero sequence reactance	(0.10-9000.00) Ω/phase	
Zero sequence resistance	(0.01-3000.00) Ω/phase	
Fault resistance, phase-to-earth	(0.10-9000.00) Ω/loop	
Fault resistance, phase-to-phase	(0.10-3000.00) Ω/loop	
Dynamic overreach	<5% at 85 degrees measured with CVT's and 0.5<SIR<30	-
Definite time delay phase-phase and phase-earth operation	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Operate time	25 ms typically	IEC 60255-121
Reset ratio	105% typically	-
Reset time at 0.1 to 2 x Zreach	Min. = 20 ms Max. = 35 ms	-

Table 39. Phase selection with load encroachment, quadrilateral characteristic FRPSPDIS

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

Function	Range or value	Accuracy
Number of zones	3 selectable directions, 3 fixed directions	-
Minimum operate current, Ph-Ph and Ph-E	(5-6000)% of IBase	±1.0% of I_r
Positive sequence reactance reach, Ph-E and Ph-Ph loop	(0.01 - 3000.00) ohm/phase	
Positive sequence resistance reach, Ph-E and Ph-Ph loop	(0.00 - 1000.00) ohm/phase	
Zero sequence reactance reach	(0.01 - 9000.00) ohm/p	±2.0% of 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
Zero sequence resistive reach	(0.00 - 3000.00) ohm/p	
Fault resistance reach, Ph-E and Ph-Ph	(0.01 -9000.00) ohm/l	
Dynamic overreach	< 5% at 85 degrees measured with CVTs and 0.5 < SIR < 30	
Definite time delay to trip, Ph-E and Ph-Ph operation	(0.000-60.000) s	±2.0% or ±35 ms whichever is greater
Operate time	16 ms typically	IEC 60255-121
Reset time at 0.1 to 2 x Zreach	Min = 20 ms Max = 35 ms	-
Reset ratio	105% typically	

Table 41. Distance zones quad with high speed distance for series compensated networks ZMFCPDIS

Function	Range or value	Accuracy
Number of zones	3 selectable directions, 3 fixed directions	-
Minimum operate current, Ph-Ph and Ph-E	(5 - 6000)% of IBase	±1.0% of I_n
Positive sequence reactance reach, Ph-E and Ph-Ph loop	(30 - 3000) Ω/phase	
Positive sequence resistance reach, Ph-E and Ph-Ph loop	(30 - 3000) Ω/phase	
Zero sequence reactance reach	(100.00 - 9000.00) Ω/p	"+-2.0% static accuracy +-2.0 deg static angular accuracy Conditions: Voltage range: (0.1 - 1.1) x Ur Current range: (0.5 - 30) x Ir Angle: At 0 deg and 85 deg"
Zero sequence resistive reach	(15.00 - 3000.00) Ω/p	
Fault resistance reach, Ph-E and Ph-Ph	(1.00 - 9000.00) Ω/l	
Dynamic overreach	< 5% at 85 deg measured with CVT's and 0.5 < SIR <30	
Definite time delay to trip, Ph-E and Ph-Ph operation	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Operate time	16 ms typically	IEC 60255-121
Reset time at 0.1 to 2 x Z_{reach}	Min = 20 ms Max = 35 ms	-
Reset ratio	105% typically	-

Table 42. Power swing detection ZMRPSB

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

Table 43. Power swing logic PSLPSCH

Function	Range or value	Accuracy
Permitted maximum operating time difference between higher and lower zone	(0.000 — 60.0000) s	±0.2% or ±15 ms whichever is greater
Delay for operation of underreach zone with detected difference in operating time	(0.000 — 60.0000) s	±0.2% or ±15 ms whichever is greater
Conditional timer for sending the CS at power swings	(0.000 — 60.0000) s	±0.2% or ±15 ms whichever is greater
Conditional timer for tripping at power swings	(0.000 — 60.0000) s	±0.2% or ±15 ms whichever is greater
Timer for blocking the overreaching zones trip	(0.000 — 60.0000) s	±0.2% or ±15 ms whichever is greater

Table 44. Pole slip protection PSPPPAM

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

Table 45. Out-of-step protection OOSPPAM

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

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Table 46. Phase preference logic PPLPHIZ

Function	Range or value	Accuracy
Operate value, phase-to-phase and phase-to-neutral undervoltage	(1 - 100)% of UBase	±0.5% of U_r
Reset ratio, undervoltage	< 105%	-
Operate value, residual voltage	(5 - 300)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Reset ratio, residual voltage	> 95%	-
Operate value, residual current	(10 - 200)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio, residual current	> 95%	-
Independent time delay for residual current at 0 to 2 x I_{set}	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Independent time delay for residual voltage at 0.8 to 1.2 x U_{set}	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Independent dropoff-delay for residual voltage at 1.2 to 0.8 x U_{set}	(0.000 - 60.000) s	±0.2% or ±25 ms whichever is greater
Operating mode	No Filter, NoPref Cyclic: 1231c, 1321c Acyclic: 123a, 132a, 213a, 231a, 312a, 321a	

Table 47. Automatic switch onto fault logic ZCVPSOF

Parameter	Range or value	Accuracy
Operate voltage, detection of dead line	(1–100)% of *UBase*	±0.5% of U_r
Operate current, detection of dead line	(1–100)% of *IBase*	±1.0% of I_r
Time delay to operate for the switch onto fault function	(0.03-120.00) s	±0.2% or ±20 ms whichever is greater
Time delay for UI detection	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Delay time for activation of dead line detection	(0.000-60.000) s	±0.2% or ±20 ms whichever is greater
Drop-off delay time of switch onto fault function	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater

Current protection

Table 48. Instantaneous phase overcurrent protection PHPIOC

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

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Table 49. Four-step phase overcurrent protection OC4PTOC

Function	Setting range	Accuracy
Operate current, step 1 - 4	(5-2500)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Minimum operate current, step 1 - 4	(1-10000)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Relay characteristic angle (RCA)	(40.0–65.0) degrees	±2.0 degrees
Relay operating angle (ROA)	(40.0–89.0) degrees	±2.0 degrees
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2 % or ±35 ms whichever is greater
Minimum operate time for inverse curves , step 1 - 4	(0.000-60.000) s	±0.2 % or ±35 ms whichever is greater
Inverse time characteristics, see table 172, table 173 and table 174	16 curve types	See table 172, table 173 and table 174
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 50. Instantaneous residual overcurrent protection EFPIOC

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

Table 51. Four step residual overcurrent protection EF4PTOC technical data

Function	Range or value	Accuracy
Operate current, step 1 - 4	(1-2500)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Relay characteristic angle (RCA)	(-180 to 180) degrees	±2.0 degrees
Operate current for directional release	(1–100)% of *IBase*	For RCA ±60 degrees: ±2.5% of I_r at I ≤ I_r ±2.5% of I at I > I_r
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1 - 4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see Table 172, Table 173 and Table 174	16 curve types	See Table 172, Table 173 and Table 174
Second harmonic blocking	(5–100)% of fundamental	±2.0% of I_r
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

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Table 52. Four step negative sequence overcurrent protection NS4PTOC

Function	Range or value	Accuracy
Operate current, step 1 - 4	(1-2500)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio	> 95% at (10-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}, step 1 - 4	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum operate time for inverse curves, step 1 - 4	(0.000 - 60.000) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see table 172, table 173 and table 174	16 curve types	See table 172, table 173 and table 174
Minimum operate current, step 1 - 4	(1.00 - 10000.00)% of *IBase*	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Relay characteristic angle (RCA)	(-180 to 180) degrees	±2.0 degrees
Operate current for directional release	(1–100)% of *IBase*	For RCA ±60 degrees: ±2.5% of I_r at I ≤ I_r ±2.5% of I at I > I_r
Minimum polarizing voltage	(1–100)% of *UBase*	±0.5% of U_r
Minimum polarizing current	(2-100)% of *IBase*	±1.0% of I_r
Real part of negative sequence source impedance used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of negative sequence source impedance used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, start non-directional at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start non-directional at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start non-directional at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start non-directional at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Transient overreach	<10% at τ = 100 ms	-

Table 53. Sensitive directional residual overcurrent and power protection SDEPSDE

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

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Table 54. Thermal overload protection, one time constant LCPTTR/LFPTTR

Function	Range or value	Accuracy
Reference current	(2-400)% of IBase	±1.0% of I_r
Reference temperature	(0-300)°C, (0 - 600)°F	±1.0°C, ±2.0°F
Operate time: $$t = \tau \ln \left[\frac{I^2 - I_p^2}{I^2 - I_p^2 - \frac{T_{Trip} - T_{Amb}}{T_{ref}} \cdot I_{ref}^2} \right]$$ (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 60255-149, ±5.0% or ±200 ms whichever is greater
Alarm temperature	(0-200)°C, (0-400)°F	±2.0°C, ±4.0°F
Operate temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F
Reset level temperature	(0-300)°C, (0-600)°F	±2.0°C, ±4.0°F

Table 55. 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%	-
Operate time for current detection	20 ms typically	-
Reset time for current detection	25 ms maximum	-
Time delay for re-trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Time delay for back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Time delay for back-up trip at multi-phase start at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Additional time delay for a second back-up trip at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Time delay for alarm for faulty circuit breaker	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater

Table 56. Stub protection STBPTOC

Function	Range or value	Accuracy
Operating current	(5-2500)% of *IBase*	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio	> 95% at (50-2500)% of *IBase*	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater
Operate time, start at 0 to 2 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-

Table 57. Pole discordance protection CCPDSC

Function	Range or value	Accuracy
Operate current	(0–100)% of *IBase*	±1.0% of I_r
Independent time delay between trip condition and trip signal	(0.000-60.000) s	±0.2% or ± 25 ms whichever is greater

Table 58. Directional underpower protection GUPPDUP

Function	Range or value	Accuracy
Power level for Step 1 and Step 2	(0.0–500.0)% of *SBase*	±1.0% of S_r at $S \le S_r$ ±1.0% of S at $S > S_r$ where $S_r = 1.732 \cdot U_r \cdot I_r$
Characteristic angle for Step 1 and Step 2	(-180.0–180.0) degrees	±2.0 degrees
Independent time delay to operate for Step 1 and Step 2 at 2 to 0.5 x S_r and *k=0.000*	(0.01-6000.00) s	±0.2% or ±40 ms whichever is greater

Table 59. Directional overpower protection GOPPDOP

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

Table 60. Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of *IBase*	±1.0% of I_r
Unbalance current operation	(50–90)% of maximum current	±1.0% of I_r
Independent operate time delay	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Independent reset time delay	(0.010-60.000) s	±0.2% or ±30 ms whichever is greater
Start time at current change from I_r to 0	Min. = 25 ms Max. = 35 ms	-
Reset time at current change from 0 to I_r	Min. = 5 ms Max. = 20 ms	-

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Voltage protection

Table 61. Two step undervoltage protection UV2PTUV

Function	Range or value	Accuracy
Operate voltage, low and high step	(1.0–100.0)% of *UBase*	±0.5% of U_r
Absolute hysteresis	(0.0–50.0)% of *UBase*	±0.5% of U_r
Internal blocking level, step 1 and step 2	(1–50)% of *UBase*	±0.5% of U_r
Inverse time characteristics for step 1 and step 2, see table 176	-	See table 176
Definite time delay, step 1 at 1.2 to 0 x U_{set}	(0.00-6000.00) s	±0.2% or ±40ms whichever is greater
Definite time delay, step 2 at 1.2 to 0 x U_{set}	(0.000-60.000) s	±0.2% or ±40ms whichever is greater
Minimum operate time, inverse characteristics	(0.000–60.000) s	±0.5% or ±40ms whichever is greater
Operate time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Reset time, start at 0 to 1.2 x U_{set}	Min. = 15 ms Max. = 35 ms	-
Critical impulse time	5 ms typically at 1.2 to 0 x U_{set}	-
Impulse margin time	15 ms typically	-

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Table 62. Two step overvoltage protection OV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and 2	(1.0-200.0)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Absolute hysteresis	(0.0–50.0)% of *UBase*	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Inverse time characteristics for steps 1 and 2, see table 175	-	See table 175
Definite time delay, low step (step 1) at 0 to 1.2 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±45 ms whichever is greater
Definite time delay, high step (step 2) at 0 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Minimum operate time, Inverse characteristics	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 63. Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1 and step 2	(1.0-200.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Absolute hysteresis	(0.0–50.0)% of *UBase*	± 0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Inverse time characteristics for low and high step, see table 177	-	See table 177
Definite time delay low step (step 1) at 0 to 1.2 x U_{set}	(0.00–6000.00) s	± 0.2% or ± 45 ms whichever is greater
Definite time delay high step (step 2) at 0 to 1.2 x U_{set}	(0.000–60.000) s	± 0.2% or ± 45 ms whichever is greater
Minimum operate time	(0.000-60.000) s	± 0.2% or ± 45 ms whichever is greater
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 1.2 x U_{set}	Min. = 20 ms Max. = 35 ms	-
Reset time, start at 1.2 to 0 x U_{set}	Min. = 5 ms Max. = 25 ms	-
Critical impulse time	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 64. Overexcitation protection OEXPVPH

Function	Range or value	Accuracy
Operate value, start	(100–180)% of ($UBasef_{rated}$)	±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 ($UBasef_{rated}$)	±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)	±5.0 % or ±45 ms, whichever is greater
Minimum time delay for inverse function	(0.000–60.000) s	±1.0% or ±45 ms, whichever is greater
Maximum time delay for inverse function	(0.00–9000.00) s	±1.0% or ±45 ms, whichever is greater
Alarm time delay	(0.00–9000.00)	±1.0% or ±45 ms, whichever is greater

Table 65. Voltage differential protection VDCPTOV

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

Table 66. Loss of voltage check LOVPTUV

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

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Table 67. Radial feeder protection PAPGAPC

Function	Range or value	Accuracy
Residual current detection	(10 - 150)% of IBase	±1.0% of Ir at I ≤ Ir ±1.0% of I at I > Ir
Reset ratio	>95% at (50 - 150)% of IBase	-
Operate time, residual current detection at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Independent time delay to operate, residual current detection at 0 to 2 x I_{set}	(0.000 - 60.000) s	±0.2% or ±40 ms whichever is greater
Voltage based phase selection	(30 - 100)% of UBase	±1.0% of U_r
Reset ratio	<115%	-
Operate time, voltage based phase selection at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Independent time delay to operate, voltage based phase selection at 1.2 to 0.8 x U_{set}	(0.000 – 60.000) s	±0.2% or ±40 ms whichever is greater

Frequency protection

Table 68. Underfrequency protection SAPTUF

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

$$t = \left[\frac{U - UMin}{UNom - UMin} \right]^{Exponent} \cdot (tMax - tMin) + tMin \qquad \text{(Equation 3)}$$

$U = U_{measured}$

Table 69. Overfrequency protection SAPTOF

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

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Table 70. 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, restore enable frequency	(45.00-65.00) Hz	±2.0 mHz
Definite restore time delay	(0.000-60.000) s	±0.2% or ±100 ms whichever is greater
Definite time delay for frequency gradient trip	(0.200-60.000) s	±0.2% or ±120 ms whichever is greater
Definite reset time delay	(0.000-60.000) s	±0.2% or ±250 ms whichever is greater

Multipurpose protection

Table 71. General current and voltage protection CVGAPC

Function	Range or value	Accuracy
Measuring current input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Measuring voltage input	phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph	-
Start overcurrent, step 1 - 2	(2 - 5000)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Start undercurrent, step 1 - 2	(2 - 150)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Independent time delay, overcurrent at 0 to 2 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Independent time delay, undercurrent at 2 to 0 x I_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overcurrent (non-directional):		
Start time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Start time at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Undercurrent:		
Start time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Overcurrent:		
Inverse time characteristics, see table 172, 173 and table 174	16 curve types	See table 172, 173 and table 174
Overcurrent:		
Minimum operate time for inverse curves, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Voltage level where voltage memory takes over	(0.0 - 5.0)% of UBase	±0.5% of U_r
Start overvoltage, step 1 - 2	(2.0 - 200.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Start undervoltage, step 1 - 2	(2.0 - 150.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Independent time delay, overvoltage at 0.8 to 1.2 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater

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Table 71. General current and voltage protection CVGAPC , continued

Function	Range or value	Accuracy
Independent time delay, undervoltage at 1.2 to 0.8 x U_{set}, step 1 - 2	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Overvoltage:		
Start time at 0.8 to 1.2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Undervoltage:		
Start time at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 1.2 to 0.8 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Overvoltage:		
Inverse time characteristics, see table 175	4 curve types	See table 175
Undervoltage:		
Inverse time characteristics, see table 176	3 curve types	See table 176
High and low voltage limit, voltage dependent operation, step 1 - 2	(1.0 - 200.0)% of UBase	±1.0% of U_r at $U \le U_r$ ±1.0% of U at $U > U_r$
Directional function	Settable: NonDir, forward and reverse	-
Relay characteristic angle	(-180 to +180) degrees	±2.0 degrees
Relay operate angle	(1 to 90) degrees	±2.0 degrees
Reset ratio, overcurrent	> 95%	-
Reset ratio, undercurrent	< 105%	-
Reset ratio, overvoltage	> 95%	-
Reset ratio, undervoltage	< 105%	-
Overcurrent:		
Critical impulse time	10 ms typically at 0 to 2 x I_{set}	-
Impulse margin time	15 ms typically	-
Undercurrent:		
Critical impulse time	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time	15 ms typically	-
Overvoltage:		
Critical impulse time	10 ms typically at 0.8 to 1.2 x U_{set}	-
Impulse margin time	15 ms typically	-
Undervoltage:		
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

Table 72. Rotor earth fault protection based on General current and voltage protection (CVGAPC) and RXTTE4

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

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Table 73. Voltage-restrained time overcurrent protection VRPVOC

Function	Range or value	Accuracy
Start overcurrent	(2.0 - 5000.0)% of IBase	±1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
Reset ratio, overcurrent	> 95%	-
Operate time, start overcurrent at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start overcurrent at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start overcurrent at 0 to 10 x I_{set}	Min. = 5 ms Max. = 20 ms	-
Reset time, start overcurrent at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Independent time delay to operate at 0 to 2 x I_{set}	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Inverse time characteristics, see tables 172 and 173	13 curve types	See tables 172 and 173
Minimum operate time for inverse time characteristics	(0.00 - 60.00) s	±0.2% or ±35 ms whichever is greater
High voltage limit, voltage dependent operation	(30.0 - 100.0)% of UBase	±1.0% of U_r
Start undervoltage	(2.0 - 100.0)% of UBase	±0.5% of U_r
Reset ratio, undervoltage	< 105%	-
Operate time start undervoltage at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time start undervoltage at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Independent time delay to operate, undervoltage at 2 to 0 x U_{set}	(0.00 - 6000.00) s	±0.2% or ±35 ms whichever is greater
Internal low voltage blocking	(0.0 - 5.0)% of UBase	±0.25% of U_r
Overcurrent: Critical impulse time Impulse margin time	10 ms typically at 0 to 2 x I_{set} 15 ms typically	-
Undervoltage: Critical impulse time Impulse margin time	10ms typically at 2 to 0 x U_{set} 15 ms typically	-

Secondary system supervision

Table 74. Current circuit supervision CCSSPVC

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

Table 75. Fuse failure supervision FUFSPVC

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

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Table 76. Fuse failure supervision VDSPVC

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

Control

Table 77. Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, $\varphi_{line} - \varphi_{bus}$	(-180 to 180) degrees	-
Voltage high limit for synchronizing and synchrocheck	(50.0-120.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Reset ratio, synchrocheck	> 95%	-
Frequency difference limit between bus and line for synchrocheck	(0.003-1.000) Hz	±2.5 mHz
Phase angle difference limit between bus and line for synchrocheck	(5.0-90.0) degrees	±2.0 degrees
Voltage difference limit between bus and line for synchronizing and synchrocheck	(0.02-0.5) p.u	±0.5% of U_r
Time delay output for synchrocheck when angle difference between bus and line jumps from "PhaseDiff" + 2 degrees to "PhaseDiff" - 2 degrees	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Frequency difference minimum limit for synchronizing	(0.003-0.250) Hz	±2.5 mHz
Frequency difference maximum limit for synchronizing	(0.050-0.500) Hz	±2.5 mHz
Breaker closing pulse duration	(0.050-60.000) s	±0.2% or ±15 ms whichever is greater
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-6000.00) s	±0.2% or ±35 ms whichever is greater
Minimum time to accept synchronizing conditions	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Voltage high limit for energizing check	(50.0-120.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Reset ratio, voltage high limit	> 95%	-
Voltage low limit for energizing check	(10.0-80.0)% of UBase	±0.5% of U_r
Reset ratio, voltage low limit	< 105%	-
Maximum voltage for energizing	(50.0-180.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Time delay for energizing check when voltage jumps from 0 to 90% of Urated	(0.000-60.000) s	±0.2% or ±100 ms whichever is greater
Operate time for synchrocheck function when angle difference between bus and line jumps from "PhaseDiff" + 2 degrees to "PhaseDiff" - 2 degrees	Min. = 15 ms Max. = 30 ms	–
Operate time for energizing function when voltage jumps from 0 to 90% of Urated	Min. = 70 ms Max. = 90 ms	–

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Table 78. 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 3Ph	(0.000-120.000) s	±0.2% or ±35 ms whichever is greater
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Extended autorecloser open time	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater
Minimum time CB must be closed before AR becomes ready for autoreclosing cycle	(0.00-6000.00) s	±0.2% or ±35 ms whichever is greater
Maximum operate pulse duration	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Reclaim time	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Circuit breaker closing pulse length	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Wait for master release	(0.00-6000.00) s	±0.2% or ±15 ms whichever is greater
Inhibit reset time	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater
Autorecloser maximum wait time for sync	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
CB check time before unsuccessful	(0.00-6000.00) s	±0.2% or ±45 ms whichever is greater
Wait time after close command before proceeding to next shot	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater

Scheme communication

Table 79. Scheme communication logic for distance or overcurrent protection ZCPSCH

Function	Range or value	Accuracy
Scheme type	Off Intertrip Permissive UR Permissive OR Blocking DeltaBlocking	-
Operate voltage, Delta U	(0–100)% of UBase	±5.0% of ΔU
Operate current, Delta I	(0–200)% of IBase	±5.0% of ΔI
Operate zero sequence voltage, Delta 3U0	(0–100)% of UBase	±10.0% of Δ3U0
Operate zero sequence current, Delta 3I0	(0–200)% of IBase	±10.0% of Δ3I0
Co-ordination time for blocking communication scheme	(0.000-60.000) s	±0.5% ±10 ms
Minimum duration of a carrier 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 80. 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	±0.2% or ±15 ms whichever is greater
Minimum duration of a carrier send signal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 81. 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% at (20-90)% of UBase	
Operate time for current reversal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Delay time for current reversal	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater
Coordination time for weak-end infeed logic	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 82. Scheme communication logic for residual overcurrent protection ECPSCH

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

Table 83. Current reversal and weak-end infeed logic for residual overcurrent protection ECRWPSCH

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

Direct transfer trip

Table 84. 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%	-
Operate value, low power factor	0.00-1.00	±0.02
Independent time delay to operate for low active power at 1.2 to 0.8 x P_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Independent time delay to operate for low power factor at 1.2 to 0.8 x PF_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Critical impulse time, low active power	10 ms typically at 1.2 to 0.8 x P_{set}	-
Impulse margin time, low active power	10 ms typically	-

Table 85. Compensated over- and undervoltage protection COUVGAPC

Function	Range or value	Accuracy
Operate value, undervoltage	(1-100)% of UBase	±0,5% of U_r
Absolute hysteresis	(0.00–50.0)% of UBase	±0.5% of U_r at $U \le U_r$ ±0.5% of U at $U > U_r$
Critical impulse time, undervoltage	10 ms typically at 1.2 to 0.8x U_{set}	-
Impulse margin time, undervoltage	15 ms typically	-
Operate value, overvoltage	(1-200)% of UBase	±0.5% of U_r at $U \le U_r$ ± 0.5% of U at $U > U_r$
Critical impulse time, overvoltage	10 ms typically at 0.8 to 1.2 x U_{set}	-
Impulse margin time, overvoltage	15 ms typically	-
Independent time delay for undervoltage functionality at 1.2 to 0.8 x U_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater
Independent time delay for overvoltage functionality at 0.8 to 1.2 x U_{set}	(0.000-60.000) s	±0.2% or ±40 ms whichever is greater

Table 86. Sudden change in current variation SCCVPTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-100)% of IBase	±2.0% of I_r
Hold time for operate signal at 0 to 2 x Iset	(0.000-60.000) s	±0.2% or ±15 ms whichever is greater

Table 87. Carrier receive logic LCCRPTRC

Function	Range or value	Accuracy
Operation mode	1 Out Of 2 2 Out Of 2	-
Independent time delay	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater

Table 88. 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 $U \le U_r$ ±0.5% of U at $U > U_r$
Reset ratio, negative sequence overvoltage	>95% at (10–200)% of UBase	-
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Critical impulse time, negative sequence overvoltage	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time, negative sequence overvoltage	15 ms typically	-
Independent time delay to operate at 0 to 1.2 x U_{set}	(0.000-120.000) s	±0.2% or ±40 ms whichever is greater

Table 89. 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 $U \le U_r$ ±0.5% of U at $U > U_r$
Reset ratio, zero sequence overvoltage	>95% at (10–200)% of UBase	-
Operate time, start at 0 to 2 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x U_{set}	Min. = 15 ms Max. = 30 ms	-
Critical impulse time, zero sequence overvoltage	10 ms typically at 0 to 2 x U_{set}	-
Impulse margin time, zero sequence overvoltage	15 ms typically	-
Independent time delay to operate at 0 to 1.2 x U_{set}	(0.000-120.000) s	±0.2% or ±40 ms whichever is greater

Table 90. Negative sequence overcurrent protection LCNSPTOC

Function	Range or value	Accuracy
Operate value, negative sequence overcurrent	(3 - 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% at (50–2500)% of IBase	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 15 ms Max. = 25 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time, negative sequence overcurrent	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, negative sequence overcurrent	15 ms typically	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms, whichever is greater
Transient overreach, start function	<5% at τ = 100 ms	-

Table 91. Zero sequence overcurrent protection LCZSPTOC

Function	Range or value	Accuracy
Operate value, zero sequence overcurrent	(3-2500)% 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% at (50–2500)% of IBase	-
Operate time, start at 0 to 2 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time, start at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Operate time, start at 0 to 10 x I_{set}	Min. = 10 ms Max. = 20 ms	-
Reset time, start at 10 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time, zero sequence overcurrent	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, zero sequence overcurrent	15 ms typically	-
Independent time delay at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±35 ms whichever is greater

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Table 92. Three phase overcurrent LCP3PTOC

Function	Range or value	Accuracy
Operate value, overcurrent	(5-2500)% of IBase	±1.0% of I_r at I ≤ I_r ±1.0% of I at I > I_r
Reset ratio, overcurrent	> 95% at (50-2500)% of IBase	-
Start time at 0 to 2 x I_{set}	Min. = 10 ms Max. = 25 ms	-
Reset time at 2 to 0 x I_{set}	Min. = 20 ms Max. = 35 ms	-
Critical impulse time, overcurrent	5 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time, overcurrent	10 ms typically	-
Independent time delay to operate at 0 to 2 x I_{set}	(0.000-60.000) s	±0.2% or ±30 ms whichever is greater

Table 93. Three phase undercurrent LCP3PTUC

Function	Range or value	Accuracy
Operate value, undercurrent	(1.00-100.00)% of IBase	±1.0% of I_r
Reset ratio, undercurrent	< 105% at (50.00-100.00)% of IBase	-
Start time at 2 to 0 x I_{set}	Min. = 15 ms Max. = 30 ms	-
Reset time at 0 to 2 x I_{set}	Min. = 10 ms Max. = 25 ms	-
Critical impulse time, undercurrent	10 ms typically at 2 to 0 x I_{set}	-
Impulse margin time, undercurrent	10 ms typically	-
Independent time delay to operate at 2 to 0 x I_{set}	(0.000-60.000) s	±0.2% or ±45 ms whichever is greater

Logic

Table 94. Tripping logic common 3-phase output SMPPTRC

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

Table 95. Number of SMPPTRC instances

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

Table 96. Number of TMAGAPC instances

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

Table 97. Number of ALMCALH instances

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

Table 98. Number of WRNCALH instances

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

Table 99. Number of INDCALH instances

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

Table 100. Number of AND instances

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

Table 101. Number of GATE instances

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

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Table 102. Number of INV instances

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

Table 103. Number of LLD instances

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

Table 104. Number of OR instances

Logic block	Quantity with cycle time		
	3 ms	8 ms	100 ms
OR	69	60	160

Table 105. Number of PULSETIMER instances

Logic block	Quantity with cycle time			Range or Value	Accuracy
	3 ms	8 ms	100 ms		
PULSETIMER	10	10	20	(0.000–90000.000) s	±0.5% ±10 ms

Table 106. Number of RSMEMORY instances

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

Table 107. Number of SRMEMORY instances

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

Table 108. Number of TIMERSET instances

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

Table 109. Number of XOR instances

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

Table 110. Number of ANDQT instances

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

Table 111. Number of INDCOMBSPQT instances

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

Table 112. Number of INDEXTSPQT instances

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

Table 113. Number of INVALIDQT instances

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

Table 114. Number of INVERTERQT instances

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

Table 115. Number of ORQT instances

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

Table 116. Number of PULSETIMERQT instances

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

Table 117. Number of RSMEMORYQT instances

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

Table 118. Number of SRMEMORYQT instances

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

Table 119. Number of TIMERSETQT instances

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

Table 120. Number of XORQT instances

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

Table 121. Number of instances in the extension logic package

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

Table 122. Number of B16I instances

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

Table 123. Number of BTIGAPC instances

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

Table 124. Number of IB16 instances

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

Table 125. Number of ITBGAPC instances

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

Table 126. Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	3	0 ~ 999999.9 s	±0.2% or ±20 ms whichever is greater
	8	0 ~ 999999.9 s	±0.2% or ±100 ms whichever is greater
	100	0 ~ 999999.9 s	±0.2% or ±250 ms whichever is greater

Table 127. Number of TEIGAPC instances

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

Table 128. Running hour-meter TEILGAPC

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

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Monitoring

Table 129. Measurements CVMMXN

Function	Range or value	Accuracy
Frequency	(0.95-1.05) × f_r	±2.0 mHz
Voltage	(10 to 300) V	±0.3% of U at U≤ 50 V ±0.2% of U at U> 50 V
Current	(0.1-4.0) × I_r	±0.8% of I at 0.1 × I_r< I < 0.2 × I_r ± 0.5% of I at 0.2 × I_r< I < 0.5 × I_r ±0.2% of I at 0.5 × I_r< I < 4.0 × I_r
Active power, P	(10 to 300) V (0.1-4.0) × I_r	±0.5% of S_r at S ≤0.5 × S_r ±0.5% of S at S > 0.5 × S_r
	(100 to 220) V (0.5-2.0) × I_r cos φ< 0.7	±0.2% of P
Reactive power, Q	(10 to 300) V (0.1-4.0) × I_r	±0.5% of S_r at S ≤0.5 × S_r ±0.5% of S at S > 0.5 × S_r
	(100 to 220) V (0.5-2.0) × I_r cos φ> 0.7	±0.2% of Q
Apparent power, S	(10 to 300) V (0.1-4.0) × I_r	±0.5% of S_r at S ≤0.5 × S_r ±0.5% of S at S >0.5 × S_r
	(100 to 220) V (0.5-2.0) × I_r	±0.2% of S
Power factor, cos (φ)	(10 to 300) V (0.1-4.0) × I_r	<0.02
	(100 to 220) V (0.5-2.0) × I_r	<0.01

Table 130. Phase current measurement CMMXU

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

Table 131. Phase-phase voltage measurement VMMXU

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

Table 132. Phase-neutral voltage measurement VNMMXU

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

Table 133. Current sequence component measurement CMSQI

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

Table 134. Voltage sequence measurement VMSQI

Function	Range or value	Accuracy
Voltage positive sequence, U1	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Voltage zero sequence, 3U0	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Voltage negative sequence, U2	(10 to 300) V	±0.5% of U at U ≤ 50 V ±0.2% of U at U > 50 V
Phase angle	(10 to 300) V	±0.5 degrees at U ≤ 50 V ±0.2 degrees at U > 50 V

Table 135. 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 136. Limit counter L4UFCNT

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

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Table 137. 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 168
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 138. Insulation gas monitoring function SSIMG

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

Table 139. Insulation liquid monitoring function SSIML

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

Table 140. Breaker monitoring SSCBR

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

Table 141. Fault locator LMBRFLO

Function	Value or range	Accuracy
Reactive and resistive reach	(0.001-1500.000) Ω/phase	±2.0% static accuracy Conditions: Voltage range: (0.1-1.1) x U_r Current range: (0.5-30) x I_r
Phase selection	According to input signals	-
Maximum number of fault locations	100	-

Table 142. Event list

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

Line differential protection RED670 2.1 IEC
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Table 143. Indications

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

Table 144. 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 145. Trip value recorder

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

Table 146. 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

Table 147. Limit counter L4UFCNT

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

Metering

Table 148. Pulse-counter logic PCFCNT

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

Table 149. 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

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Station communication

Table 150. Communication protocols

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

Table 151. IEC 61850-9-2 communication protocol

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

Table 152. LON communication protocol

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

Table 153. SPA communication protocol

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

Table 154. IEC 60870-5-103 communication protocol

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

Table 155. SLM – LON port

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

*) depending on optical budget calculation

Table 156. SLM – SPA/IEC 60870-5-103/DNP3 port

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

*) depending on optical budget calculation

Table 157. 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 158. 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 159. IEC 62439-3 Edition 1 and Edition 2 parallel redundancy protocol

Function	Value
Communication speed	100 Base-FX

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Remote communication

Table 160. Line data communication module

Characteristic	Range or value		
Type of LDCM	Short range (SR)	Medium range (MR)	Long range (LR)
Type of fiber	Graded-index multimode 62.5/125 µm	Singlemode 9/125 µm	Singlemode 9/125 µm
Peak Emission Wave length Nominal Maximum Minimum	 820 nm 865 nm 792 nm	 1310 nm 1330 nm 1290 nm	 1550 nm 1580 nm 1520 nm
Optical budget Graded-index multimode 62.5/125 µm, Graded-index multimode 50/125 µm	13 dB (typical distance about 3 km/2 mile *) 9 dB (typical distance about 2 km/1 mile *)	22 dB (typical distance 80 km/50 mile *)	26 dB (typical distance 110 km/68 mile *)
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 161. 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 162. 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 163. Weight

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

Electrical safety

Table 164. Electrical safety according to IEC 60255-27

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

Connection system

Table 165. 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 166. Auxiliary power supply and binary I/O connectors

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

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

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Basic IED functions

Table 167. Self supervision with internal event list

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

Table 168. 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 169. 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 170. GPS – Antenna and cable

Function	Value
Max antenna cable attenuation	26 db @ 1.6 GHz
Antenna cable impedance	50 ohm
Lightning protection	Must be provided externally
Antenna cable connector	SMA in receiver end TNC in antenna end
Accuracy	+/-1µs

Table 171. IRIG-B

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

Inverse characteristic

Table 172. ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{(I^P - 1)} + B \right) \cdot k + tDef$ Reset characteristic: $t = \frac{t_r}{(I^2 - 1)} \cdot k$ $I = I_{measured}/I_{set}$	$0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$	ANSI/IEEE C37.112 , ±2.0% or ±40 ms whichever is greater
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0 , tr=29.1	
ANSI Very inverse	A=19.61, B=0.491, P=2.0 , tr=21.6	
ANSI Normal Inverse	A=0.0086, B=0.0185, P=0.02, tr=0.46	
ANSI Moderately Inverse	A=0.0515, B=0.1140, P=0.02, tr=4.85	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0, tr=30	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0, tr=13.46	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02, tr=4.6	

Table 173. IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{(I^P - 1)} \right) \cdot k$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 3.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	
Programmable characteristic Operate characteristic: $t = \left(\frac{A}{(I^P - C)} + B \right) \cdot k$ Reset characteristic: $t = \frac{TR}{(I^{PR} - CR)} \cdot k$ $I = I_{measured}/I_{set}$	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 174. RI and RD type inverse time characteristics

Function	Range or value	Accuracy
RI type inverse characteristic $t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$ $I = I_{measured}/I_{set}$	$0.10 \le k \le 3.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$	IEC 60255-151, ±2.0% or ±40 ms whichever is greater
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k} \right)$ $I = I_{measured}/I_{set}$		

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Table 175. Inverse time characteristics for overvoltage protection

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

Table 176. Inverse time characteristics for undervoltage protection

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

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Table 177. Inverse time characteristics for residual overvoltage protection

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

22. Ordering for customized IED

Table 178. General guidelines

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

Table 179. Example ordering code

To obtain the complete ordering code, please combine code from the selection tables, as given in the example below. The selected qty of each table must be filled in, if no selection is possible the code is 0 Example of a complete code: RED670*2.1 - F00X00 - A000000302[illegible] - B5225255221255221111101000 - C3300032122020022221000300 - D22212 011 - E2220 - F4 - S6 - G232 - H20401100000 - K11111111 - L11 - M21 - P01 - B1X0 - AC -MB - B - A3X0 - D1D1ARGN1N1XXXXXXX - AAFXXX - AX

Product definition					-	Differential protection														-
RED670*	2.1	-		X00	-	A	0	0	0	0	0	0		0						-

Impedance protection																										-
B																					0		0	0	0	-

Current protection																								-
C			00								0		00					1	0	0	0		0	0	-

Voltage protection									-	Frequency protection				-	Multipurpose protection		-	General calculation		-
D							0	1	-	E			0	-	F		-	S		-

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

Scheme communication						-	Logic		-	Monitoring		-	Station communication												-
K						-	L		-	M	1	-	P		0	0	0	0	0	0	0	0	0	0	-

Language	-	Casing and Mounting	-	Connection and power	-	HMI	-	Analog input	-	Binary input/output	-
B 1	-		-		-		-		-		-

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

Table 180. Product definition

RED670*	2.1		X00

Table 181. Product definition ordering codes

Product	RED670*
Software version	2.1
Configuration alternatives	
Line differential protection RED670	F00
Line differential protection RED670 61850-9-2LE	N00
Selection:	
ACT configuration	
No ACT configuration downloaded	X00

Table 182. Differential protection

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

Table 183. Differential functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
1Ph High impedance differential protection	HZPDIF	1MRK005904-HA	7	0-3		
Restricted earth fault protection, low impedance	REFPDIF	1MRK005904-LC	9	0-2		
Line differential protection, 3 CT sets, 2-3 line ends	L3CPDIF	1MRK005904-MB	10	0-1		Note: One, and only one PDIF must be ordered.
Line differential protection, 6 CT sets, 3-5 line ends	L6CPDIF	1MRK005904-NB	11	0-1		
Line differential protection 3 CT sets, with inzone transformers, 2-3 line ends	LT3CPDIF	1MRK005904-PB	12	0-1		
Line differential protection 6 CT sets, with inzone transformers, 3-5 line ends	LT6CPDIF	1MRK005904-RB	13	0-1		
Additional security logic for differential protection	LDRGFC	1MRK005904-TA	14	0-1		

Table 184. Impedance protection

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

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Table 185. Impedance functions, alternatives

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Note: One, and only one alternative can be selected. Selected qty is 0 for other functions in an unselected alternative.						
Alternative 1 Distance protection, quadrilateral						
Distance protection zone, quadrilateral characteristic	ZMQPDIS, ZMQAPDIS	1MRK005907-AA	1	0-5		
Directional impedance quadrilateral	ZDRDIR	1MRK005907-BA	2	0-2		
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Alternative 2 Distance protection for series compensated lines, quadrilateral						
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Distance measuring zone, quadrilateral characteristic for series compensated lines	ZMCPDIS, ZMCAPDIS	1MRK005907-DA	4	0-5		
Directional impedance quadrilateral, including series compensation	ZDSRDIR	1MRK005907-EA	5	0-2		
Alternative 3 Distance protection, mho (mho for phase - phase fault and mho in parallel with quad for earth fault)						
Fullscheme distance protection, mho characteristic	ZMHPDIS	1MRK005907-FA	6	0-5		
Fullscheme distance protection, quadrilateral for earth faults	ZMMPDIS, ZMMAPDIS	1MRK005907-GA	7	0-5		
Directional impedance element for mho characteristic	ZDMRDIR	1MRK005907-HA	8	0-2		
Additional distance protection directional function for earth faults	ZDARDIR	1MRK005907-KA	9	0-2		
Mho impedance supervision logic	ZSMGAPC	1MRK005907-LA	10	0-1		
Faulty phase identification with load encroachment	FMPSPDIS	1MRK005907-MA	11	0-2		
Alternative 4 Distance protection, quadrilateral with separate settings for PP and PE						
Directional impedance quadrilateral	ZDRDIR	1MRK005907-BA	2	0-2		
Distance protection zone, quadrilateral characteristic, separate settings	ZMRPDIS, ZMRAPDIS	1MRK005907-NA	12	0-5		
Phase selection, quadrilateral characteristic with settable angle	FRPSPDIS	1MRK005907-PA	13	0-2		
Alternative 5 High speed distance protection, quadrilateral and mho						
High speed distance protection, quad and mho characteristic	ZMFPDIS	1MRK005907-SB	14	0-1		
Alternative 6 High speed distance protection for series compensated lines, quadrilateral and mho						
High speed distance protection for series compensated lines, quad and mho characteristic	ZMFCPDIS	1MRK005907-RB	15	0-1		
Optional for alternative 1						
Directional impedance element for mho characteristic	ZDMRDIR	1MRK005907-HA	8	0-2		
Optional for alternative 3						
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS	1MRK005907-CA	3	0-2		
Optional for alternatives 1, 2 and 4						
Additional distance protection directional function for earth faults	ZDARDIR	1MRK005907-KA	9	0-2		
Faulty phase identification with load encroachment	FMPSPDIS	1MRK005907-MA	11	0-2		
Optional with any alternative						
Power swing detection	ZMRPSB	1MRK005907-UA	16	0-1		
Automatic switch onto fault logic, voltage and current based	ZCVPSOF	1MRK005908-AA	17	0-1		
Power swing logic	PSLPSCH	1MRK005907-VA	18	0-1		
PoleSlip/Out-of-step protection	PSPPPAM	1MRK005908-CB	19	0-1		
Out-of-step protection	OOSPPAM	1MRK005908-GA	20	0-1		
Phase preference logic	PPLPHIZ	1MRK005908-DA	22	0-1		

Table 186. Current protection

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

Table 187. Current functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Instantaneous phase overcurrent protection	PHPIOC	1MRK005910-AC	1	0-3		
Four step phase overcurrent protection	OC4PTOC	1MRK005910-BB	2	0-3		
Instantaneous residual overcurrent protection	EFPIOC	1MRK005910-DC	4	0-1		
Four step residual overcurrent protection	EF4PTOC	1MRK005910-EC	5	0-3		
Four step directional negative phase sequence overcurrent protection	NS4PTOC	1MRK005910-FB	6	0-2		
Sensitive Directional residual over current and power protetcion	SDEPSDE	1MRK005910-GA	7	0-1		
Thermal overload protection, one time constant, Celcius	LCPTTR	1MRK005911-BA	8	0-2		
Thermal overload protection, one time constant, Fahrenheit	LFPTTR	1MRK005911-AA	9	0-2		
Breaker failure protection	CCRBRF	1MRK005910-LA	11	0-2		
Stub protection	STBPTOC	1MRK005910-NA	13	0-2		
Pole discordance protection	CCPDSC	1MRK005910-PA	14	0-2		
Directional Underpower protection	GUPPDUP	1MRK005910-RA	15	0-2		
Directional Overpower protection	GOPPDOP	1MRK005910-TA	16	0-2		
Broken conductor check	BRCPTOC	1MRK005910-SA	17	1		
Voltage restrained overcurrent protection	VRPVOC	1MRK005910-XA	21	0-3		

Table 188. Voltage protection

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

Table 189. Voltage functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Two step undervoltage protection	UV2PTUV	1MRK005912-AA	1	0-2		
Two step overvoltage protection	OV2PTOV	1MRK005912-BA	2	0-2		
Two step residual overvoltage protection	ROV2PTOV	1MRK005912-CA	3	0-2		
Overexcitation protection	OEXPVPH	1MRK005912-DA	4	0-1		
Voltage differential protection	VDCPTOV	1MRK005912-EA	5	0-2		
Loss of voltage check	LOVPTUV	1MRK005912-GA	7	1		
Radial feeder protection	PAPGAPC	1MRK005912-HA	8	0-1		

Table 190. Frequency protection

Position	1	2	3	4
E				00

Table 191. Frequency functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Underfrequency protection	SAPTUF	1MRK005914-AA	1	0-6		
Overfrequency protection	SAPTOF	1MRK005914-BA	2	0-6		
Rate-of-change frequency protection	SAPFRC	1MRK005914-CA	3	0-6		

Table 192. Multipurpose protection

Position	1
F	

Table 193. Multipurpose functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
General current and voltage protection	CVGAPC	1MRK005915-AA	1	0-4		

Table 194. General calculation

Position	1
S	

Table 195. General calculation functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Frequency tracking filter	SMAIHPAC	1MRK005915-KA	1	0-6		

Table 196. Secondary system supervision

Position	1	2	3
G			

Table 197. Secondary system supervision functions

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

Table 198. Control

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

Table 199. Control functions

Function	Function identification	Ordering no	Position	Available qty	Selected Qty	Notes and rules
Synchrocheck, energizing check and synchronizing	SESRSYN	1MRK005917-AA	1	0-2		
Autorecloser	SMBRREC	1MRK005917-BA	3	0-4		
Apparatus control for single bay, max 10 app. (1CB) incl. Interlocking	APC10	1MRK005917-AY	5	0-1		Note: Only one Apparatus control can be ordered.
Apparatus control for single bay, max 15 app. (2CBs) incl. Interlocking	APC15	1MRK005917-BY	6	0-1		

Table 200. Scheme communication

Position	1	2	3	4	5	6	7	8
K								

Table 201. Scheme communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Scheme communication logic for distance or Overcurrent protection	ZCPSCH	1MRK005920-AA	1	0-2		Note: Only one of ZCPSCH/ ZC1PPSCH can be selected
Phase segregated Scheme communication logic for distance protection	ZC1PPSCH	1MRK005920-BA	2	0-2		
Current reversal and weak-end infeed logic for distance protection	ZCRWPSCH	1MRK005920-CA	3	0-2		Note: Only one of ZCRWPSCH/ ZC1WPSCH to be selected
Current reversal and weak-end infeed logic for phase segregated communication	ZC1WPSCH	1MRK005920-DA	4	0-2		
Local acceleration logic	ZCLCPSCH	1MRK005920-EA	5	0-1		
Scheme communication logic for residual overcurrent protection	ECPSCH	1MRK005920-FA	6	0-1		
Current reversal and weakend infeed logic for residual overcurrent protection	ECRWPSCH	1MRK005920-GA	7	0-1		
Direct transfer trip	DTT	1MRK005921-AX	8	0-1		

Table 202. Logic

Position	1	2
L		

Table 203. Logic functions

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

Table 204. Monitoring

Position	1	2
M		1

Table 205. Monitoring functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Circuit breaker condition monitoring	SSCBR	1MRK005924-HA	1	00-06		
Fault locator	LMBRFLO	1MRK005925-XB	2	1		

Table 206. Station communication

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

Table 207. Station communication functions

Function	Function identification	Ordering no	Position	Available qty	Selected qty	Notes and rules
Process Bus communication IEC 61850-9-2		1MRK005930-TA	1	0 if F00 is selected, 6 if N00 is selected		Note: RED670 customized qty = 0, RED670 61850-9-2 qty = 6
IEC 62439-3 parallel redundancy protocol	PRP	1MRK002924-YB	2	1		Note: Not valid in RED670 61850-9-2LE product. Note: Requires 2-channel OEM

Table 208. Language selection

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

Table 209. Casing selection

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

Table 210. Mounting selection

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

Table 211. Connection type for Power supply module

	Selection		Notes and Rules
Compression terminals	M		
Ringlug terminals	N		
Auxiliary power supply			
Power supply module 24-60 VDC		A	
Power supply module 90-250 VDC		B	
Selected			

Table 212. Connection type for Input/Output modules

	Selection		Notes and Rules
Compression terminals	P		
Ringlug terminals	R		
Selected			

Table 213. Human machine interface selection

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

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Table 214. Analog system selection

Analog system	Selection				Notes and Rules
No first TRM included	X0				Note: Only valid in RED670–N00
Compression terminals	A				Note: Only the same type of TRM (compression or ringlug) in the same terminal.
Ringlug terminals	B				
First TRM 12I 1A, 50/60Hz		1			
First TRM 12I 5A, 50/60Hz		2			
First TRM 9I+3U 1A, 100/220V, 50/60Hz		3			
First TRM 9I+3U 5A, 100/220V, 50/60Hz		4			
First TRM 5I, 1A+4I, 5A+3U, 100/220V, 50/60Hz		5			
First TRM 6I+6U 1A, 100/220V, 50/60Hz		6			
First TRM 6I+6U 5A, 100/220V, 50/60Hz		7			
First TRM 6I 1A, 50/60Hz		8			Maximum qty = 1
First TRM 6I 5A, 50/60Hz		9			Maximum qty = 1
First TRM 7I+5U 1A, 100/220V, 50/60Hz		12			
First TRM 7I+5U 5A, 100/220V, 50/60Hz		13			
First TRM 6I, 5A + 1I, 1A + 5U, 110/220V, 50/60Hz		14			
First TRM 3I, 5A + 4I, 1A + 5U, 110/220V, 50/60Hz		15			
First TRM 3I, 5A + 3I, 1A + 6U, 110/220V, 50/60Hz		16			
First TRM 3IM, 1A + 4IP, 1A + 5U, 110/220V, 50/60Hz		17			
First TRM 3IM, 5A + 4IP, 5A + 5U, 110/220V, 50/60Hz		18			
No second TRM included			X0		
Compression terminals			A		
Ringlug terminals			B		
Second TRM 12I 1A, 50/60Hz				1	
Second TRM 12I 5A, 50/60Hz				2	
Second TRM 9I+3U 1A, 100/220V, 50/60Hz				3	
Second TRM 9I+3U 5A, 100/220V, 50/60Hz				4	
Second TRM 5I, 1A+4I, 5A+3U, 100/220V, 50/60Hz				5	
Second TRM 6I+6U 1A, 100/220V, 50/60Hz				6	
Second TRM 6I+6U 5A, 100/220V, 50/60Hz				7	
Second TRM 6I 1A, 50/60Hz				8	Maximum qty = 1
Second TRM 6I 5A, 50/60Hz				9	Maximum qty = 1
Second TRM 7I+5U 1A, 100/220V, 50/60Hz				12	
Second TRM 7I+5U 5A, 100/220V, 50/60Hz				13	
Second TRM 6I, 5A + 1I, 1A + 5U, 110/220V, 50/60Hz				14	
Second TRM 3I, 5A + 4I, 1A + 5U, 110/220V, 50/60Hz				15	
Second TRM 3I, 5A + 3I, 1A + 6U, 110/220V, 50/60Hz				16	
Second TRM 3IM, 1A + 4IP, 1A + 5U, 110/220V, 50/60Hz				17	
Second TRM 3IM, 5A + 4IP, 5A + 5U, 110/220V, 50/60Hz				18	
Selected					

Table 215. Maximum quantity of I/O modules

Note: When ordering I/O modules, observe the maximum quantities according to the table below

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

Table 216. Binary input/output module selection

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

Table 216. Binary input/output module selection, continued

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

Table 217. Remote end serial communication selection

Remote end communication, DNP serial comm. and time synchronization modules	Selection						Notes and Rules
Slot position (rear view)	X312	X313	X302	X303	X322	X323	Note: The maximum number and type of LDCM modules supported depend on the total amount of modules (BIM, BOM, LDCM, OEM, GTM, SLM, RS485, IRIG-B) in the IED.
Available slots in 1/2, 3/4 or 1/1 case with 1TRM	■	■	■	■			Note: Max 2 LDCM in 1/2 case
Available slots in 3/4 and 1/1 case with 2 TRM	■	■	■	■	■	■	
No remote communication board included	X	X	X	X	X	X	
Optical short range LDCM	A	A	A	A	A	A	Max 4 LDCM (same or different type) can be selected. Always place LDCM modules on the same board to support redundant communication; in P30:2 and P30:3, P31:2 and P31:3 or P32:2 and P32:3
Optical medium range, LDCM 1310 nm	B	B	B	B	B	B	
Optical long range, LDCM 1550 nm	C	C	C	C	C	C	
Galvanic X21 line data communication module	E	E	E	E	E	E	
IRIG-B Time synchronization module	F	F	F	F	F	F	
Galvanic RS485 communication module	G	G	G	G	G	G	
GPS time synchronization module	S	S			S	S	
Selected							

Table 218. Serial communication unit for station communication selection

Serial communication unit for station communication	Selection		Notes and Rules
Slot position (rear view)	X301	X311	
No communication board included	X	X	
Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface	A		
Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface	B		
Serial SPA/LON/DNP/IEC 60870-5-103 glass interface	C		
Optical ethernet module, 1 channel glass		D	
Optical ethernet module, 2 channel glass		E	
Selected.			

23. Ordering for pre-configured IED

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

To obtain the complete ordering code, please combine code from the tables, as given in the example below.
Example code: RED670 *2.1-A30X00- A02H02-B1A3-AC-MB-B-A3X0-DAB1RGN1N1XXXXXXX-AXFXXX-AX. Using the code of each position #1-13 specified as RED670*1-2 2-3 3 3 3 3 3 3 3 3 3 3 3 3 3-4 4-5-6-7 8-9-10 10 10 10-110 11 11 11 11 11 11 11 11 11 11-12 12 12 12 12-13 13

#	1	-	2	-	3	-	4	-	5	6	-	7	-	8	-	9	-
RED670*		-		-		-		-			-		-		-		-

10	-	11	-	12	-	13
	-		-		-	

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

Configuration alternatives		#2	Notes and Rules
Single breaker, 3 phase tripping	A31		
Multi breaker, 3 phase tripping	B31		
Single breaker, 1 phase tripping	A32		
Multi breaker, 1 phase tripping	B32		
ACT configuration			
ABB standard configuration		X00	
Selection for position #2.			

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Software options	#3	Notes and Rules
No option	X 00	All fields in the ordering form do not need to be filled in
High impedance differential protection	A 02	
Line differential protection 6 CT sets, 3-5 line ends	A 04	Note: Only one Line differential protection have to be selected Note: A04/A05 only in A31/A32
Line differential protection 3 CT sets, with in-zone transformers, 2-3 line ends	A 05	
Line differential protection 6 CT sets, with in-zone transformers, 3-5 line ends	A 06	
Power swing logic	B 03	
Phase preference logic	B 04	Note: Only for A31
Phase segregated scheme communication	B 05	Note: Only for A32 and B32
Distance zones quadrilateral, 4th zone	B 10	Note: Only one of B10/B11/B16/B17/B28/B 29 to be selected. B11 is required with B10. 1 block of STBPTOC alrady included on B31/B32
Distance zones quadrilateral, 3 zones	B 11	
Distance zones quadrilateral series compensation, 3 zones	B 16	
Line Distance protection - mho - 4 zones	B 17	
Directional distance protection with phase selection	B 28	
Directional distance protection with phase selection, series compensation	B 29	
Out-of-step protection	B 22	
Sensitive directional residual overcurrent and power protection	C 16	
Directional power protection	C 17	
Residual overcurrent protection	C 24	
Overexcitation protection	D 03	
Frequency protections - line	E 02	
General current and voltage protection	F0 1	
Fuse failure supervision based on voltage difference	G 03	
Autorecloser, 1 circuit breaker	H 04	Note: H04 only for A31/ A32, 1 block already included
Autorecloser, 2 circuit breaker	H 05	Note: H05 only for B31/ B32, 2 blocks already included
Apparatus control 10 objects	H 27	Note: Only one Apparatus control can be ordered Note: H27 only for A31/ A32, H08 only for B31/B32
Apparatus control 15 objects	H 08	
Circuit breaker condition monitoring - 3 CB	M 13	Note: M13 only for A31/32, M15 only for B31/B32
Circuit breaker condition monitoring - 6 CB	M 15	
IEC 62439-3 parallel redundancy protocol	P 03	Note: P03 requires a 2-channel OEM.
Selection for position #3		

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

Casing	#5	Notes and Rules
1/2 x 19" case	A	
3/4 x 19" case 1 TRM slot	B	
3/4 x 19" case 2 TRM slots	C	
1/1 x 19" case 1TRM slots	D	
1/1 x 19" case 2 TRM slots	E	
Selection for position #5.		

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

Connection type for Power supply module	#7		Notes and Rules
Compression terminals	M		
Ringlug terminals	N		
Auxiliary power supply			
24-60 VDC		A	
90-250 VDC		B	
Selection for position #7.			

Connection type for Input/output and Communication modules	#8		Notes and Rules
Compression terminals	P		
Selection for position #8.			

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

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Analog input system	#10				Notes and Rules
Compression terminals	A				
Ringlug terminals	B				
First TRM, 6I+6U 1A, 100/220V		6			
First TRM, 6I+6U 5A, 100/220V		7			
First TRM, 3I, 5A + 3I, 1A + 6U, 110/220V		15			Note: Only for A31 and A32
No second TRM included			X0		
Compression terminals			A		
Ringlug terminals			B		
Second TRM, 9I+3U 1A, 110/220V				3	
Second TRM, 9I+3U 5A, 110/220V				4	
Second TRM, 5I, 1A+4I, 5A+3U, 110/220V				5	
Second TRM, 6I+6U, 1A, 110/220V				6	
Second TRM, 6I+6U, 5A, 110/220V				7	
Second TRM, 6I, 1A, 110/220V				8	
Second TRM, 6I, 5A, 5A, 110/220V				9	
Second TRM, 7I+5U 1A, 110/220V				12	
Second TRM, 7I+5U 5A, 110/220V				13	
Second TRM, 3I, 5A + 3I, 1A + 6U, 110/220V				16	Note: Only for A31 and A32
Selection for position #10.					

Binary input/output module, mA and time synchronizating boards.	X31	X41	X51	X61	X71	X81	X91	X101	X111	X121	X131	X141	X151	X161	Notes and Rules
Make BIM with 50 mA inrush current the primary choice. BIM with 50 mA inrush current fulfill additional standards. As a consequence the EMC withstand capability is further increased. BIM with 30 mA inrush current is still available. For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used. Note: 1 BIM and 1 BOM included.	#11														
Slot position (rear view)															Note: Max 3 positions in 1/2 rack, 8 in 3/4 rack with 1 TRM, 5 in 3/4 rack with 2 TRM, 14 in 1/1 rack with 1 TRM and 11 in 1/1 rack with 2 TRM
1/2 Case with 1 TRM	■	■	■												
3/4 Case with 1 TRM	■	■	■	■	■	■	■	■							
3/4 Case with 2 TRM	■	■	■	■	■										
1/1 Case with 1 TRM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1/1 Case with 2 TRM	■	■	■	■	■	■	■	■	■	■	■				
No board in slot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Binary output module 24 output relays (BOM)		A	A	A	A	A	A	A	A	A	A	A	A	A	Note: Maximum 4 (BOM+SOM +MIM) boards.
BIM 16 inputs, RL24-30 VDC, 50 mA	B 1		B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	B 1	
BIM 16 inputs, RL48-60 VDC, 50 mA	C 1		C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	C 1	
BIM 16 inputs, RL110-125 VDC, 50 mA	D 1		D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	D 1	
BIM 16 inputs, RL220-250 VDC, 50 mA	E 1		E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	E 1	
BIM 16 inputs, 220-250 VDC, 120mA	E 2		E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	E 2	
BIMp 16 inputs, RL24-30 VDC, 30 mA, for pulse counting			F	F	F	F	F	F	F	F	F	F	F	F	
BIMp 16 inputs, RL48-60 VDC, 30 mA, for pulse counting			G	G	G	G	G	G	G	G	G	G	G	G	
BIMp 16 inputs, RL110-125 VDC, 30 mA, for pulse counting			H	H	H	H	H	H	H	H	H	H	H	H	
BIM 16 inputs, RL220-250 VDC, 30 mA, for pulse counting			K	K	K	K	K	K	K	K	K	K	K	K	
IOM 8 inputs, 10+2 output, RL24-30 VDC, 50 mA			L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1	
IOM 8 inputs, 10+2 output, RL48-60 VDC, 50 mA			M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	M 1	
IOM 8 inputs, 10+2 output, RL110-125 VDC, 50 mA			N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	N 1	
IOM 8 inputs, 10+2 output, RL220-250 VDC, 50 mA			P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	P 1	
IOM 8 inputs 10+2 output relays, 220-250 VDC, 110mA			P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	P 2	
IOM with MOV 8 inputs, 10-2 output, 24-30 VDC, 30 mA			U	U	U	U	U	U	U	U	U	U	U	U	
IOM with MOV 8 inputs, 10-2 output, 48-60 VDC, 30 mA			V	V	V	V	V	V	V	V	V	V	V	V	
IOM with MOV 8 inputs, 10-2 output, 110-125 VDC, 30 mA			W	W	W	W	W	W	W	W	W	W	W	W	
IOM with MOV 8 inputs, 10-2 output, 220-250 VDC, 30 mA			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
mA input module MIM 6 channels			R	R	R	R	R	R	R	R	R	R	R	R	Note: maximum 1 MIM board in 1/2 case
SOM Static output module, 12 outputs, 48-60 VDC			T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	Note: SOM must not to be placed in position nearest to NUM; 1/2 case slot P5, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 1 TRM slot P16, 1/1 case 2 TRM slot P13
SOM static outputs module, 12 outputs, 110-250 VDC			T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	T 2	
Selection for position #11.															

Remote end communication, DNP serial comm. and time synchronization modules	X312	X313	X302	X303	X322	X323	Notes and Rules
Slot position (rear view)	#12						Note: The maximum number and type of LDCM modules supported depend on the total amount of modules (BIM, BOM, LDCM, OEM, GTM, SLM, RS485, IRIG-B) in the IED.
Available slots in 1/2 and 3/4 case with 1TRM	■	■	■	■			Note: Only for A31/A32. One LDCM must be ordered. Max 2 LDCM in 1/2 case.
Available slots in 3/4 and 1/1 case with 2 TRM	■	■	■	■	■	■	Note: 2 LDCM in B31 and B32 must be ordered. Max 4 LDCM
No remote communication board included	X	X		X	X	X	A31 and A32 - 1 LDCM always in position P30:2(X302)
No remote communication board included	X	X			X	X	B31 and B32 - 1 LDCM always in position P30:2(X302) and P30:3(X303)
Optical short range LDCM	A	A	A	A	A	A	Max 4 LDCM (same or different type) can be selected. Always place LDCM modules on the same board to support redundant communication; in P30:2 and P30:3, P31:2 and P31:3 or P32:2 and P32:3
Optical medium range, LDCM 1310 nm	B	B	B	B	B	B	
Optical long range, LDCM 1550 nm	C	C	C	C	C	C	
Galvanic X21 line data communication module	E	E	E	E	E	E	
IRIG-B Time synchronization module, with PPS	F	F	F	F	F	F	
Galvanic RS485 communication module	G	G		G	G	G	Note: No RS485 in position X303 in B31/B32
GPS time module GTM	S	S			S	S	
Selection for position #12.							

Serial communication unit for station communication	X301	X311	Notes and Rules
Slot position (rear view)	#13		
No first communication board included	X		
No second communication board included		X	
Serial and LON communication module (plastic)	A		
Serial (plastic) and LON (glass) communication module	B		
Serial and LON communication module (glass)	C		
Optical ethernet module, 1 channel glass		D	
Optical ethernet module, 2 channel glass		E	
Selection for position #13.			

24. Ordering for Accessories

Accessories

GPS antenna and mounting details

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

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 IEDs 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 references to corresponding documents.

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

Protection cover

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

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ОРИГИНАЛ

External resistor unit

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

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

Configuration and monitoring tools

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

Manuals

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

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

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User documentation

Rule: Specify the number of printed manuals requested

Application manual	IEC	Quantity:	☐	1MRK 505 343-UEN
	ANSI	Quantity:	☐	1MRK 505 307-UUS
Technical manual	IEC	Quantity:	☐	1MRK 505 308-UEN
	ANSI	Quantity:	☐	1MRK 505 308-UUS
Commissioning manual	IEC	Quantity:	☐	1MRK 505 345-UEN
	ANSI	Quantity:	☐	1MRK 505 309-UUS
Communication protocol manual, IEC 61850 Edition 1	IEC	Quantity:	☐	1MRK 511 349-UEN
Communication protocol manual, IEC 61850 Edition 2	IEC	Quantity:	☐	1MRK 511 350-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity:	☐	1MRK 511 351-UEN
Communication protocol manual, LON	IEC	Quantity:	☐	1MRK 511 352-UEN
Communication protocol manual, SPA	IEC	Quantity:	☐	1MRK 511 353-UEN
Communication protocol manual, DNP	ANSI	Quantity:	☐	1MRK 511 348-UUS
Point list manual, DNP	ANSI	Quantity	☐	1MRK 511 354-UUS
Operation manual	IEC	Quantity:	☐	1MRK 500 123-UEN
	ANSI	Quantity:	☐	1MRK 500 123-UUS
Installation manual	IEC	Quantity:	☐	1MRK 514 024-UEN
	ANSI	Quantity:	☐	1MRK 514 024-UUS

ДЗЗД „ЕИК ДРАГАЛЕВЦИ"

ВЯРНО С ОРИГИНАЛА

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

Reference information

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

Country: End user:

Station name: Voltage level: kV

Related documents

Documents related to RED670	Document numbers
Application manual	IEC:1MRK 505 343-UEN ANSI:1MRK 505 343-UUS
Commissioning manual	IEC:1MRK 505 345-UEN ANSI:1MRK 505 345-UUS
Product guide	1MRK 505 346-BEN
Technical manual	IEC:1MRK 505 308-UEN ANSI:1MRK 505 308-UUS
Type test certificate	IEC:1MRK 505 346-TEN ANSI:1MRK 505 346-TUS

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

Contact us

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www.abb.com/substationautomation

1MRK 505 346-BEN

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ВЯРНО С ОРИГИНАЛА

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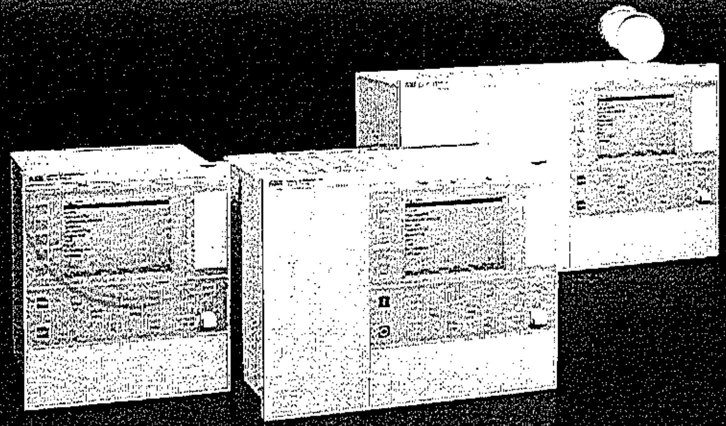

Relion® Protection and Control

670 series 2.1 IEC
Engineering manual

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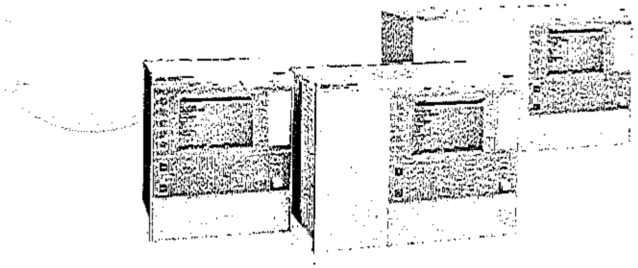

Document ID: 1MRK 511 355-UEN
Issued: December 2015
Revision: -
Product version: 2.1

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Trademarks

Warranty

Please inquire about the terms of warranty from your nearest ABB representative.

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Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not to be deemed as a statement of guaranteed properties. All persons responsible for applying the equipment addressed in this manual must satisfy themselves that each intended application is suitable and acceptable, including that any applicable safety or other operational requirements are complied with. In particular, any risks in applications where a system failure and/or product failure would create a risk for harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity applying the equipment, and those so responsible are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This document has been carefully checked by ABB but deviations cannot be completely ruled out. In case any errors are detected, the reader is kindly requested to notify the manufacturer. Other than under explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from the use of this manual or the application of the equipment.

ВЯРНО С ОРИГИНАЛА

ДЗЗД „ЕИК ДРАГАЛЕВЦИ"

Conformity

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

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ДЗЗД „ЕИК ДРАГАЛЕВЦИ" Пловдив

Section 1 Introduction

1.1 This manual

The engineering manual contains instructions on how to engineer the IEDs using the various tools available within the PCM600 software. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for the engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 60870-5-103, IEC 61850, DNP3, LON and SPA.

1.2 Intended audience

This manual addresses system and project engineers involved in the engineering process of a project, and installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service.

The system engineer must have a thorough knowledge of protection and/or control systems, protection and/or control equipment, protection and/or control functions and the configured functional logics in the IEDs. The installation and commissioning personnel must have a basic knowledge of handling electronic equipment.

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1.3 Product documentation

1.3.1 Product documentation set

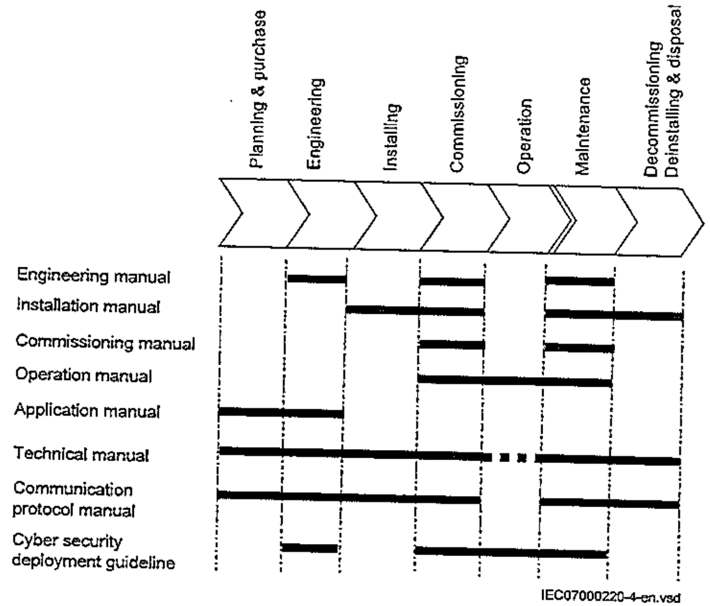

Figure 1: The intended use of manuals throughout the product lifecycle

The engineering manual contains instructions on how to engineer the IEDs using the various tools available within the PCM600 software. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for the engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 60870-5-103, IEC 61850, DNP3, LON and SPA.

The installation manual contains instructions on how to install the IED. The manual provides procedures for mechanical and electrical installation. The chapters are organized in the chronological order in which the IED should be installed.

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for the checking of external circuitry and energizing the IED, parameter setting and configuration as well as verifying settings by secondary injection. The manual describes the process of testing an IED in a substation which is not in service. The chapters are organized in the chronological order in which the IED should be commissioned. The relevant procedures may be followed also during the service and maintenance activities.

The operation manual contains instructions on how to operate the IED once it has been commissioned. The manual provides instructions for the monitoring, controlling and setting of the IED. The manual also describes how to identify disturbances and how to view calculated and measured power grid data to determine the cause of a fault.

The application manual contains application descriptions and setting guidelines sorted per function. The manual can be used to find out when and for what purpose a typical protection function can be used. The manual can also provide assistance for calculating settings.

The technical manual contains operation principle descriptions, and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data, sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

The communication protocol manual describes the communication protocols supported by the IED. The manual concentrates on the vendor-specific implementations.

The point list manual describes the outlook and properties of the data points specific to the IED. The manual should be used in conjunction with the corresponding communication protocol manual.

The cyber security deployment guideline describes the process for handling cyber security when communicating with the IED. Certification, Authorization with role based access control, and product engineering for cyber security related events are described and sorted by function. The guideline can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

1.3.2 Document revision history

Document revision/date	History
December 2015	First release

1.3.3 Related documents

Documents related to REB670	Document numbers
Application manual	1MRK 505 337-UEN
Commissioning manual	1MRK 505 339-UEN
Product guide	1MRK 505 340-BEN
Technical manual	1MRK 505 338-UEN
Type test certificate	1MRK 505 340-TEN

Documents related to REC670	Document numbers
Application manual	1MRK 511 358-UEN
Commissioning manual	1MRK 511 360-UEN
Product guide	1MRK 511 361-BEN
Technical manual	1MRK 511 359-UEN
Type test certificate	1MRK 511 361-TEN

Documents related to RED670	Document numbers
Application manual	1MRK 505 343-UEN
Commissioning manual	1MRK 505 345-UEN
Product guide	1MRK 505 346-BEN
Technical manual	1MRK 505 308-UEN
Type test certificate	1MRK 505 346-TEN

Documents related to REG670	Document numbers
Application manual	1MRK 502 065-UEN
Commissioning manual	1MRK 502 067-UEN
Product guide	1MRK 502 068-BEN
Technical manual	1MRK 502 066-UEN
Type test certificate	1MRK 502 068-TEN

Documents related to REL670	Document numbers
Application manual	1MRK 506 353-UEN
Commissioning manual	1MRK 506 355-UEN
Product guide	1MRK 506 356-BEN
Technical manual	1MRK 506 354-UEN
Type test certificate	1MRK 506 356-TEN

Documents related to RET670	Document numbers
Application manual	1MRK 504 152-UEN
Commissioning manual	1MRK 504 154-UEN
Product guide	1MRK 504 155-BEN
Technical manual	1MRK 504 153-UEN
Type test certificate	1MRK 504 155-TEN

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

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

1.4 Document symbols and conventions

1.4.1 Symbols

The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

The warning icon indicates the presence of a hazard which could result in personal injury.

The caution hot surface icon indicates important information or warning about the temperature of product surfaces.

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The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. It is important that the user fully complies with all warning and cautionary notices.

1.4.2 Document conventions

- Abbreviations and acronyms in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  For example, to navigate between the options, use ▲ and ▼.
- HMI menu paths are presented in bold.
  For example, select **Main menu/Settings**.
- LHMI messages are shown in Courier font.
  For example, to save the changes in non-volatile memory, select `Yes` and press ▣.
- Parameter names are shown in italics.
  For example, the function can be enabled and disabled with the *Operation* setting.
- Each function block symbol shows the available input/output signal.
  - the character ^ in front of an input/output signal name indicates that the signal name may be customized using the PCM600 software.
  - the character * after an input signal name indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.
- Logic diagrams describe the signal logic inside the function block and are bordered by dashed lines.

- Signals in frames with a shaded area on their right hand side represent setting parameter signals that are only settable via the PST or LHMI.
- If an internal signal path cannot be drawn with a continuous line, the suffix -int is added to the signal name to indicate where the signal starts and continues.
- Signal paths that extend beyond the logic diagram and continue in another diagram have the suffix "-cont."

1.5 IEC61850 edition 1 / edition 2 mapping

Table 1: IEC61850 edition 1 / edition 2 mapping

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
AEGPVOC	AEGGAPC	AEGPVOC
AGSAL	AGSAL SECLLN0	AGSAL
ALMCALH	ALMCALH	ALMCALH
ALTIM		ALTIM
ALTMS		ALTMS
ALTRK		ALTRK
BCZSPDIF	BCZSPDIF	BCZSPDIF
BCZTPDIF	BCZTPDIF	BCZTPDIF
BDCGAPC	SWSGGIO	BBCSWI BDCGAPC
BRCPTOC	BRCPTOC	BRCPTOC
BRPTOC	BRPTOC	BRPTOC
BTIGAPC	B16IFCVI	BTIGAPC
BUSPTRC_B1	BUSPTRC BBSPLLN0	BUSPTRC
BUSPTRC_B2	BUSPTRC	BUSPTRC
BUSPTRC_B3	BUSPTRC	BUSPTRC
BUSPTRC_B4	BUSPTRC	BUSPTRC
BUSPTRC_B5	BUSPTRC	BUSPTRC
BUSPTRC_B6	BUSPTRC	BUSPTRC
BUSPTRC_B7	BUSPTRC	BUSPTRC
BUSPTRC_B8	BUSPTRC	BUSPTRC
BUSPTRC_B9	BUSPTRC	BUSPTRC
BUSPTRC_B10	BUSPTRC	BUSPTRC
BUSPTRC_B11	BUSPTRC	BUSPTRC
BUSPTRC_B12	BUSPTRC	BUSPTRC
BUSPTRC_B13	BUSPTRC	BUSPTRC
BUSPTRC_B14	BUSPTRC	BUSPTRC

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Function block name	Edition 1 logical nodes	Edition 2 logical nodes
BUSPTRC_B15	BUSPTRC	BUSPTRC
BUSPTRC_B16	BUSPTRC	BUSPTRC
BUSPTRC_B17	BUSPTRC	BUSPTRC
BUSPTRC_B18	BUSPTRC	BUSPTRC
BUSPTRC_B19	BUSPTRC	BUSPTRC
BUSPTRC_B20	BUSPTRC	BUSPTRC
BUSPTRC_B21	BUSPTRC	BUSPTRC
BUSPTRC_B22	BUSPTRC	BUSPTRC
BUSPTRC_B23	BUSPTRC	BUSPTRC
BUSPTRC_B24	BUSPTRC	BUSPTRC
BUTPTRC_B1	BUTPTRC BBTPLLN0	BUTPTRC
BUTPTRC_B2	BUTPTRC	BUTPTRC
BUTPTRC_B3	BUTPTRC	BUTPTRC
BUTPTRC_B4	BUTPTRC	BUTPTRC
BUTPTRC_B5	BUTPTRC	BUTPTRC
BUTPTRC_B6	BUTPTRC	BUTPTRC
BUTPTRC_B7	BUTPTRC	BUTPTRC
BUTPTRC_B8	BUTPTRC	BUTPTRC
BZISGGIO	BZISGGIO	BZISGAPC
BZITGGIO	BZITGGIO	BZITGAPC
BZNSPDIF_A	BZNSPDIF	BZASGAPC BZASPDIF BZNSGAPC BZNSPDIF
BZNSPDIF_B	BZNSPDIF	BZBSGAPC BZBSPDIF BZNSGAPC BZNSPDIF
BZNTPDIF_A	BZNTPDIF	BZATGAPC BZATPDIF BZNTGAPC BZNTPDIF
BZNTPDIF_B	BZNTPDIF	BZBTGAPC BZBTPDIF BZNTGAPC BZNTPDIF
CBPGAPC	CBPLLN0 CBPMMXU CBPPTRC HOLPTOV HPH1PTOV PH3PTUC PH3PTOC RP3PDOP	CBPMMXU CBPPTRC HOLPTOV HPH1PTOV PH3PTOC PH3PTUC RP3PDOP
CCPDSC	CCRPLD	CCPDSC
CCRBRF	CCRBRF	CCRBRF

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
CCRWRBRF	CCRWRBRF	CCRWRBRF
CCSRBRF	CCSRBRF	CCSRBRF
CCSSPVC	CCSRDIF	CCSSPVC
CMMXU	CMMXU	CMMXU
CMSQI	CMSQI	CMSQI
COUVGAPC	COUVLLN0 COUVPTOV COUVPTUV	COUVPTOV COUVPTUV
CVGAPC	GF2LLN0 GF2MMXN GF2PHAR GF2PTOV GF2PTUC GF2PTUV GF2PVOC PH1PTRC	GF2MMXN GF2PHAR GF2PTOV GF2PTUC GF2PTUV GF2PVOC PH1PTRC
CVMMXN	CVMMXN	CVMMXN
D2PTOC	D2LLN0 D2PTOC PH1PTRC	D2PTOC PH1PTRC
DPGAPC	DPGGIO	DPGAPC
DRPRDRE	DRPRDRE	DRPRDRE
ECPSCH	ECPSCH	ECPSCH
ECRWPSCH	ECRWPSCH	ECRWPSCH
EF2PTOC	EF2LLN0 EF2PTRC EF2RDIR GEN2PHAR PH1PTOC	EF2PTRC EF2RDIR GEN2PHAR PH1PTOC
EF4PTOC	EF4LLN0 EF4PTRC EF4RDIR GEN4PHAR PH1PTOC	EF4PTRC EF4RDIR GEN4PHAR PH1PTOC
EFPIOC	EFPIOC	EFPIOC
EFRWPIOC	EFRWPIOC	EFRWPIOC
ETPMMTR	ETPMMTR	ETPMMTR
FDPSPDIS	FDPSPDIS	FDPSPDIS
FMPSPDIS	FMPSPDIS	FMPSPDIS
FRPSPDIS	FPSRPDIS	FPSRPDIS
FTAQFVR	FTAQFVR	FTAQFVR
FUFSPVC	SDDRFUF	FUFSPVC SDDSPVC
GENPDIF	GENPDIF	GENGAPC GENPDIF GENPHAR GENPTRC
GOOSEBINRCV	BINGREC	

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
GOOSEDPRCV	DPGREC	
GOOSEINTLKRCV	INTGREC	
GOOSEINTRCV	INTSGREC	
GOOSEMVRCV	MVGREC	
GOOSESPRCV	BINSGREC	
GOOSEVCTRRCV	VCTRGREC	
GOPPDOP	GOPPDOP	GOPPDOP PH1PTRC
GRPTTR	GRPTTR	GRPTTR
GSPTTR	GSPTTR	GSPTTR
GUPPDUP	GUPPDUP	GUPPDUP PH1PTRC
HZPDIF	HZPDIF	HZPDIF
INDCALCH	INDCALH	INDCALH
ITBGAPC	IB16FCVB	ITBGAPC
L3CPDIF	L3CPDIF	L3CGAPC L3CPDIF L3CPHAR L3CPTRC
L4UFCNT	L4UFCNT	L4UFCNT
L6CPDIF	L6CPDIF	L6CGAPC L6CPDIF L6CPHAR L6CPTRC
LAPPGAPC	LAPPLLN0 LAPPPDUP LAPPPUPF	LAPPPDUP LAPPPUPF
LCCRPTRC	LCCRPTRC	LCCRPTRC
LCNSPTOC	LCNSPTOC	LCNSPTOC
LCNSPTOV	LCNSPTOV	LCNSPTOV
LCP3PTOC	LCP3PTOC	LCP3PTOC
LCP3PTUC	LCP3PTUC	LCP3PTUC
LCPTTR	LCPTTR	LCPTTR
LCZSPTOC	LCZSPTOC	LCZSPTOC
LCZSPTOV	LCZSPTOV	LCZSPTOV
LD0LLN0	LLN0	
LDLPSCH	LDLPDIF	LDLPSCH
LDRGFC	STSGGIO	LDRGFC
LEXPDIS	LEXPDIS	LEXPDIS LEXPTRC
LFPTTR	LFPTTR	LFPTTR
LMBRFLO	LMBRFLO	LMBRFLO
LOVPTUV	LOVPTUV	LOVPTUV
LPHD	LPHD	

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
LPTTR	LPTTR	LPTTR
LT3CPDIF	LT3CPDIF	LT3CGAPC LT3CPDIF LT3CPHAR LT3CPTRC
LT6CPDIF	LT6CPDIF	LT6CGAPC LT6CPDIF LT6CPHAR LT6CPTRC
MVGAPC	MVGGIO	MVGAPC
NS2PTOC	NS2LLN0 NS2PTOC NS2PTRC	NS2PTOC NS2PTRC
NS4PTOC	EF4LLN0 EF4PTRC EF4RDIR GEN4PHAR PH1PTOC	EF4PTRC EF4RDIR PH1PTOC
O2RWPTOV	GEN2LLN0 O2RWPTOV PH1PTRC	O2RWPTOV PH1PTRC
OC4PTOC	OC4LLN0 GEN4PHAR PH3PTOC PH3PTRC	GEN4PHAR PH3PTOC PH3PTRC
OEXPVPH	OEXPVPH	OEXPVPH
OOSPPAM	OOSPPAM	OOSPPAM OOSPTRC
OV2PTOV	GEN2LLN0 OV2PTOV PH1PTRC	OV2PTOV PH1PTRC
PAPGAPC	PAPGAPC	PAPGAPC
PCFCNT	PCGGIO	PCFCNT
PH4SPTOC	GEN4PHAR OCNDLLN0 PH1BPTOC PH1PTRC	GEN4PHAR PH1BPTOC PH1PTRC
PHPIOC	PHPIOC	PHPIOC
PRPSTATUS	RCHLCCH	RCHLCCH SCHLCCH
PSLPSCH	ZMRPSL	PSLPSCH
PSPPPAM	PSPPPAM	PSPPPAM PSPPTRC
QCBAY	QCBAY	
QCRSV	QCRSV	QCRSV
REFPDIF	REFPDIF	REFPDIF
ROTIPHIZ	ROTIPHIZ	ROTIPHIZ ROTIPTRC

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
ROV2PTOV	GEN2LLN0 PH1PTRC ROV2PTOV	PH1PTRC ROV2PTOV
SAPFRC	SAPFRC	SAPFRC
SAPTOF	SAPTOF	SAPTOF
SAPTUF	SAPTUF	SAPTUF
SCCVPTOC	SCCVPTOC	SCCVPTOC
SCILO	SCILO	SCILO
SCSWI	SCSWI	SCSWI
SDEPSDE	SDEPSDE	SDEPSDE SDEPTOC SDEPTOV SDEPTRC
SESRSYN	RSY1LLN0 AUT1RSYN MAN1RSYN SYNRSYN	AUT1RSYN MAN1RSYN SYNRSYN
SINGLELCCH		SCHLCCH
SLGAPC	SLGGIO	SLGAPC
SMBRREC	SMBRREC	SMBRREC
SMPPTRC	SMPPTRC	SMPPTRC
SP16GAPC	SP16GGIO	SP16GAPC
SPC8GAPC	SPC8GGIO	SPC8GAPC
SPGAPC	SPGGIO	SPGAPC
SSCBR	SSCBR	SSCBR
SSIMG	SSIMG	SSIMG
SSIML	SSIML	SSIML
STBPTOC	STBPTOC	BBPMSS STBPTOC
STEFPHIZ	STEFPHIZ	STEFPHIZ
STTIPHIZ	STTIPHIZ	STTIPHIZ
SXCBR	SXCBR	SXCBR
SXSWI	SXSWI	SXSWI
T2WPDIF	T2WPDIF	T2WGAPC T2WPDIF T2WPHAR T2WPTRC
T3WPDIF	T3WPDIF	T3WGAPC T3WPDIF T3WPHAR T3WPTRC
TCLYLTC	TCLYLTC	TCLYLTC TCSLTC
TCMYLTC	TCMYLTC	TCMYLTC
TEIGAPC	TEIGGIO	TEIGAPC TEIGGIO

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
TEILGAPC	TEILGGIO	TEILGAPC
TMAGAPC	TMAGGIO	TMAGAPC
TPPIOC	TPPIOC	TPPIOC
TR1ATCC	TR1ATCC	TR1ATCC
TR8ATCC	TR8ATCC	TR8ATCC
TRPTTR	TRPTTR	TRPTTR
U2RWPTUV	GEN2LLN0 PH1PTRC U2RWPTUV	PH1PTRC U2RWPTUV
UV2PTUV	GEN2LLN0 PH1PTRC UV2PTUV	PH1PTRC UV2PTUV
VDCPTOV	VDCPTOV	VDCPTOV
VDSPVC	VDRFUF	VDSPVC
VMMXU	VMMXU	VMMXU
VMSQI	VMSQI	VMSQI
VNMMXU	VNMMXU	VNMMXU
VRPVOC	VRLLN0 PH1PTRC PH1PTUV VRPVOC	PH1PTRC PH1PTUV VRPVOC
VSGAPC	VSGGIO	VSGAPC
WRNCALH	WRNCALH	WRNCALH
ZC1PPSCH	ZPCPSCH	ZPCPSCH
ZC1WPSCH	ZPCWPSCH	ZPCWPSCH
ZCLCPSCH	ZCLCPLAL	ZCLCPSCH
ZCPSCH	ZCPSCH	ZCPSCH
ZCRWPSCH	ZCRWPSCH	ZCRWPSCH
ZCVPSOF	ZCVPSOF	ZCVPSOF
ZGVPDIS	ZGVLLN0 PH1PTRC ZGVPDIS ZGVPTUV	PH1PTRC ZGVPDIS ZGVPTUV
ZMCAPDIS	ZMCAPDIS	ZMCAPDIS
ZMCPDIS	ZMCPDIS	ZMCPDIS
ZMFCPDIS	ZMFCLLN0 PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU	PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU
ZMFPDIS	ZMFLLN0 PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU	PSFPDIS PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU
ZMHPDIS	ZMHPDIS	ZMHPDIS

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Function block name	Edition 1 logical nodes	Edition 2 logical nodes
ZMMAPDIS	ZMMAPDIS	ZMMAPDIS
ZMMPDIS	ZMMPDIS	ZMMPDIS
ZMQAPDIS	ZMQAPDIS	ZMQAPDIS
ZMQPDIS	ZMQPDIS	ZMQPDIS
ZMRAPDIS	ZMRAPDIS	ZMRAPDIS
ZMRPDIS	ZMRPDIS	ZMRPDIS
ZMRPSB	ZMRPSB	ZMRPSB
ZSMGAPC	ZSMGAPC	ZSMGAPC

Section 2 Engineering tool set

2.1 Introduction

The structure of a monitoring and control system for electrical substations has a principle structure as shown in Figure 2. It contains a number of IEDs for the various purposes.

For performance reasons, do not insert more than 40 IEDs in one PCM600 project. Larger projects can be divided into several PCM600 projects.

It can be subdivided in the three main parts:

- Bay level IEDs
- Station communication
- Station level IEDs

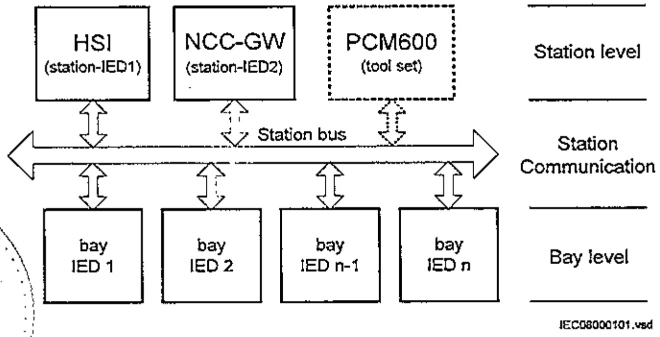

Figure 2: Principle structure of a monitoring and control system for a substation

All three parts require specific engineering and configuration. PCM600 is used to do the complete engineering and configuration activities needed for bay level IEDs.

Each IED type and version has its own connectivity package module used in PCM600.

PCM600 communicates with the bay IEDs via an Ethernet connection. The connection allows to reading and writing all configuration data needed for proper

operation from or to the IED. The IEDs have communication interfaces for protocols and media used for station communication. IEC 61850 communication files for a bay IED or a complete station can be exported from PCM600 to station engineering tools for engineering of station communication between bay IEDs and station IEDs.

A PC with PCM600 can be connected to any IED within a station using the Ethernet connection.

The Ethernet connection can then later also be used for service and maintenance purposes. The connection is also used to handle disturbance records in COMTRADE format from protection IEDs using the IEC 61850 file transfer or FTP.

The IEDs of today are designed on the concept of the IEC 61850 standard. This is mainly given for the organization of functions represented by an equivalent logical node in the IEC 61850 standard. The mapping between the logical node data model in the IED, following the structure and rules in part 7 of the IEC 61850 standard, and the function blocks in an IED configuration is given in the IEC 61850 communication protocol manual.

The same IEC 61850–based concept is also used for the DNP3 protocol. The signals used or delivered by a function block are automatically generated and available for station communication. This concept allows a very efficient cost saving signal engineering.

The engineering of the used communication protocols is a separate task and an addition to the engineering of protection and control functions.

PCM600 can be used for different purposes throughout the IED life cycle. A set of special tools is available for different applications.

The applications can be organized in:

- IED product engineering
- IED communication engineering per protocol
- IED system monitoring
- IED product diagnostic

This manual is valid for PCM600 supporting the IED series product ver.2.1.

2.2 IED engineering process

PCM600 is used for various tasks in the IED engineering process. See Figure 3:

- IED engineering management

- Organizing the bay IEDs in the structure of the substation by defining voltage levels and bays below the substation. A PCM600 project can have only one substation.
- Configuring the IED functions (for example protection and control functions and LHMI functions) by using the Application Configuration tool.
- Configuring the parameters and setting values for the IED itself and for the process functionality by using the Parameter Setting tool.
- Drawing single line diagrams and do the link to dynamic process values by using the Graphical Display Editor tool. The single line diagrams are shown on the LHMI on the bay IED.
- Configuring connections between the application configuration function blocks and physical hardware input and outputs by using the Signal Matrix tool or the Application Configuration tool.

- Communication engineering
  - IEC 61850 station communication engineering can be done in two ways, with a separate tool. IET600 or with the PCM600 built in IEC 61850 configuration tool. PCM600 interacts with IET600 by importing and exporting SCL files. The built in tool can be used for small projects including ABB IEDs only. To engineer communication between ABB IED's and third party devices it's recommended to use IET600.
  - Organizing GOOSE messages received is done by using the Signal Matrix tool.
  - Communication engineering for the DNP3 protocol by using the Communication Management tool.
- Disturbance record management
  - Generating overviews about the available (disturbance) recordings in all connected protection IEDs by using the Disturbance Handling tool.
  - Manually reading the recording files (in COMTRADE format) from the protection IEDs by using the Disturbance Handling tool or automatically by using the PCM600 scheduler.
  - Managing recording files with the assistance of the Disturbance Handling tool.
  - Creating overview reports of recording file content for fast evaluation with assistance of the Disturbance Handling tool.
- Service management
  - Monitoring selected signals of an IED for commissioning or service purposes by using the Signal Monitoring tool.
  - Listing all actual existing IED internal events by using the Event Viewer tool.
  - Listing all actual pending process events as they are stored in the IED internal disturbance report event list by using the Event Viewer tool.

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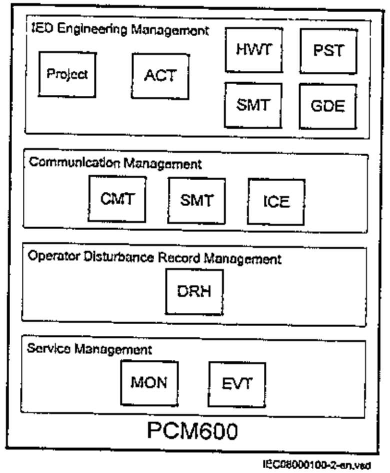

Figure 3: Organization of PCM600 in different management tasks

Additional functionality to manage the project and to organize the user rights:

- PCM600 user management
  - Organizing users with their rights, profile and password to use the different tools and activities within the tools.
  - Defining allowed activities for the user profiles to use tools in PCM600.
- IED user management
  - Organizing users with their rights, profile and password to read and write files of the IED. See the Cyber security deployment guideline for more information.
  - Defining allowed activities for the user profiles to use the read and write function.
- Central account management
  - Configuration of the central account server, deployment and management of IED certificates. See the Cyber security deployment guideline for more information.
  - Defining allowed activities for the user profiles to use the read and write function.

Once the engineering of the IED is done, the results must be written to the IED. Conversely some parts of the engineering information can be uploaded from the IED for various purposes.

The connection between the physical IED and PCM600 is established via an Ethernet link on the front or rear port on the IED.

The IP addresses of the different ports are not allowed to belong to same subnet.

Section 3 Engineering process

3.1 Workflow

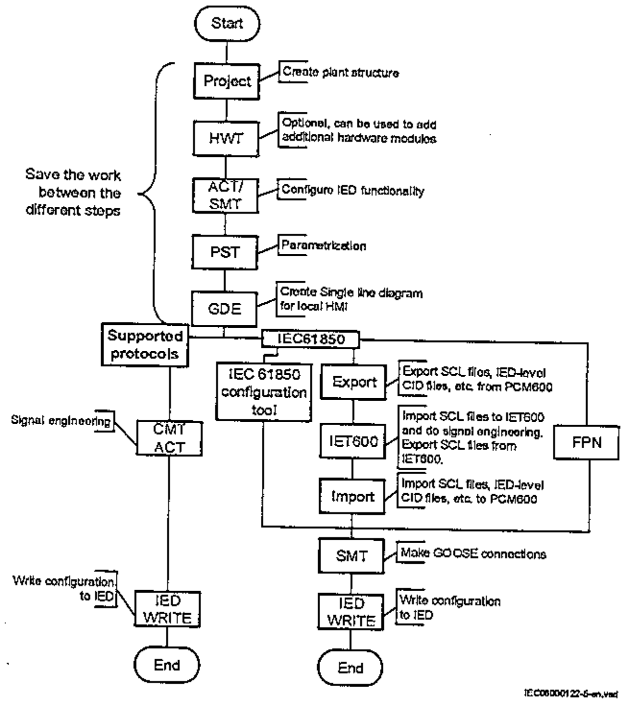

Figure 4: IED engineering workflow

The described sequence in Figure 4 is a proposal based on practical experience and dependencies of the steps. It is possible to do a different sequence based on the available information at the time the project is started. This means that several iterations may be needed to finish the project.

- Setting up the PCM600 project

- Build the plant structure according to the substation structure.

> For performance reasons, do not insert more than 40 IEDs in one PCM600 project. Larger projects can be divided into several PCM600 projects.

- Insert an IED in plant structure which can be done in many ways. By inserting the IED in online mode where the configuration is read from the physical IED, by inserting an IED in offline mode, by importing a *.pcmi file or by selecting an IED template from the template library (*.pcmt).
- Rename the IED objects in PCM600 to the projects definitions.
- Set the IEC61850 technical key (or use the default one from PCM600).
- ACT Application configuration
  - Configure the protection or control function for example for a transformer application as requested.
  - Save the configuration made with ACT to make the interfaces and signals available for other engineering tools within PCM600, for example for PST.
- PST Parameter setting and configuration
  - Check the configuration parameters of the physical IED for communication channels, CT and VT conversion values of the transformer module, for example.
  - Check and adjust if needed the setting values for example for:
    - Presentation parameters for local HMI.
    - Settings for protection or control functions.
    - Number of setting groups.
- GDE Single line diagram configuration
  - Create a single line diagram.
  - Include measurements when needed.
  - Link the dynamic elements to functions created in ACT, for example a breaker object to the switch function.
- Local HMI engineering
  - Include and engineer the function blocks for LHMI element groups with ACT and SMT.
  - Define the LED behavior with PST.
  - Configure the LEDs with ACT and SMT.
- Communication protocol engineering
  - The engineering steps are protocol dependent.
  - Use the communication management tool (CMT) for DNP3 engineering.
  - Use the IET600 station configuration tool or the PCM600 IEC 61850 Configuration tool for IEC 61850 engineering.
  - See the application manual for other protocols (LON, SPA, IEC103).

Section 4 Setting up a project

4.1 PCM600 projects

A typical project in PCM600 contains a plant structure including one or several IED objects, where each IED object contains the engineering data created or modified using the different PCM600 tools.

Several projects can be created and managed by PCM600, but only one project can be active at a time.

4.2 Installing Connectivity packages

A Connectivity package contains the complete description of the IED data signals, parameters and protocol addresses for a certain IED type and version. Several types of IEDs can be managed in one PCM600 project, thus the corresponding Connectivity package has to be installed on the PC. Connectivity Packages and Connectivity Package Updates are managed in the Update Manager.

PCM600 must be installed before the connectivity packages can be installed.

PCM600 version 2.7 or newer must be used with the 2.1 version of the IED. The Connectivity package used with PCM600 2.7 and the 2.1 version of the IED must be of version 3.1.0.0.

A Connectivity package for a specific IED type and version is divided in two parts. The IED Connectivity package base module is common for all IEDs. The IED specific module is separate for each type of IED.

Installing the IED Connectivity package

The Connectivity package is available on the CD that was distributed along with the IED. The user manuals for all IEDs are contained in a separate installation package *Relion 670 v.2.1 series User Documentation*. This package must be installed to access manuals for a specific IED type in PCM600.

Procedure

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1. Close PCM600 before running the IED connectivity package installation.
2. Install the IED series Connectivity package base.
3. Select and install the IED modules as required.
4. Install the documentation.

Installing 670 2.1.5 (or lower) version of the Connectivity package on top of the 670 3.1.0.0 Connectivity package will corrupt the Connectivity package installation. To work around this, uninstall all the Connectivity packages (starting from the lowest version first), and then install the 670 3.1.0.0 Connectivity package freshly again. Because of parallel Connectivity package support, 670 3.1.0.0 Connectivity package will background install 670 3.0.1.0, 670 2.1.6 and 670 2.1.5 Connectivity packages.

4.3 Setting technical key

Both a physical IED and an IED object in PCM600 have a technical key. The purpose of the technical key is to prevent download of a configuration to wrong IED. The technical key in the IED and PCM600 must be the same, otherwise it is not possible to download a configuration. Each IED in a PCM600 project must have a unique technical key. It is therefore not possible to set the same technical key for several IEDs in the same PCM600 project.

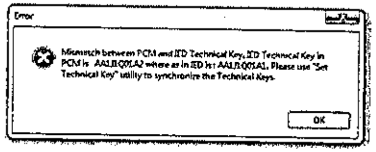
For details on technical key settings, see Naming conventions for IEC 61850

The technical key property in PCM600 corresponds to the IED name attribute in SCL files. Avoid changing the IED name attribute outside PCM600, because data in PCM600 might be lost when importing SCL files.

When using PCM600 for writing to the IED, it is important that the LHMI is not in a menu position where settings can be made. Only one active transaction, from LHMI or PCM600, is allowed at any one time.

When writing a configuration to the IED, PCM600 checks the mismatch between the IED object in PCM600 and the physical IED technical key, if any. For communication between the IED and PCM600, the technical key must be the same. Users have the option to read the technical key from the IED and update it to PCM600 or write the

PCM600 technical key to the IED. The user can also define an own technical key. The error message displayed due to mismatch between PCM600 and IED technical key is shown in Figure 5.



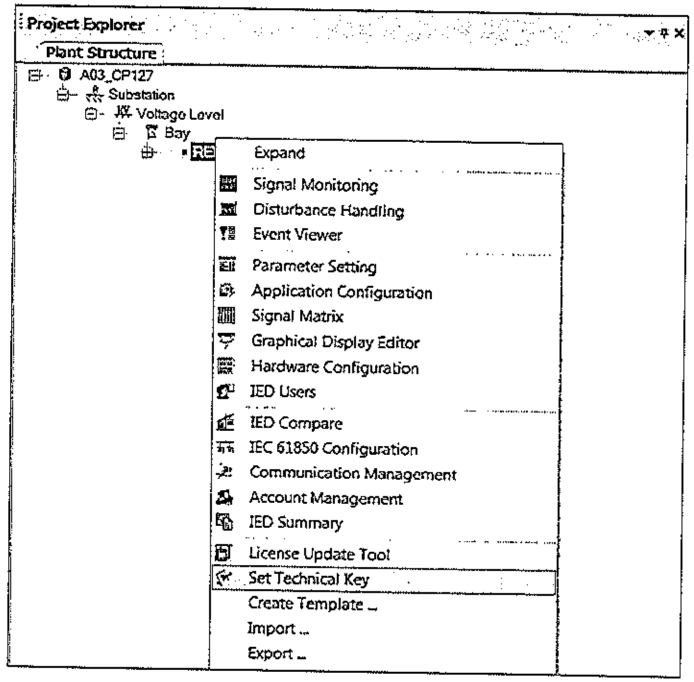
IEC09000378-2-en.vsd

Figure 5: Error message due to mismatch between PCM600 and IED technical key

Be sure that the IED object in PCM600 has the same IP address as the physical IED, which is intended to be connected through the technical key concept.

The technical key for an IED object in PCM600 can also be changed in the *Object properties* window.

1. Select the *IED* in the *Plant Structure*.
2. Right-click and select *Set Technical Key*, see Figure 6.

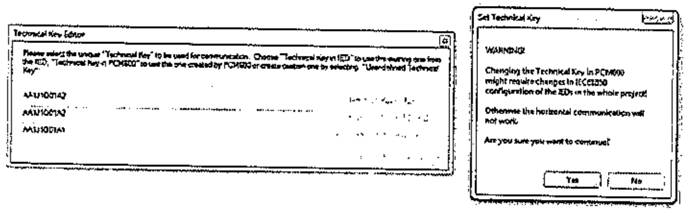


IEC08000657-4-en.vsd

Figure 6: PCM600: Set technical key menu at IED level

A dialog window opens to inform about the technical key concept.

3. Click *OK* in the dialog window.
   The technical key is read from the IED and the technical key editor window opens, see Figure 7.



IEC09000380-2-en.vsd

Figure 7: PCM600: Technical key editor

Using the *Technical Key Editor* the following selections are possible.

- use the existing technical key in the IED
- use the existing technical key defined for the IED object in PCM600 or
- set a user defined technical key, which changes the technical key for both the physical IED and IED object in PCM600.

The maximum technical key length is 25 characters for Edition 1 and 55 characters for Edition 2.

4. Click *OK* to confirm the selection.
   It is not possible to set a user defined name or select the *Technical key in IED* if the value is the same as already given to another IED object in the PCM600 project. A dialog window opens if this is the case.

4.4 Setting up communication between PCM600 and the IED

The communication between the IED and PCM600 is independent of the communication protocol used within the substation or to the NCC.

The communication media is always Ethernet and the used protocol is TCP/IP.

Each IED has an RJ-45 Ethernet interface connector on the front. The front Ethernet connector shall be used for communication with PCM600.

When an Ethernet-based station protocol is used, PCM600 communication can use the same Ethernet port and IP address.

To connect PCM600 to the IED, two basic variants must be considered.

- Direct point-to-point link between PCM600 and the IED front port. The front port can be seen as a service port.
- Indirect link via a station LAN or from remote via a network.

The physical connection and the IP address must be configured in both cases to enable communication.

The communication procedures are the same in both cases.

1. If needed, set the IP address for the IEDs.
2. Set up the PC or workstation for a direct link (point-to-point), or
3. Connect the PC or workstation to the LAN/WAN network.
4. Configure the IED IP addresses in the PCM600 project for each IED to match the IP addresses of the physical IEDs.

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Setting up IP addresses

The IP address and the corresponding communication subnetwork mask must be set via the LHMI for each available Ethernet interface in the IED. Each Ethernet interface has a default factory IP address when the IED is delivered. The IP adress and the subnetwork mask might have to be reset when an additional Ethernet interface is installed or an interface is replaced.

- The default IP address for the IED front port is 10.1.150.3 and the corresponding subnetwork mask is 255.255.255.0, which can be set via the local HMI path **Main menu/Configuration/Communication/Ethernet configuration/FRONT:1.**

Setting up the PC or workstation for point-to-point access to IEDs front port

An ethernet cable (max 2 m length) with RJ-45 connectors is needed to connect two physical Ethernet interfaces together without a hub, router, bridge or switch in between.

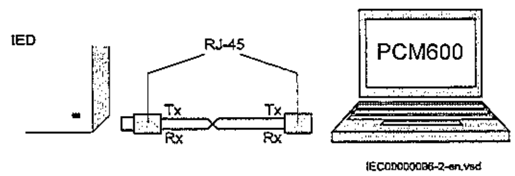

Figure 8: Point-to-point link between IED and PCM600

The following description is an example valid for standard PCs using Microsoft Windows operating system. The example is taken from a Laptop with one Ethernet interface.

Administrator rights are required to change the PC communication setup. It is automatically detected that Tx signals from the IED are received on the Tx pin on the PC. Thus, a straight (standard) Ethernet cable can be used.

1. Select **Search programs and files** in the **Start menu** in Windows.

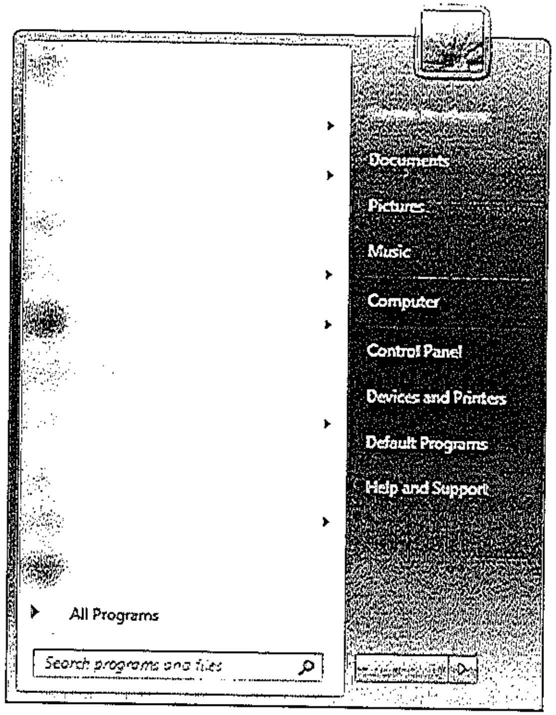

Figure 9: Select: Search programs and files

2. Type **View network connections** and click on the **View network connections** icon.

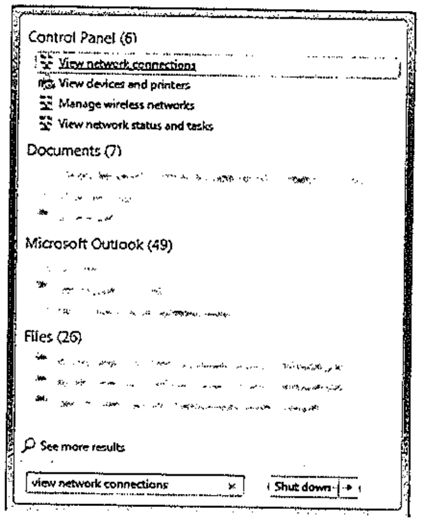

Figure 10: Click View network connections

3. Right-click and select **Properties**.

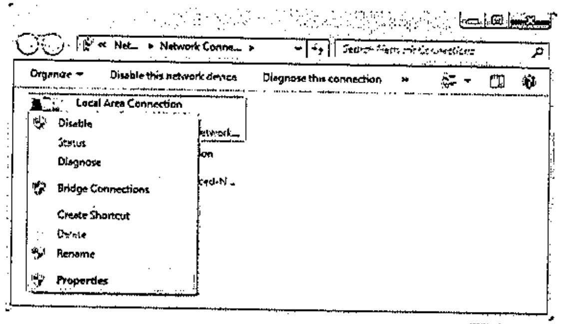

Figure 11: Right-click Local Area Connection and select Properties

4. Select the TCP/IPv4 protocol from the list of configured components using this connection and click **Properties**.

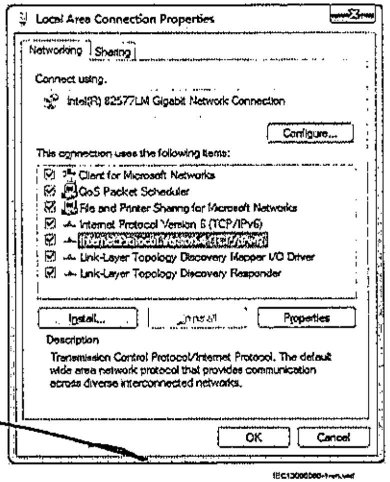

Figure 12: Select the TCP/IPv4 protocol and open Properties

5. Select **Use the following IP address** and define *IP address* and *Subnet mask* if the front port is used and if the *IP address* is not set to be obtained automatically by the IED, see Figure 13. The IP address must be different from the IP address chosen for the IED.

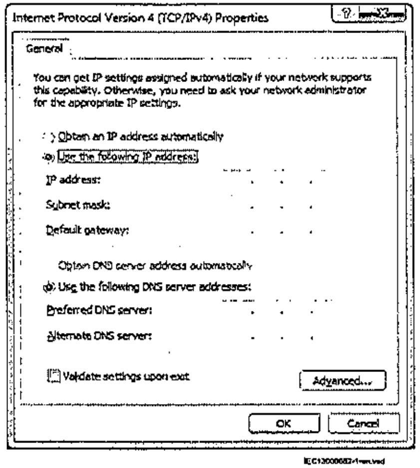

Figure 13: Select: Use the following IP address

6. Use the *ping* command to verify connectivity with the IED.
7. Close all open windows and start PCM600.

The PC and IED must belong to the same subnetwork for this set-up to work.

Setting up the PC to access the IED via a network

The same method is used as for connecting to the front port.

The PC and IED must belong to the same subnetwork for this set-up to work.

4.5 Project managing in PCM600

It is possible to:

- Open existing projects
- Import projects
- Create new projects

- Export projects
- Delete projects
- Rename projects
- Copy and paste projects
- Migrate projects from one product version to another

It is possible to open projects created in previous versions of PCM to the current version, but the opposite is not possible.

Extensions of the exported project file is *.pcmp and those files are only used for exporting and importing the projects between PCM600s.

Creating a new project

Procedure

1. Select *File* and *Open/Manage Project* ... to see the projects that are currently available in the PCMDataBases.
2. Open *Projects on my computer*.
3. Click the icon *New Project*. To create new project currently open projects and object tools shall be closed.
4. The *New Project* window opens, see Figure 14.

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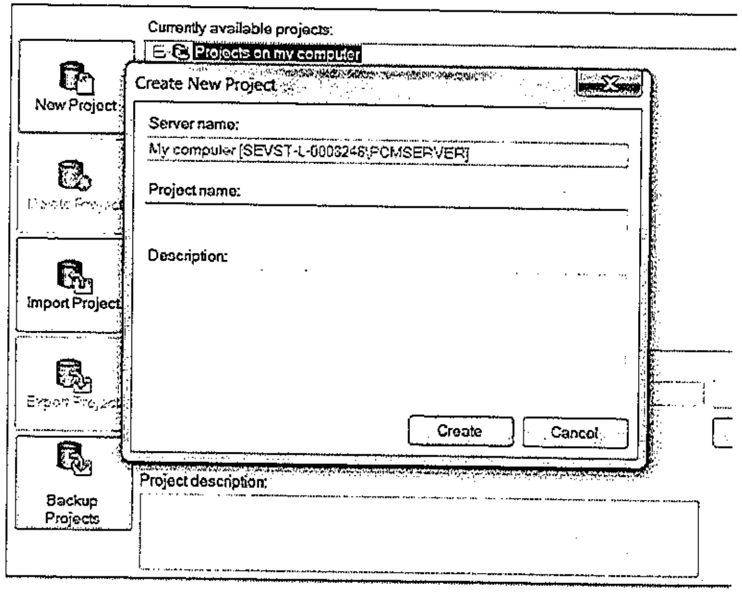

Figure 14: PCM600: Create a new project window

5. Name the project and include a description (optional) and click *Create*.
6. PCM600 sets up a new project that will be listed under *Projects on my computer*.

4.6 Building a plant structure

The plant structure is used to identify each IED in its location within the substation organization. It is a geographical image of the substation and the bays within the substation. The organization structure for the IEDs may differ from the structure of the primary equipment in the substation. In PCM600 it is possible to set up a hierarchical structure of five levels for the IED identification.

Build up the plant structure according to the project requirements. PCM600 offers several levels to build the hierarchical order from Center down to the IEDs in a bay.

The following levels are available:

1. Project = project name
2. Substation = name of the substation
3. Voltage Level = grid type or part in the substation the IED belongs to
4. Bay = bay within the voltage level
5. IED = selection of the IED used in the bay. Several IEDs are possible within a bay, for example one control IED and two protection IEDs.

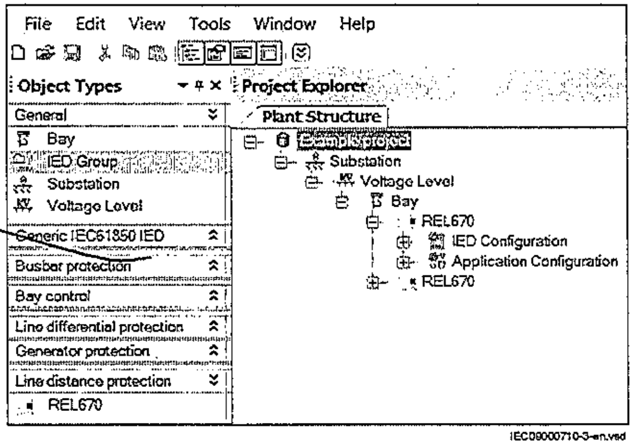

Figure 15: PCM600: Set up a plant structure

Once a plant structure is built, the name of each level in the structure should be renamed by the names/identifications used in the grid. Use the right mouse button to build the plant structure by selecting the elements from the context menu. Rename the level after insertion using the *Rename* possibility or the *Object Properties*. Figure 15 shows the start of a project with two IEDs placed but still not renamed.

The plant structure corresponds to the complete grid including the needed IEDs.

Procedure to build a plant structure:

- Right-click on the plant structure, select *New* and *Create from Template ...*, or
- Right-click on the plant structure, select *New*, *General* and select either *IED Group* or *Substation*.
- Click *View* in the menu bar and select *Object Types*. Select the needed elements and drag and drop them into the plant structure. Close the window if it does not close automatically.

4.6.1 IEC 61850 naming conventions to identify an IED

This section is only valid when the IEC 61850 standard is used for station bus communication. According to the IEC 61850–6 clause 8.4, the SCL model allows two kinds of project designation in the object properties.

- A technical key is used on engineering drawings and for signal identifications. The technical key is used within SCL for referencing other objects. Observe that name is a relative identification within a hierarchy of objects. The maximum number of characters allowed for a technical key is 25 for Edition 1 and 55 for Edition 2.
- A user-oriented textual designation is contained in the attribute desc. Attributes cannot contain carriage return, line feed or tab characters. The semantics of desc must also be relative within an object hierarchy.

PCM600 takes care of these two possibilities. The two possible signal designations are available per object in the object properties for all hierarchical levels beginning with the station as the highest level.

The technical key is automatically generated based on the rules and type specifications of IEC 61346and the extended definitions done for substations by a technical committee. The technical key is shown in the *Object Properties* under *SCL Technical Key* or *Technical Key*.

- The station level is predefined by "AA1", where 1 is the index.
- The voltage level is predefined by "J1", where 1 is the index.
- The bay level is predefined by "Q01", where 01 is the index.
- The IED is predefined by "A1", where 1 is the index.

The predefined full path name of the technical key for the IED would be AA1J1Q01A1.

For all practical engineering purposes (both towards the IED and towards the 61850 engineering process), the user should keep the default SCL technical key. However, it is possible, for example due to company naming policies, to rename the SCL technical key for the station level, voltage level, bay level and IED level using the Object properties window as shown in Figure 16.

- The station level has been renamed as "DMSTAT"
- The voltage level has been renamed as "C1"
- The bay level has been renamed as "Q1"
- The IED has been renamed as "SB1"

The renamed full path name of the technical key for the IED would be DMSTATC1Q1SB1.

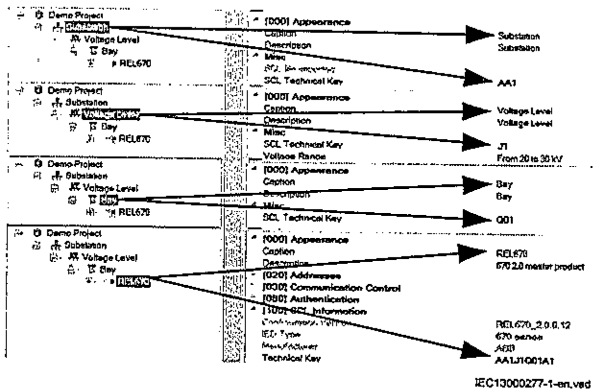

Figure 16: PCM600: IEC 61850 signal designation concept

4.6.2 Changing the SCL version of an IED

You can change the SCL version of an IED in PCM600 from Edition 1 of IEC61850 to Edition 2 or the other way around. You can also convert a .pcmi file to from Edition 1 to Edition 2 or the other way around.

It is not possible to mix Edition 1 and Edition 2 IEDs in the same PCM600 project. Therefore, it is possible to change the SCL version only when there is one IED in the project.

1. Enable SCL version changing in PCM600.
   1.1. Select **Tools/Options...**.
   1.2. In **Options/IEC 61850 Configuration,** open the **Miscellaneous** tab.
   1.3. Check **Allow changing SCL version of an IED configuration.**
   1.4. Click **OK** to exit.
2. In a project that has no IEDs, right-click the bay and select **Import...** to insert the IED from a .pcmi file.
3. Right-click the IED and select **Change SCL Version** and **IEC61850 Edition 1** or **IEC61850 Edition 2.**
   The **Change SCL Version** dialog opens.
4. Click **Yes** to confirm the edition change.
   Changing SCL Version dialog opens and shows the conversion progress. When the conversion is complete, the **Change SCL Version** dialog opens.
   Close the dialog by clicking **OK**.
6. Right-click the IED and select **Export...** to save the converted IED in a .pcmi file.

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4.7 Inserting an IED

The context menu or the *Object Types* view shows the available IEDs possible to insert on the bay level in the plant structure according to the installed connectivity package.

On the bay level in the plant structure it is possible to:

- Insert an IED in *Online mode* or in *Offline mode* :
  - Online mode: when the IED is already connected to PCM600 and the communication is established, PCM600 can read the configuration directly from the physical IED. This is useful when an order-specific IED is used. The order configuration is written to the IED at the factory, and can be accessed by PCM600. The housing type, the used overlay version for local HMI and the IO boards included in the IED will be read from the IED directly.
  - Offline mode: when the physical IED is not available or not connected to PCM600, the engineering steps are done without any synchronization with the IED. The offline configuration in PCM600 can be synchronized with the physical IED at a later state by connecting the IED to PCM600.

The green check mark (as shown in Figure 17) indicates that communication between the IED object in PCM and the physical IED is established.

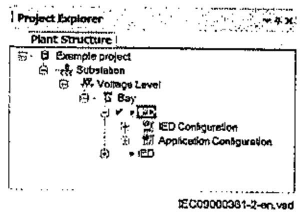

Figure 17: Plant structure with pingable IED

- Import a template IED available in the template library as a *.pcmt file.
- Import a pre-configured IED available as a *.pcmi file.

Inserting an IED in online mode

An Ed2 node cannot be inserted in an Ed1 project and vice versa.

Procedure:

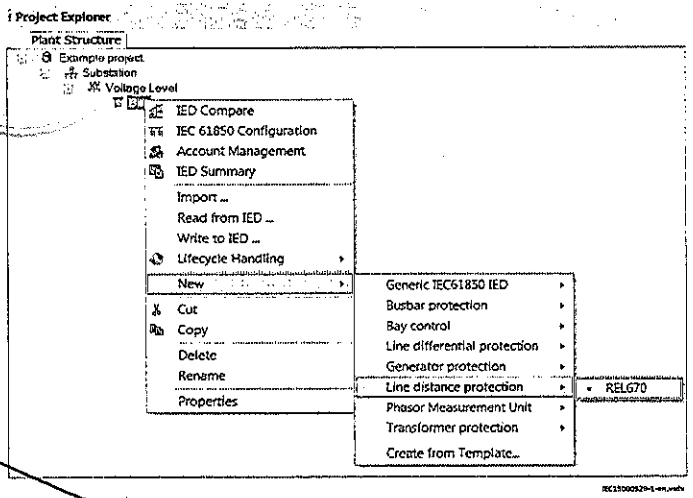

Figure 18: *IED insertion in online mode*

1. Right-click the Bay and select *New* and application type of IED.
2. Select the IED type to insert.

> It is also possible to drag an IED from the Object Types window to the Bay level.

3. Select the *Online Configuration* mode, see Figure 19.

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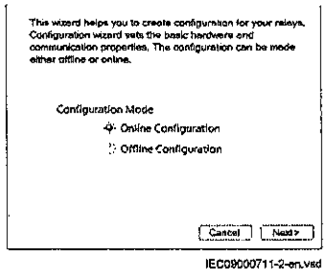

Figure 19: *PCM600: Configuration mode selection wizard*

4. Select the IED Communication protocol, see Figure 20.

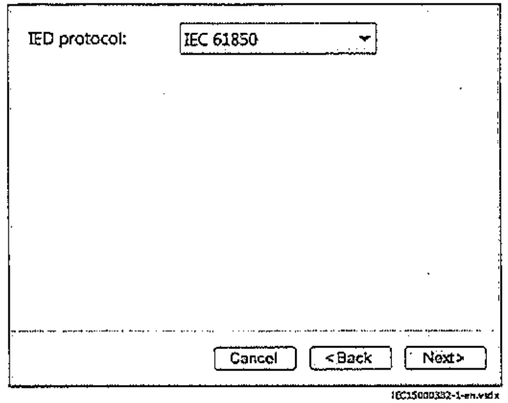

Figure 20: *PCM600: Communication protocol selection wizard*

5. Select the port and insert the IP address of the physical IED to configure, see Figure 21.

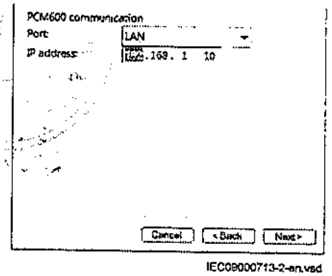

Figure 21: PCM600: Communication port and IP address

6. Cross-check that the IED whose IP address has been inserted, has been detected online by PCM600, see Figure 17.

> The user cannot scan data from the IED or proceed further if the IED is not online or if the IP address is not correct.

7. Click the *Scan* option to scan/read the *IED Type* and *IED Version* for the IED that is online, see Figure 22.

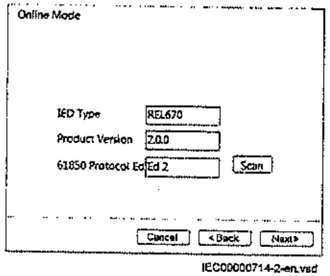

Figure 22: PCM600: IED Version detection

The IED version can be changed later in the **Plant Structure** view by right-clicking on the IED and selecting **Change SCL Version** if it is the only IED in the plant structure.

8. Click **Next** to open the *Housing Selection Page*. The IED housing type and display type are detected and displayed as shown in Figure 23

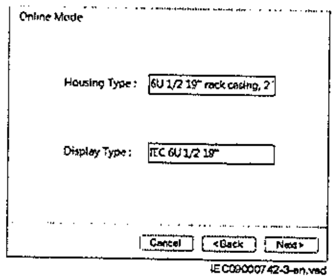

Figure 23: PCM600: IED housing and display type detection

9. The *Setup Complete Page* dialog shows the summary of the *IED Type*, *IED Version*, *IP Address of IED* and *Order Number*, see Figure 24. It is possible to *Cancel* the insertion or confirm the configuration and do the insertion with *Finish*.

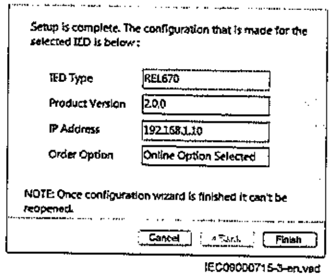

Figure 24: PCM600: IED Setup completion wizard

> It is not possible to go back and do any modifications in the setup complete page. If an error is detected, the insertion has to be canceled and the IED has to be inserted again.

> When the online configuration is completed, it is advised to read the configuration from the IED to ensure that the IED object in PCM600 has the same configuration data as the physical IED.

Inserting an IED in offline mode

Working in offline mode has an advantage compared to online mode in that one can start preparing configuration even though the IED is not available. Setting up an IED in offline mode is almost similar to inserting it in online mode. However, in offline mode it is not necessary to type the correct IP address in the Communication port and IP address dialog.

The version information needs to be selected from the drop down menu as shown in Figure 25

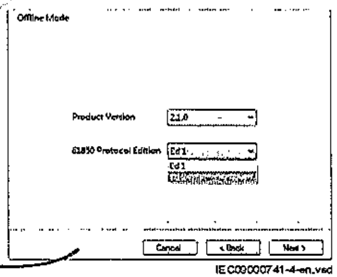

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Figure 25: PCM600: IED Version selection

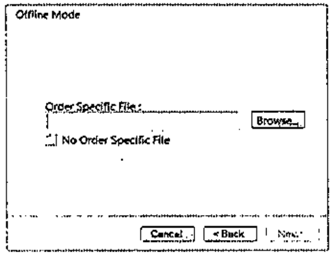

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Figure 26: PCM600: IED Order code selection

Inserting an IED from the template library

An IED in the plant structure can be exported as a template (*.pcmt). The user can build up a template library with all the exported IED templates. It is possible to insert an IED from the template library to create a new IED in the plant structure. Change the IP address and the name that corresponds to the physical IED after a template IED has been imported.

A template IED can only be inserted when the bay is selected in the plant structure.

Procedure to insert a template IED

1. Right-click the *Bay* in the plant structure.
2. Select *New* and *Create from Template ...* to open the *Create New Object from Template* window, see Figure 27.

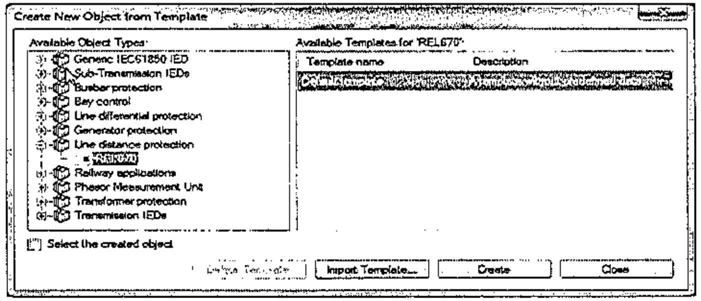

Figure 27: PCM600: Selecting an IED from the template library

3. Select the IED from the list of available IEDs.
4. Click the icon in the right column of the list of available templates to open the *Template Properties*. Verify the template information, see Figure 28 and click *Close* to close the window.

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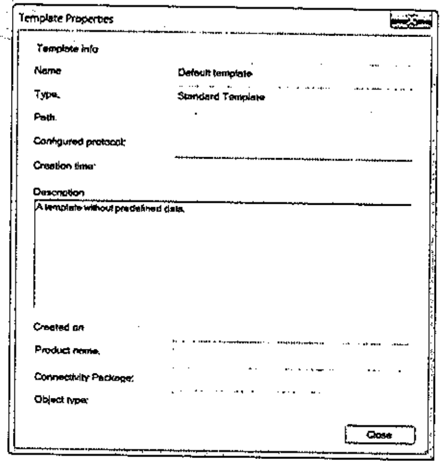

Figure 28: *PCM600: IED Template Properties*

5. Click *Delete Template* to delete the template, click *Import Template* to import a template from the selection window or click *Create* to insert the selected IED to the bay, see Figure 27.

It is possible to insert more than one IED from the *Create New Object from Template* window and the selection window remains open until the user clicks *Close*.

Inserting a pre-configuration

Pre-configurations in PCM600 are available as *.pcmi files and include all information that is related to the IED object in PCM600. A given pre-configuration is bound to a specific hardware configuration.

Options for inserting a pre-configuration:

- Use the pre-configuration that has been ordered together with the IED.
- Create your own configuration, export the configuration as *.pcmi file and use it to configure other IEDs.
- Use a pre-configuration from the Connpack DVD if more than one pre-configurations exist for the IED.

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Procedure to insert a pre-configuration

Because Ed1 and Ed 2 templates are incompatible, convert an Ed1 template to Ed2 before you insert it.

1. Right-click the bay and select *Import ...* to select the IED configuration file (*.pcmi), see Figure 29.

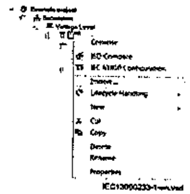

Figure 29: *Import an IED from the context menu*

2. Import the *.pcmi file from the bay level in the plant structure.
3. Click *OK* to insert the new IED object in the plant structure.
4. Modify the configuration according to the needed application.
5. Write the configuration to the IED.

Ordered default configurations are not locked. The user can use any of the available default configurations for a particular product type as a base to create an own configuration. The only requirement is that all needed hardware and software options are available.

It is possible to give the inserted IED in the plant structure a user-defined name. Be sure to only user characters a-z, A-Z, 0-9 and _. Do not use space character in IED names.

4.7.1 Setting IED IP address in the project

There are two alternatives to set the IP address of the IED object in PCM600. The IED object in PCM600 must have the same IP address and subnetwork mask as the front or rear port on the physical IED to which the PC is connected. The IP address of the physical IED's front and rear port cannot be set from PCM600 but only from the LHMI.

- Via the first window of the wizard when including a new IED in a project, see Figure 30.

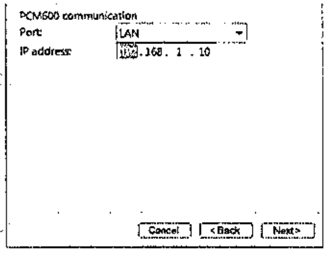

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Figure 30: Alternative 1: IP address via the first Wizard window

- Via the IP address property of the IED in the *Object Properties* window, see Figure 31.

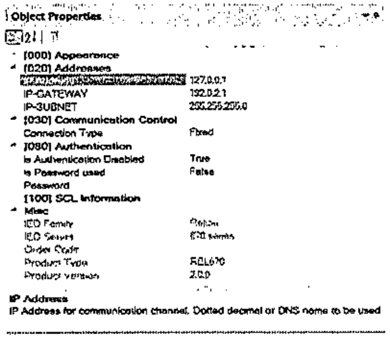

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Figure 31: Alternative 2: IP address via the IED Object Properties window

Procedure

1. Select the IED to enter the IP address.
2. Open the *Object Properties* window.
3. Place the cursor on the *IP address* row and enter the IP address.

The used alternative depends on the time at which the IP address is available.

Section 5 Protection and control engineering

5.1 Creating an application configuration with ACT

5.1.1 Overview

ACT is used to create the application configuration for an IED. The application configuration is built up with function blocks.

Function blocks are dedicated for different functionality, for example:

- Preprocessing blocks
- Control related functions
- Protection related functions
- Monitoring functions
- Communication

For detailed information about function blocks see the technical manual and the application manual.

SMBIs and SMBOs are still available in PCM600 but the user does not have to use them anymore. Instead, the user can connect the function block inputs and outputs directly to the hardware channels.

Some function blocks are mapped as logical nodes according to the IEC 61850 standard. Other function blocks are not mapped as logical nodes, for example:

- Logical gates
- Timers

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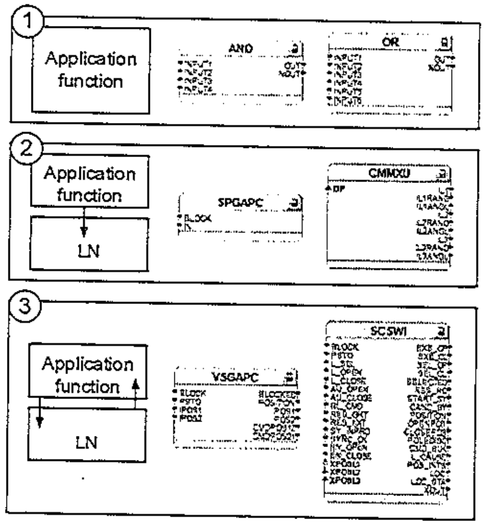

Figure 32: Examples of function blocks with and without monitoring and commands

1 Function blocks without communication
2 Function blocks with communication only
3 Function blocks with monitoring and commands
AFL The function block's AFL
LN The logical node of the function block's AFL

The basic general features of the Application configuration tool ACT:

- Organization of an application configuration
  - Organize an application configuration into a number of logical parts (MainApplication).
  - Organize a MainApplication over a number of pages.
- Features to program an application configuration:
  - Insert function blocks, make connections and create variables.
  - Include the hardware IO channels directly in the application configuration.
  - Set function blocks and signal visibility to SMT and PST.

SMT is not supporting signals of integer type or group signals. So, even if these types of signals are set as visible for SMT, they will not be shown in SMT.

- Document the application configuration, for example to make printouts.
- Test the application configuration online.
- Save application configurations as templates in an application library to reuse them in other IEDs.
- Validate the application configuration during the configuration process on demand and while writing the application configuration to the IED.

For instructions on how to perform the different tasks in PCM600, see PCM600 online help.

5.1.2 Function blocks

- Function blocks are the main elements of an application configuration. They are designed for a various number of functions and organized in type groups. The different function block types are shown in the Object Types View. Figure 33 presents an overview of the main parts that are relevant for function blocks.
- Set user defined names for function blocks and signals marked with blue text.

Signals that have a user defined name created in ACT, will only be visible in PST if the IED configuration is written to the IED and read back to PCM600. Otherwise the default signal name is shown in PST.

Do not use other characters than a-z, A-Z, 0-9 and _ when setting user defined names for signals and function blocks, since other characters might not display properly in local HMI. Also avoid using space character.

- Set IEC or/and ANSI naming style.
- Lock function blocks.
- Set visibility for execution order, cycle time and instance number.
- Manage signals, for example hide, show and rearrange.
- Invert Boolean inputs and Boolean outputs.

Mandatory signals must be connected.

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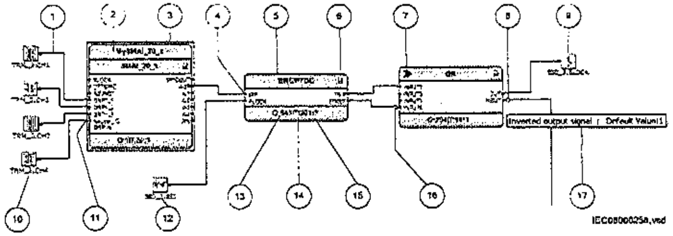

Figure 33: ACT: Function block overview

1 Connection(s)
2 User defined function block name
3 Function block, selected (red)
4 Mandatory signal (indicated by a red triangle if not connected)
5 Function block name
6 Function block, locked (red)
7 ANSI symbol
8 Inverted output
9 Hardware, binary output channel
10 Hardware, analog input channel
11 User defined signal name
12 Hardware, binary input channel
13 Execution order
14 Cycle time
15 Instance number
16 Inverted input
17 Signal description note

5.1.3 Signals and signal management

A function block has set of input and output signals.

A function block can contain more signals than needed in that application part. A signal that is not used in a particular application is possible to hide in the function block view in ACT. It is not necessary to connect all inputs and outputs at a function block. If not connected, the signals always have a default value. The default value can be seen when hove over the signal with the mouse.

Signals are located on both sides of the middle position up and down. When there is space left, move some signals up or down for a better visibility and connection routing.

Boolean input and output signals may need to be inverted to fulfill the logic. ACT supports to add the inversion logic to a binary signal.

> The input signal on glue logic function blocks can only be inverted if a glue logic function block with lower execution order in the same cycle time is available. Similar, the output signal can only be inverted if a glue logic function block with higher execution order in the same cycle time is available. Up to two input signals and two output signals can be inverted for glue logic blocks in the same cycle time.

> Even though current is injected to the IED and the IED is connected to PCM600 in online mode, the signal value in ACT is shown as zero.

All not mandatory input signals have a default value that will be used when not connected.

5.1.4 Function block execution parameters

Three function block execution parameters have influence on the runtime execution of the function block within the application configuration.

- *Execution Order*
- *Cycle Time*
- *Instance Number*

Each time a new function block is selected, one or more of these parameters become available for selection from the drop down lists in ACT depending on the function block type. The *Cycle Time* may be predefined to one value with certain functions. The *Instance Number* is a counter for the total possible number of function blocks of that type used within an application configuration.

Execution Order and *Instance Number* are given in the list as a selectable pair predefined within a product. Figure 34 shows an example how the drop down list could look like.

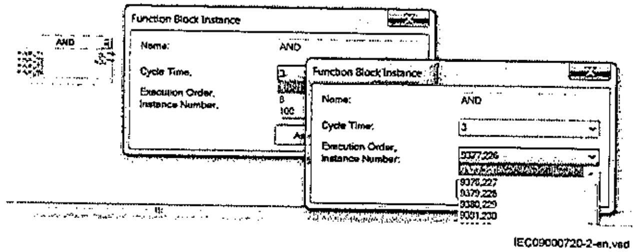

Figure 34: ACT: function block organization parameters

> A minus sign in front of the cycle time, for example -200ms, indicates that the application is time driven, otherwise the application is analog data driven. Analog data driven applications require sample values from Analog input modules - in case the physical module is broken, applications are not executed. Time driven applications are executed periodically regardless of the status of the analog signal processing.

The *Cycle Time* can be selected to 1, 3, 8 or 100 ms for certain functions (for example SMAI). Depending on the function block and IED type, one or more possibilities may be available.

> If used, 3PHSUM must have the same cycle time as SMAI.

The combination *Execution Order*, *Instance Number* is predefined by ABB. Mainly for basic logic function blocks like for example *AND*, *OR*, a set of combinations spread over the full range of execution orders is available. This gives the possibility to select a combination which fits to the execution order range needed in that application part.

Application configuration cycle time and execution order organization

The application execution within the IEDs is organized in three time classes, see Figure 35.

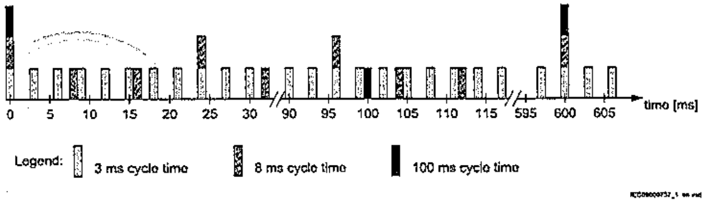

Figure 35: ACT: Possible MainApplication cycle times

For the same time point, faster cycle times are executed first.

A function block that is placed after a function block in the execution flow must have the same or a higher cycle time and/or execution order. See Figure 36.

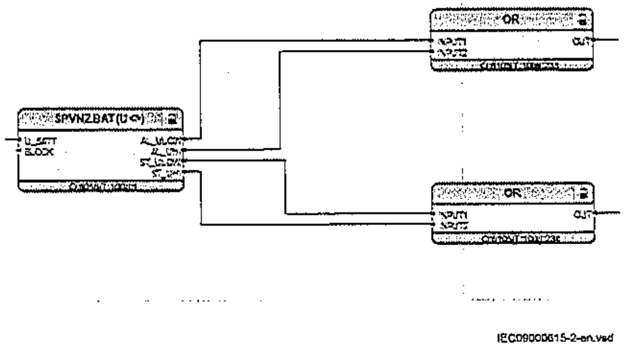

Figure 36: Cycle time and execution order

A function block type can be defined to be a member of one or several cycle times. A function block instance can be set only to one cycle time.

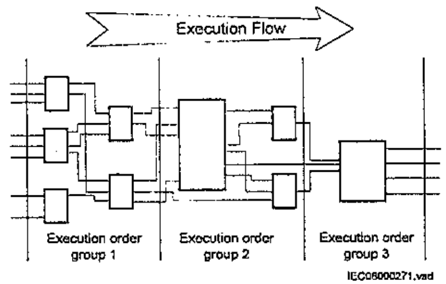

Figure 37: ACT: Concept of Execution order sequence

In the conceptual MainApplication example in Figure 37, the execution order of the main function block in the execution order group 2 defines the execution orders needed in group 1 and 3. The preceding logic done with function blocks in group 1 must have a lower execution order than the ones in group 2. The following function blocks in group 3 must have a higher execution order than the main function block in group 2.

5.1.5 Configuration parameters

5.1.6 Connections and variables

A connection is the link or "wire" between function block outputs and inputs.

Rules and methods to do connections:

- Drag a line between two signals.
- Link two signals by using variables.

It is possible to search and replace variable names in ACT.

Connection validation

A connection is only useful and possible between two signals of the same data type, see Figure 38.

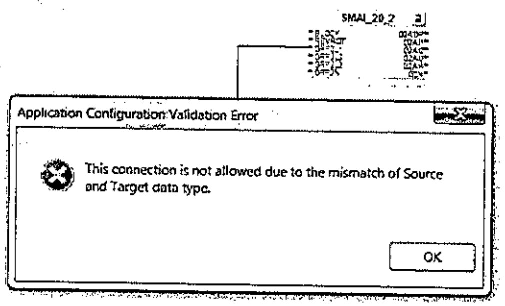

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Figure 38: ACT: Warning message by signal mismatch for a connection

5.1.7 Hardware channels

Hardware channels can only be connected to a function block input or output. A hardware connection can be established in ACT or SMT. When a hardware channel is connected a graphical symbol appears in ACT, see Figure 39. The connection is also represented in SMT with a cross mark. Hardware channels are always visible in SMT.

Supported hardware channels are:

- Binary input channels
- Binary output channels
- Analog input channels

A hardware input channel can be used as often as it is needed. A hardware binary output channel is taken from the list of available channels when a new channel is requested. That prevents for using a hardware binary output channel twice. As an example, see Figure 39.

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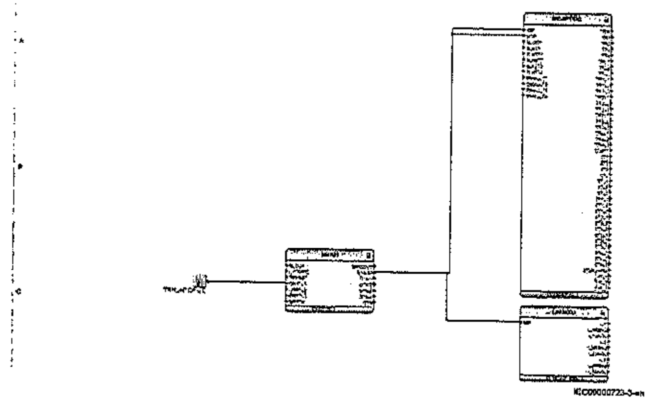

Figure 39: ACT: HW signal channels

5.1.8 Validation

Validation checks the application configuration on errors about the rules and restrictions defined for doing a MainApplication on three levels.

- During creating the logic while doing a connection or placing a function block.
- On demand by starting the validation.
- When writing the application configuration into the IED.

Validation when creating the application configuration

Validation is made when creating the application configuration, for example:

- A connection between two input signals or two output signals is not possible.
- A connection between two different data types is not possible, for example a binary output to an analog input.

Validation on demand

To check the validity of an application configuration, click the 'Validate Configuration' icon in the toolbar. ACT will check the application configuration for formal correctness. Found problems are qualified in:

- Warnings, marked by a yellow warning icon

- Example: A variable connected to an output signal that is not connected.
- Example: If the user connects output from higher execution order function to inputs of lower execution order function.
- Errors, marked by a red circle with a cross
  - Example: A mandatory input signal that is not connected.

Warnings will not prevent writing to the IED. Errors have to be corrected before writing the application configuration to the IED. An application configuration can be saved and ACT can be closed with open errors, but not written to the IED, see Figure 40.

These problems are listed in the *Output View* under the Tab *Application Configuration*. A double-click in the error or warning row will navigate to the MainApplication>Page>Area where the problems are identified.

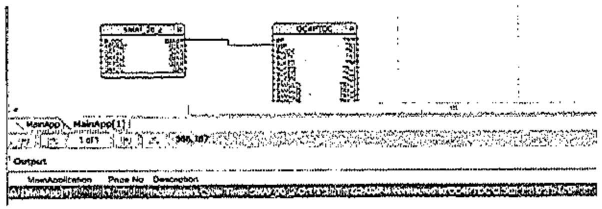

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Figure 40: ACT: Validation on demand

Validation when writing to the IED

When writing the application configuration to the IED an automatic validation is performed. The validation is the same as the manually demanded validation. Errors will abort the writing.

5.2 Setting configuration and setting parameters in PST

Configuration parameters and settings parameters are changeable either from LHMI or from PST in PCM600.

Note that the some parameters are only visible in PST and some are only visible on LHMI.

A common write from PCM600 to the IED, where parameters are changed in PST, will overwrite any parameter changes made locally from LHMI.

To export parameters from PST, both XRIO and CSV formats are supported.

All variables listed and shown in the parameter list can be sorted into two groups:

- Configuration parameter or
- Setting parameter

Configuration parameter

A configuration parameter specifies an operation mode of an application function or of the IED. These are basic configurations, which are normally configured only once and then settled. The IED configures itself at start-up according to the given configuration parameter values.

Setting parameter

A setting parameter (short form only "setting") is a parameter that can be changed in the IED at runtime.

Setting group

Nearly all settings used by the IED for the protection application functions are organized in a group of settings. Up to six setting groups can be configured with different values. The IED supports the selection of a setting group at runtime.

IED parameters organization

The organization of the parameters in a tree structure is visible in the plant structure by expanding the setting tree. For each function, the parameters are organized in basic and advanced groups. The advanced settings are used for application optimization.

During a common write both the basic and advanced settings are written to the IED.

5.2.1 Graphical Parameter Setting Tool

The Graphical Parameter Setting Tool (GPST) is a tool in PCM600 that is used to present parameter settings in a graphical user interface. GPST is a part of the Parameter Setting Tool (PST), the settings are done in PST and can be presented in GPST.

GPST is available for distance protection functions:

Distance protection zone, quadrilateral characteristic	ZMQPDIS, ZMQAPDIS
Distance measuring zone, quadrilateral characteristic for series compensated lines	ZMCPDIS, ZMCAPDIS
Fullscheme distance protection, mho characteristic	ZMHPDIS
Fullscheme distance protection, quadrilateral for earth faults	ZMMPDIS, ZMMAPDIS
Distance protection zone, quadrilateral characteristic, separate settings	ZMRPDIS, ZMRAPDIS
High speed distance protection, quadrilateral and mho	ZMFPDIS
High speed distance protection for series compensated lines, quadrilateral and mho	ZMFCPDIS
Underimpedance protection for generators and transformers	ZGVPDIS
Power swing detection	ZMRPSB
Phase selection, quadrilateral characteristic with fixed angle	FDPSPDIS
Phase selection, quadrilateral characteristic with settable angle	FRPSPDIS
Faulty phase identification with load encroachment	FMPSPDIS

For more information on GPST, see the online help for PCM600.

5.3 Connecting signals in SMT

SMT is used to do cross references, see Figure 41:

- between physical IO signals and function blocks.
- for the GOOSE engineering.

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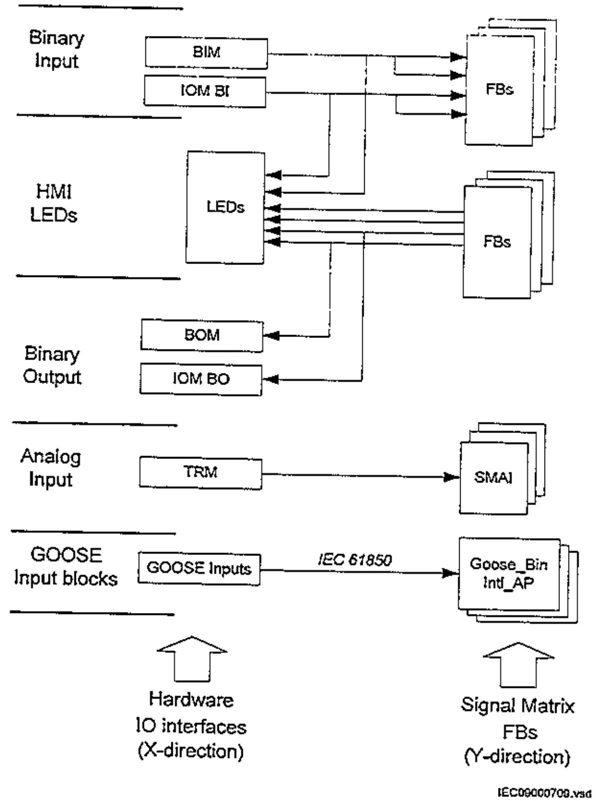

Figure 41: SMT: Operation principles

A binary input channel can be connected to one or several function block inputs, see Figure 42. If a binary input channel is connected to several different function blocks in ACT, the connection will appear as glue logic in SMT.

A binary output channel can only be activated from one function block output. If it should be activated from more than one function block output, glue logic has to be used. Glue logic means inserting a logical gate (OR and AND blocks) between the function blocks and the binary output channel. This can be engineered in SMT.

Connections made in SMT are automatically shown in ACT.
Connections made in ACT are automatically shown in SMT.

It is possible to group and collapse hardware channels in SMT to get a better overview.

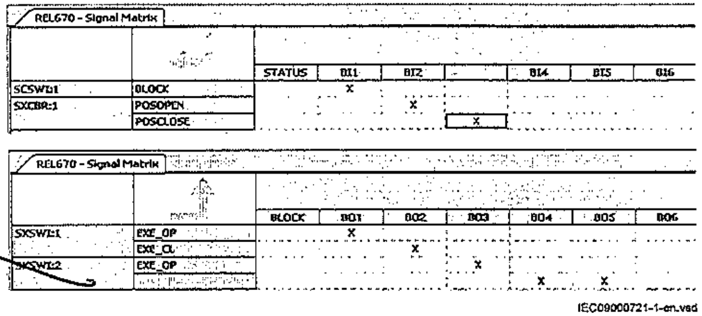

Figure 42: SMT Connection between binary input channels to binary input signals

Depending on the IED capability, SMT has a separate sheet for each possible combination.

The possible sheets are:

- Binary Inputs
- Binary Outputs
- Analog Inputs
- Functions
- GOOSE Receive

Section 6 Local HMI engineering

6.1 LED and function key engineering

6.1.1 Local HMI engineering process

Figure 43 shows the different steps of the engineering process of the local HMI (LHMI) and their relative order.

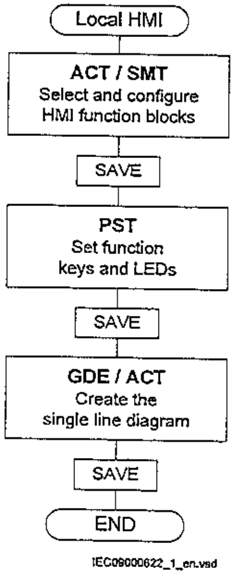

Figure 43: LHMI: Engineering process flowchart

- Application Configuration tool with possible assistance of Signal Matrix tool

    - To use the function keys and LEDs on LHMI it is necessary to insert the corresponding special function blocks for these operation element groups.
    - The function blocks for the LEDs are organized as single function block per LED but indexed to the group identification, for example GRP1_LED3 (indication LED 3 in virtual LED group 1).
    - The function blocks for the LHMI are visible by default for the Parameter Setting tool.
    - Use the Application Configuration tool to connect binary input signals from application functions to LED function blocks.
- Parameter Setting tool
    - The operation mode of the function keys and LEDs is defined in the Parameter Setting tool.
    - The presented text labels on the LCD for LHMI keys and LEDs.
- Graphical Display Editor with assistance of the Application Configuration tool, for example
    - to make the single line diagram of the primary process part.
    - to make the dynamic links for the apparatus.
    - to make the dynamic links for measurements.

Application Configuration tool and local HMI function blocks

See the *Technical Manual* for more information on function blocks.

The LHMI provides a set of special function blocks to be utilized in the Application Configuration tool:

- LHMICTRL
- FNKEYMD1 to FNKEYMD5
- LEDGEN
- GRP1_LED1 to GRP1_LED15
- GRP2_LED1 to GRP2_LED15
- GRP3_LED1 to GRP3_LED15

The function blocks for the LEDs are organized in function blocks per LED. They can be placed close to the logic where the information per LED is built in the Application Configuration tool.

Figure 44 describes the basic LHMI and the operation element groups. These are the 15 LEDs and their belonging text elements on the LCD [A]. They are operated by keys [a] and [b].

The other group is the five function keys with their LEDs and the corresponding text elements on the LCD [B].

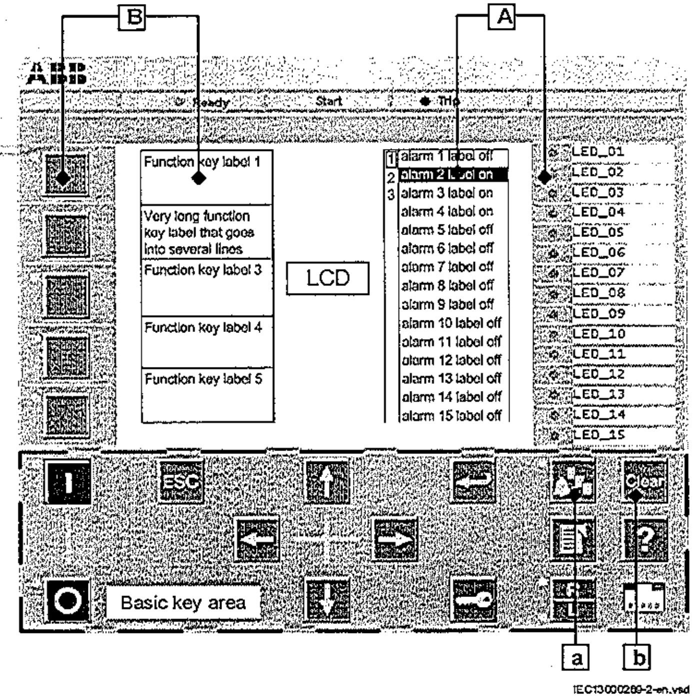

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Figure 44: Local HMI: Placement of local HMI operation elements

Function block LEDGEN

- Handles an external acknowledge signal as source to acknowledge the LEDs.
- Generates an additional pulse for general purposes whenever the LEDs are acknowledged by the operator.
- Generates a pulse whenever a new LED signal occurs. It may be used to trigger an acoustical alarm.
- Handles timers *tReset* and *tMax* for the LED operation mode 'LatchedReset-S'.

Function block GRP1_LED1 to GRP3_LED15

- The 15 LEDs on the right side of the LCD can indicate in total 45 alarms, warnings or other signals to the operator. They are organized in three groups 1 to 3.
- Each signal group belongs to one function block.
- Each LED illuminates in one of the three colors: RED, YELLOW or GREEN.

- The organization of flashing, acknowledgment and group selection is done directly between the function blocks and the basic LHMI keys, the 'Multifunction' key [a] to toggle between the three groups or the 'Clear' key [b] to acknowledge or reset the LEDs.
- Only the programming of the signals is needed for the LEDs.
- The operation mode of the LEDs is defined in the Parameter Setting tool.

Function block FNKEYMD1 to 5

- Every function key has its own FNKEYMD function block.
- The 5 function keys on the left side of the LCD [B] can be used to process demands.
- The function block handles the signal for the LED included in the key as input signals.
- The LED signal of the key is independent of the key function and must be programed to process demands.
- The function block handles the operators command when the key is pressed as output signal.
- The functions are activated whenever a key is pressed for the first time. The corresponding text elements for the five keys appear on the left side of the LCD. No execution of the function is done. So the first push is used to activate the presentation only.
- The next key push is handled as activate function and the output signal of the function block is set.
- The operation mode of the function key is defined in the Parameter Setting tool (pulse, toggle).

Parameter Setting tool and function block configuration

The operation mode of the function keys and the LEDs must be defined per key and LED in the Parameter Setting tool.

The function key can operate as:

- Pulsed signal
  - Each push forces a pulse of a configured time.
  - The pulse time can be set in the Parameter Setting tool.
  - The default pulse time is 200 ms.
- Toggle signal
  - Each push changes the state of the signal: OFF-ON-OFF-ON-OFF...
  - The default position after power up or reset is OFF.
- Menu shortcut
  - When pressing a key configured for that purpose, the function key panel is hidden and the LHMI opens directly in the configured menu.

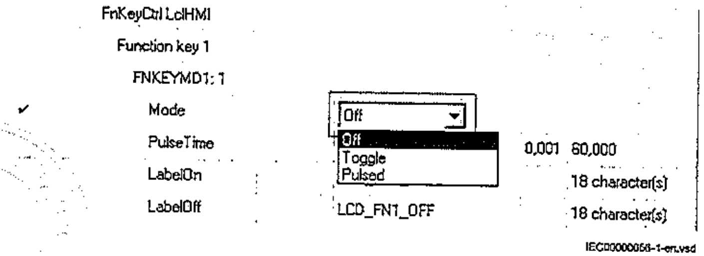

Figure 45: LHMI: Function key operation mode

The LEDs have a number of different operation modes, see Figure 46:

- General definitions
  - Each LED can illuminate in one of three colors: RED, YELLOW, GREEN.
  - Only one color is illuminated at a time.
  - The priority for illumination and the color is linked.
    - Prio 1 = RED
    - Prio 2 = YELLOW
    - Prio 3 = GREEN
    - When RED and YELLOW are ON at the same time, the LED will illuminate in RED.
  - The operator's acknowledgement for the LED signals is done for all three signals (RED, YELLOW, GREEN) of the LED.
  - A reset of the LEDs operates also on all three signals of the LEDs.
- Follow-S
  - The LED illumination follows the status of the signal. The LED illuminates steady (S).
- Follow-F
  - The LED illumination follows the status of the signal. The LED illuminates flashing (F).
- LatchedAck-F-S
  - The LED latches the signal change OFF-ON and flashes (F) until it is acknowledged.
  - When the signal is still ON at the time the signal is acknowledged, the LED changes to steady (S) mode.
  - When the signal has already changed to OFF before the time it is acknowledged, the LED turns to OFF.
- LatchedAck-S-F
  - The same as LatchedAck-F-S but the LED starts with steady state and flashes after acknowledgment.
- LatchedColl-S
  - The LED illuminates in all cases in steady mode only
  - The LED latches a signal change from OFF-ON until it is acknowledged by the operator.
  - The LED stays in steady mode when it is reset and the signal is still in ON state.
  - The LED is OFF only after the signal has changed to OFF state AND it is reset by the operator via 'Clear' operation.
- LatchedReset-S
  - This mode is used for all LEDs that are used to indicate a disturbance. The LEDs will stay in the last state after the disturbance run time until they are reset after a defined time.
  - The timers are set in the Parameter Setting tool in the function block LEDGEN.

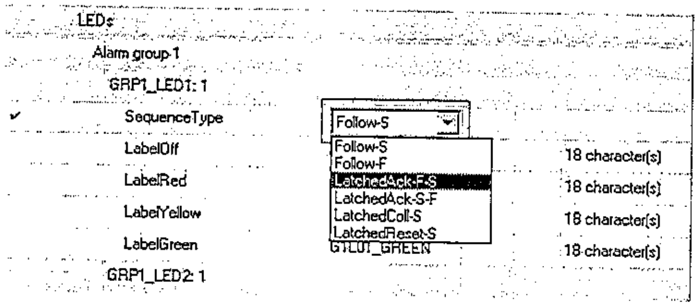

Figure 46: LHMI: LED operation mode

6.1.2 LED operation modes

The *SequenceType* parameter enables each LED to operate in one out of six different modes.

- Follow-S
- Follow-F
- LatchedAck-F-S
- LatchedAck-S-F
- LatchedColl-S
- LatchedReset-S

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LED operation mode Follow-S

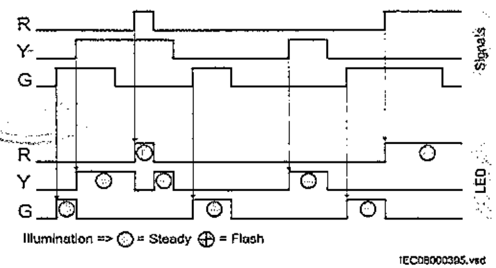

Figure 47: LHMI: LED operation mode Follow-S

In the Follow-S mode, the LED adopts a steady behavior. It is lit on a binary *On* signal and switched off on a binary *Off* signal. See Figure 47 for details.

LED operation mode Follow-F

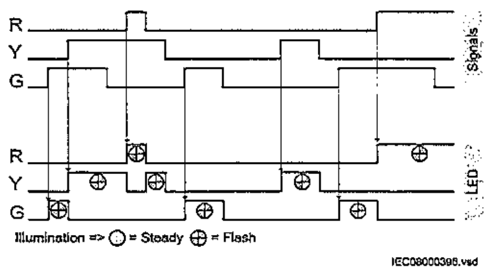

Figure 48: LHMI: LED operation mode Follow-F

In the Follow-F mode, the LED starts flashing when receiving a steady binary *On* signal. At other times it is unlit. SeeFigure 48. This mode may be used to indicate that a tap changer or Petersen coil is moving.

LED operation mode LatchedAck-F-S

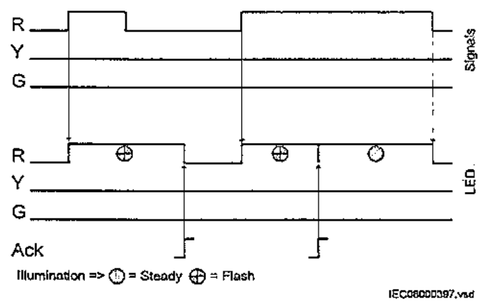

Figure 49: LHMI: LED operation mode LatchedAck-F-S / Base

The LatchedAck-F-S mode is used to indicate unconfirmed alarms or warnings. On a binary *On* signal (steady or pulse), the LED enters a flashing state. If acknowledged and if the signal is still *On*, the LED transitions into a steady state. If the signal at this point is *Off*, the LED is switched off (for this color). SeeFigure 49 for details.

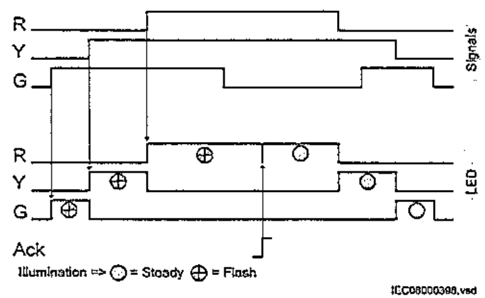

Figure 50: LHMI LED operation mode LatchedAck-F-S Ack Prio / 1

Each LED has one binary input for each of the colors: red, yellow and green representing high, medium and low priority respectively. Each priority also applies to the presentation of the state (acknowledged or unacknowledged) of each color. Excluding *Off* signals, the presentation of a state of higher priority always overrides the presentation of any state of lower priority.

See Figure 50 and Figure 51 for these two principles.

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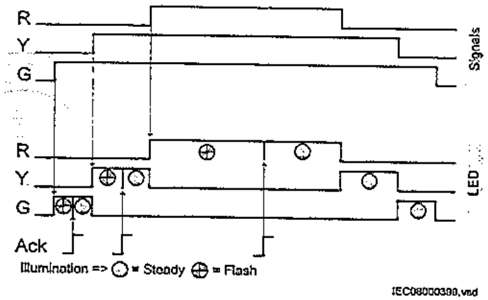

Figure 51: *LHMI LED operation mode LatchedAck-F-S Prio / 2*

LED operation mode LatchedAck-S-F

The LatchedAck-S-F mode operates in a similar manner as the LatchedAck-F-S mode. However, on receiving a binary *On* signal, the LED enters a steady lit state. When acknowledged and the signal remains *On*, it starts flashing.

LED operation mode LatchedColl-S

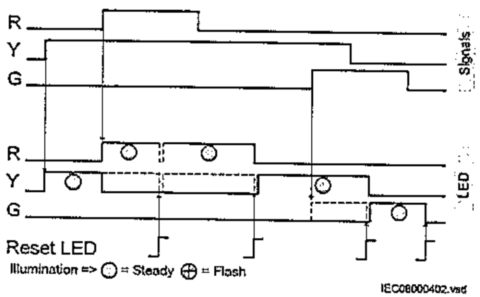

Figure 52: *LHMI: LED operation mode LatchedColl-S*

A LED operating in the LatchedColl-S mode enters a steady lit state on receiving a binary *On* signal. The LED remains lit even if the signal immediately transitions to *Off* (pulse). When acknowledged, the LED is switched off, unless the attached signal remains *On*. SeeFigure 52 for details.

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LED operation mode LatchedReset-S

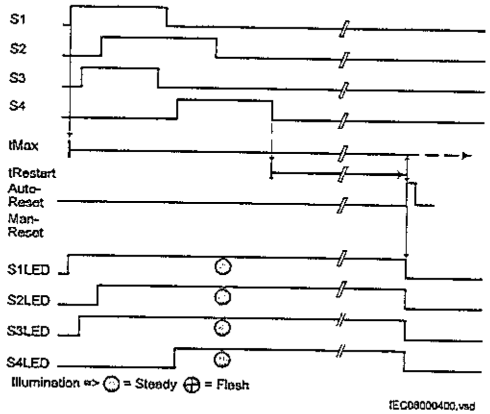

Figure 53: *LHMI: LED operation mode LatchedReset-S*

The LatchedReset-S mode is designed for multi-signal disturbance monitoring. For this reason, the General LED indication function block (LEDGEN) has two parameters: tRestart and tMax. Both are timers used to determine the end of a disturbance window.

A disturbance window starts when a LED receives a binary *On* signal. The LED then enters a steady lit state. At the point where all signals, related to the LEDs in this particular mode, are *Off*, the timer tRestart is triggered. This timer is common for all LEDs and when it elapses, the disturbance window ends.

The second timer, tMax, starts whenever a LED is lit. If there are no activities until tMax elapses, tRestart is triggered. This means that the disturbance window eventually ends even if a signal remains *On* for a long time. See Figure 53.

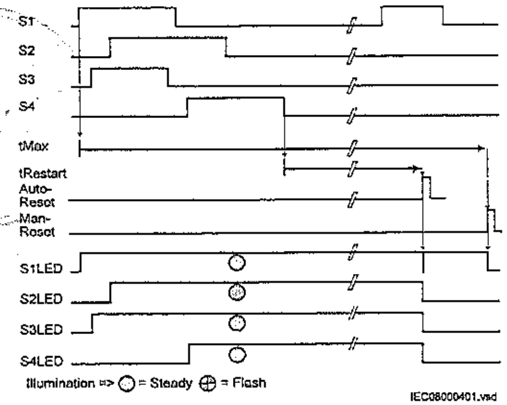

Figure 54: LHMI LED operation mode LatchedReset-S / 2

6.2 Single-line diagram engineering

Phase angles are shown in radians in the single line diagram view, but in degrees in other views on the LHMI.

6.2.1 Concept description to present and generate diagrams in graphical display editor

Additional concept information to use GDE, see Figure 55:

- Different GDE windows
- HMI display raster layouts
- Drawing lines (doing a Link)

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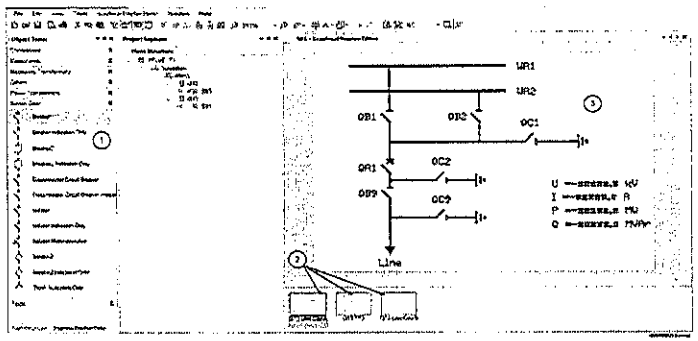

Figure 55: GDE: Screen image with active GDE

1	Object type library window
2	HMI display window pages
3	IED HMI display window

Procedure

1. Start GDE to open a presentation of the tool.
2. GDE has a object type library window on the left side of the display.
3. The presentation is empty when no page exists for the IED.

Display window and sequence order

It is important to link correctly between the HMI display page and the corresponding bay that is presented as a single line diagram on this HMI page.

Rules to handle HMI pages:

- Several single line diagrams can be created for one bay.
- The IED supports one bay.
- The sequence order of the HMI pages in the Graphical Display Editor starts from left to right.
- Measurements and the single line diagram can be shown on the page in any possible order and placement.
- All symbol objects, for example apparatus, text and measurement, on the HMI page must be linked to the correct function block in the application configuration in order to present the correct process values.

Object types

The Graphical Display Editor window contains some panes that include drawing symbols or elements to create a single line diagram, measurements and texts on a page. Click on the name bar of the selected element to open the pane.

The object types shows the symbols either in ANSI standard or in IEC standard. The standard is selected by the drop down list box located on top of the display window.

When changing to the other symbol standard, GDE closes the object type window, changes the symbols according to the selected new standard and redraws the single line diagram in the display window.

Select the different panes and their symbols to become familiar with the available symbols.

Measurements (Measurands) are presented in one format that explains itself when selected. Select the format and drop it in the drawing area. Use the object properties to make adaptations.

Special symbols for dynamic text

In the text pane the object types contains a set of special symbols to present text that depends on the status of variables. A set of three symbols is either valid for a double bit information or for a list of up to 32 different inputs. The corresponding function blocks in ACT are of type xxxGAPC.

- *Dynamic Text* or *Indication* button is used when a position shall be monitored on single line diagram, Figure 56
- *Select Button* is used when the functions shall be manoeuvred from a single line diagram.

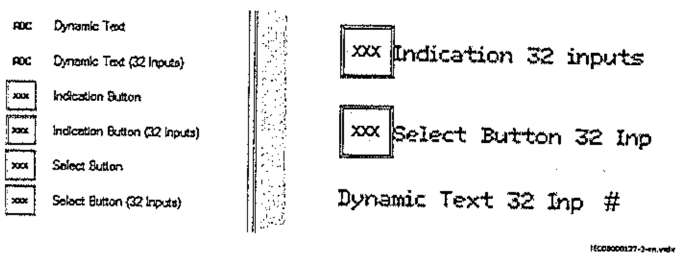

Figure 56: GDE: Dynamic Text symbols

The standard (IEC or ANSI) for the symbols and the selection of the font size for the text elements can be changed using the icons and drop down on top of the page window.

HMI display raster layout and text font selection

The raster in the page changes from symbol presentation to text presentation when a text object is selected and vice versa.

The text can be presented in two different font sizes:

- UniCode characters (6 x 12 pixels)
- UniCode characters (13 x 14 pixels)

The total size of the presented white area (page) represents the visible part of the local HMI display without header and foot-line.

The visible display for a single line diagram is organized in a raster of 13 x 8 (columns x rows). Each symbol presented by 24 x 24 pixels included by the drag and drop method must be dropped in a raster box. The apparatus object name can be placed in all four directions around the symbol. The name is part of the apparatus object.

Handling text

The raster switches when text is selected in a raster of 45 x 15 (columns x rows). One raster box is the placeholder for one character. A text element must be placed in the position of the raster. The signal name can changed either by double click or via the property window. Unit and scaling of the signal can only be changed via the property window.

Select and toggle *Show Texts using the IED Fonts* to get a view how it will look like later on the real HMI display.

Doing Link to draw lines

The line width has to fit to the line width used for the symbols. The standard size is 2. Choose the line width in a selection box placed in the upper area above the page. A line that is not connected to a symbol may be done in any line width in the range 1 - 5. But it needs to be simple connection points to be drawn.

For the procedure to draw lines when the apparatus symbols are placed, see Figure 57.

1. Place the apparatus or transformer symbols by drag and drop in a raster box.
2. Place the connections symbols by drag and drop in a raster box.
3. Center the mouse pointer on the center of a connection point; visible in two triangles if not connetions are made, otherwise two circles at the endpoints of a line, to draw a line.
4. Click to start and move the mouse pointer to the destination connection point. Center once again the mouse pointer and click to drop the line.
5. Draw all line elements that are necessary.

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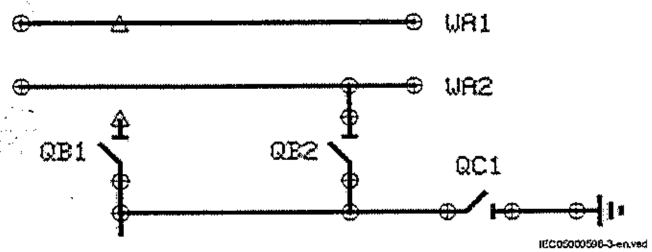

Figure 57: GDE: Drawing a line

6.2.2 Supported single-line diagram symbols

Table 2: Supported symbols

Category	IEC Symbol Name	IEC Symbol Definitions	ANSI Y32.2/ IEEE 315 Symbol Definitions	Function Block Type
Connections	Junction	·	·	
Connections	Busbar junction	—	—	
Connections	Feeder end	↓	↓	
Connections	Earth			
Connections	Star point			
Measuring transformers	Current transformer			
Measuring transformers	Voltage transf. 2 windings			

Table continues on next page

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Category	IEC Symbol Name	IEC Symbol Definitions	ANSI Y32.2/ IEEE 315 Symbol Definitions	Function Block Type
Measurands	Measurand	θ12	θ12	CMMXU SMBRREC TRPTTR VMMXU CMSQI VMSQI VNMMXU TCMYLTC PCFCNT SSCBR SSIML SSIMG HZPDIF GENPDIF T2WPDIF T3WPDIF MVGAPC SESRSYN LCPTTR LFPTTR LMBRFLO OEXPVPH L4UFCNT SXSWI CVMMXN TEIGAPC SXCBR ETPMMTR CBPGAPC GRPTTR GSPTTR VDCPTOV LT6CPDIF L6CPDIF LT3CPDIF L3CPDIF TCLYLTC BZNSPDIF BZNTPDIF
Others	Capacitor			
Others	Surge arrestor			
Others	Reactor			
Others	Motor	M	MOT	
Others	Generator	G	GEN	
Others	Coil			
Others	Fuse			

Table continues on next page

Category	IEC Symbol Name	IEC Symbol Definitions	ANSI Y32.2/ IEEE 315 Symbol Definitions	Function Block Type
Others	Resistor			
Others	Fieldwinding			
Others	Rectifier			
Others	Earthing transformer			
Power transformers	Transformer 2 windings			
Power transformers	Transformer 3 windings			
Power transformers	Autotransformer			
Switchgear	Isolator, 00 = middle position			SCSWI, VSGAPC
	Isolator, 01 = Open			
	Isolator, 10 = Closed			
	Isolator, 11 = Undefined			
Switchgear	Isolator indication only, 00 = Middle position			SCSWI, SXSWI, DPGAPC, VSGAPC
	Isolator indication only, 01 = Open			
	Isolator indication only, 10 = Closed			
	Isolator indication only, 11 = Undefined			
Switchgear	Isolator motor-operated, 00 = Middle position			SCSWI, VSGAPC
	Isolator motor-operated, 01 = Open			
	Isolator motor-operated, 10 = Closed			
	Isolator motor-operated, 11 = Undefined			

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Category	IEC Symbol Name	IEC Symbol Definitions	ANSI Y32.2/ IEEE 315 Symbol Definitions	Function Block Type
Switchgear	Breaker, 00 = Middle position			SCSWI, VSGAPC
	Breaker, 01 = Open			
	Breaker, 10 = Closed			
	Breaker, 11 = Undefined			
Switchgear	Breaker Indication only, 00 = Middle position			SCSWI, SXCBR, DPGAPC, VSGAPC
	Breaker indication only, 01 = Open			
	Breaker Indication only, 10 = Closed			
	Breaker Indication only, 11 = Undefined			
Switchgear	Truck breaker, 00 = Middle position			SXSWI, SXCBR
	Truck breaker, 01 = Open			
	Truck breaker, 10 = Closed			
	Truck breaker, 11 = Undefined			
Switchgear	Isolator2, 00 = Middle position			SCSWI, VSGAPC
	Isolator2, 01 = Open			
	Isolator2, 10 = Closed			
	Isolator2, 11 = Undefined			

Table continues on next page

Category	IEC Symbol Name	IEC Symbol Definitions	ANSI Y32.2/ IEEE 315 Symbol Definitions	Function Block Type
Switchgear	Isolator2 indication only, 00 = Middle position			SCSWI, SXSWI, DPGAPC, VSGAPC
	Isolator2 indication only, 01 = Open			
	Isolator2 indication only, 10 = Closed			
	Isolator2 indication only, 11 = Undefined			
Switchgear	Breaker2, 00 = Middle position			SCSWI, VSGAPC
	Breaker2, 01 = Open			
	Breaker2, 10 = Closed			
	Breaker2, 11 = Undefined			
Switchgear	Breaker2 indication only, 00 = Middle position			SCSWI, SXCBR, DPGAPC, VSGAPC
	Breaker2 indication only, 01 = Open			
	Breaker2 indication only, 10 = Closed			
	Breaker2 indication only, 11 = Undefined			
Switchgear	Disconnector circuit breaker, 00 = Middle position			SCSWI, VSGAPC
	Disconnector circuit breaker, 01 = Open			
	Disconnector circuit breaker, 10 = Closed			
	Disconnector circuit breaker, 11 = Undefined			

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Category	IEC Symbol Name	IEC Symbol Definitions	ANSI Y32.2/ IEEE 315 Symbol Definitions	Function Block Type
Switchgear	Disconnector circuit breaker indication only, 00 = Middle position			SCSWI, SXCBR, VSGAPC
	Disconnector circuit breaker indication only, 01 = Open			
	Disconnector circuit breaker indication only, 10 = Closed			
	Disconnector circuit breaker indication only, 11 = Undefined			
Texts	Static text	ABC	ABC	
Texts	Dynamic text	ABC	ABC	VSGAPC
Texts	Select button, 00 = Middle position	XXX	XXX	VSGAPC
	Select button, 01 = Open	XXX	XXX	
	Select button, 10 = Closed	XXX	XXX	
	Select button, 11 = Undefined	XXX	XXX	
Texts	Indication button, 00 = Middle position	XXX	XXX	VSGAPC
	Indication button, 01 = Open	XXX	XXX	
	Indication button, 10 = Closed	XXX	XXX	
	Indication button, 11 = Undefined	XXX	XXX	
Texts	Dynamic text (32 inputs)	012	012	SLGAPC
Texts	Select button (32 positions), 1 - 32	XXX	XXX	SLGAPC
Texts	Indication button (32 positions), 1 - 32	XXX	XXX	SLGAPC

6.2.3 Bay configuration engineering

A page with a single line diagram and measurements contains active living objects. The object values are updated by the IED periodically (measurement) or in case of an event. Once the symbols are placed on the HMI page they must be linked to the corresponding function block in the application configuration, which protects or controls the object that the symbol on the HMI page represents.

Creating a complete HMI display page

Procedure:

1. Make a sketch how to present the single line diagram.
2. Place the apparatus, transformer and other symbols that are needed for the single line diagram into the raster boxes.
3. Add connection points where needed.
4. Link the apparatus symbols with line elements.
5. Adjust the text symbols while writing to north, east, south or west. Use the object property window to do it.
6. Place measurements when needed.
7. Edit the name, unit and number of decimals of the measurements.
8. Select each object that has a dynamic link and do the link to the corresponding process object, see Figure 58.
9. Check to select the correct function block. Function blocks of the same type can have different instance numbers.
10. Validate that all links are done. Unlinked objects are greyed out.
11. Save the complete picture.
12. Repeat the steps for all pages when more than one is needed.
13. Write the display configuration to IED from the GDE tool.

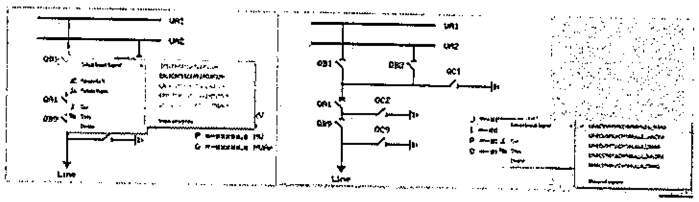

Figure 58: GDE: Establish a dynamic object link

Linking process objects

To describe a process object within an IED it needs to be established in the application configuration, configured when given with its parameters by PST and linked to be displayed in the HMI.

Three tools are involved for the described steps:

- ACT to program the application function block for apparatus and/or measurements.
- PST to adapt the settings and/or configuration parameter of the application function block.
- GDE to establish the link for updating the selected data attribute in the HMI of the application function block.

The following application function blocks are used to deliver the needed information:

- Switch controller (of type CSWI) for an apparatus.
- All configured function blocks with measurements (of type MMXU) for the measurements.
- VSGAPC for two bit indications for the dynamic text symbols.
- SLGAPC for 32 bit indications for the dynamic text symbols.

Procedure

1. Right-click the apparatus symbol and select *Select Input Signal*. A list of engineered switch control application function blocks opens, see Figure 59.
2. Select the switch control application function block that corresponds to the selected apparatus.
3. Right-click the measurement symbol and select *Select Input Signal*. A list of the engineered measurement application function blocks opens.
4. Select the measurement application function block that corresponds to the selected symbol.

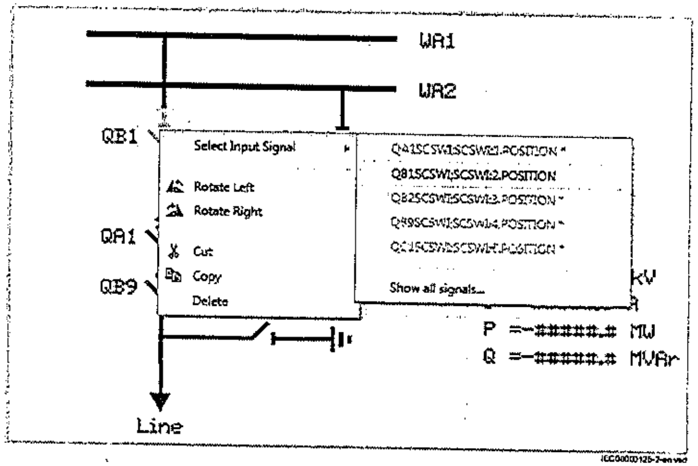

Figure 59: GDE: Input signal selection

The number of order in the selection window of the process objects corresponds to the number given in the PST tree and to the application function block in ACT.

Only those apparatus and measurements are shown that are configured in the application configuration program.

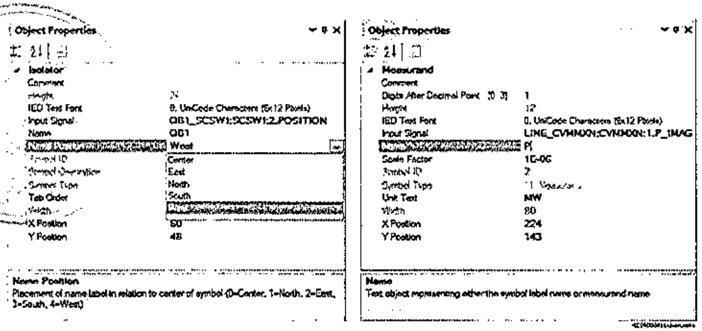

Figure 60: GDE: Object properties windows for text insertion

The single line diagram screen can display different values, with the help of the dynamic text fields. Please remember that these values are displayed by default in SI units (for example - active power is displayed in W). Modify the *Scale Factor* in the object properties (see Figure 61) to display values in more readable units (for example MW). Be sure to write the proper unit under the *Unit Text* field.

As the function delivers angles in radians, a scale factor of 180/pi = 57.3 shall be used to display the angle in degrees

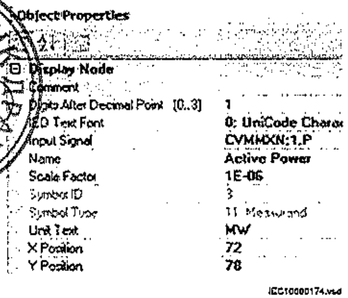

Figure 61: GDE: Object properties window for unit change

6.3 Events and indications

To get IED events to the LHMI event list and indications for *Ready*, *Start* and *Trip* indication LEDs, disturbance report needs to be engineered.

Detailed information about disturbance report subfunctions is found in the technical manual.

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Section 7 IEC 61850 communication engineering

7.1 IEC 61850 interface in the IED and tools

For more information on the implementation of IEC 61850 standards in IEDs, see the IEC 61850 communication protocol manual.

7.1.1 Function view for IEC 61850 in PCM600

The IED function blocks have a design based on the demands and advantages of the IEC 61850 standard. This means that there is a strict relation between the function blocks and the logical node types. This relation is automatically handled by the PCM600 tools.

The concept in IED is such that the 61850 data for each function instantiated in ACT will be automatically created. This means that the user do not need to handle any instance information for the functions regarding IEC 61850.

7.1.2 IEC 61850 interface in IED

See Figure 62 for a principle view of the IEC 61850 logical node concept in the IED.

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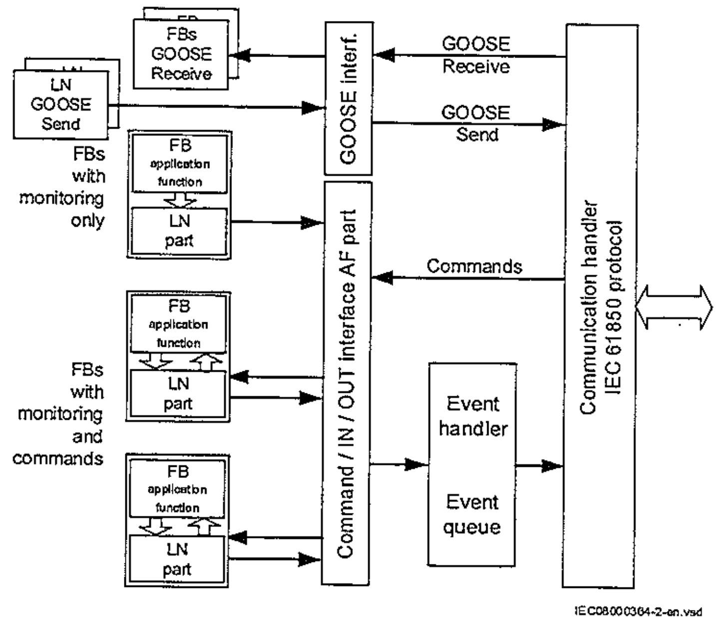

Figure 62: IEC 61850: Communication interface principle

IEC 61850 has as a concept for the identification of all signals for communication that belong to a function by a logical node as a placeholder. All signal information in command and monitoring direction, which belongs to a function, is available within the logical node.

Whenever a function block is instantiated in ACT, PCM600 automatically generates the corresponding logical node data. In Figure 62 this is shown by two parts per function block. The upper part is the visible function block in ACT and the lower part is the logical node data for the function block.

7.1.2.1 GOOSE data exchange

The IEC 61850 protocol supports a method to directly exchange data between two or more IEDs. This method is described in the IEC 61850–7–2 clause 15. The concept is based on sending a multicast over the Ethernet. Whoever needs the information detects the telegram by its source address and will read the telegram and deals with it. The telegrams are multicast sent and not acknowledged by the receiver.

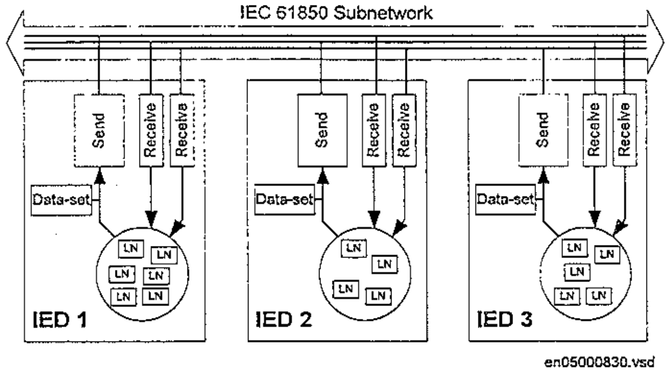

Figure 63: IEC 61850: Horizontal communication principle

Figure 63 shows an example with three IEDs where each one communicates with all the others.

When a GOOSE message is to be sent is defined by configuring the data set with the defined trigger option and the GOOSE control block (GoCB). This engineering process is done in the IET600 station configuration tool. The task involves configuring lists with the signal, value and quality (data attributes) that belong to the GOOSE message dataset.

In the opposite direction the standard only defines the IED as a receiver of the GOOSE message. How the GOOSE input signals are handled must be defined in the IED application configuration. The SCD file generated by the IET600 (or any other station configuration tool) contains these GOOSE data sets as input data. The input data must be connected to a GOOSE receive function block (GOOSEBINRCV and GOOSEINTLKRCV) in SMT.

7.1.3 Station configuration description file types

The IEC 61850 standard defines SCL-file types in the sequence of engineering. These files have a different definition, which is explained in IEC 61850–6. Three of these file types are used in the engineering process for an IED.

- ICD = IED Capability Description

> The IED name in an exported .icd file is always named TEMPLATE.

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- Capability description of the IED in logical nodes and their data. No information about communication configuration, for example, is included.
- An IED is already extended by default data sets. They are predefined by ABB. Changes or additional data sets, for example, have to be done with the IET600 station configuration tool.

- SCD = Station Configuration Description
  - Complete configuration description of all IEDs in a station and the full engineering of process signals and communication structure is included. This includes all needed data sets and all control blocks.
- CID = Configured IED Description
  - The CID file contains the information needed to configure just one specific IED.

> The uploading of IEC 61850 communication configuration is not supported when reading a configuration from an online IED.

7.2 IEC 61850 engineering procedure

7.2.1 IEC 61850 protocol references and pre-conditions

To engineer the IEC 61850 protocol interface for the IED, the following additional manuals or knowledge of their contents is required.

- Knowledge of the IEC 61850 engineering process as described in the IEC 61850 standard.
- The IEC 61850 conformance documents for the IED to be engineered.
- The Technical reference manual describes function blocks defined as logical nodes.
- IEC 61850 Data objects list for the IED.

7.2.2 Sequence for engineering of IEC 61850 protocol

The IEC 61850 standard defines the complete part needed for information communication in a substation. This can be split into the following parts:

- Description of the substation part including the used logical nodes
- Description of the IEDs with their logical nodes
- Description of the communication network
- Description of the engineering process

For more details please refer to the IEC 61850 standards. In the following description it is assumed that PCM600 together with IET600 is used as system configuration tool.

A short form of a typical sequence is shown in Figure 64 when a complete station is exported as a SCD file.

1. Export SCL files from PCM600. In the scenario in Figure 64 it is a SCD file. Other SCL file types are possible to export.
2. Configure horizontal and vertical communication in the IET600 station configuration tool.
3. Import SCL files to PCM600 project. In the scenario in Figure 64 it is the updated SCD file.

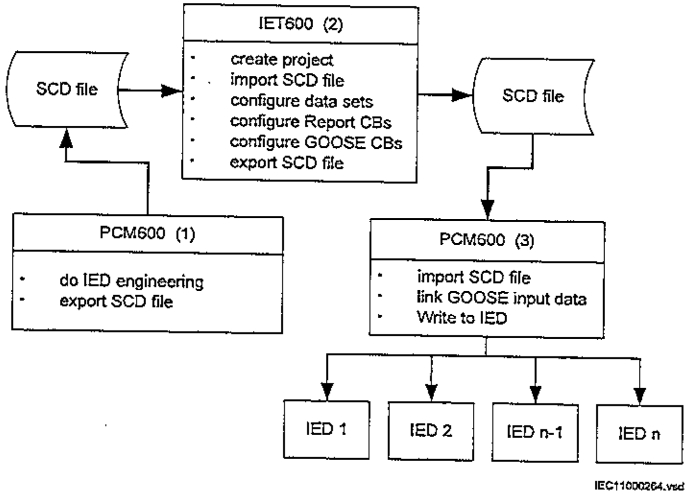

Figure 64: IEC 61850: Signal engineering procedure flow

7.3 Exporting SCL files from PCM600

The pre-condition for exporting SCL files from PCM600 is that IEDs included in the project are configured. The hardware interface, for example the IP address, must be selected and configured. Station communication has to be activated in the IED, that is, the IEC61850-8-1 setting *Operation* must be set to *On*.

7.3.1 Exporting SCD files

Procedure for exporting SCD files from PCM600:

1. Select the sub-station in the plant structure (see Figure 65).

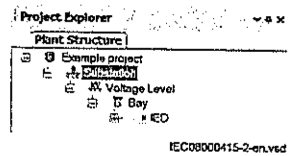

Figure 65: IEC 61850: Export SCD step 1

2. Right-click on the sub-station, and select *Export* ....
3. Select a location to store the SCD file with a chosen name.
4. The *SCL Export Options* window opens (see Figure 66).

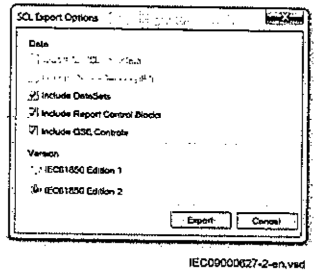

Figure 66: IEC 61850: SCL Export Options

5. Click *Export* to export the SCD file to your chosen location.

7.3.2 Exporting ICD or CID files

Procedure for selecting the export type when an IED is selected in the plant structure:

1. Right-click on the IED in the plant structure and select *Export* to open the *Export* window.
2. Select the type of file to export from the *Save as type* drop down list (see Figure 67):
   - Configured IED Description (*.cid) for the IEC 61850 structure as needed for the IED at runtime.
   - IED Capability Description (*.icd) for the IEC 61850 structure.

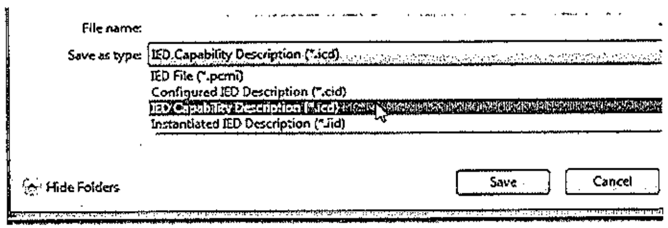

Figure 67: IEC 61850: Export IED file type selection

3. The *SCL Export Options* window opens (see Figure 68).
4. Select *Export Private Sections*, *Export As SCL Template* or *Include Goose Sending IEDs*, and click *Export*. Options in the *SCL Export Options* window are only available when an ICD file is exported.

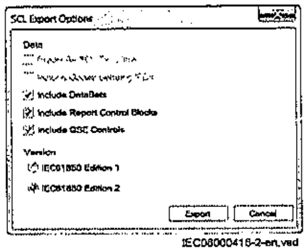

Figure 68: IEC 61850: Export IED file Options

7.4 Engineering of vertical and horizontal communication in IET600

For IEC 61850 engineering, a separate system configuration tool may be needed with PCM600 (for example, when using other than ABB IEDs).

Procedure for vertical engineering using IET600:

1. Create a project in IET600.
2. Import the SCD file exported from PCM600.

   All data sets, report control blocks and GOOSE control blocks must be located at LD0/LLN0. There are limitations regarding

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the maximum number of data sets, number of entries in a data set and the number of report control blocks that can be used.

3. Add and/or reconfigure data sets. The configured IED includes a number of predefined data sets, but it is possible to add additional data sets and/or reconfigure default data sets according to the requirements.

   Reporting data sets only contain data intended to be used by vertical clients, for example MicroSCADA or RTU560.

4. Configure report control blocks for each data set used in vertical communication. Pre-configured IEDs include predefined report control blocks which can be reconfigured. If additional control blocks are needed, it is possible to add them according to requirements.

   Up to 8 vertical clients can be configured.

5. Connect the report control blocks to vertical clients.

   The vertical client must belong to the same sub-network as the IEDs.

6. Export the SCD file.

Please see the IET600 user manual for additional information about vertical and horizontal station communication engineering.

Procedure for horizontal engineering using IET600:

1. Create a project in IET600.
2. Import the SCD file exported from PCM600.

   All data sets, report control blocks and GOOSE control blocks must be located at LD0/LLN0. There are limitations regarding the maximum number of data sets, number of entries in a data set and the number of report control blocks that can be used.

3. Create a GOOSE data set for the sending IED. Define the content of the data set according to the requirements.

   The data set for GOOSE contains signals on the data attribute or FCDA levels. The latter is also known as structured GOOSE.

Data for one signal can only be included in one GOOSE data set. The data set for GOOSE cannot be empty.

4. Create a GOOSE control block and connect it to the GOOSE data set. Check parameters for GOOSE control block, for eaxample *MinTime* and *MaxTime*, and update as required.
5. Connect the GOOSE control block to receiving IEDs that subscribe GOOSE data.
6. Export the SCD file.

7.5 Importing SCL files to PCM600

PCM600 is able to import SCD, ICD and CID files.

7.5.1 Importing SCD files

Procedure to import an SCD file to PCM600:

1. Select the sub-station in the plant structure.
2. Right-click on the sub-station and select *Import* ...
3. Select the file and start the import.
4. An *SCL Import Options* window opens to enable you to configure import handling (see Figure 69):

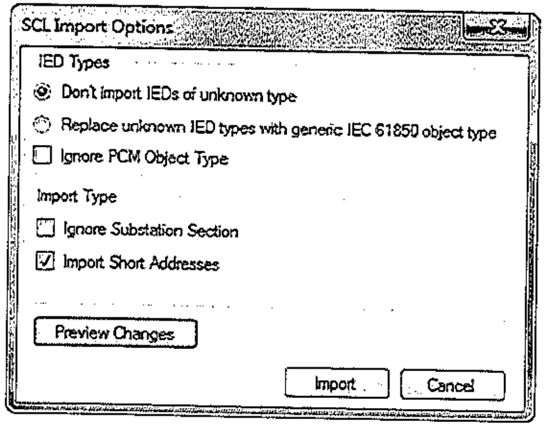

Figure 69: IEC 61850: Import SCD file

   4.1. Select *Ignore Substation Section* to ignore the sub-station section in the SCD file during import.
   4.2. Select *Don't import IEDs* ... to disable the import of unknown IED types (for example third-party IEDs).
   4.3. Select *Replace unknown* ... to replace unknown IED types with IED type "Generic IEC 61850 IED". Use this option if you need to import third-party IEDs into PCM600.
   4.4. Select *Ignore PCM Object Type* if the IED type is modified outside PCM600.
   4.5. Click *Import*.
5. Configure how to receive data from sending IEDs:
   5.1. In SMT, configure connections between signals the server is sending and the GOOSE receive function blocks.

If a client is defined for GOOSE receive, at least one cross in SMT is required to write the configuration to the IED.

It is important to set *Operation* to *On* for all configured GOOSE receiving function blocks.

7.5.2 Importing ICD or CID files

Procedure to import an ICD or CID file:

1. Select an IED in the plant structure.
2. Right-click on the IED and select *Import* ...
3. Select the file to be imported.
4. An *SCL Import Options* window opens to enable you to configure import handling (see Figure 70):
   4.1. Select *Ignore Substation Section* to ignore the sub-station section in the chosen file during import.
   4.2. Select *Don't import IEDs* ... to disable the import of unknown IED types (for example third-party IEDs).
   4.3. Select *Replace unknown* ... to replace unknown IED types with IED type "Generic IEC 61850 IED". Use this option if you need to import third-party IEDs into PCM600.
   4.4. Select *Ignore PCM Object Type* if the IED type is modified outside PCM600.
   4.5. Click *Import*.

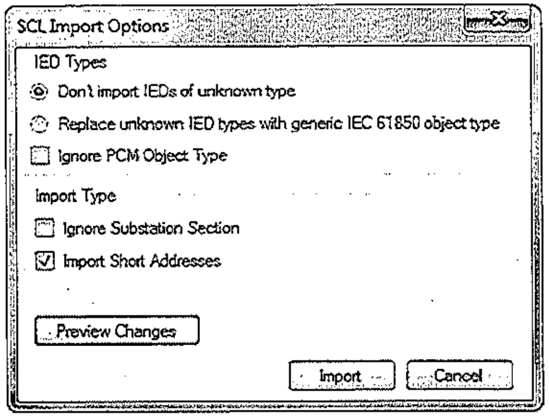

Figure 70: IEC 61850: SCL Import option

7.6 Writing IEC 61850 communication configuration to an IED

When a changed IEC 61850 communication configuration is written to an IED, the user is asked to update the communication configuration:

1. Click **Yes** in the **Update Communication** window to update the communication configuration in the IED.
2. Click **No** in the **Update Communication** window to keep the existing communication configuration in the IED.

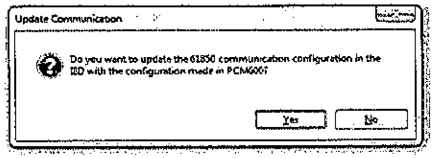

Figure 71: Update communication configuration window in PCM600

Section 8 IEC 60870-5-103 communication engineering

8.1 Engineering in PCM600

The Application Configuration tool (ACT) and the Parameter Setting tool (PST) in PCM600 are used to configure the communication for IEC 60870-5-103 protocol.

1. Add the desired IEC 60870-5-103 function blocks to the application configuration in the Application Configuration tool.
2. Connect the outputs of desired protection and monitoring function in the application configuration to the inputs of the corresponding IEC 60870-5-103 function block.
3. Set the function type and desired information number, where an information number must be supplied, for each IEC 60870-5-103 function block instance in the Parameter Setting tool.
4. Set the general communication settings for IEC 60870-5-103 and time synchronization parameters in the Parameter Setting tool.

See the Communication protocol manual for IEC 60870-5-103 for more information about the IEC 60870-5-103 implementation in the IED series.

8.1.1 Settings for RS485 and optical serial communication

General settings

SPA, DNP and IEC 60870-5-103 can be configured to operate on the SLM optical serial port while DNP and IEC 60870-5-103 only can utilize the RS485 port. A single protocol can be active on a given physical port at any time.

Two different areas in the HMI are used to configure the IEC 60870-5-103 protocol.

1. The port specific IEC 60870-5-103 protocol parameters are configured under: **Main menu/Configuration/Communication/Station Communication/ IEC6870-5-103/**
   - <config-selector>
   - SlaveAddress
   - BaudRate
   - RevPolarity (optical channel only)
   - CycMeasRepTime
   - MasterTimeDomain
   - TimeSyncMode
   - EvalTimeAccuracy
   - EventRepMode
   - CmdMode
   - RepIntermediatePos

   <config-selector> is:

   - "OPTICAL103:1" for the optical serial channel on the SLM
   - "RS485103:1" for the RS485 port
2. The protocol to activate on a physical port is selected under: **Main menu/Configuration/Communication/Station Communication/Port configuration/**
   - RS485 port
     - RS485PROT:1 (off, DNP, IEC103)
   - SLM optical serial port
     - PROTOCOL:1 (off, DNP, IEC103, SPA)

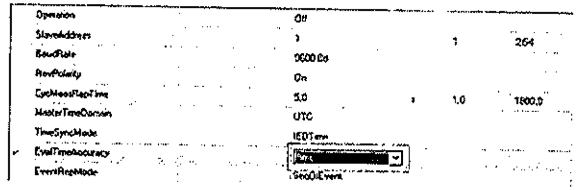

Figure 72: Settings for IEC 60870-5-103 communication

The general settings for IEC 60870-5-103 communication are the following:

- *SlaveAddress* and *BaudRate*: Settings for slave number and communication speed (baud rate).
  The slave number can be set to any value between 1 and 254. The communication speed, can be set either to 9600 bits/s or 19200 bits/s.
- *RevPolarity*: Setting for inverting the light (or not). Standard IEC 60870-5-103 setting is *On*.
- *CycMeasRepTime*: See I103MEAS function block for more information.
- *EventRepMode*: Defines the mode for how events are reported. The event buffer size is 1000 events.

Event reporting mode

If *EventRepMode* = *SeqOfEvent*, all GI and spontaneous events will be delivered in the order they were generated by BSW. The most recent value is the latest value delivered. All GI data from a single block will come from the same cycle.

If *EventRepMode* = *HiPriSpont*, spontaneous events will be delivered prior to GI event. To prevent old GI data from being delivered after a new spontaneous event, the pending GI event is modified to contain the same value as the spontaneous event. As a result, the GI dataset is not time-correlated.

Section 9 DNP3 communication engineering

9.1 Signal configuration user information

Basic knowledge about DNP3 and the used definitions are required to use CMT. See the DNP3 communication protocol manual for information on the DNP3 implementation in the IED.

CMT is a part of PCM600 and allows to configure the signals that are used to communicate with clients or master units for DNP3 protocols.

On the left window CMT organizes all available signals from the application configuration in containers that are preselected as signal types.

On the right window CMT provides containers that are selected by tabs. Each container represents one communication channel. The number of possible communication channels is IED type dependent. The IED uses TCP/IP as communication channel. DNP3 can be tunneled over TCP/IP. Serial communication over RS485 or optical is supported. .

Use direction icons that are located between the windows to move all signals or a set of individual signals between the windows.

DNP3 signal types, index and default setting for classes are predefined in CMT. Adapt the signal configuration to project definitions. The signal type can not be modified due to the fact that the internal signal set up is fixed.

When the default configuration values are sufficient, the task is finished when all signal are moved according to the project requirements.

With the *Save* option, the signals are stored for the communication part of the IED according to the default selections.

Only for analog measurements additional configuration parameters are shown to do signal scaling to DNP3 protocol presentation. This can be done when the *Configuration Table View* is selected.

Finally, the signal configuration to the different DNP3 channels can be listed in a report on demand and per signal type.

9.2 Adding setting groups

In order to show for a DNP master which setting group is used, the procedure outlines here can be performed.

In this example, only setting groups one and two are used. The DNP master will get two binary inputs: the first is set if setting group one is used, the second is set if setting group two is used.

1. Configure ACTVGRP (Basic IED functions) and SP16GAPC (Monitoring) with the Application Configuration Tool (ACT).

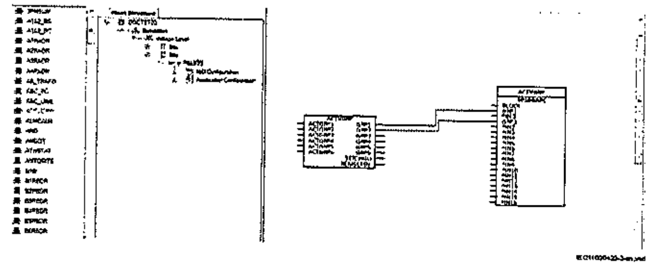

Figure 73: Application configuration tool

To make it easier to recognize the signals for the active setting group, user-defined names are used.

2. Open the Communication Management Tool (CMT). Set the *Signal Type* to *Binary Input Object*, and choose the connection of the master for which the values should be presented.

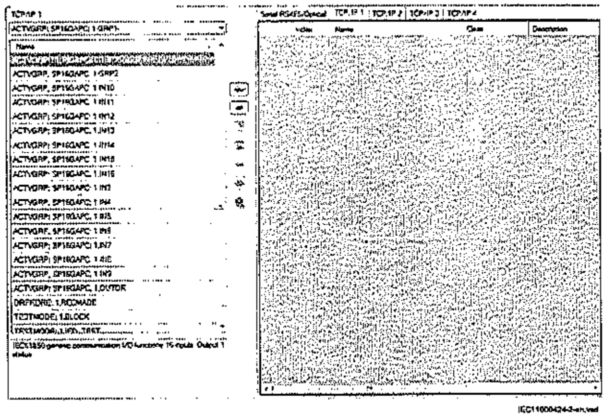

Figure 74: Communication Management tool

3. Select the signals and move them into the DNP signal list of the master. DNP point zero and one of the Binary Input Objects are used for indicating the active setting group in this case.

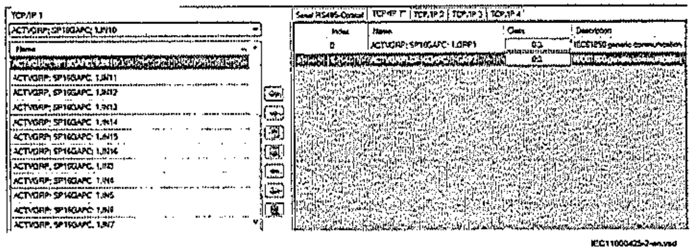

Figure 75: Selecting the signals into the DNP signal list

9.3 Configuring DNP3 protocol signals

1. Save the actual project configuration in PCM600 to make all signals visible for CMT.

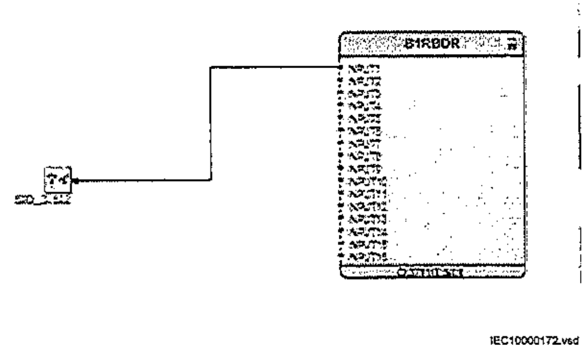

Figure 76: Configuring hardware channels directly to the function blocks

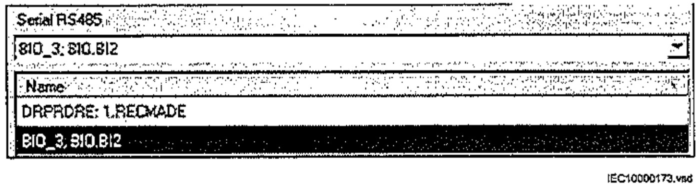

Figure 77: CMT: Hardware channels appearing in the Communication Management Tool

2. Right-click the IED in the plant structure and select *Communication Management* to start the Communication management tool.
3. Select the DNP3 protocol from the new window and click *OK*. Figure 78 presents the design of the two container windows, which open after the selection of DNP3.
   - The right window shows tabs for possible communication channels.
   - The left window has a drop down menu for signal selection and buttons for signal movement, see Figure 78.

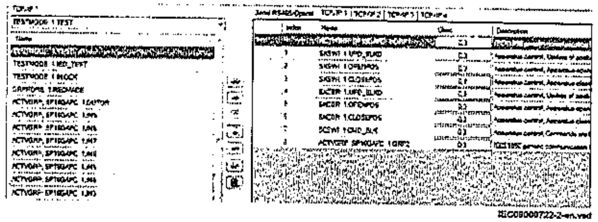

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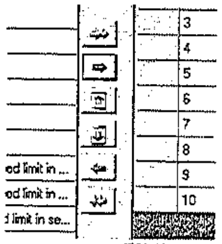
Figure 78: CMT: Container window design when selecting DNP3 protocol

Procedure to move signals:

1. Select one or several signals.
   - Click in the list of signals to select one signal.
   - Press *Shift* or *Ctrl* and several signals to select a set of signals.
   - Right-click in the list of signals, select *Select All* from the context menu or press *Ctrl+A* to select all signals.
2. Press the blue arrow button to insert the selected signals into the configuration.
3. Press the green double arrow button to insert all signals into the configuration, see Figure 79.



IEC08000361.vsd

Figure 79: CMT: Move buttons

4. Click the drop down list *Signal Type:* to select the other signal types for this channel.
5. Repeat to move signals for all signal types and save the selection.

Content changes in the DNP3 container are marked with a star at the end of the name, see Figure 80. The star indicates that changes in the container have to be saved before leaving CMT.

IEC08000339-2-en.vsd

Figure 80: CMT: Marker to indicate changes in the container

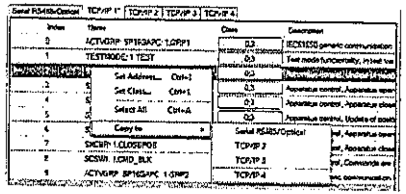
9.4 Setting DNP3 signal parameters

Two parameters per signal can be set for all signal types:

- The index of the signal
- The class configuration

Procedure to set the index of the signal:

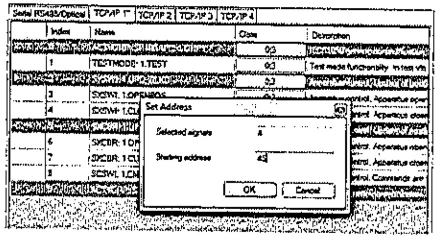
1. Click the two inner arrows to sort signals to another index sequence, or select *Set Index…* from the context menu to move one or a set of signals to another array, see Figure 81.



IEC08000336-2-en.vsd

Figure 81: CMT: Context menu in DNP3 window

2. The selection window shows the number of signals selected, see Figure 82.



IEC08000363-2-en.vsd

Figure 82: CMT: Set Index menu

3. Define the *Starting index* for this group and click *OK*.

Procedure to set class configuration:

1. Click in the class field of the signal to change the class configuration.
2. The *Select Class* window opens.
3. Make the selection according to the definitions in the project and click *OK* to close the window and get the new configuration, see Figure 83.

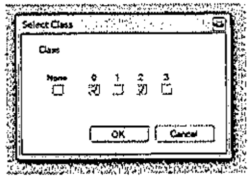


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Figure 83: CMT: Select Class window

9.4.1 Configuring DNP3 class

In DNP3 the user classifies the signals and defines those signals that are not member of any class. CMT has a default predefined organization of classes per signal type. In the master station the classes can be polled in sequences according to the demands in the project. Unsolicited reporting is possible as well.

Modify the organization of the classes for each signal individually.

Procedure

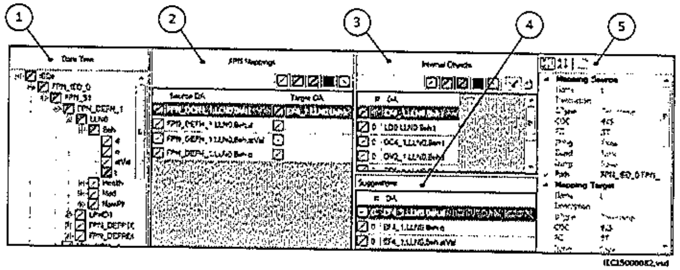
1. Click in the *Class* field of the signal. A new window *Select Class* opens where the user classifies the signal.
2. Select the signal classes and choose between *None* and *0* to *3* according to the project demands.
3. Click *OK* to set the signal classification.
4. Write to IED.

Section 10 Flexible product naming

10.1 Flexible product naming mapping tool

The FPN Mapping Tool is used to manage the IED and data attribute relations between the FPN and PCM internal SCL models.

10.1.1 User interface



1. Data Tree
2. FPN Mappings
3. Internal Objects
4. Object Properties
5. Suggestions

Status icons

- Completely mapped
- Not mapped
- Broken mapping
- Partially mapped
- Object is excluded from the mappings

10.1.1.1 Data Tree

The data tree displays the Flexible Product Naming (FPN) IEDs and their SCL data model down to data attribute level. The IEDs displayed in the data tree are filtered based on the current selection in the PCM plant structure.

10.1.1.2 FPN Mappings

The FPN mappings list displays the FPN objects based on the current selection in the data tree. The list may display either IEDs or data attributes. The FPN object's name is displayed in the column on the left and the name of the mapped PCM internal object is displayed in the column on the right.

10.1.1.3 Internal Objects

Internal objects list displays the PCM internal objects. The list may display either IEDs or data attributes. When displaying the data attributes, the list will also contain information on how many times the PCM internal data attribute is mapped with an FPN data attribute.

10.1.1.4 Suggestions

The Suggestions list displays the PCM internal data attributes that the FPN Mapping Tool suggests to be mapped with the FPN data attribute currently selected in the FPN Mappings list.

10.1.1.5 Object Properties

Object properties window displays properties of objects currently selected in the FPN Mappings and Internal Objects lists. The properties are mostly read-only and cannot be modified by user.

10.2 IED and Signal Naming Convention

The names used for the internal objects can be defined to be either the names used in PCM or the names defined in the internal IEC 61850 model.

10.3 Starting the FPN Mapping Tool

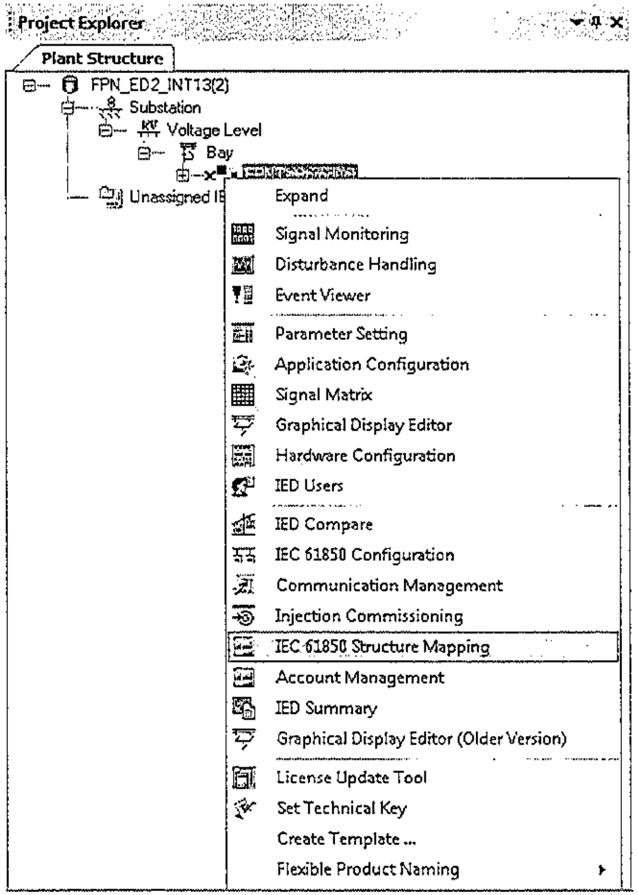
The tool can be started from any node from Substation to IED level.

1. Right click on one of the nodes.
2. Select Flexible Product Naming from the menu.

There are three options to choose from.

- IEC 61850 Structure starts the FPN Mapping tool.
- Exlude from Mapping exludes the IED from the mapping concept.
- Include in Mapping is used to include an IED that has previously been excluded from the mapping concept.

For more information on including and excluding IEDs refer to the chapter about Excluding IED from mapping.



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10.4 Filtering options

Displayed objects can be filtered using the filtering options on top of the object list.

Figure 84: Filter option bar

The filtering options are:

- free text filter
- show/hide objects by status
- matching objects filter

Free text filter

The objects are filtered by free text, showing all the objects with a certain name.

Show/hide objects by status

The objects are filtered by status, showing only unmapped objects etc.

Matching objects filter

The "matching objects" is a user-configurable filter used to find the best possible matches for a selected FPN object from all available PCM internal objects. The desired filter criteria can be selected to match the objects.

History based filter

The FPN Mapping Tool learns from the data attribute mappings that the user is doing manually to show suggestions of PCM internal data attributes based on the currently selected FPN data attribute.

10.5 Reporting and Printing

The report consist of a cross-reference list of the IED and data attribute mappings. I.e. a table of all FPN objects together with the PCM internal objects they are mapped with.

Table 3: Table 3. IED mappings.

FPN IED	PCM internal IED
AA1J2Q03A4 (FPN IED 1)	AA1J1Q01A1 (PCM IED 1)

001

FPN DA	PCM internal DA	Signal Name
LD_A.QB1CSWI.Pos.stVal	LD_A.QB1CSWI.OpOpn.gener al	SCSWI: 1.POSITION.stVal
LD_A.QB1CSWI.BlkCmd.stVal	LD0.SCSWI1.BlkCmd.stVal	SCSWI: 1.CMD_BLK.stVal
LD_A.QB1CSWI.OpOpn.gener al	LD0.SCSWI1.OpOpn.general	SCSWI: 1.EXE_OP.general

10.6 Undo and Redo

It is possible to undo and redo actions made in the FPN Mapping Tool. The undo/redo functionality will be limited to the FPN Mapping Tool only. I.e. when the changes made in the tool are saved, the undo and redo stacks are cleared and it will not be possible to get back to the state prior to the save.

10.7 IED mapping

The first step is the IED Mapping. IED mapping means that each server IED in the FPN model is mapped with a corresponding IED in the internal PCM model, that is, the real device in the substation. A server IED is an IED that has an access point containing a server. IED mapping does not yet map the data attributes between the IEDs unless the data attribute mapping is applied from a template. IED mapping can be done in the PCM600 plant structure and in the FPN Mapping Tool.

Customer SCDs can be imported into a configured PCM project and then mapped, or into an empty one where IED templates can be imported.

Refer to the PCM600 online help for more detailed information about mapping.

10.7.1 IED mapping in PCM600 Plant Structure

IED mapping

IED mapping is done in plant structure by dragging and dropping a PCM IED from the Unassigned IEDs group on an FPN IED in the Substation or vice versa. IED mapping status is indicated visually in the plant structure.

Removing the IED mapping

IED mapping is removed from the plant structure by dragging and dropping a mapped FPN IED on the Unassigned IEDs group. The removed mapping will be indicated visually in the plant structure. The PCM internal IED, with which the unmapped FPN IED was mapped, will appear back in the Unassigned IEDs group if it is not anymore mapped with any FPN IEDs.

10.7.2 IED mapping in the FPN Mapping Tool

IED mapping

The tool will display all FPN IEDs and all PCM IEDs in separate lists. Mapping will be done by dragging and dropping an FPN IED on a PCM IED or vice versa. The tool indicates the mapping status visually.

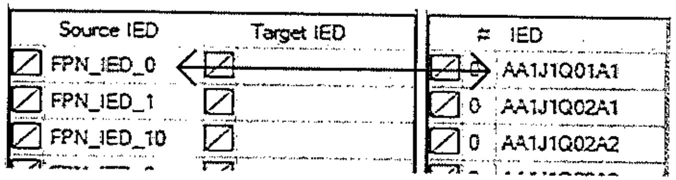

Figure 85: Mapping of IEDs in FPN Mapping Tool

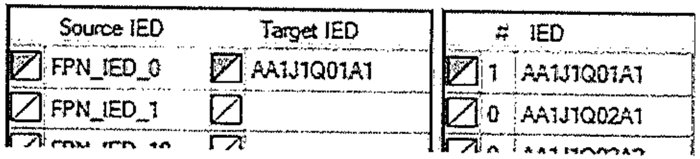

Figure 86: Visual indication of the mapping

The mapping will be applied when the save button of the FPN Mapping Tool is clicked.

Removing the IED mapping

Removing IED mapping is done in the FPN Mapping Tool by right-clicking the mapping and selecting the context menu option or pressing the Delete key. The tool indicates the mapping status visually.

The mapping removal will be applied when the save button of the FPN Mapping Tool is clicked.

10.7.3 Excluding IED from Mapping

FPN IEDs that cannot or does not need to be mapped can be excluded from the mapping concept. Excluded IEDs will be ignored when determining whether or not the mapping of all IEDs is complete. IEDs can be excluded in the FPN mapping tool by selecting the IEDs to exclude, right-clicking and selecting the exclude option from

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the context menu. IED can be excluded directly in the PCM600 plant structure by right-clicking the IED and selecting the excluded option from the context menu

FPN IEDs can be included back to the mapping concept in the FPN mapping tool by selecting the IEDs to include, right-clicking and selecting the include option from the context menu. FPN IED can be included back to the mapping concept directly in the PCM600 plant structure by right-clicking the IED and selecting the include option from the context menu

10.8 Data Attribute Mapping

Data attribute mapping means that each FPN data attribute in the FPN model is mapped with a corresponding data attribute in the internal PCM model, that is, the real device in the substation.

The mapping status is indicated visually. It can be seen what FPN data attribute is mapped to what PCM internal data attribute and how many FPN data attributes are mapped to a PCM internal data attribute.

Data attribute mapping is complete when all data attributes of the FPN IED, which are not excluded from the mappings, are mapped with a PCM internal data attribute. The data attribute mapping must be complete in order to be able to write to IED.

Data attribute mapping is broken if any of the data attributes - FPN or PCM internal - that are mapped, does not exist in the SCL database.

All data attributes in the FPN model must be mapped or excluded, otherwise write to IED fails.

10.8.1 Data Attribute Level Mapping

The FPN Mapping tool displays the FPN data attributes and PCM internal data attributes in separate lists. The mapping is done by dragging and dropping the FPN data attribute onto a PCM internal data attribute or vice versa.

The mapping is removed by right clicking and selecting remove from the context menu or by clicking the Delete key while the mapping is selected.

10.8.2 Data Object Level Mapping

The FPN mapping tool displays the FPN data objects and PCM internal data objects in separate lists and pre-maps the data objects based on several criteria to find the best match for example name, CDC, LN class, contained data attributes and their types, names etc.

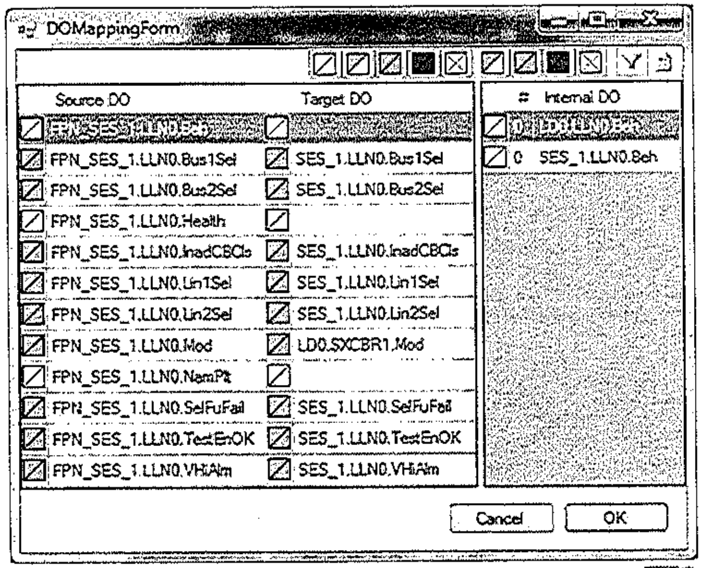

Figure 87: Pre-mapped data objects

If the tool was not able to pre-map all of the data objects or guessed some of the mappings wrong, user can fix and complete the mapping before accepting it.

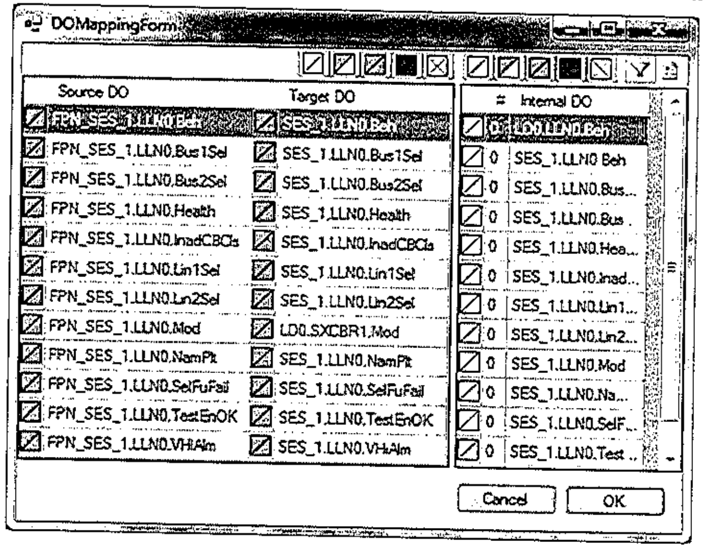

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Figure 88: Completed data object mapping

When OK is pressed, the tool maps the data attributes between the mapped FPN and PCM internal data objects based on criteria such as name, FC, etc. If the tool is not able to map all data attributes, the mapping needs to be completed manually.

10.8.3 Logical Node Level Mapping

The FPN mapping tool displays the FPN logical nodes and PCM internal logical nodes in separate lists and pre-maps the logical nodes based on criteria such as class, instance, contained data objects, data attributes and their types, names etc. to find the best match.

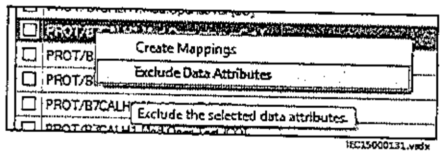
If all logical nodes were not mapped or mapped incorrectly the mapping can be completed manually before accepting it.

When OK is pressed the data attributes between the mapped FPN and PCM internal logical nodes are mapped based on criteria such as name, FC, etc. If there are data attributes left unmapped the mapping needs to be completed manually.

10.8.4 Excluding Data Attributes from Mapping

Data attributes can be excluded by selecting the data attributes to exclude, right-clicking and selecting the exclude option from the context menu. It is possible to

exclude all unmapped data attributes from the mapping at once by right-clicking and selecting the exclude all option.



IEC15000131.vsdx

Figure 89: Excluding data attributes from mapping

The data attributes that are excluded from the mapping will not be excluded from the model. Excluded mappings will be ignored when determining if an IED mapping is complete.

It is crucial to set a value to the excluded data attributes before initiating the mapping.

10.8.5 Setting the data attribute value

The data attribute value can be set by editing the Value field in the Object Properties window. For enum type of data attributes there is a list of available values to select. For numeric and string type data attributes the value can be entered directly in the Value field.

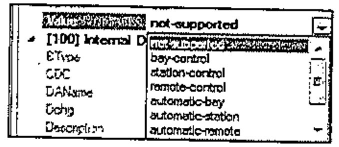


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Figure 90: Setting the data attribute value

Value cannot be set for all types of data attributes, for example, quality and timestamp values cannot be edited.

10.9 Mapping Templates

It is possible to create a template of an IED's data attribute mapping and store it for reuse. The template contains description of the data attribute mapping between two IED SCL models.

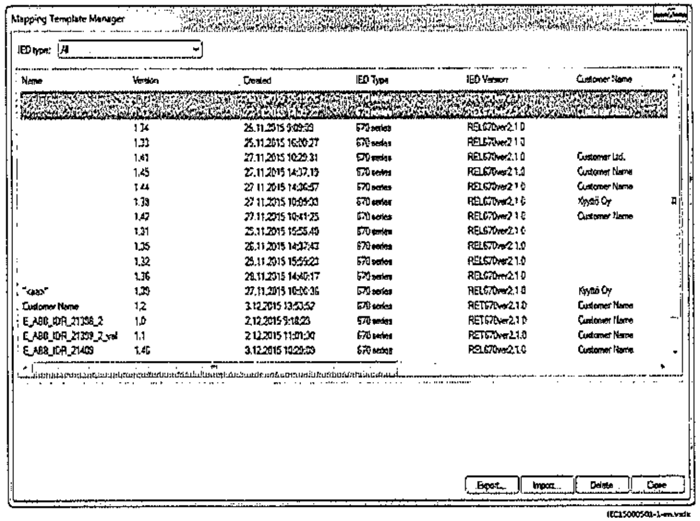
All mapping templates created in PCM600 are stored in a template library. The template library is not specific to certain PCM600 project but it is common for all projects. Templates in the library can be managed in the following ways.

- Delete selected templates
- Export templates
  - A single or multiple template files can be exported.
- Import templates
  - A single or multiple template files can be imported.
  - If a template being imported already exists in the library, user will be prompted whether to override the existing one.
- Export project's templates
  - When PCM project is exported, all templates used in the project will be automatically included in the exported PCMP file.
- Import project's templates
  - When PCM project is imported, all templates included in the imported PCMP file will be automatically imported into the template library.
  - If a template being imported already exists in the library it will be overridden.

The mapping templates are also used by IET600 to translate the internal data references in the signal library to the FPN references. Because IET600 needs to know what template to use to resolve the internal data references, the template information must be included in every FPN IED's SCL data as a private element.

10.9.1 Exporting FPN templates

1. Right click on the PCM600 plant structure.
2. Select Manage Mapping Templates under Flexible Product Naming in the menu.
3. Select the templates to export and click Export.



4. Select the folder where to export the templates and click OK.

10.9.2 Creating a Mapping Template

Data attribute mapping templates that are mapped with a PCM internal IED can be created from FPN IED. If the template is created from an incompletely mapped IED, an information dialog will be shown. User can select an option to not show the dialog again. The dialog can be resumed afterwards from the PCM Options menu.

The template can be created either from the FPN mapping tool or from the PCM600 plant structure. The required template information has to be filled in before it can be created.

When the template is created, the private element describing the template will be added to the FPN IED's SCL data model.

10.9.3 Applying Mapping Template on IED

The template can be selected from a list consisting of all available templates. The FPN IED must be mapped with a PCM internal IED before the template can be applied.

The template can be applied either in the FPN mapping tool or in the PCM600 plant structure. In the FPN mapping tool the template can be applied to one or several IEDs at once. In the plant structure the template can be applied on one IED at a time by right clicking on an IED or on all IEDs under a bay by right clicking on the bay .

Section 11 Glossary

11.1 Glossary

AC	Alternating current
ACC	Actual channel
ACT	Application configuration tool within PCM600
A/D converter	Analog-to-digital converter
ADBS	Amplitude deadband supervision
ADM	Analog digital conversion module, with time synchronization
AI	Analog input
ANSI	American National Standards Institute
AR	Autoreclosing
ASCT	Auxiliary summation current transformer
ASD	Adaptive signal detection
ASDU	Application service data unit
AWG	American Wire Gauge standard
BBP	Busbar protection
BFOC/2,5	Bayonet fibre optic connector
BFP	Breaker failure protection
BI	Binary input
BIM	Binary input module
BOM	Binary output module
BOS	Binary outputs status
BR	External bistable relay
BS	British Standards
BSR	Binary signal transfer function, receiver blocks
BST	Binary signal transfer function, transmit blocks
C37.94	IEEE/ANSI protocol used when sending binary signals between IEDs
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication

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CB	Circuit breaker
CBM	Combined backplane module
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations-sponsored standards body within the International Telecommunications Union.
CCM	CAN carrier module
CCVT	Capacitive Coupled Voltage Transformer
Class C	Protection Current Transformer class as per IEEE/ ANSI
CMPPS	Combined megapulses per second
CMT	Communication Management tool in PCM600
CO cycle	Close-open cycle
Codirectional	Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions
COM	Command
COMTRADE	Standard Common Format for Transient Data Exchange format for Disturbance recorder according to IEEE/ANSI C37.111, 1999 / IEC60255-24
Contra-directional	Way of transmitting G.703 over a balanced line. Involves four twisted pairs, two of which are used for transmitting data in both directions and two for transmitting clock signals
COT	Cause of transmission
CPU	Central processing unit
CR	Carrier receive
CRC	Cyclic redundancy check
CROB	Control relay output block
CS	Carrier send
CT	Current transformer
CU	Communication unit
CVT or CCVT	Capacitive voltage transformer
DAR	Delayed autoreclosing
DARPA	Defense Advanced Research Projects Agency (The US developer of the TCP/IP protocol etc.)
DBDL	Dead bus dead line
DBLL	Dead bus live line
DC	Direct current

DFC	Data flow control
DFT	Discrete Fourier transform
DHCP	Dynamic Host Configuration Protocol
DIP-switch	Small switch mounted on a printed circuit board
DI	Digital input
DLLB	Dead line live bus
DNP	Distributed Network Protocol as per IEEE Std 1815-2012
DR	Disturbance recorder
DRAM	Dynamic random access memory
DRH	Disturbance report handler
DSP	Digital signal processor
DTT	Direct transfer trip scheme
EHV network	Extra high voltage network
EIA	Electronic Industries Association
EMC	Electromagnetic compatibility
EMF	Electromotive force
EMI	Electromagnetic interference
EnFP	End fault protection
EPA	Enhanced performance architecture
ESD	Electrostatic discharge
F-SMA	Type of optical fibre connector
FAN	Fault number
FCB	Flow control bit; Frame count bit
FOX 20	Modular 20 channel telecommunication system for speech, data and protection signals
FOX 512/515	Access multiplexer
FOX 6Plus	Compact time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers
FTP	File Transfer Protocol
FUN	Function type
G.703	Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines
GCM	Communication interface module with carrier of GPS receiver module

ДЗЗД „ЕИК ДРАГАЛЕВЦИ"
ВЯРНО С ОРИГИНАЛА

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GDE	Graphical display editor within PCM600
GI	General interrogation command
GIS	Gas-insulated switchgear
GOOSE	Generic object-oriented substation event
GPS	Global positioning system
GSAL	Generic security application
GSE	Generic substation event
GSM	GPS time synchronization module
GTM	GPS Time Module
HDLC protocol	High-level data link control, protocol based on the HDLC standard
HFBR connector type	Plastic fiber connector
HMI	Human-machine interface
HSAR	High speed autoreclosing
HV	High-voltage
HVDC	High-voltage direct current
ICT	Installation and Commissioning Tool for injection based protection in REG670
IDBS	Integrating deadband supervision
IEC	International Electrical Committee
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
IEC 60870-5-103	Communication standard for protection equipment. A serial master/slave protocol for point-to-point communication
IEC 61850	Substation automation communication standard
IEC 61850–8–1	Communication protocol standard
IEEE	Institute of Electrical and Electronics Engineers
IEEE 802.12	A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable
IEEE P1386.1	PCI Mezzanine Card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common Mezzanine Card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical EMF (Electromotive force).
IEEE 1686	Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities
IED	Intelligent electronic device

I-GIS	Intelligent gas-insulated switchgear
IOM	Binary input/output module
Instance	When several occurrences of the same function are available in the IED, they are referred to as instances of that function. One instance of a function is identical to another of the same kind but has a different number in the IED user interfaces. The word "instance" is sometimes defined as an item of information that is representative of a type. In the same way an instance of a function in the IED is representative of a type of function.
IP	1. Internet protocol. The network layer for the TCP/IP protocol suite widely used on Ethernet networks. IP is a connectionless, best-effort packet-switching protocol. It provides packet routing, fragmentation and reassembly through the data link layer. 2. Ingression protection, according to IEC 60529
IP 20	Ingression protection, according to IEC 60529, level 20
IP 40	Ingression protection, according to IEC 60529, level 40
IP 54	Ingression protection, according to IEC 60529, level 54
IRF	Internal failure signal
IRIG-B:	InterRange Instrumentation Group Time code format B, standard 200
ITU	International Telecommunications Union
LAN	Local area network
LIB 520	High-voltage software module
LCD	Liquid crystal display
LDCM	Line differential communication module
LDD	Local detection device
LED	Light-emitting diode
LNT	LON network tool
LON	Local operating network
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MIM	Milli-ampere module
MPM	Main processing module
MVAL	Value of measurement
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.

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NCC	National Control Centre
NOF	Number of grid faults
NUM	Numerical module
OCO cycle	Open-close-open cycle
OCP	Overcurrent protection
OEM	Optical Ethernet module
OLTC	On-load tap changer
OTEV	Disturbance data recording initiated by other event than start/pick-up
OV	Overvoltage
Overreach	A term used to describe how the relay behaves during a fault condition. For example, a distance relay is overreaching when the impedance presented to it is smaller than the apparent impedance to the fault applied to the balance point, that is, the set reach. The relay "sees" the fault but perhaps it should not have seen it.
PCI	Peripheral component interconnect, a local data bus
PCM	Pulse code modulation
PCM600	Protection and control IED manager
PC-MIP	Mezzanine card standard
PMC	PCI Mezzanine card
POR	Permissive overreach
POTT	Permissive overreach transfer trip
Process bus	Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components
PSM	Power supply module
PST	Parameter setting tool within PCM600
PT ratio	Potential transformer or voltage transformer ratio
PUTT	Permissive underreach transfer trip
RASC	Synchrocheck relay, COMBIFLEX
RCA	Relay characteristic angle
RISC	Reduced instruction set computer
RMS value	Root mean square value
RS422	A balanced serial interface for the transmission of digital data in point-to-point connections
RS485	Serial link according to EIA standard RS485
RTC	Real-time clock

RTU	Remote terminal unit
SA	Substation Automation
SBO	Select-before-operate
SC	Switch or push button to close
SCL	Short circuit location
SCS	Station control system
SCADA	Supervision, control and data acquisition
SCT	System configuration tool according to standard IEC 61850
SDU	Service data unit
SLM	Serial communication module.
SMA connector	Subminiature version A, A threaded connector with constant impedance.
SMT	Signal matrix tool within PCM600
SMS	Station monitoring system
SNTP	Simple network time protocol – is used to synchronize computer clocks on local area networks. This reduces the requirement to have accurate hardware clocks in every embedded system in a network. Each embedded node can instead synchronize with a remote clock, providing the required accuracy.
SOF	Status of fault
SPA	Strömberg Protection Acquisition (SPA), a serial master/slave protocol for point-to-point and ring communication.
SRY	Switch for CB ready condition
ST	Switch or push button to trip
Starpoint	Neutral point of transformer or generator
SVC	Static VAr compensation
TC	Trip coil
TCS	Trip circuit supervision
TCP	Transmission control protocol. The most common transport layer protocol used on Ethernet and the Internet.
TCP/IP	Transmission control protocol over Internet Protocol. The de facto standard Ethernet protocols incorporated into 4.2BSD Unix. TCP/IP was developed by DARPA for Internet working and encompasses both network layer and transport layer protocols. While TCP and IP specify two protocols at specific protocol layers, TCP/IP is often used to refer to the entire US Department of Defense protocol suite based upon these, including Telnet, FTP, UDP and RDP.

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TEF	Time delayed earth-fault protection function
TLS	Transport Layer Security
TM	Transmit (disturbance data)
TNC connector	Threaded Neill-Concelman, a threaded constant impedance version of a BNC connector
TP	Trip (recorded fault)
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
TRM	Transformer Module. This module transforms currents and voltages taken from the process into levels suitable for further signal processing.
TYP	Type identification
UMT	User management tool
Underreach	A term used to describe how the relay behaves during a fault condition. For example, a distance relay is underreaching when the impedance presented to it is greater than the apparent impedance to the fault applied to the balance point, that is, the set reach. The relay does not "see" the fault but perhaps it should have seen it. See also Overreach.
UTC	Coordinated Universal Time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals. UTC is derived from International Atomic Time (TAI) by the addition of a whole number of "leap seconds" to synchronize it with Universal Time 1 (UT1), thus allowing for the eccentricity of the Earth's orbit, the rotational axis tilt (23.5 degrees), but still showing the Earth's irregular rotation, on which UT1 is based. The Coordinated Universal Time is expressed using a 24-hour clock, and uses the Gregorian calendar. It is used for aeroplane and ship navigation, where it is also sometimes known by the military name, "Zulu time." "Zulu" in the phonetic alphabet stands for "Z", which stands for longitude zero.
UV	Undervoltage
WEI	Weak end infeed logic
VT	Voltage transformer
X.21	A digital signalling interface primarily used for telecom equipment
$3I_O$	Three times zero-sequence current.Often referred to as the residual or the earth-fault current
$3U_O$	Three times the zero sequence voltage. Often referred to as the residual voltage or the neutral point voltage

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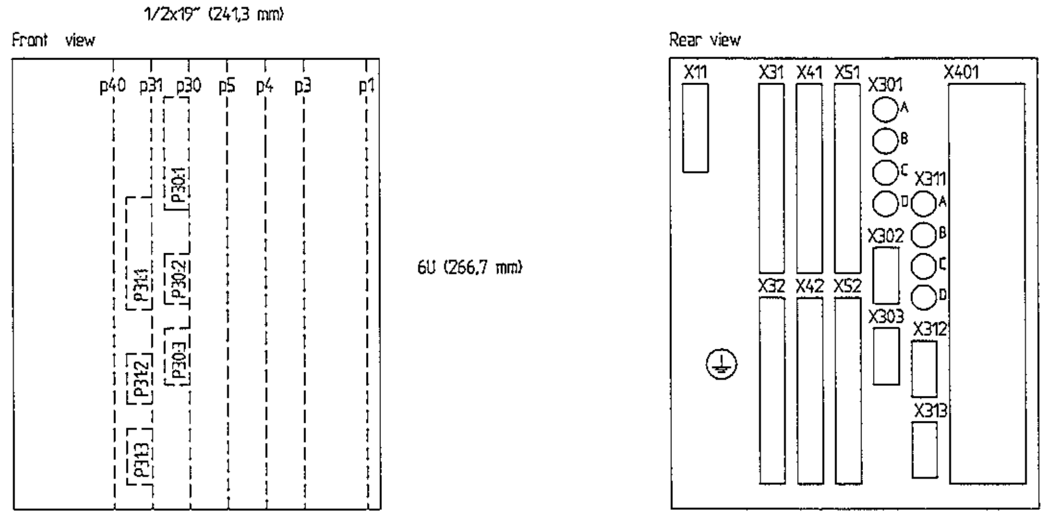
Based on	Prepared 2014-04-14 Jill Eriksson	Title Connection diagram	Doc.des. Doc.kind / Ref.des. =Xn.Qn
	Approved 2015-09-04 Patrik Nyback	RED670 A31X00	Resp.dept. / Rev.ind. A / Lang. en
Rev / Rev. Note / Date / Name	Project	Single breaker, 3 phase tripping — ABB AB	Doc.No. 1MRK002803-DA / Sheet 1 / Cont. 2

Designations for 1/2x19" casing with 1 TRM slot



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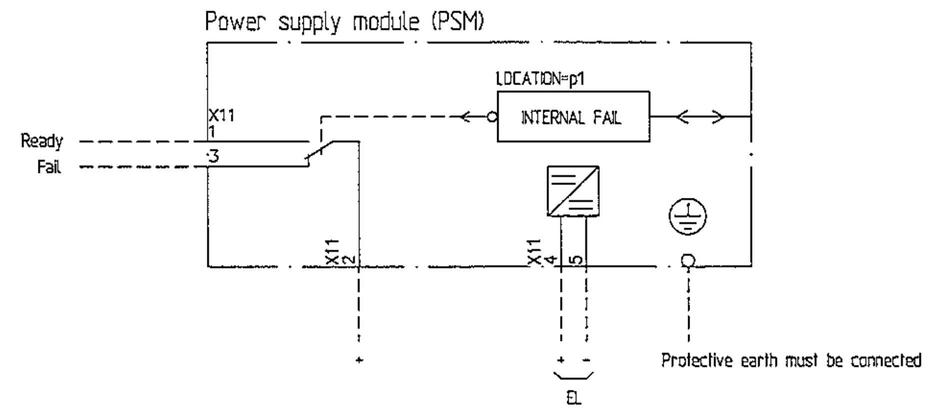

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	Approved 2015-09-04 Patrik Nyback		Resp.dept. / Rev.ind. A / Long.
Rev / Rev. Note / Date / Name	Project	ABB / ABB AB	Doc.No. 1MRK002803-DA / Sheet 3 / Cont. 4

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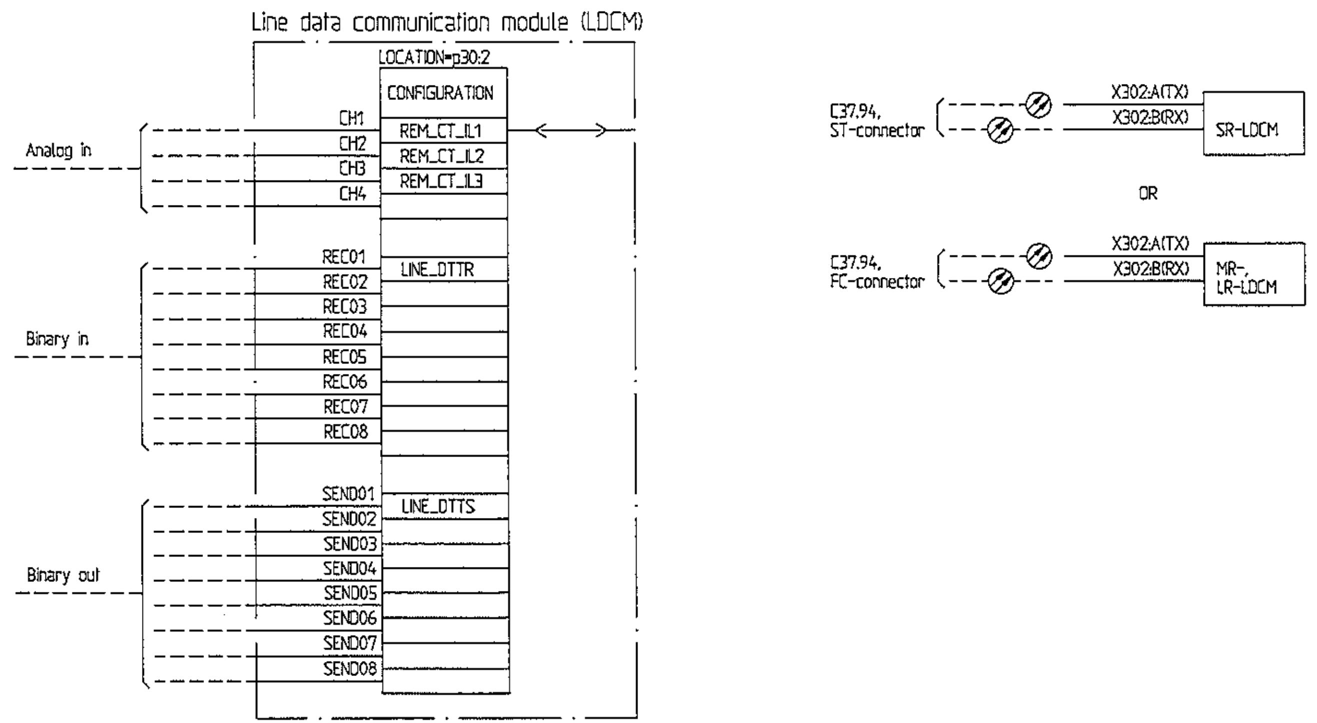

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			Approved 2015-09-04	Patrik Nyback		Resp.dept.		Rev.ind. A / Lang.
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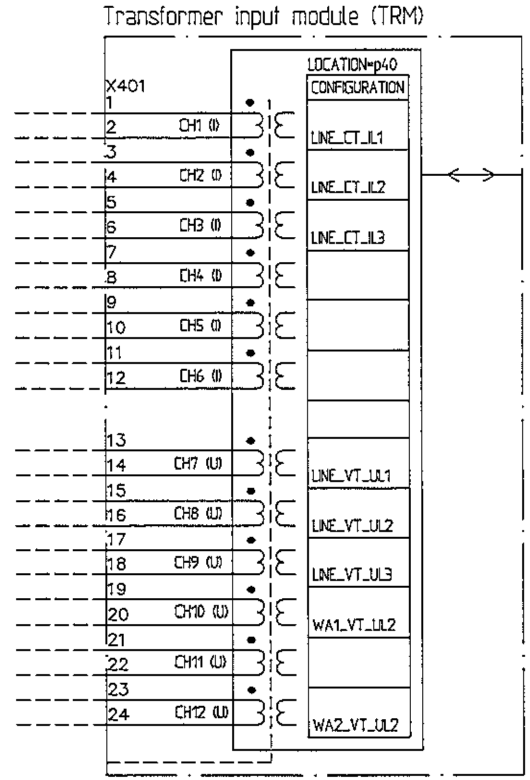

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			Approved 2015-09-04	Patrik Nyback		Resp.dept.	Rev.ind. A	Lang.
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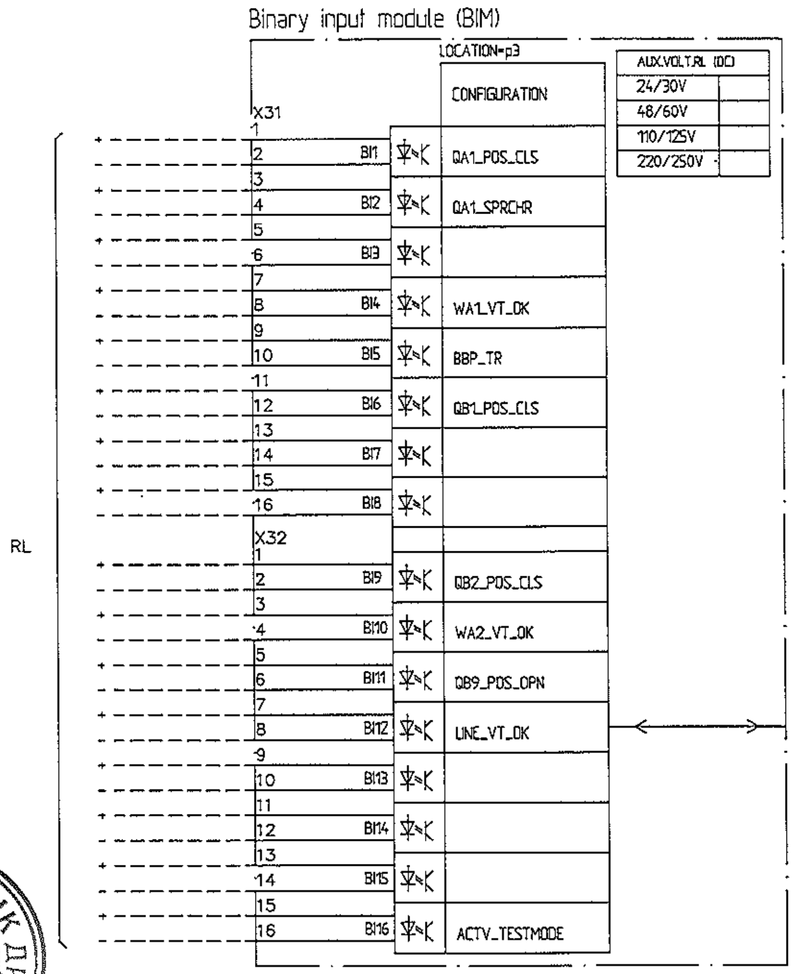

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	Approved 2015-09-04 Patrik Nyback	RED670 A31X00	Ref.des. Xn.Qn
	Project	Single breaker, 3 phase tripping	Resp.dept. / Rev.ind. A / Lang.
Rev / Rev. Note / Date / Name		ABB / ABB AB	Doc.No. 1MRK002803-DA / Sheet 6 / Cont. 7

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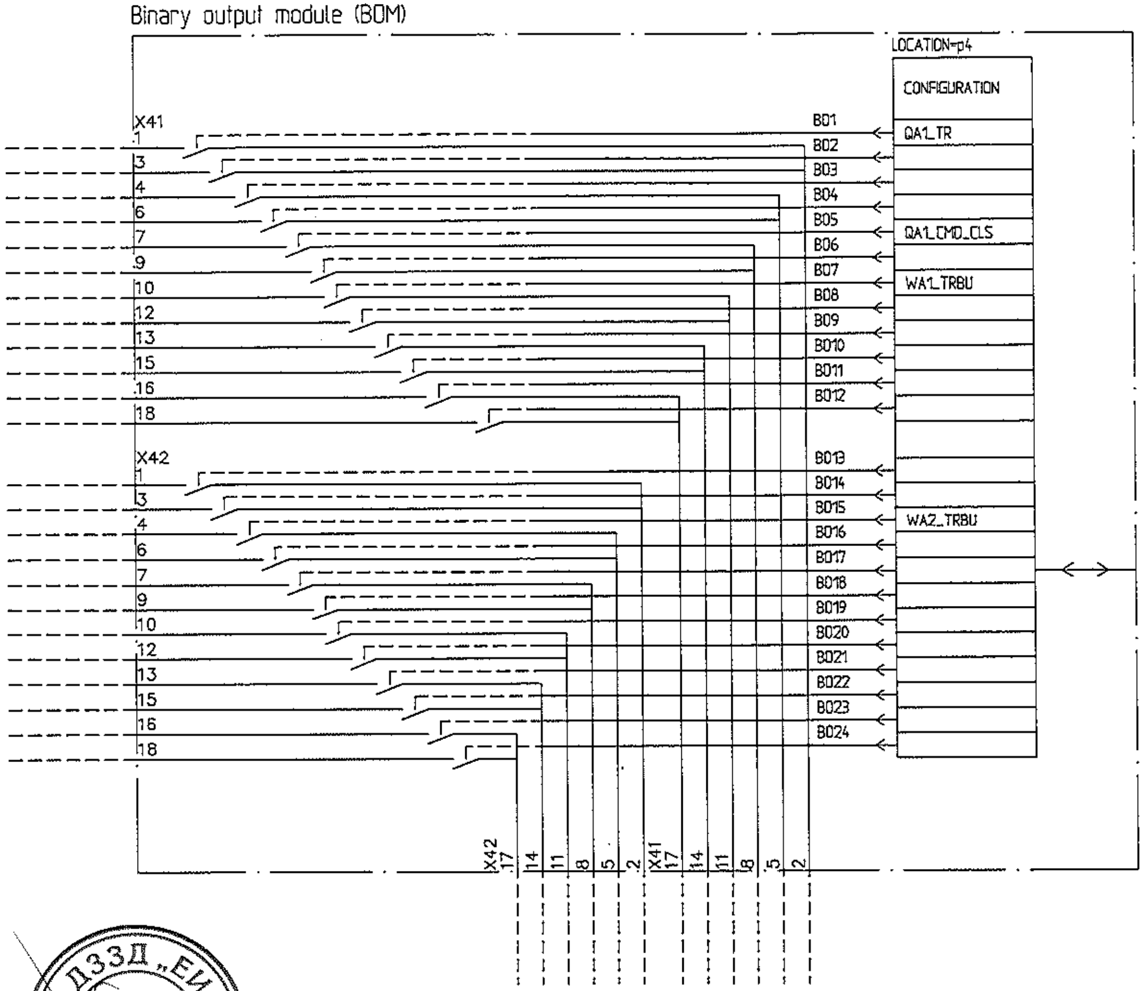

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	Approved 2015-09-04	Patrik Nyback		Resp.dept.	Rev.ind. A / Lang.
Rev / Rev. Note / Date / Name	Project		ABB — ABB AB	Doc.No. 1MRK002803-DA	Sheet 7 / Cont. –

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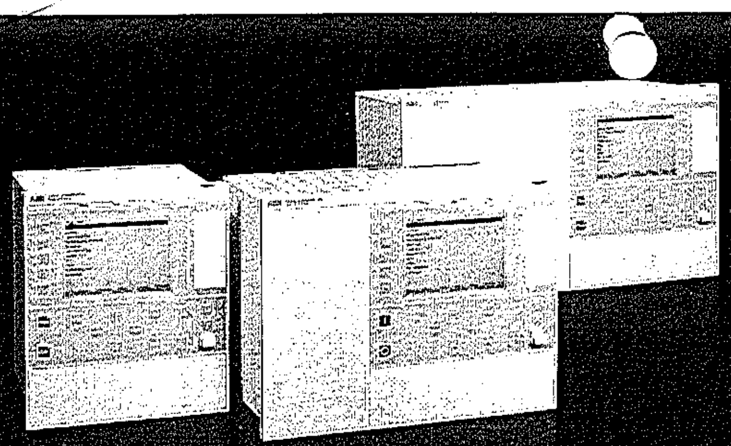

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670 series 2.1 IEC
IEC 61850 Edition 2 Communication protocol manual

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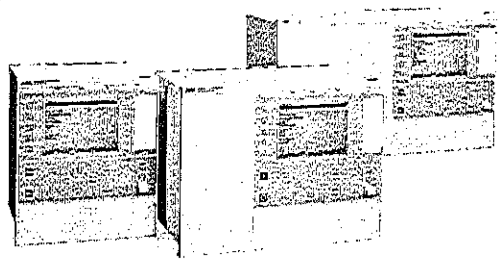

Document ID: 1MRK 511 350-UEN
Issued: December 2015
Revision: -
Product version: 2.1

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Conformity

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

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Section 1 Introduction

1.1 This manual

The communication protocol manual describes the communication protocols supported by the IED. The manual concentrates on the vendor-specific implementations.

1.2 Intended audience

This manual addresses the communication system engineer or system integrator responsible for pre-engineering and engineering for communication setup in a substation from an IED perspective.

The system engineer or system integrator must have a basic knowledge of communication in protection and control systems and thorough knowledge of the specific communication protocol.

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1.3 Product documentation

1.3.1 Product documentation set

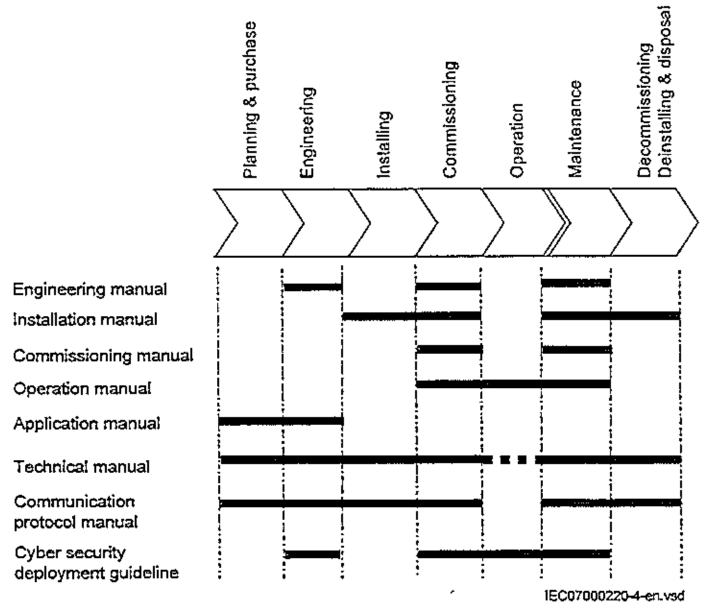

Figure 1: The intended use of manuals throughout the product lifecycle

The engineering manual contains instructions on how to engineer the IEDs using the various tools available within the PCM600 software. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for the engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 60870-5-103, IEC 61850, DNP3, LON and SPA.

The installation manual contains instructions on how to install the IED. The manual provides procedures for mechanical and electrical installation. The chapters are organized in the chronological order in which the IED should be installed.

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for the checking of external circuitry and energizing the IED, parameter setting and configuration as well as verifying settings by secondary injection. The manual describes the process of testing an IED in a substation which is not in service. The chapters are organized in the chronological order in which the IED should be commissioned. The relevant procedures may be followed also during the service and maintenance activities.

The operation manual contains instructions on how to operate the IED once it has been commissioned. The manual provides instructions for the monitoring, controlling and setting of the IED. The manual also describes how to identify disturbances and how to view calculated and measured power grid data to determine the cause of a fault.

The application manual contains application descriptions and setting guidelines sorted per function. The manual can be used to find out when and for what purpose a typical protection function can be used. The manual can also provide assistance for calculating settings.

The technical manual contains operation principle descriptions, and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data, sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

The communication protocol manual describes the communication protocols supported by the IED. The manual concentrates on the vendor-specific implementations.

The point list manual describes the outlook and properties of the data points specific to the IED. The manual should be used in conjunction with the corresponding communication protocol manual.

The cyber security deployment guideline describes the process for handling cyber security when communicating with the IED. Certification, Authorization with role based access control, and product engineering for cyber security related events are described and sorted by function. The guideline can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

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1.3.2 Document revision history

Document revision/date	History
December 2015	First release

1.3.3 Related documents

Documents related to REB670	Document numbers
Application manual	1MRK 505 337-UEN
Commissioning manual	1MRK 505 339-UEN
Product guide	1MRK 505 340-BEN
Technical manual	1MRK 505 338-UEN
Type test certificate	1MRK 505 340-TEN

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Documents related to REC670	Document numbers
Application manual	1MRK 511 358-UEN
Commissioning manual	1MRK 511 360-UEN
Product guide	1MRK 511 361-BEN
Technical manual	1MRK 511 359-UEN
Type test certificate	1MRK 511 361-TEN

Documents related to RED670	Document numbers
Application manual	1MRK 505 343-UEN
Commissioning manual	1MRK 505 345-UEN
Product guide	1MRK 505 346-BEN
Technical manual	1MRK 505 308-UEN
Type test certificate	1MRK 505 346-TEN

Documents related to REG670	Document numbers
Application manual	1MRK 502 065-UEN
Commissioning manual	1MRK 502 067-UEN
Product guide	1MRK 502 068-BEN
Technical manual	1MRK 502 066-UEN
Type test certificate	1MRK 502 068-TEN

Documents related to REL670	Document numbers
Application manual	1MRK 506 353-UEN
Commissioning manual	1MRK 506 355-UEN
Product guide	1MRK 506 356-BEN
Technical manual	1MRK 506 354-UEN
Type test certificate	1MRK 506 356-TEN

Documents related to RET670	Document numbers
Application manual	1MRK 504 152-UEN
Commissioning manual	1MRK 504 154-UEN
Product guide	1MRK 504 155-BEN
Technical manual	1MRK 504 153-UEN
Type test certificate	1MRK 504 155-TEN

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

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

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1.4 Document symbols and conventions

1.4.1 Symbols

The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

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The warning icon indicates the presence of a hazard which could result in personal injury.

The caution hot surface icon indicates important information or warning about the temperature of product surfaces.

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. It is important that the user fully complies with all warning and cautionary notices.

1.4.2 Document conventions

- Abbreviations and acronyms in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  For example, to navigate between the options, use [icon] and [icon].
- HMI menu paths are presented in bold.
  For example, select **Main menu/Settings**.
- LHMI messages are shown in Courier font.
  For example, to save the changes in non-volatile memory, select `Yes` and press [icon].
- Parameter names are shown in italics.
  For example, the function can be enabled and disabled with the *Operation* setting.
- Each function block symbol shows the available input/output signal.
  - the character ^ in front of an input/output signal name indicates that the signal name may be customized using the PCM600 software.
  - the character * after an input signal name indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.
- Logic diagrams describe the signal logic inside the function block and are bordered by dashed lines.

- Signals in frames with a shaded area on their right hand side represent setting parameter signals that are only settable via the PST or LHMI.
- If an internal signal path cannot be drawn with a continuous line, the suffix -int is added to the signal name to indicate where the signal starts and continues.
- Signal paths that extend beyond the logic diagram and continue in another diagram have the suffix "-cont."

1.5 IEC61850 edition 1 / edition 2 mapping

Table 1: IEC61850 edition 1 / edition 2 mapping

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
AEGPVOC	AEGGAPC	AEGPVOC
AGSAL	AGSAL SECLLN0	AGSAL
ALMCALH	ALMCALH	ALMCALH
ALTIM		ALTIM
ALTMS		ALTMS
ALTRK		ALTRK
BCZSPDIF	BCZSPDIF	BCZSPDIF
BCZTPDIF	BCZTPDIF	BCZTPDIF
BDCGAPC	SWSGGIO	BBCSWI BDCGAPC
BRCPTOC	BRCPTOC	BRCPTOC
BRPTOC	BRPTOC	BRPTOC
BTIGAPC	B16IFCVI	BTIGAPC
BUSPTRC_B1	BUSPTRC BBSPLLN0	BUSPTRC
BUSPTRC_B2	BUSPTRC	BUSPTRC
BUSPTRC_B3	BUSPTRC	BUSPTRC
BUSPTRC_B4	BUSPTRC	BUSPTRC
BUSPTRC_B5	BUSPTRC	BUSPTRC
BUSPTRC_B6	BUSPTRC	BUSPTRC
BUSPTRC_B7	BUSPTRC	BUSPTRC
BUSPTRC_B8	BUSPTRC	BUSPTRC
BUSPTRC_B9	BUSPTRC	BUSPTRC
BUSPTRC_B10	BUSPTRC	BUSPTRC
BUSPTRC_B11	BUSPTRC	BUSPTRC
BUSPTRC_B12	BUSPTRC	BUSPTRC
BUSPTRC_B13	BUSPTRC	BUSPTRC
BUSPTRC_B14	BUSPTRC	BUSPTRC

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
BUSPTRC_B15	BUSPTRC	BUSPTRC
BUSPTRC_B16	BUSPTRC	BUSPTRC
BUSPTRC_B17	BUSPTRC	BUSPTRC
BUSPTRC_B18	BUSPTRC	BUSPTRC
BUSPTRC_B19	BUSPTRC	BUSPTRC
BUSPTRC_B20	BUSPTRC	BUSPTRC
BUSPTRC_B21	BUSPTRC	BUSPTRC
BUSPTRC_B22	BUSPTRC	BUSPTRC
BUSPTRC_B23	BUSPTRC	BUSPTRC
BUSPTRC_B24	BUSPTRC	BUSPTRC
BUTPTRC_B1	BUTPTRC BBTPLLN0	BUTPTRC
BUTPTRC_B2	BUTPTRC	BUTPTRC
BUTPTRC_B3	BUTPTRC	BUTPTRC
BUTPTRC_B4	BUTPTRC	BUTPTRC
BUTPTRC_B5	BUTPTRC	BUTPTRC
BUTPTRC_B6	BUTPTRC	BUTPTRC
BUTPTRC_B7	BUTPTRC	BUTPTRC
BUTPTRC_B8	BUTPTRC	BUTPTRC
BZISGGIO	BZISGGIO	BZISGAPC
BZITGGIO	BZITGGIO	BZITGAPC
BZNSPDIF_A	BZNSPDIF	BZASGAPC BZASPDIF BZNSGAPC BZNSPDIF
BZNSPDIF_B	BZNSPDIF	BZBSGAPC BZBSPDIF BZNSGAPC BZNSPDIF
BZNTPDIF_A	BZNTPDIF	BZATGAPC BZATPDIF BZNTGAPC BZNTPDIF
BZNTPDIF_B	BZNTPDIF	BZBTGAPC BZBTPDIF BZNTGAPC BZNTPDIF
CBPGAPC	CBPLLN0 CBPMMXU CBPPTRC HOLPTOV HPH1PTOV PH3PTUC PH3PTOC RP3PDOP	CBPMMXU CBPPTRC HOLPTOV HPH1PTOV PH3PTOC PH3PTUC RP3PDOP
CCPDSC	CCRPLD	CCPDSC
CCRBRF	CCRBRF	CCRBRF

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
CCRWRBRF	CCRWRBRF	CCRWRBRF
CCSRBRF	CCSRBRF	CCSRBRF
CCSSPVC	CCSRDIF	CCSSPVC
CMMXU	CMMXU	CMMXU
CMSQI	CMSQI	CMSQI
COUVGAPC	COUVLLN0 COUVPTOV COUVPTUV	COUVPTOV COUVPTUV
CVGAPC	GF2LLN0 GF2MMXN GF2PHAR GF2PTOV GF2PTUC GF2PTUV GF2PVOC PH1PTRC	GF2MMXN GF2PHAR GF2PTOV GF2PTUC GF2PTUV GF2PVOC PH1PTRC
CVMMXN	CVMMXN	CVMMXN
D2PTOC	D2LLN0 D2PTOC PH1PTRC	D2PTOC PH1PTRC
DPGAPC	DPGGIO	DPGAPC
DRPRDRE	DRPRDRE	DRPRDRE
ECPSCH	ECPSCH	ECPSCH
ECRWPSCH	ECRWPSCH	ECRWPSCH
EF2PTOC	EF2LLN0 EF2PTRC EF2RDIR GEN2PHAR PH1PTOC	EF2PTRC EF2RDIR GEN2PHAR PH1PTOC
EF4PTOC	EF4LLN0 EF4PTRC EF4RDIR GEN4PHAR PH1PTOC	EF4PTRC EF4RDIR GEN4PHAR PH1PTOC
EFPIOC	EFPIOC	EFPIOC
EFRWPIOC	EFRWPIOC	EFRWPIOC
ETPMMTR	ETPMMTR	ETPMMTR
FDPSPDIS	FDPSPDIS	FDPSPDIS
FMPSPDIS	FMPSPDIS	FMPSPDIS
FRPSPDIS	FPSRPDIS	FPSRPDIS
FTAQFVR	FTAQFVR	FTAQFVR
FUFSPVC	SDDRFUF	FUFSPVC SDDSPVC
GENPDIF	GENPDIF	GENGAPC GENPDIF GENPHAR GENPTRC
GOOSEBINRCV	BINGREC	

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
GOOSEDPRCV	DPGREC	
GOOSEINTLKRCV	INTGREC	
GOOSEINTRCV	INTSGREC	
GOOSEMVRCV	MVGREC	
GOOSESPRCV	BINSGREC	
GOOSEVCTRRCV	VCTRGREC	
GOPPDOP	GOPPDOP	GOPPDOP PH1PTRC
GRPTTR	GRPTTR	GRPTTR
GSPTTR	GSPTTR	GSPTTR
GUPPDUP	GUPPDUP	GUPPDUP PH1PTRC
HZPDIF	HZPDIF	HZPDIF
INDCALCH	INDCALH	INDCALH
ITBGAPC	IB16FCVB	ITBGAPC
L3CPDIF	L3CPDIF	L3CGAPC L3CPDIF L3CPHAR L3CPTRC
L4UFCNT	L4UFCNT	L4UFCNT
L6CPDIF	L6CPDIF	L6CGAPC L6CPDIF L6CPHAR L6CPTRC
LAPPGAPC	LAPPLLN0 LAPPPDUP LAPPPUPF	LAPPPDUP LAPPPUPF
LCCRPTRC	LCCRPTRC	LCCRPTRC
LCNSPTOC	LCNSPTOC	LCNSPTOC
LCNSPTOV	LCNSPTOV	LCNSPTOV
LCP3PTOC	LCP3PTOC	LCP3PTOC
LCP3PTUC	LCP3PTUC	LCP3PTUC
LCPTTR	LCPTTR	LCPTTR
LCZSPTOC	LCZSPTOC	LCZSPTOC
LCZSPTOV	LCZSPTOV	LCZSPTOV
LD0LLN0	LLN0	
LDLPSCH	LDLPDIF	LDLPSCH
LDRGFC	STSGGIO	LDRGFC
LEXPDIS	LEXPDIS	LEXPDIS LEXPTRC
LFPTTR	LFPTTR	LFPTTR
LMBRFLO	LMBRFLO	LMBRFLO
LOVPTUV	LOVPTUV	LOVPTUV
LPHD	LPHD	

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Function block name	Edition 1 logical nodes	Edition 2 logical nodes
LPTTR	LPTTR	LPTTR
LT3CPDIF	LT3CPDIF	LT3CGAPC LT3CPDIF LT3CPHAR LT3CPTRC
LT6CPDIF	LT6CPDIF	LT6CGAPC LT6CPDIF LT6CPHAR LT6CPTRC
MVGAPC	MVGGIO	MVGAPC
NS2PTOC	NS2LLN0 NS2PTOC NS2PTRC	NS2PTOC NS2PTRC
NS4PTOC	EF4LLN0 EF4PTRC EF4RDIR GEN4PHAR PH1PTOC	EF4PTRC EF4RDIR PH1PTOC
O2RWPTOV	GEN2LLN0 O2RWPTOV PH1PTRC	O2RWPTOV PH1PTRC
OC4PTOC	OC4LLN0 GEN4PHAR PH3PTOC PH3PTRC	GEN4PHAR PH3PTOC PH3PTRC
OEXPVPH	OEXPVPH	OEXPVPH
OOSPPAM	OOSPPAM	OOSPPAM OOSPTRC
OV2PTOV	GEN2LLN0 OV2PTOV PH1PTRC	OV2PTOV PH1PTRC
PAPGAPC	PAPGAPC	PAPGAPC
PCFCNT	PCGGIO	PCFCNT
PH4SPTOC	GEN4PHAR OCNDLLN0 PH1BPTOC PH1PTRC	GEN4PHAR PH1BPTOC PH1PTRC
PHPIOC	PHPIOC	PHPIOC
PRPSTATUS	RCHLCCH	RCHLCCH SCHLCCH
PSLPSCH	ZMRPSL	PSLPSCH
PSPPPAM	PSPPPAM	PSPPPAM PSPPTRC
QCBAY	QCBAY	
QCRSV	QCRSV	QCRSV
REFPDIF	REFPDIF	REFPDIF
ROTIPHIZ	ROTIPHIZ	ROTIPHIZ ROTIPTRC

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
ROV2PTOV	GEN2LLN0 PH1PTRC ROV2PTOV	PH1PTRC ROV2PTOV
SAPFRC	SAPFRC	SAPFRC
SAPTOF	SAPTOF	SAPTOF
SAPTUF	SAPTUF	SAPTUF
SCCVPTOC	SCCVPTOC	SCCVPTOC
SCILO	SCILO	SCILO
SCSWI	SCSWI	SCSWI
SDEPSDE	SDEPSDE	SDEPSDE SDEPTOC SDEPTOV SDEPTRC
SESRSYN	RSY1LLN0 AUT1RSYN MAN1RSYN SYNRSYN	AUT1RSYN MAN1RSYN SYNRSYN
SINGLELCCH		SCHLCCH
SLGAPC	SLGGIO	SLGAPC
SMBRREC	SMBRREC	SMBRREC
SMPPTRC	SMPPTRC	SMPPTRC
SP16GAPC	SP16GGIO	SP16GAPC
SPC8GAPC	SPC8GGIO	SPC8GAPC
SPGAPC	SPGGIO	SPGAPC
SSCBR	SSCBR	SSCBR
SSIMG	SSIMG	SSIMG
SSIML	SSIML	SSIML
STBPTOC	STBPTOC	BBPMSS STBPTOC
STEFPHIZ	STEFPHIZ	STEFPHIZ
STTIPHIZ	STTIPHIZ	STTIPHIZ
SXCBR	SXCBR	SXCBR
SXSWI	SXSWI	SXSWI
T2WPDIF	T2WPDIF	T2WGAPC T2WPDIF T2WPHAR T2WPTRC
T3WPDIF	T3WPDIF	T3WGAPC T3WPDIF T3WPHAR T3WPTRC
TCLYLTC	TCLYLTC	TCLYLTC TCSLTC
TCMYLTC	TCMYLTC	TCMYLTC
TEIGAPC	TEIGGIO	TEIGAPC TEIGGIO

Table continues on next page

Function block name	Edition 1 logical nodes	Edition 2 logical nodes
TEILGAPC	TEILGGIO	TEILGAPC
TMAGAPC	TMAGGIO	TMAGAPC
TPPIOC	TPPIOC	TPPIOC
TR1ATCC	TR1ATCC	TR1ATCC
TR8ATCC	TR8ATCC	TR8ATCC
TRPTTR	TRPTTR	TRPTTR
U2RWPTUV	GEN2LLN0 PH1PTRC U2RWPTUV	PH1PTRC U2RWPTUV
UV2PTUV	GEN2LLN0 PH1PTRC UV2PTUV	PH1PTRC UV2PTUV
VDCPTOV	VDCPTOV	VDCPTOV
VDSPVC	VDRFUF	VDSPVC
VMMXU	VMMXU	VMMXU
VMSQI	VMSQI	VMSQI
VNMMXU	VNMMXU	VNMMXU
VRPVOC	VRLLN0 PH1PTRC PH1PTUV VRPVOC	PH1PTRC PH1PTUV VRPVOC
VSGAPC	VSGGIO	VSGAPC
WRNCALH	WRNCALH	WRNCALH
ZC1PPSCH	ZPCPSCH	ZPCPSCH
ZC1WPSCH	ZPCWPSCH	ZPCWPSCH
ZCLCPSCH	ZCLCPLAL	ZCLCPSCH
ZCPSCH	ZCPSCH	ZCPSCH
ZCRWPSCH	ZCRWPSCH	ZCRWPSCH
ZCVPSOF	ZCVPSOF	ZCVPSOF
ZGVPDIS	ZGVLLN0 PH1PTRC ZGVPDIS ZGVPTUV	PH1PTRC ZGVPDIS ZGVPTUV
ZMCAPDIS	ZMCAPDIS	ZMCAPDIS
ZMCPDIS	ZMCPDIS	ZMCPDIS
ZMFCPDIS	ZMFCLLN0 PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU	PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU
ZMFPDIS	ZMFLLN0 PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU	PSFPDIS PSFPDIS ZMFPDIS ZMFPTRC ZMMMXU
ZMHPDIS	ZMHPDIS	ZMHPDIS

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Function block name	Edition 1 logical nodes	Edition 2 logical nodes
ZMMAPDIS	ZMMAPDIS	ZMMAPDIS
ZMMPDIS	ZMMPDIS	ZMMPDIS
ZMQAPDIS	ZMQAPDIS	ZMQAPDIS
ZMQPDIS	ZMQPDIS	ZMQPDIS
ZMRAPDIS	ZMRAPDIS	ZMRAPDIS
ZMRPDIS	ZMRPDIS	ZMRPDIS
ZMRPSB	ZMRPSB	ZMRPSB
ZSMGAPC	ZSMGAPC	ZSMGAPC

Section 2 Introduction to IEC 61850

The general scope of the IEC 61850 protocol standard is designed to support the communication of all functions being performed in the substation. Its' main goal is interoperability; this is the ability for IEDs from one or different manufacturers to exchange information and use the information for their own functions. Moreover, the standard allows a free allocation of these functions and accepts any system philosophy, from a distributed architecture (for example, decentralised substation automation) to a centralised configuration (for example, RTU based).

The standard separates the functionality represented by the data model and the related communication services from the communication implementation (stack).

The data model of the standard is an object-oriented one, grouping the data into the smallest possible sets referring to the smallest possible functions to be implemented independently. These smallest possible data groups or functions are named logical nodes. The logical nodes and all data and attributes contained are named according to a standardised semantic, which is mandatory.

This manual describes how the IEC61850 standard is applied in the IEDs. References and brief descriptions of the standard are also included. It is assumed that the reader has basic knowledge of the IEC 61850 standard.

The following parts of the IEC61850 standard are of importance as they relate to this manual:

- Station Configuration description Language (SCL) is described in IEC 61850-6. The SCL is an XML based definition of how to describe the parts of a substation. This part of the standard also includes the roles of different tools as well as the engineering concepts.
- Communication profile (IEC 61850 stack) is described in IEC 61850-8-1. This part of the standard includes a number of possible communication profiles, and how the services defined in IEC 61850-7-2 are mapped to the communication profile.
- Communication services are described in IEC 61850-7-2. This part deals mainly with the communication facilities from client and server point of view. It includes the different possibilities of communication functionality.
- Logical node data model. This is described in IEC 61850-7-3 and IEC 61850-7-4.
- Conformance tests and the basis for conformance documents are handled in IEC 61850-10.

Detailed information regarding the IEC61850 implementation of the IED is described inside the conformance documents.

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- MICS, Modeling Information Conformance Statement, contains the declaration of the used logical node types.
- PICS, Protocol Information Conformance Statement, contains the details and what is supported regarding protocol facilities.
- PIXIT. Protocol Extra Information, contains additional information on how the IEC 61850 is implemented and used.
- TICS, Tissue Information Conformance Statement, contains the supported Tissues, which are handled in the Tissues process as defined by UCA, Utility Communication Architecture forum. The Tissues handling is found in http://www.tissue.iec61850.com.

The conformance documents are unique for each product release and refer to each other. The identities included in the related documents refer to a specific version of the IED series.

The communication profile in IEC 61850 uses the MMS standard, which uses Ethernet and TCP/IP to handle the information transport within the substation.

The data modelling uses the concept of logical nodes to identify the published information for communication. The standard defines a set of logical nodes, each representing a communication view of a process function with a number of data objects. For example, a transformer differential - or line differential protection, because the standard defines only a differential protection. Therefore, it is possible to adapt the logical node, which is defined in the standard, as a logical node class. The standard defines methods to describe the actually used logical node as a logical node type which is then based upon the logical node class. This allows all partners to interpret the logical node type information because the description is completely given in the standard. The type description of all logical nodes is part of the Data Type Template (DTT) section in the SCL description file of a station or the IED.

Besides the information about the configuration of the communication facilities, this manual contains the full description of all logical nodes available in the IEDs. The information about the logical nodes and their data objects may be used to identify which signals are available for the functions as described in the technical manual. The link to the technical manual is done in the logical node tables by listing the signal name as given in the function block, or as seen in PCM600 or the LHMI.

2.1.1 Related documentation to IEC 61850

Use the latest revision of the documents listed, unless stated otherwise.

Document ID	Title
IEC 61850-SER Ed1.0 (2013-12-12) - (English)	Communication networks and systems in substations - ALL PARTS
IEC 61850-3 Ed2.0 (2013-12-12) - (English - French)	Communication networks and systems for power utility automation - Part 3: General requirements

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IEC 61850-4 Ed2.0 (2011-04-11) - (English - French)	Communication networks and systems for power utility automation - Part 4: System and project management
IEC 61850-5 Ed2.0 (2013-01-30) - (English - French)	Communication networks and systems for power utility automation - Part 5: Communication requirements for functions and devices models
IEC 61850-6 Ed2.0 (2009-12-17) - (English)	Communication networks and systems for power utility automation - Part 6: Configuration description language for communication in electrical substations related to IEDs
IEC 61850-7-1 Ed2.0 (2011-07-15) - (English - French)	Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models
IEC 61850-7-2 Ed2.0 (2010-08-24) - (English)	Communication networks and systems for power utility automation - Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)
IEC 61850-7-3 Ed2.0 (2010-12-16) - (English - French)	Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes
IEC 61850-7-4 Ed2.0 (2010-03-31) - (English)	Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes
IEC 61850-7-410 Ed2.0 (2012-10-30) - (English - French)	Communication networks and systems for power utility automation - Part 7-410: Basic communication structure - Hydroelectric power plants - Communication for monitoring and control
IEC 61850-7-420 Ed1.0 (2009-03-10) - (English)	Communication networks and systems for power utility automation - Part 7-420: Basic communication structure - Distributed energy resources logical nodes
IEC 61850-8-1 Ed2.0 (2011-06-17) - (English - French)	Communication networks and systems for power utility automation - Part 8-1: Specific Communication Service Mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
IEC 61850-9-2 Ed2.0 (2011-09-22) - (English - French)	Communication networks and systems for power utility automation - Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3

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IEC 61850-10 Ed2.0 (2012-12-14) - (English - French)	Communication networks and systems for power utility automation - Part 10: Conformance testing
IEC 61850 MICS 1MRG021098	IED series version 2.1 Ed2 - MICS: Modelling implementation conformance statement
IEC 61850 PICS 1MRG021052	IED series version 2.1 Ed2 - PICS: Protocol implementation conformance statement
IEC 61850 PIXIT 1MRG021053	IED series version 2.1 Ed2 - PIXIT: Protocol implementation extra information
IEC 61850 TICS 1MRG021051	IED series version 2.1 Ed2 - TICS: Tissue implementation conformance statement

Section 3 Substation Configuration description Language (SCL)

Four different types of SCL files - SCD, CID, IID, and ICD, can be exported from PCM 600.

The SCL language is based on XML. However, detailed knowledge of the XML contents is not needed.

The SCL XML file (ICD/SCD/CID/IID) contains five sections, which are specified in IEC 61850–6 clause 9.

- Header
- Substation section describes the functional structure and its relation to primary devices.
- Communication section describes the connection between the IED access points to the respective subnetwork. and includes also the properties (addresses) of the access points.
- IED section contains a description of the supported communication services, the access point(s) and the IEDs logical devices, logical nodes and their attributes.
- Data type template section contains a declaration of all types used in the SCL file, logical nodes type, DO types, attributes and enums.

The system structure is defined by the organization of the plant structure in PCM600. The signal engineering and the signal routing are IET600 tasks, signal engineering regarding DS, rcb,gcb, GOOSE subscribers can be done also in PCM600. The IED needs to be configured with PCM600 before the system is configured with IET600.

The SCL engineering must be done in an SCL engineering tool. The data sets and the control blocks are logically defined as part of the logical nodes (see IEC 61850–7–2 clause 9). The IED also needs a correctly configured communication section for GOOSE engineering, which can be done in IET600 and PCM600.

The data type templates section provides the correct content description of each logical node type to all tools and users (clients) of the information. Each IED and vendor may have their own logical node type definitions included in the data type template section together with all other logical node types based on the standard.

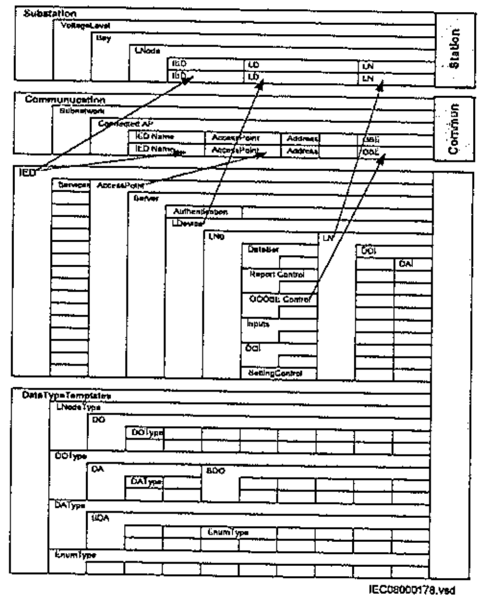

Figure 2: IEC 61850: Principle structure of the SCL XML file

The arrows show the link between the different sections given when an IED is integrated in the substation structure and/or in the communication structure. All needed logical nodes of an IED are linked to the substation section by the SCL tool.

A reference to GOOSE Control Blocks (GoCB) is included in the communication section when GoCB is configured.

3.1 The substation section

The substation description in IEC 61850-6 clause 9 describes the arrangement of the primary equipment. In addition, it also includes a list of the applied logical nodes and the relation of those logical nodes to the primary equipment.

3.2 The communication section

The organization of the physical IEDs to the communication network is independent of the substation structure. The IEC 61850 standard defines the communication network with no relation to an existing media or protocol. The mapping to an existing media and protocol is specified in IEC 61850–8–1.

The IEC 61850 standard describes in part 7–2 the ACSI in a media and protocol independent form. Part 8–1 specifies the mapping of this ACSI to the existing MMS.

The communication section describes how information is routed between the IEDs and contains the following parts:

- Subnetworks
- IEDs connected to different subnetworks
- Access points per IED to subnetworks
- Address
- IP address of LAN network (is exceptionally part of the address elements)
- Link to GoCB message in transmission direction (extended during signal engineering and routing)

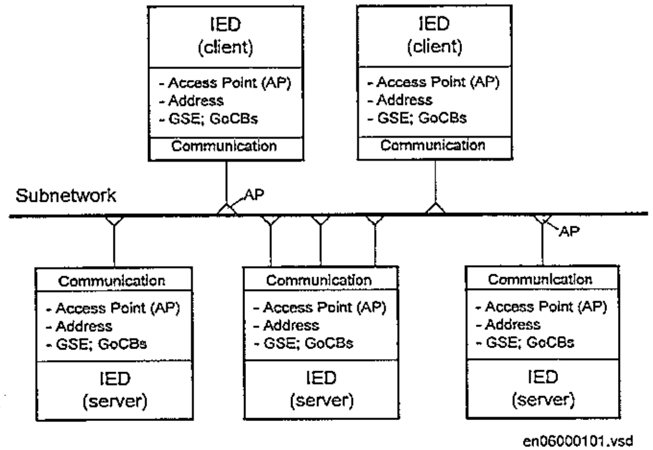

Figure 3: *IEC 61850–6: Communication network*

Additional information about the server is part of the IED.

3.3 The IED section

The IED section describes the complete IED as it is needed for IEC 61850 communication and signal engineering. The data type template part of an IED may be seen as part of the IED, even when separated in its own section. The IED's ICD files include the description of the logical nodes, their data type templates and the used or

supported services. The structure of the IED section follows the definitions made in the IEC 61850 standard.

Two basic IED types are used in system configuration.

- Station level IEDs
  are located on the station level and are identified as client IEDs when they read or write information from or to the bay IEDs. This functionality is represented by logical nodes of group "Information (I)". These are the logical nodes (LN) = ITCI, IHMI and ITMI. Client IEDs are the receiver of information in monitoring direction and sender of commands (control). These logical nodes have no data objects. They are only used to link the report control blocks (BRCBs) from the server IEDs. They have to read their information about the signals and the signal configuration from the bay IEDs. This is possible by checking all control blocks for a link to it as a client.
- Bay level IEDs
  are located on the bay level and are identified as server IEDs when they read or write information vertically. When GOOSE messages are received, the bay level IED also has the client role.

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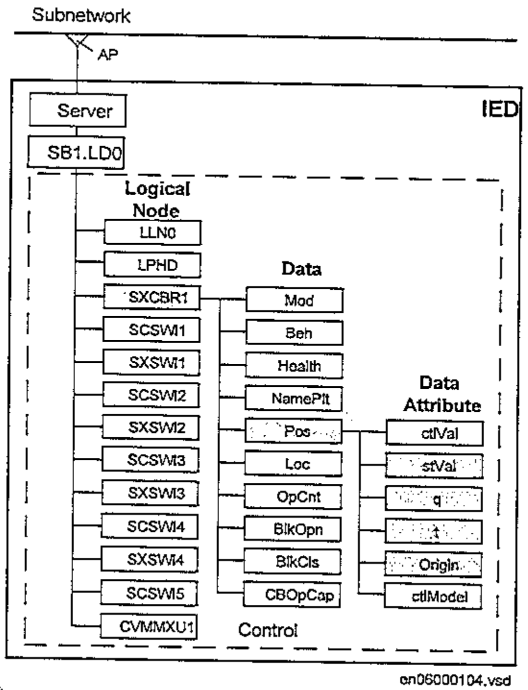

Figure 4: Organization of LDs, LNs, DOs and DAs in an IED

- A server represents the communication interface to the subnetwork (Ethernet).
- One or more logical device(s) (LD) are connected to a server.
- A set of logical nodes belong to a LD.
- The LN LLN0 is a special logical node per LD and contains for example the data sets, the various control blocks, inputs (from GOOSE messages). In the IED series, the data sets and the control blocks shall be located to LD0.
- The LN LPHD is a special logical node per LD and contains data objects that describe the status of the physical device (the IED)
- Each logical node represents a function and contains a number of data objects (DO)
- Each DO includes a number of data attributes (DA)

The data objects represent information signals that may be routed to station level IEDs or to other bay IEDs that are communicating via GOOSE. The signal engineering task is to select the requested signals (DOs) and link them to the client IEDs as receiver. When using a dataset for MMS, the requested signals are DOs but when creating a dataset for GOOSE messaging, DAs are used.

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The number of data objects and data attributes per DO is defined by the used LN type in the IED. The content of logical node types and DO types are defined in the DTT. This also means that the definitions in the DTT section have to be unique within an SCD file.

3.4 Tool concept

The IEC 61850-6 defines a number of roles for tools. In the Relion® series, PCM600 is defined as the IED tool, and IET600 is defined as the system engineering tool.

The sections in SCL contain properties that are to be configured by these tools. There is no relation between one section and one specific tool. The task of the IED tool is to configure all properties for the IED, while the system tool has the task to define the place of the IED in the system and its communication dependencies. For example, the plant structure in PCM600 results in the subsystem section in SCL regarding the subsystem structure down to the IED level. The PCM600 also configures the IED section as a result of the IED configuration. In PCM600, the configuration properties for SCL are handled automatically as a result of the configuration, except for the receiving of GOOSE information that has a dependency with the system tool.

IEC 61850 engineering with PCM600, PCM600 IEC61850 Configuration tool and IET600

PCM600:

- When an IED is instantiated, its place in the plant structure creates the corresponding structure in the substation section in SCL. The communication facilities is also created in the communication section.
- The functionality of the IED is configured by using ACT in PCM600. For each function, the corresponding logical device and logical node(s) is created in the IED section together with its type definition in data type template section
- The above forms the IED capabilities from a communication perspective and will then be included in the file exported from PCM600 as SCD, ICD, IID and CID file

PCM600: IEC61850 Configuration tool

- Included in PCM600 is the new IEC61850 Configuration tool which allows the user to define data sets and control blocks for both Client Server and GOOSE communication.
- The IEC61850 Configuration tool gives the user the possibility to make the IEC61850 engineering without export / import step.

It does NOT however allow the User to define the substation part.

IET600:

- Open a SCD file or import/merge a SCD, ICD or CID file for the particular IED(s).
- For each IED, the user defines the datasets, the control blocks for reporting (this means unbufffered/buffered reporting and GOOSE) and the properties for each report control block.

Data sets (DS) are generated automatically in PCM600. Report control blocks (RCBs) are not generated automatically in PCM600.

- If client definitions (like client. ICD) are required in the system configuration, they are merged into IET600 and connected to the unbuffered/buffered report control blocks.
- Logical nodes, which are not related to the conducting equipment, must be included in the bay level in the substation section.
- The resulting SCD file is exported from IET600.

PCM600:

Define the inputs for the client in IET600 and cross-reference the signals in SMT. Import the SCD file to PCM600 to receive GOOSE data. For each IED that shall receive GOOSE information, the received data is connected to the applications using SMT in PCM600.To be able to import scd-file to PCM600 61850 engineering in PCM must be set to disabled.

If input signals are not defined for clients in IET600, they will not be visible in SMT. Inputs (GOOSE clients) can also be defined in PCM600.

3.5 Engineering concept in IEC 61850-6

- Top-down approach means that the system engineering tool has ICD files available for each IED to be included in the system configuration. The ICD files may be of the template type and represent a pre-configured IED.
- Bottom-up approach means that the configurations are produced by the IED tool, and that are exported as CID, or IID files (or SCD file) to be imported into the system tools.

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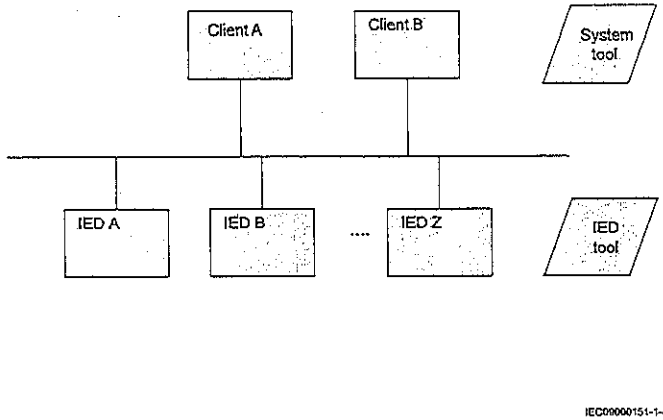

Figure 5: Relation between system and IED tools

Regardless of the engineering approach, the idea is that the IED tool provides the CID, ICD, or IID file for each IED. These ICD/CID/IID files are then imported into the system tool and merged into a SCD file, representing the complete substation or a part of the substation, like one for each voltage level.

Section 4 Communication profile

The IEC 61850 standard is conceptually written to be independent of an existing communication media and message transmission concept. Out of this, a specific communication profile is decided and has been commonly used. The profile contains:

- Ethernet as the media
- TCP/IP
- ISO session and presentation layer
- MMS (Manufacturing Message Specification (ISO 9506-1 and ISO 9506-2)

The IEC 61850 standard describes its requested services in ACSI, which is contained in part 7-2 of the standard. The mapping to the MMS for all aspects of services and Ethernet usage is specified in part 8-1 of IEC 61850.

Each device manufacturer, which is a partner of an IEC 61850 based communication network, has to take these two specifications and adapt their respective product to the requirements and definitions given in the standard. To make this profile visible to all other partners, so they can check what they can expect and what they have to support, the PICS document is defined. The PICS contains in a table based form the possibility of a product or product family.

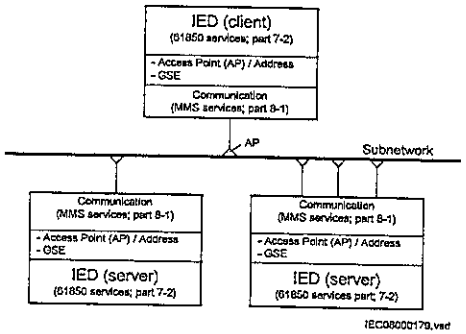

Figure 6: IEC 61850 Protocol: related standards for communication

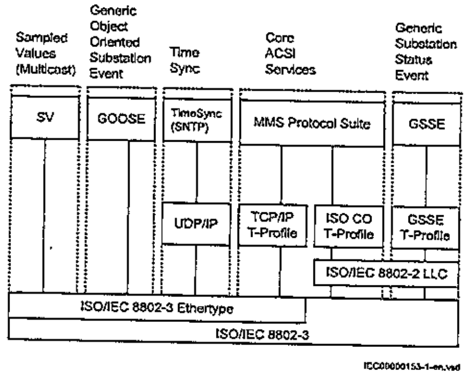

Figure 7: Overview of functionality and profiles according to IEC 61850-8-1

Out of this content, the implementation supports:

- GOOSE
- TimeSync using SNTP
- The peer-to-peer/vertical communication using MMS protocol suite with the T-profile TCP/IP

For each of the above, the resulting underlying protocols as stated in Figure 7.

See the PICS and PIXIT for more information.

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Section 5 Supported services

IEC 61850-7-2 describes the services in the standard. IEC 61850-8-1 describes how the services are applied in the communication. The conformance documents contain the description of the supported services in the IED.

Services that are not mentioned in this chapter or in the conformance document are not supported by the IED.

GOOSE simulation is supported according to IEC 61850 7-2.

If *LD0.PHD.ST.Sim.stVal* is set to true, then incoming GOOSE with test-bit in GOOSE header set is treated as real GOOSE and real GOOSE is discarded starting on first received GOOSE with test-bit set until *LD0.LPHD.ST.Sim.stVal* is rested to false. After that the real GOOSE is active again and GOOSE with test-bit set is discarded.

Data set

Define data sets by the SCD description.

Create data sets under LD0/LLN0.

For more information on data sets, see the PIXIT-related documents.

Substitution

Substitution is supported for the respective DATA, according to IEC 61850-7-4, that have the substitution attributes defined.

Setting group control block

There is only one setting group control block, which is located in LD0/LLN0 (Logical Device0/Logical Node 0).

Change or edit of some setting values as well as reading of setting values is supported in IEC 61850. Note that change/edit of setting over IEC 61850 is only supported when the IED is configured in Edition 2 mode.

In the IED a parameter regarding IEC 61850 settings has to be enabled to allow writing/modifying settings from a IEC 61850 client. The status of output REMSETEN in the function block ACTVGRP in the IED shows whether it is possible or not to change settings over IEC 61850.

The Setting range is expressed in the minVal and maxVal data attributes (DAs) in each setting data object (DO). When writing settings a check will be done to compare the

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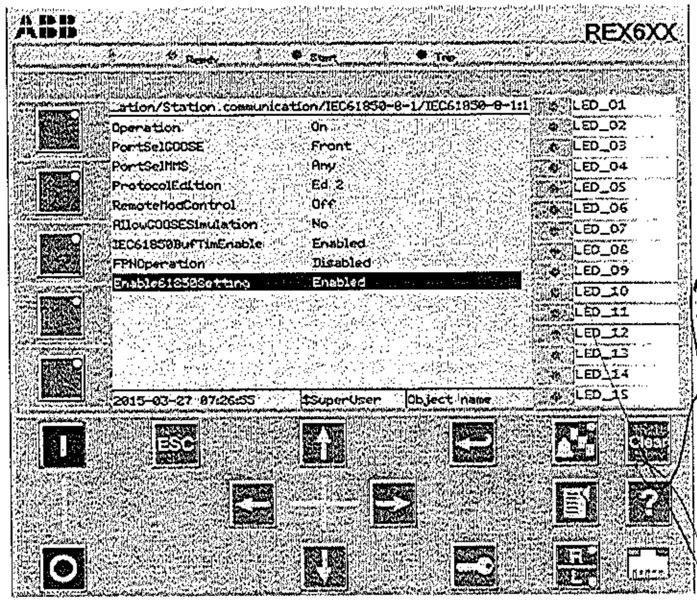
new value with the minVal and maxVal attributes, when applicable (this depends on the data type and if the minVal and maxVal are mapped). So if the minVal and maxVal is not mapped, all values in the range of the data type will be accepted. If the written value is outside the range, Object-Value-Invalid will be returned to the client.

Note that the actual number of used setting groups is defined by the parameter *MaxNoSetGRP* in the function *SETGRPS*, which is configured in PST in PCM600. But six setting groups is the maximum and it cannot be exceeded.

Setting parameter values via IEC 61850 Edition 2

Some parameters values can be set over IEC 61850 Edition 2 communication, provided that the parameter *Enable61850Setting* has been set to *Enabled* in **Main menu/Configuration/Communication/Station communication/IEC61850–8–1/IEC61850–8–1:1/Enable61850Setting** by PCM600 or in the LHMI.



IEC15000002-1-en.vsd

Figure 8: Enabling parameter setting via IEC 61850

Setting parameter values over the communication link doesn't require any authorization if *Enable61850Setting* has been set to *Enabled*.

Write to parameters with functional constraint (FC) = SP

- Issue: *write* to parameter

Writes to parameters where (FC) = SP should not be done while there is an ongoing setting group edit session.

Write to parameters with functional constraint FC = SE

- Issue: *write* to *SelectEditSG(n)*. (n) is the setting group
- Issue: *write* to one or several parameters
- Issue: *write* to *ConfirmEditSG* (*CnfEdit=TRUE*)

If a second *SelectEditSG(n)* is issued where n differs from the actual, any setting changes are discarded and a new edit session is started.

Cancellation of an ongoing edit session. there are two ways to cancel an ongoing edit session:

- Issue: *write* to *ConfirmEditSG* (*CnfEdit=FALSE*)

or

- Issue: *write* to *SelectEditSG(0)*

Reading values where FC = SP

- Issue: *read* from parameter

Report control block

For properties about report control blocks, see PIXIT.

UnBuffered reporting as well as Buffered reporting is supported.

Generic object oriented substation event (GOOSE)

The structured GOOSE is supported. This means that the data sets can be defined with FCDA as well as explicit attributes.

The supported data types to be published and received over GOOSE are binary values, double point values, integer values and measured values, together with their quality. One signal is available inside the application to validate the reception of a GOOSE

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message. Invalid means that the correct GOOSE message is not received prior 2*TAL(Time Allowed to Live).

GOOSE with TAL= 0 ms is treated as GOOSE with TAL = 100 ms and accepted.

Note that the data sets that are used or referred to by GOOSE control blocks can only include a data attribute once. In other words, there may not be the same data attribute in more than one data set.

When publishing a measured value, the user must take care of which measured value data attributes are added to a data set. If the measured value is event-handled (like in the case of MMXU functions), then one can add that value directly to the data set. If the value is not event-handled, (like in the case of Synchrocheck function), it is recommended to connect the value desired to be published to a MVGAPC function block (in ACT) and then use the measured value given by the MVGAPC.

Example of functions that have event-handled measured values (can be added directly to the data set).

- CVMMXN - Measurements
- CMMXU - Phase current measurement
- VMMXU - Phase-phase voltage measurement
- CMSQI - Current sequence component measurement
- VMSQI - Voltage sequence measurement
- VNMMXU - Phase-neutral voltage measurement
- MVGAPC - IEC 61850 generic communication I/ O functions

Generic function blocks are provided to make available to the 61850 bus signals that are not defined inside any of the available function blocks. Example of such functions include:

- SPGAPC - IEC 61850 generic communication I/ O functions
- DPGAPC - IEC 61850 generic communication I/ O functions
- MVGAPC - IEC 61850 generic communication I/ O functions

Control

Of the different control sequences, the 'direct-with-normal-security' and 'SBO-with-enhanced' security are supported (defined by the ctlModel parameter, IEC 61850-7-2).

Check bits: interlock check and synchrocheck check, are only valid for LN types based upon CSWI class.

Verification of Originator Category is supported, see also PIXIT.

GOOSE simulation

Receiving GOOSE simulation is supported according to IEC 61850-7-2.

You can enable the GOOSE-simulation feature in PST or HMI by setting "AllowSimulation" to "Yes" in **Main menu/Configuration/Communication/ Station communication/IEC61850–8–1/IEC61850–8–1:1**. By enabling *...LD0.LPHD1.Sim.stVal*, IEC 61850 is set to "true" and GOOSE simulation activates. From then on, receiving GOOSE with simulation-bit (set in the GOOSE header) is treated as real GOOSE and the original real GOOSE is ignored.

If you switch the simulated GOOSE off, the GOOSE receiver does not automatically switch back to the real original GOOSE. Internal GOOSE data is set to invalid, because the simulated GOOSE is missing. Only if the GOOSE-simulation feature is switched off in PST or HMI by setting "AllowGOOSESimulation" to "No" (*...LD0.LPHD1.Sim.stVal*, IEC 61850 is set to "false"), the real GOOSE becomes active again and simulated GOOSE is ignored.

If the PST setting "AllowGOOSESimulation" is set to "No" (default), all operations to LPHD.Sim data object will be rejected.

Service tracking (available for IEC 61850 Ed2)

The LN ALTRK1 allows to track service parameters. The service parameters will stay visible after the execution of service. For this purpose, common data classes are specified which contain the parameters of the services according to IEC 61850-7-2 Ed2.

These data objects for service tracking are supported:

- **Tracking of services:**
  - SpcTrk: Control service tracking for controllable single point
  - DepTrk: Control service tracking for controllable double point
  - IncTrk: Control service tracking for controllable integer
  - EncTrk1: Control service tracking for enumerated controllable
  - ApcFTrk: Control service tracking for controllable analogue set point with float command
  - ApcIntTrk: Control service tracking for controllable analogue set point with integer command
  - BscTrk: Control service tracking for binary controlled step position information
  - IscTrk: Control service tracking for integer controlled step position information
  - BacTrk: Control service tracking for binary controlled analogue process value
- **Tracking of generic services:**
  - GenTrk: Common service tracking for all services for which no specific tracking data exists.

For supported generic services, see PIXIT.

- **Tracking of control block services:**
  - UrcbTrk: Access service tracking for unbuffered report control block
  - BrcbTrk: Access service tracking for buffered report control block
  - LocbTrk: Access service tracking for log control block
  - GocbTrk: Access service tracking for goose control block
  - SgcbTrk Access service tracking for setting group control block

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Section 6 Data sets and control blocks

6.1 Data sets

IEC 61850 has defined data sets and report control blocks to transmit signals for monitoring purposes. Data sets are also used for GOOSE messages in horizontal communication among IEDs. The project defines the data objects or single data attributes that should be collected in a data set. The following figure shows a data set where all position information of the apparatuses of a bay are put into one data set.

PCM600 will generate default data sets, based on the current ACT configuration. The default data sets can be modified or removed in the engineering tools. No RCBs are created automatically by PCM600. However, the configured IEDs are delivered with RCBs for all default the data sets.

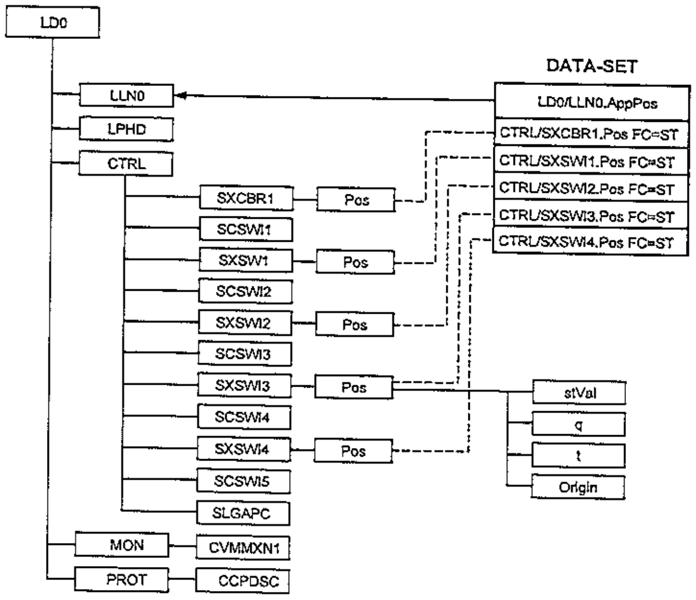

Figure 9: IEC 61850–7–2: Example of a data set for MMS

General rules for data set configuration:

- All data objects or their data attributes can be selected for a data set.
- Only those data attributes of a data object can/will be selected which have the same function constraint (FC).
- Data objects with different FC can be selected for a data set. For example, DOs with FC = ST and DOs with FC=MX can be member in one data set.
- A single data attribute can be selected when it is specified with a trigger option. For example, the data attribute stVal of the data object Pos can be selected as a member of a data set, because it is specified with the trigger option data change detected (dchg).

The description of the data sets with name and the list of data object members (FCDAs is included in the SCL file in the IED section in the Logical device subsection. As specified in IEC 61850–7–2 clause 9, the data sets are part of a logical node. They are most likely included in the LLN0.

6.2 Report control block (URCB/BRCB)

To be able to transmit the signals configured in a DataSet, a report control block must be configured to handle and specify how the events are transmitted to the clients. There are two types of report control blocks; unbuffered and buffered. The buffered report control block stores the events during a communication interrupt, while the unbuffered is sent upon data change and not stored during interruption.

The content of a BRCB is listed in IEC 61850-7-2 in clause 14. The BRCB contains many attributes which are of interest to handle and secure the communication between the client and the server and may be set once as default in a project. Others are of application interest in the way events are handled in a project.

- Buffer time (valid only for BRCB)
  - This parameter describes how long the report should wait for other expected events before it sends the report to the client. When it is known, that additional events are generated as a follow up, it is useful to wait, for example, 500 ms for additional events stored in the report. This feature reduces the number of telegrams transmitted in case of a burst of changes.
- Trigger options
  - The data attributes know three different trigger options (dchg, qchg, dupd). Within the BRCB, the two other can be defined (integrity and general interrogation). The attribute Trigger option is a multiple choice and allows to mask the supported trigger options in this BRCB.
- Integrity period
  - When integrity is selected in the trigger option attribute, it is needed to define an integrity period to force the transmission of all data listed in the DataSet. This is done by the attribute Integrity period. This feature can be

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used as a background cycle to ensure that the process image in all partners is the same.

- General interrogation
  - A general interrogation is only done on request from a client. Not all Data-sets may contain information which is needed for a general update of the client. For example data with T(ransient) = TRUE are not part of a GI. When the BRCB attribute general interrogation is set to TRUE a GI request from the client will be handled. The report handler will transmit all data defined in the Data-set with their actual values. The IEC 61850 standard defines that all buffered events shall be transmitted first before the GI is started. A running GI shall be stopped and a new GI shall be started, when a new GI request is received while a GI is running.
- Purge buffer (valid only for BRCB)
  - This BRCB attribute can be used by a client to clean the event buffer from old events. The events are discarded on request of the client. This feature can be used to delete old events not transmitted to the client due to stopped communication. After the link is reestablished the client can decide to clean the buffer or to receive the history.

Trigger Options

IEC 61850 has defined in total five different TrgOp. Three of them belonging to data attributes and marked per data attribute in the column TrgOp of the CDC tables in part 7–3. The other two belonging to the configuration of control blocks.

- dchg = data-change
  - Whenever a process value has changed its value either binary or a measurement a transmission is done.
- qchg = quality change
  - Looking to the possibilities of the quality data attribute type (q) any changes in the quality description will be transmitted.
- dupd = data value update
  - This trigger option give the possibility to define that a transmission should be done on a condition which can be controlled by the application.
- integrity
  - This trigger forces the transmission of all process values defined in the data set when a timer value (the integrity period) expires.
- general interrogation
  - This trigger is forced by the clients (= station level IED: NCC gateway, station HMI, ...). Normally a GI is asked for, when the client and the server start or restart a session. When the client is able to receive the actual values and when the logical device has scanned all process values at least once, an image of the actual process signal status can be transmitted to the client.

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Note that the possible trigger options for each attribute are included and defined in the datatype template section in SCL.

Link BRCB to a client LN

The BRCB has to know to whom the events shall be transmitted. This is the signal routing engineering step. The IEC standard 61850–6 describes that this is given by including the LN of the client IED in the ReportBlockEnabled option.

The selected client IED with the corresponding LN, for example, ITCI is included in the SCL structure of the Report Control description of the IED section.

The description of the BRCB with selected DataSet, configured parameters and selected IEDs is included in the SCL file in the IED section in the LN0 structure for the LD where this LN0 belongs to.

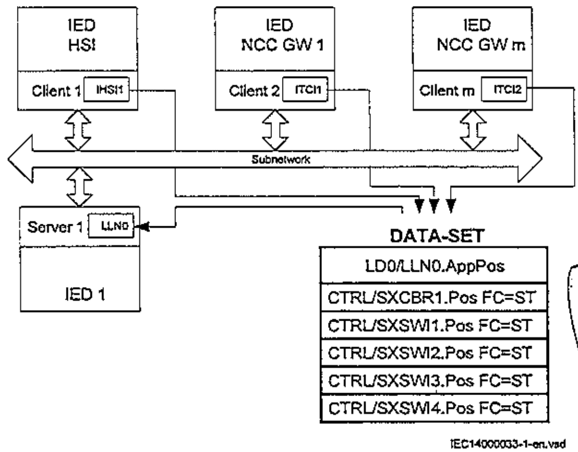

Figure 10: Link BRCB to a client LN

6.3 GOOSE Control Blocks (GoCB)

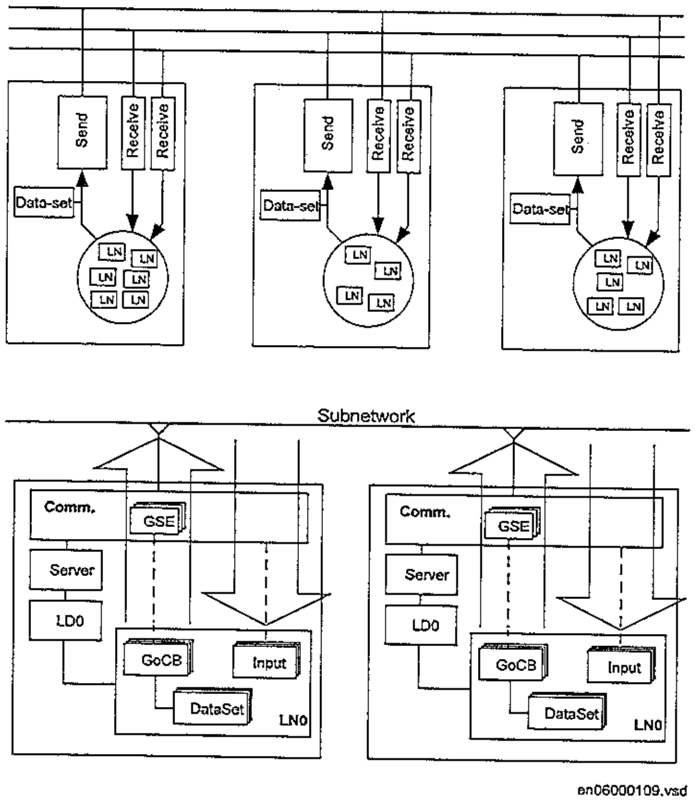

Figure 11: *IEC 61850: Principle operation of GOOSE messages*

The Generic Object Oriented Substation Event (GOOSE) class model is used to distribute input and output data values between IEDs on bay level (in horizontal direction) through the use of multicast services. GOOSE messages enable fast transmission from a publisher to one or several subscribers (receivers).

The GOOSE service model of IEC 61850-7-2 provides the possibility for fast and reliable system-wide distribution of input and output data values. This implementation uses a specific scheme of re-transmission to achieve the appropriate level of reliability. When a GOOSE server generates a SendGOOSEMessage request, the current data set values are encoded in a GOOSE message and transmitted on the

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multicast association. The event that causes the server to invoke a SendGOOSE service is a local application issue as defined in IEC 61850-7-2. Each update may generate a message in order to minimize throughput time.

Additional reliability is achieved by re-transmitting the same data (with gradually increasing SqNum and retransmission time).

T0	retransmission in stable conditions (no event for a long time)
(T0)	retransmission in stable conditions may be shortened by an event
T1	shortest retransmission time after the event
T2, T3	retransmission times until achieving the stable conditions time

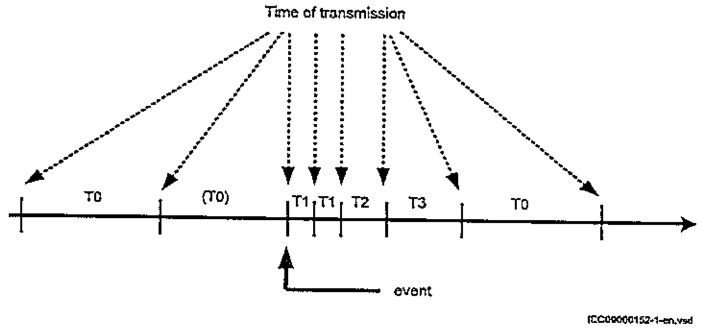

Figure 12: *Transmission time for events*

Each message in the retransmission sequence carries a timeAllowedToLive parameter that informs the receiver of the maximum time to wait for the next re-transmission. If a new message is not received within that time interval, the receiver assumes that the association is lost. The specific intervals used by any GOOSE publisher are a local issue. The timeAllowedtoLive parameter informs subscribers of how long to wait. The detection time of lost GOOSE is 2* timeAllowedToLive in the subscriber. This allows one lost GOOSE message and to cope with possible transmission delays in the network.

The GOOSE message concept is used for all application functions where two or more IEDs are involved. Typical example is the station-wide interlocking procedure or breaker failure protection.

Figure 11 shows the GOOSE concept for three IEDs which interchange GOOSE messages between each other.

To send GOOSE messages a GoCB must be defined and a data set is needed that contains the data objects of single data attributes to be sent.

A GOOSE message is forced to be transmitted when a trigger change is detected for a data attribute. All members of the data set are copied in the send buffer with their actual value and the message is sent. The subscribers, who knows the address of this GOOSE message, receives the telegram. The GOOSE message includes a sequence number to verify that all messages are received.

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Section 7 Logical node data model

The data model used by IEC 61850 is based on logical nodes containing a set of data objects. The data model is defined in the standards.

- IEC 61850-7-4 Compatible logical node classes and data classes
- IEC 61850-7-3 Common data classes

The standard describes only classes of logical nodes and data objects on one side and common data classes for the data object attributes. Also here it is given has the elements in these classes are defined as:

- Mandatory (M)
- Optional (O)
- Conditional optional (Cxxx)
- In addition, the IEC 61850 states rules for adding vendor-specific definitions to the standard, in order to cope with extra functionality.

The possible description of the data model according to the standard allows to adapt a logical node of a LN class to that what the product is supporting or using for this LN. This definition of what parts of a class is used in the actual product and possible addition is called a type, according to IEC 61850-6. There are LN types based upon LN classes. The LN type attributes are called Data Objects (or DATA) and are in of DO types, base upon respective CDC class. This allows all partners in the IEC 61850 project who need this LN to understand the LN in all details for the communication part.

The IEC 61850 standard does not describe the functionality and way of operation. Each supplier has to describe this separately. ABB has described their function blocks that represent a logical node and all other function blocks in the technical manuals. This chapter in the communication protocol manual has two purposes:

- Describe the Logical Node types and their data object attribute types.
- Make the link to the description of the function block.

7.1 Common data objects in each logical node

The IEC 61850 standard describes in part 7-5, a Common Logical Node. The data objects contained in that LN are both mandatory and optional. The mandatory data objects have to be included in each LN. This clause describes the general handling of the data objects in the IEDs.

The mandatory data objects as defined in IEC 61850-7-4 as part of the Common Logical Node are Mode, Behavior, Health and NamePlate. Mod, Health and NamePlate are mandatory only in the root LLN0. and optional in all other LNs.

Mode

Only On and Off are supported on all LNs except for LD0/LLN0, where On, Blocked, Test, and Test-Blocked are supported. Beh can then get all the possible values (On, Blocked, Test, Test-blocked and Off) as a result of Mod on the Root LLN0 and the individual LNs.

The operation modes ON (enabled) and BLOCKED are supported remotely by a command or locally from the LHMI of the IED.

If the setting "RemoteModControl" is set to "Off" (default), all remote writes to Mod will be rejected.

Behaviour

The operational mode as given by the Mode control is shown in the data object Beh according to priority rules described for Beh in clause 6 of IEC 61850-7-4.

The Beh shows the actual state of the function depending on the hierarchy described in clause 6 of IEC 61850-7-4.

It is possible that the behavior is influenced also by other sources independent from the Mod, for example Insertion of the test handle, loss of SV, IED configuration tool (PCM600), or LHMI.

In case the setting "operation" of a function is set to Off from the LHMI or PCM600, the Beh will be set to Off independent of the value of the Mod.

The state Off can be set from the LHMI or the PCM600 for the functions having the setting "operation".

The TEST and the TEST/BLOCKED mode can be operated locally from the LHMI or by using PCM600.

Health

Health will reflect the current status of the IED HW and configuration. Possible values are: OK, Warning, and Alarm.

Health indicates OK, Warning, or Alarm, depending on the IED status.

NamePlt

The name of the logical node and its relation to namespace definition are shown in the data object NamePlt as specified for the SCL structure.

7.2 IEC 61850 data model description Edition 2

The IEC 61850 data model description Edition 2 is delivered in online help format on the IED Connectivity package DVD as part of the product delivery. The latest versions can be downloaded from http://www.abb.com/substationautomation.

7.2.1 Using the online help file

1. Download the online help file from the link below and save the file to your local hard drive.
   - (1MRK 511 357-WEN) for IEC 61850 data model description, Edition 2, 670 series 2.1
   - (1MRK 511 389-WEN) for IEC 61850 data model description, Edition 2, RER670 2.1
2. Double-click the file.
3. Clear the **Always ask before opening this file** check box.
4. Click **Open**.

7.2.2 DO presence condition description

The Logical Node description uses these conditions:

Condition	Description
AtLeastOne	At least one of marked elements shall be present.
M	Element is mandatory.
MFcond	Not yet defined.
Mmulti	At least one element shall be present; all instances have an instance number within range [1, 99] (see Part 7-1).
MOrootLD	Element is mandatory in the context of a root logical device; otherwise it is optional.
O	Element is optional.
Omulti	Zero or more elements may be present; all instances have an instance number within range [1, 99] (see Part 7-1).

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Section 8 Flexible product naming

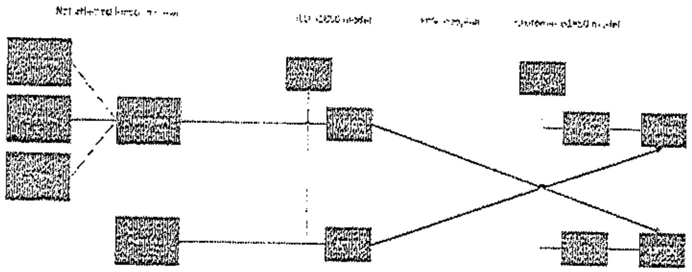
The Flexible Product Naming tool in PCM600 allows the customer to use an IED-vendor independent 61850 model of the IED. This customer model will be exposed in all IEC 61850 communication, but all other aspects of the IED will remain unchanged (e.g., names on the local HMI and names in the tools).

This offers significant flexibility to adapt the IED to the customers system and standard solution.

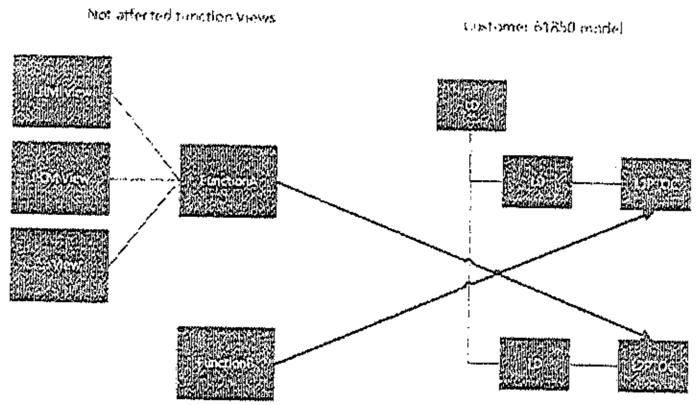
Benefits:

- IEDs uses the customer model for communication.
- Customer specific naming convention for communication can be used.
- Other IEDs and station level equipment can be defined from the customer specific communication model.
- Error tracing of the communication can be the same between different installations.

Mapping example



L1PTOC in the customer model is mapped to APTOC in the IED model and L2PTOC is mapped to BPTOC.



This results in L1PTOC is mapped to FunctionB and L2PTOC is mapped to FunctionA.

8.1.2 Mapping possibilities and requirements

The mapping between the IED model and the customer model provides a set of possibilities but also include some requirements.

The mapping is possible at several levels in the structure:

- Logical Node level (LN to LN)
- Data Object level (DO to DO)
- Data Attribute level (DA to DA).

Custom logical device name (LDName) can be used for addressing.

When the mapping is performed there are some requirements that must be fulfilled between the IED model and the customer model:

- One attribute in the customer model can only be mapped to one attribute in the IED model.
  - However one attribute in the IED model can be mapped to several attributes in the customer model.
- The functional constraint (FC) of the data attributes must match.
- The basic type of the data attributes must match.
- Trigger options of the data attributes must match.
- The version of the IEC 61850 standard must match.
- Number of data sets must not exceed the maximum number of data sets that the IED supports.

There are also some consequences that must be thought about when doing the mapping for example.

- If two DOs in one LN in the customer model are mapped to DOs in different LNs in the IED model the DOs in the customer model might be inconsistent with respect to quality in the case of different operational states of the IED Functions.
- When several LNs in the customer model are mapped to one function in the IED, the Mod of the function will affect all the customer LNs

Several other use cases like this exist. By understanding the concept of mapping from IED functions and IED model to customer model, these cases can be foreseen.

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Section 9 Glossary

9.1 Glossary

AC	Alternating current
ACC	Actual channel
ACT	Application configuration tool within PCM600
A/D converter	Analog-to-digital converter
ADBS	Amplitude deadband supervision
ADM	Analog digital conversion module, with time synchronization
AI	Analog input
ANSI	American National Standards Institute
AR	Autoreclosing
ASCT	Auxiliary summation current transformer
ASD	Adaptive signal detection
ASDU	Application service data unit
AWG	American Wire Gauge standard
BBP	Busbar protection
BFOC/2,5	Bayonet fibre optic connector
BFP	Breaker failure protection
BI	Binary input
BIM	Binary input module
BOM	Binary output module
BOS	Binary outputs status
BR	External bistable relay
BS	British Standards
BSR	Binary signal transfer function, receiver blocks
BST	Binary signal transfer function, transmit blocks
C37.94	IEEE/ANSI protocol used when sending binary signals between IEDs
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication

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CB	Circuit breaker
CBM	Combined backplane module
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations-sponsored standards body within the International Telecommunications Union.
CCM	CAN carrier module
CCVT	Capacitive Coupled Voltage Transformer
Class C	Protection Current Transformer class as per IEEE/ ANSI
CMPPS	Combined megapulses per second
CMT	Communication Management tool in PCM600
CO cycle	Close-open cycle
Codirectional	Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions
COM	Command
COMTRADE	Standard Common Format for Transient Data Exchange format for Disturbance recorder according to IEEE/ANSI C37.111, 1999 / IEC60255-24
Contra-directional	Way of transmitting G.703 over a balanced line. Involves four twisted pairs, two of which are used for transmitting data in both directions and two for transmitting clock signals
COT	Cause of transmission
CPU	Central processing unit
CR	Carrier receive
CRC	Cyclic redundancy check
CROB	Control relay output block
CS	Carrier send
CT	Current transformer
CU	Communication unit
CVT or CCVT	Capacitive voltage transformer
DAR	Delayed autoreclosing
DARPA	Defense Advanced Research Projects Agency (The US developer of the TCP/IP protocol etc.)
DBDL	Dead bus dead line
DBLL	Dead bus live line
DC	Direct current

DFC	Data flow control
DFT	Discrete Fourier transform
DHCP	Dynamic Host Configuration Protocol
DIP-switch	Small switch mounted on a printed circuit board
DI	Digital input
DLLB	Dead line live bus
DNP	Distributed Network Protocol as per IEEE Std 1815-2012
DR	Disturbance recorder
DRAM	Dynamic random access memory
DRH	Disturbance report handler
DSP	Digital signal processor
DTT	Direct transfer trip scheme
EHV network	Extra high voltage network
EIA	Electronic Industries Association
EMC	Electromagnetic compatibility
EMF	Electromotive force
EMI	Electromagnetic interference
EnFP	End fault protection
EPA	Enhanced performance architecture
ESD	Electrostatic discharge
F-SMA	Type of optical fibre connector
FAN	Fault number
FCB	Flow control bit; Frame count bit
FOX 20	Modular 20 channel telecommunication system for speech, data and protection signals
FOX 512/515	Access multiplexer
FOX 6Plus	Compact time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers
FTP	File Transfer Protocol
FUN	Function type
G.703	Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines
GCM	Communication interface module with carrier of GPS receiver module

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GDE	Graphical display editor within PCM600
GI	General interrogation command
GIS	Gas-insulated switchgear
GOOSE	Generic object-oriented substation event
GPS	Global positioning system
GSAL	Generic security application
GSE	Generic substation event
GSM	GPS time synchronization module
GTM	GPS Time Module
HDLC protocol	High-level data link control, protocol based on the HDLC standard
HFBR connector type	Plastic fiber connector
HMI	Human-machine interface
HSAR	High speed autoreclosing
HV	High-voltage
HVDC	High-voltage direct current
ICT	Installation and Commissioning Tool for injection based protection in REG670
IDBS	Integrating deadband supervision
IEC	International Electrical Committee
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
IEC 60870-5-103	Communication standard for protection equipment. A serial master/slave protocol for point-to-point communication
IEC 61850	Substation automation communication standard
IEC 61850–8–1	Communication protocol standard
IEEE	Institute of Electrical and Electronics Engineers
IEEE 802.12	A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable
IEEE P1386.1	PCI Mezzanine Card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common Mezzanine Card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical EMF (Electromotive force).
IEEE 1686	Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities
IED	Intelligent electronic device

I-GIS	Intelligent gas-insulated switchgear
IOM	Binary input/output module
Instance	When several occurrences of the same function are available in the IED, they are referred to as instances of that function. One instance of a function is identical to another of the same kind but has a different number in the IED user interfaces. The word "instance" is sometimes defined as an item of information that is representative of a type. In the same way an instance of a function in the IED is representative of a type of function.
IP	1. Internet protocol. The network layer for the TCP/IP protocol suite widely used on Ethernet networks. IP is a connectionless, best-effort packet-switching protocol. It provides packet routing, fragmentation and reassembly through the data link layer. 2. Ingression protection, according to IEC 60529
IP 20	Ingression protection, according to IEC 60529, level 20
IP 40	Ingression protection, according to IEC 60529, level 40
IP 54	Ingression protection, according to IEC 60529, level 54
IRF	Internal failure signal
IRIG-B:	InterRange Instrumentation Group Time code format B, standard 200
ITU	International Telecommunications Union
LAN	Local area network
LIB 520	High-voltage software module
LCD	Liquid crystal display
LDCM	Line differential communication module
LDD	Local detection device
LED	Light-emitting diode
LNT	LON network tool
LON	Local operating network
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MIM	Milli-ampere module
MPM	Main processing module
MVAL	Value of measurement
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.

NCC	National Control Centre
NOF	Number of grid faults
NUM	Numerical module
OCO cycle	Open-close-open cycle
OCP	Overcurrent protection
OEM	Optical Ethernet module
OLTC	On-load tap changer
OTEV	Disturbance data recording initiated by other event than start/pick-up
OV	Overvoltage
Overreach	A term used to describe how the relay behaves during a fault condition. For example, a distance relay is overreaching when the impedance presented to it is smaller than the apparent impedance to the fault applied to the balance point, that is, the set reach. The relay "sees" the fault but perhaps it should not have seen it.
PCI	Peripheral component interconnect, a local data bus
PCM	Pulse code modulation
PCM600	Protection and control IED manager
PC-MIP	Mezzanine card standard
PMC	PCI Mezzanine card
POR	Permissive overreach
POTT	Permissive overreach transfer trip
Process bus	Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components
PSM	Power supply module
PST	Parameter setting tool within PCM600
PT ratio	Potential transformer or voltage transformer ratio
PUTT	Permissive underreach transfer trip
RASC	Synchrocheck relay, COMBIFLEX
RCA	Relay characteristic angle
RISC	Reduced instruction set computer
RMS value	Root mean square value
RS422	A balanced serial interface for the transmission of digital data in point-to-point connections
RS485	Serial link according to EIA standard RS485
RTC	Real-time clock

RTU	Remote terminal unit
SA	Substation Automation
SBO	Select-before-operate
SC	Switch or push button to close
SCL	Short circuit location
SCS	Station control system
SCADA	Supervision, control and data acquisition
SCT	System configuration tool according to standard IEC 61850
SDU	Service data unit
SLM	Serial communication module.
SMA connector	Subminiature version A, A threaded connector with constant impedance.
SMT	Signal matrix tool within PCM600
SMS	Station monitoring system
SNTP	Simple network time protocol – is used to synchronize computer clocks on local area networks. This reduces the requirement to have accurate hardware clocks in every embedded system in a network. Each embedded node can instead synchronize with a remote clock, providing the required accuracy.
SOF	Status of fault
SPA	Strömberg Protection Acquisition (SPA), a serial master/slave protocol for point-to-point and ring communication.
SRY	Switch for CB ready condition
ST	Switch or push button to trip
Starpoint	Neutral point of transformer or generator
SVC	Static VAr compensation
TC	Trip coil
TCS	Trip circuit supervision
TCP	Transmission control protocol. The most common transport layer protocol used on Ethernet and the Internet.
TCP/IP	Transmission control protocol over Internet Protocol. The de facto standard Ethernet protocols incorporated into 4.2BSD Unix. TCP/IP was developed by DARPA for Internet working and encompasses both network layer and transport layer protocols. While TCP and IP specify two protocols at specific protocol layers, TCP/IP is often used to refer to the entire US Department of Defense protocol suite based upon these, including Telnet, FTP, UDP and RDP.

TEF	Time delayed earth-fault protection function
TLS	Transport Layer Security
TM	Transmit (disturbance data)
TNC connector	Threaded Neill-Concelman, a threaded constant impedance version of a BNC connector
TP	Trip (recorded fault)
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
TRM	Transformer Module. This module transforms currents and voltages taken from the process into levels suitable for further signal processing.
TYP	Type identification
UMT	User management tool
Underreach	A term used to describe how the relay behaves during a fault condition. For example, a distance relay is underreaching when the impedance presented to it is greater than the apparent impedance to the fault applied to the balance point, that is, the set reach. The relay does not "see" the fault but perhaps it should have seen it. See also Overreach.
UTC	Coordinated Universal Time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals. UTC is derived from International Atomic Time (TAI) by the addition of a whole number of "leap seconds" to synchronize it with Universal Time 1 (UT1), thus allowing for the eccentricity of the Earth's orbit, the rotational axis tilt (23.5 degrees), but still showing the Earth's irregular rotation, on which UT1 is based. The Coordinated Universal Time is expressed using a 24-hour clock, and uses the Gregorian calendar. It is used for aeroplane and ship navigation, where it is also sometimes known by the military name, "Zulu time." "Zulu" in the phonetic alphabet stands for "Z", which stands for longitude zero.
UV	Undervoltage
WEI	Weak end infeed logic
VT	Voltage transformer
X.21	A digital signalling interface primarily used for telecom equipment
$3I_O$	Three times zero-sequence current.Often referred to as the residual or the earth-fault current
$3U_O$	Three times the zero sequence voltage. Often referred to as the residual voltage or the neutral point voltage

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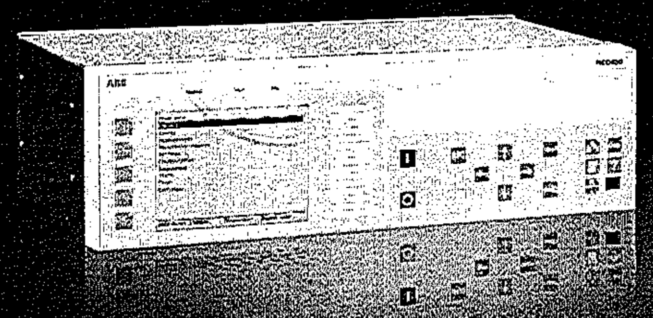

Relion© 650 series

Breaker protection REQ650
Product guide

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1. 650 series overview

Protection for a wide range of applications, control of switching devices with interlocking, and monitoring can be provided in one IED.

The 650 series IEDs provide both customized and configured solutions. With the customized IEDs you have the freedom to completely adapt the functionality according to your needs.

The 650 series IEDs provide optimum 'off-the-shelf', ready-to-use solutions. It is configured with complete protection functionality and default parameters to meet the needs of a wide range of applications for generation, transmission and sub-transmission grids.

The 650 series IEDs include:

- Customized versions providing the possibility to adapt the functionality to the application needs for protection and control in one IED.
- Configured versions solutions are completely ready to use and optimized for a wide range of applications for generation, transmission and sub-transmission grids.
- Support for user-defined names in the local language for signal and function engineering.
- Minimized rule based parameter settings based on default values and ABB's global base value concept. You only need to set those parameters specific to your own installed and activated application.
- GOOSE messaging for horizontal communication on bumpless redundant station bus following IEC62439-3 ed2 PRP.
- Extended HMI functionality with 15 dynamic three-color-indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions.
- Programmable LED text-based labels.
- Settable 1A/5A -rated current inputs.
- Role based access control with independent passwords and FTPS encrypted communication. Managed authentication and accounting of all user activities.

2. Application

The Breaker protection IED provides a standalone solution for applications, where the functions related to the breaker is not preferred or suitable to be integrated into the main protection function that is, the line distance protection for a line. The advanced automatic reclosing, synchronizing, synchrocheck and energizing check functions of the IED provides an optimized stand alone product. This IED also enables well-structured and reliable protection and control systems especially in systems where complete bay control functionality including interlocking is not required. Apparatus control for up to 8 apparatuses with interlocking can be included in one IED by function block engineering.

The IED provides backup to the main protection with redundant protection and control functions.

Three configured packages have been defined for the following applications:

- A01: Backup protection functions in a single busbar single breaker bay with three-phase trip.
- A11: Backup protection functions in a single busbar single breaker bay with single-phase trip.
- B11: Backup protection functions in a double busbar single breaker bay with single-phase trip.

The backup protection is mainly based on current and voltage functions. In line protection applications, autoreclosing with or without synchrocheck is available.

The IED is delivered configured and ready for use in the power system. Analogue inputs and binary inputs/outputs circuits are pre-defined.

The configured IED can be modified and adapted to suit specific applications with PCM600 and the graphical configuration tool ACT for example, using the glue logic and adjusting the parameter settings.

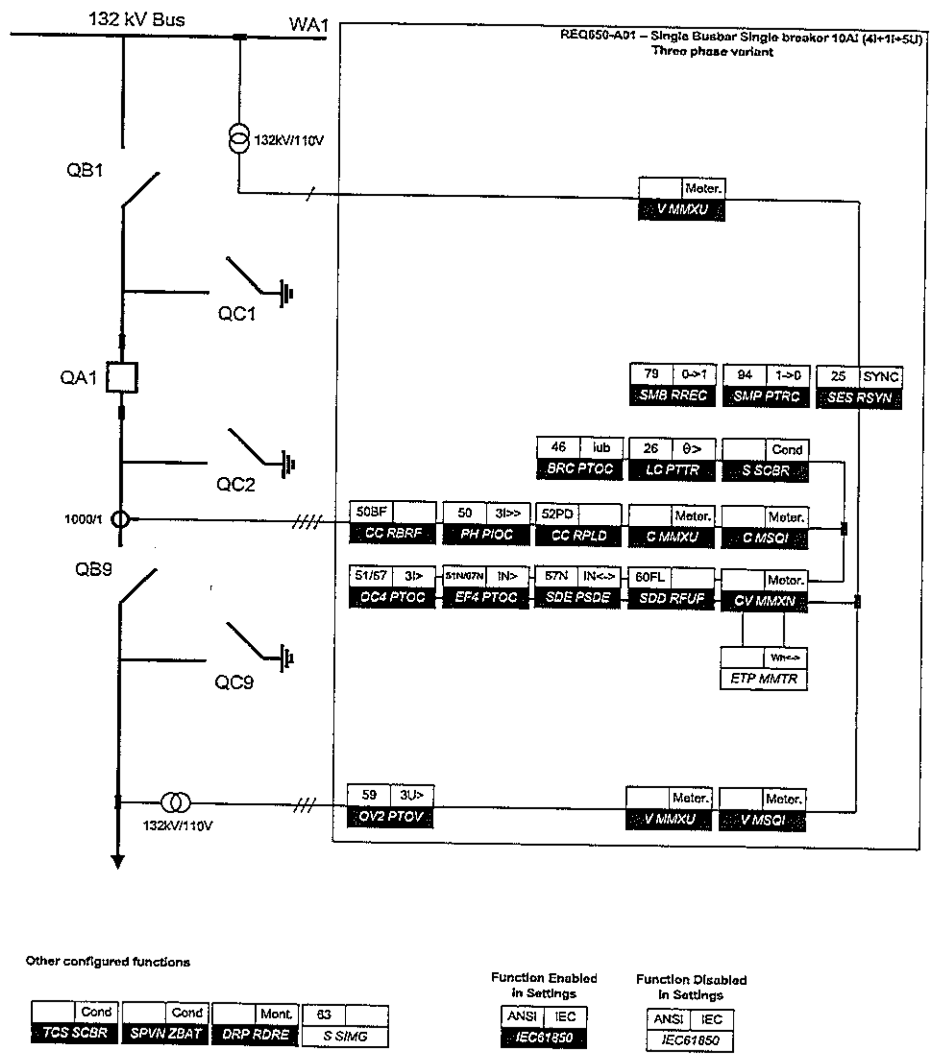

Figure 1. Typical application example of the REQ650 A01 used as backup protection in a single busbar single breaker arrangement when three-phase trip is required

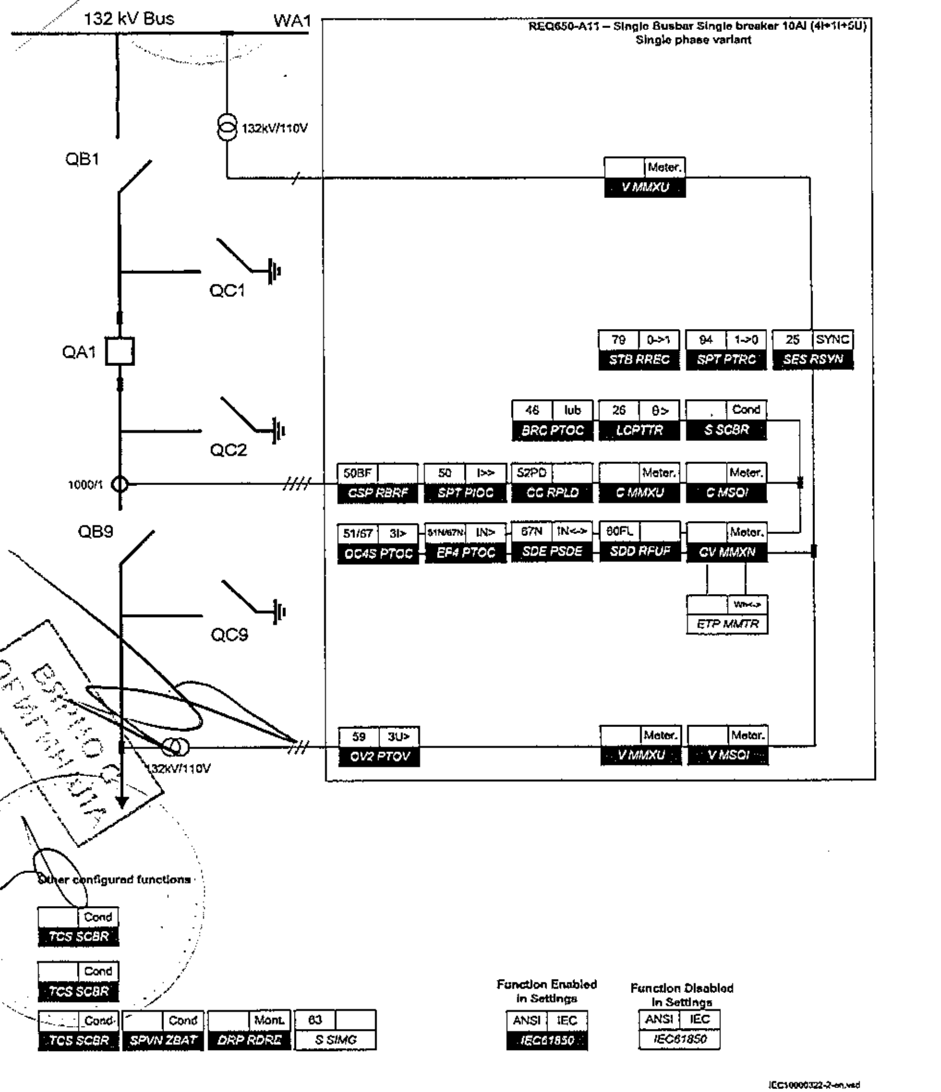

Figure 2. Typical application example of the REQ650 A11 used as backup protection in a single busbar single breaker arrangement when single-phase trip is required

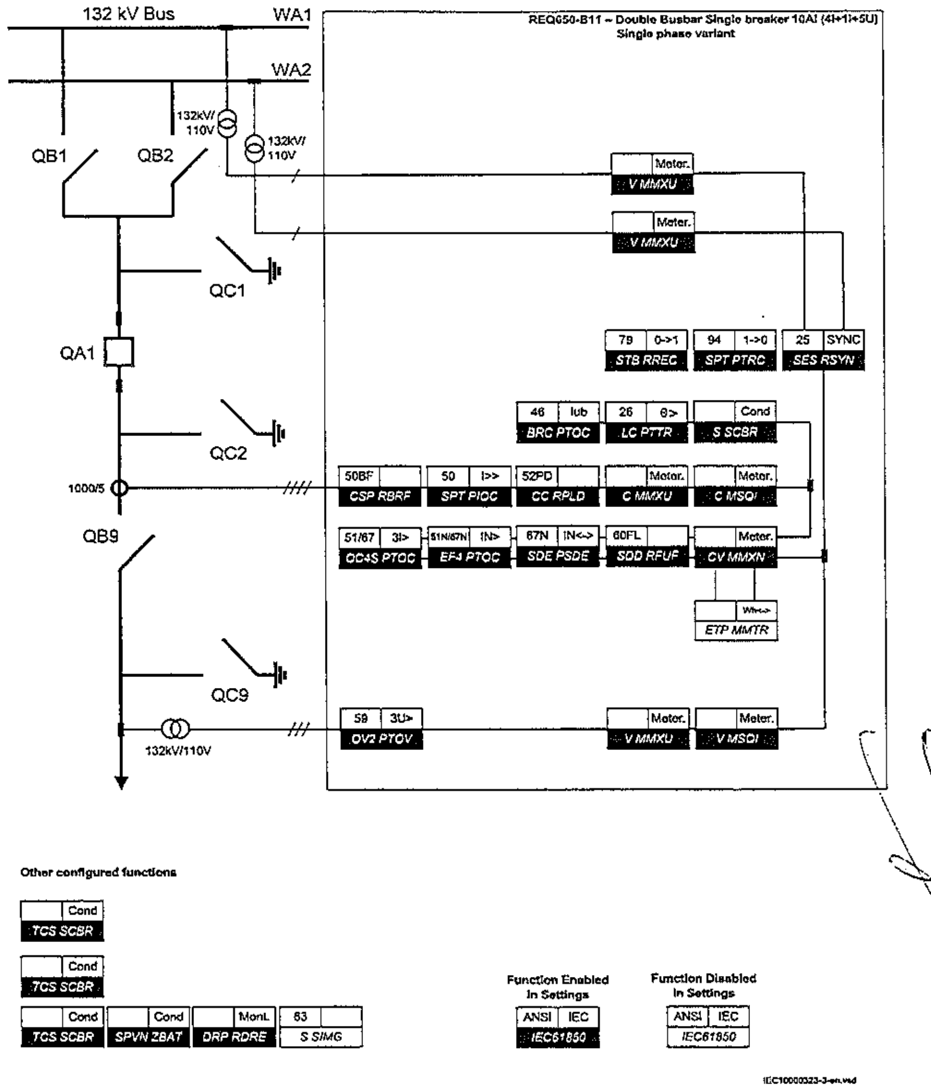

Figure 3. Typical application example of the REQ650 B11 used as backup protection in double busbar single breaker arrangement when single-phase trip is required

3. Available functions

Back-up protection functions

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3Ph/1CB/1BB	REQ650 (A11) 1Ph/1CB/1BB	REQ650 (B11) 1Ph/1CB/2BB
Current protection						
PHPIOC	50	Instantaneous phase overcurrent protection, 3–phase output	0–1	1		
SPTPIOC	50	Instantaneous phase overcurrent protection, phase segregated output	0–1		1	1
OC4PTOC	51/67	Four step phase overcurrent protection, 3-phase output	0–1	1		
OC4SPTOC	51/67	Four step phase overcurrent protection, phase segregated output	0–1		1	1
EFPIOC	50N	Instantaneous residual overcurrent protection	0–1	1	1	1
EF4PTOC	51N/67N	Four step residual overcurrent protection, zero/negative sequence direction	0–1	1	1	1
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection	0–1	1	1	1
LCPTTR	26	Thermal overload protection, one time constant, Celsius	0–1	1	1	1
LFPTTR	26	Thermal overload protection, one time constant, Fahrenheit	0–1	1	1	1
CCRBRF	50BF	Breaker failure protection, 3–phase activation and output	0–1	1		
CSPRBRF	50BF	Breaker failure protection, phase segregated activation and output	0–1		1	1
STBPTOC	50STB	Stub protection	0–1	1	1	1
CCRPLD	52PD	Pole discordance protection	0–1	1	1	1
BRCPTOC	46	Broken conductor check	0–1	1	1	1
GUPPDUP	37	Directional underpower protection	0–1	1	1	1
GOPPDOP	32	Directional overpower protection	0–1	1	1	1
DNSPTOC	46	Negative sequence based overcurrent function	0–1	1	1	1
Voltage protection						
UV2PTUV	27	Two step undervoltage protection	0–1	1	1	1
OV2PTOV	59	Two step overvoltage protection	0–1	1	1	1
ROV2PTOV	59N	Two step residual overvoltage protection	0–1	1	1	1
LOVPTUV	27	Loss of voltage check	0–1	1	1	1
Frequency protection						
SAPTUF	81	Underfrequency function	0–2	2	2	2
SAPTOF	81	Overfrequency function	0–2	2	2	2
SAPFRC	81	Rate-of-change frequency protection	0–2	2	2	2

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Control and monitoring functions

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3Ph/1CB/1BB	REQ650 (A11) 1Ph/1CB/1BB	REQ650 (B11) 1Ph/1CB/2BB
Control						
SESRSYN	25	Synchrocheck, energizing check, and synchronizing	0–1	1	1	1
SMBRREC	79	Autorecloser for 3–phase operation	0–1	1		
STBRREC	79	Autorecloser for 1/3–phase operation	0–1		1	1
SLGGIO		Logic Rotating Switch for function selection and LHMI presentation	15	15	15	15
VSGGIO		Selector mini switch	20	20	20	20
DPGGIO		IEC 61850 generic communication I/O functions double point	16	16	16	16
SPC8GGIO		Single point generic control 8 signals	5	5	5	5
AUTOBITS		AutomationBits, command function for DNP3.0	3	3	3	3
I103CMD		Function commands for IEC60870-5-103	1	1	1	1
I103IEDCMD		IED commands for IEC60870-5-103	1	1	1	1
I103USRCMD		Function commands user defined for IEC60870-5-103	4	4	4	4
I103GENCMD		Function commands generic for IEC60870-5-103	50	50	50	50
I103POSCMD		IED commands with position and select for IEC60870-5-103	50	50	50	50
QCBAY		Bay control	1	1	1	1
LOCREM		Handling of LR-switch positions	1	1	1	1
LOCREMCTRL		LHMI control of Permitted Source To Operate (PSTO)	1	1	1	1
CBC1		Circuit breaker control for 1CB	1	1	1	1
Secondary system supervision						
CCSRDIF	87	Current circuit supervision	0–1	1	1	1
SDDRFUF		Fuse failure supervision	0–1	1	1	1
TCSSCBR		Breaker close/trip circuit monitoring	3	3	3	3
Logic						
SMPPTRC	94	Tripping logic, common 3–phase output	1	1		
SPTPTRC	94	Tripping logic, phase segregated output	1		1	1
TMAGGIO		Trip matrix logic	12	12	12	12
OR		Configurable logic blocks	283	283	283	283
INVERTER		Configurable logic blocks	140	140	140	140
PULSETIMER		Configurable logic blocks	40	40	40	40
GATE		Configurable logic blocks	40	40	40	40
XOR		Configurable logic blocks	40	40	40	40
LOOPDELAY		Configurable logic blocks	40	40	40	40

IEC 61850 or Function name	ANSI	Function description	Breaker REQ650	REQ650 (A01) 3Ph/1CB/1BB	REQ650 (A11) 1Ph/1CB/1BB	REQ650 (B11) 1Ph/1CB/2BB
TIMERSET		Configurable logic blocks	40	40	40	40
AND		Configurable logic blocks	280	280	280	280
SRMEMORY		Configurable logic blocks	40	40	40	40
RSMEMORY		Configurable logic blocks	40	40	40	40
Q/T		Configurable logic blocks Q/T	0–1			
ANDQT		Configurable logic blocks Q/T	0–120			
ORQT		Configurable logic blocks Q/T	0–120			
INVERTERQT		Configurable logic blocks Q/T	0–120			
XORQT		Configurable logic blocks Q/T	0–40			
SRMEMORYQT		Configurable logic blocks Q/T	0–40			
RSMEMORYQT		Configurable logic blocks Q/T	0–40			
TIMERSETQT		Configurable logic blocks Q/T	0–40			
PULSETIMERQT		Configurable logic blocks Q/T	0–40			
INVALIDQT		Configurable logic blocks Q/T	0–12			
INDCOMBSPQT		Configurable logic blocks Q/T	0–20			
INDEXTSPQT		Configurable logic blocks Q/T	0–20			
FXDSIGN		Fixed signal function block	1	1	1	1
B16I		Boolean 16 to Integer conversion	16	16	16	16
B16IFCVI		Boolean 16 to Integer conversion with logic node representation	16	16	16	16
IB16A		Integer to Boolean 16 conversion	16	16	16	16
IB16FCVB		Integer to Boolean 16 conversion with logic node representation	16	16	16	16
TEIGGIO		Elapsed time integrator with limit transgression and overflow supervision	12	12	12	12
Monitoring						
CVMMXN		Measurements	6	6	6	6
CMMXU		Phase current measurement	10	10	10	10
VMMXU		Phase-phase voltage measurement	6	6	6	6
CMSQI		Current sequence component measurement	6	6	6	6
VMSQI		Voltage sequence measurement	6	6	6	6
VNMMXU		Phase-neutral voltage measurement	6	6	6	6
AISVBAS		Function block for service values presentation of the analog inputs	1	1	1	1
TM_P_P2		Function block for service values presentation of primary analog inputs 600TRM	1	1	1	1
AM_P_P4		Function block for service values presentation of primary analog inputs 600AIM	1	1	1	1

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IEC 61850 or Function name	ANSI	Function description	Breaker REQ650	REQ650 (A01) 3Ph/1CB/1BB	REQ650 (A11) 1Ph/1CB/1BB	REQ650 (B11) 1Ph/1CB/2BB
TM_S_P2		Function block for service values presentation of secondary analog inputs 600TRM	1	1	1	1
AM_S_P4		Function block for service values presentation of secondary analog inputs 600AIM	1	1	1	1
CNTGGIO		Event counter	5	5	5	5
L4UFCNT		Event counter with limit supervision	12	12	12	12
DRPRDRE		Disturbance report	1	1	1	1
AnRADR		Analog input signals	4	4	4	4
BnRBDR		Binary input signals	6	6	6	6
SPGGIO		IEC 61850 generic communication I/O functions	64	64	64	64
SP16GGIO		IEC 61850 generic communication I/O functions 16 inputs	16	16	16	16
MVGGIO		IEC 61850 generic communication I/O functions	16	16	16	16
MVEXP		Measured value expander block	66	66	66	66
SPVNZBAT		Station battery supervision	0–1	1	1	1
SSIMG	63	Insulation gas monitoring function	0–1	1	1	1
SSIML	71	Insulation liquid monitoring function	0–1	1	1	1
SSCBR		Circuit breaker condition monitoring	0–1	1	1	1
I103MEAS		Measurands for IEC60870-5-103	1	1	1	1
I103MEASUSR		Measurands user defined signals for IEC60870-5-103	3	3	3	3
I103AR		Function status auto-recloser for IEC60870-5-103	1	1	1	1
I103EF		Function status earth-fault for IEC60870-5-103	1	1	1	1
I103FLTPROT		Function status fault protection for IEC60870-5-103	1	1	1	1
I103IED		IED status for IEC60870-5-103	1	1	1	1
I103SUPERV		Supervison status for IEC60870-5-103	1	1	1	1
I103USRDEF		Status for user defined signals for IEC60870-5-103	20	20	20	20
Metering						
PCGGIO		Pulse counter	16	16	16	16
ETPMMTR		Function for energy calculation and demand handling	3	3	3	3

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Station communication

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3Ph/1CB/1BB	REQ650 (A11) 1Ph/1CB/1BB	REQ650 (B11) 1Ph/1CB/2BB
Station communication						
IEC61850-8-1		IEC 61850 communication protocol	1	1	1	1
DNPGEN		DNP3.0 communication general protocol	1	1	1	1
RS485DNP		DNP3.0 for RS-485 communication protocol	1	1	1	1
CH1TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH2TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH3TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
CH4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
OPTICALDNP		DNP3.0 for optical RS-232 communication protocol	1	1	1	1
MSTSERIAL		DNP3.0 for serial communication protocol	1	1	1	1
MST1TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST2TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST3TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
MST4TCP		DNP3.0 for TCP/IP communication protocol	1	1	1	1
RS485GEN		RS485	1	1	1	1
OPTICALPROT		Operation selection for optical serial	1	1	1	1
RS485PROT		Operation selection for RS485	1	1	1	1
DNPFREC		DNP3.0 fault records for TCP/IP communication protocol	1	1	1	1
OPTICAL103		IEC60870-5-103 Optical serial communication	1	1	1	1
RS485103		IEC60870-5-103 serial communication for RS485	1	1	1	1
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking	59	59	59	59
GOOSEBINRCV		GOOSE binary receive	4	4	4	4
ETHFRNT ETHLAN1 GATEWAY		Ethernet configuration of front port, LAN1 port and gateway	1	1	1	1
ETHLAN1_AB		Ethernet configuration of LAN1 port	1			
PRPSTATUS		System component for parallell redundancy protocol	1			
CONFPROT		IED Configuration Protocol	1	1	1	1
ACTIVLOG		Activity logging parameters	1	1	1	1
SECALARM		Component for mapping security events on protocols such as DNP3 and IEC103	1	1	1	1
AGSAL		Generic security application component	1	1	1	1
GOOSEDPRCV		GOOSE function block to receive a double point value	32	32	32	32

IEC 61850 or Function name	ANSI	Function description	Breaker			
			REQ650	REQ650 (A01) 3Ph/1CB/1BB	REQ650 (A11) 1Ph/1CB/1BB	REQ650 (B11) 1Ph/1CB/2BB
GOOSEINTRCV		GOOSE function block to receive an integer value	32	32	32	32
GOOSEMVRCV		GOOSE function block to receive a measurand value	16	16	16	16
GOOSESPRCV		GOOSE function block to receive a single point value	64	64	64	64

Basic IED functions

IEC 61850/Function block name	Function description	
Basic functions included in all products		
INTERRSIG	Self supervision with internal event list	1
SELFSUPEVLST	Self supervision with internal event list	1
TIMESYNCHGEN	Time synchronization	1
SNTP	Time synchronization	1
DTSBEGIN, DTSEND, TIMEZONE	Time synchronization, daylight saving	1
IRIG-B	Time synchronization	1
SETGRPS	Setting group handling	1
ACTVGRP	Parameter setting groups	1
TESTMODE	Test mode functionality	1
CHNGLCK	Change lock function	1
PRIMVAL	Primary system values	1
SMAI_20_1 - SMAI_20_12	Signal matrix for analog inputs	2
3PHSUM	Summation block 3 phase	12
GBASVAL	Global base values for settings	6
ATHSTAT	Authority status	1
ATHCHCK	Authority check	1
AUTHMAN	Authority management	1
FTPACCS	FTPS access with password	1
DOSFRNT	Denial of service, frame rate control for front port	1
DOSLAN1	Denial of service, frame rate control for LAN1A and LAN1B ports	1
DOSSCKT	Denial of service, socket flow control	1

4. Current protection

Instantaneous phase overcurrent protection, 3-phase output 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.

Instantaneous phase overcurrent protection, phase segregated output SPTPIOC
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 and where the requirement for tripping is one- and/or three-phase.

Four step phase overcurrent protection, 3-phase output 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.

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

Four step phase overcurrent protection, phase segregated output OC4SPTOC
The four step phase overcurrent function, phase segregated output OC4SPTOC has an inverse or definite time delay independent for each step separately.

All IEC and ANSI time delayed characteristics are available.

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.

The tripping can be configured for one- and/or three-phase.

Instantaneous residual overcurrent protection EFPIOC
The instantaneous residual overcurrent protection EFPIOC has a low transient overreach and short tripping times to allow the use for instantaneous earth-fault protection, with the reach limited to less than the typical eighty percent of the line at minimum source impedance. EFPIOC is configured to measure the residual current from the three-phase current inputs and can be configured to measure the current from a separate current input. 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, zero or negative sequence direction (EF4PTOC) has a settable 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.

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

The directional part of the function can be set to operate on following combinations:

- Directional current (I3PDir) versus Polarizing voltage (U3PPol)
- Directional current (I3PDir) versus Polarizing current (I3PPol)
- Directional current (I3PDir) versus Dual polarizing (UPol+ZPol x IPol) where ZPol = RPol + jXPol

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

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

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, $3I_0 \cdot \cos\varphi$ or $3I_0 \cdot \varphi$, or residual power component $3U_0 \cdot 3I_0 \cdot \cos\varphi$, for operating quantity. There is also available one non-directional $3I_0$ step and one non-directional $3U_0$ overvoltage tripping step.

Thermal overload protection, one time constant
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. The temperature is displayed in either in Celsius or in Fahrenheit depending on whether the function used is Thermal overload protection one time constant, Celsius LCPTTR or Fahrenheit LFPTTR.

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

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

Breaker failure protection CCRBRF, 3-phase activation and output
CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Breaker failure protection, 3-phase activation and output (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.

Breaker failure protection, 3-phase activation and output (CCRBRF) current criteria can be fulfilled by one or two phase currents the residual current, or one phase current plus residual current. When those currents exceed the user defined settings, the function is triggered. These conditions increase the security of the back-up trip command.

CCRBRF function can be programmed to give a three-phase re-trip of the own breaker to avoid inadvertent tripping of surrounding breakers.

Breaker failure protection, phase segregated activation and output
Breaker failure protection, phase segregated activation and output CSPRBRF ensures fast back-up tripping of surrounding breakers in case of own breaker failure to open. CSPRBRF can be current based, contact based, or adaptive combination between these two principles.

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

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

CSPRBRF function current criteria can be fulfilled by one or two phase currents, or one phase current plus residual current. When those currents exceed the user defined settings, the function is activated. These conditions increase the security of the back-up trip command.

CSPRBRF can be programmed to give a single- or three-phase re-trip of the own breaker to avoid inadvertent 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 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
Circuit breakers and disconnectors can end up with the phases in different positions (close-open), due to electrical or mechanical failures. An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

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

The pole discordance function operates based on information from the circuit breaker logic with additional criteria from phase selective current unsymmetry.

Broken conductor check BRCPTOC
Conventional protection functions can not detect the broken conductor condition. Broken conductor check BRCPTOC function, consisting of continuous phase selective current unsymmetrical check on the line where the IED is connected will give alarm or trip at detecting broken conductors.

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.

Negative sequence based overcurrent function DNSPTOC
Negative sequence based overcurrent function DNSPTOC is typically used as sensitive earth-fault protection of power lines, where incorrect zero sequence polarization may result from mutual induction between two or more parallel lines.

Additionally, it is applied in applications on cables, where zero sequence impedance depends on the fault current return paths, but the cable negative sequence impedance is practically constant.

The directional function is current and voltage polarized. The function can be set to forward, reverse or non-directional independently for each step. Both steps are provided with a settable definite time delay.

DNSPTOC protects against all unbalanced faults including phase-to-phase faults. The minimum start current of the function must be set to above the normal system unbalance level in order to avoid unwanted operation.

5. 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, where step 1 is settable as inverse or definite time delayed. Step 2 is always definite time delayed.

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

Two step overvoltage protection OV2PTOV
Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, and open line ends on long lines.

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

OV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

OV2PTOV has a 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, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

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

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

6. Frequency protection

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

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

SAPTUF is provided with undervoltage blocking.

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

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

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

SAPTOF is provided with an undervoltage blocking.

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

SAPFRC is provided with an undervoltage blocking.

7. 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 inadvertent 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 inadvertent operations that otherwise might occur.

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

The negative sequence detection 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 negative sequence voltage $3U_2$ without the presence of the negative-sequence current $3I_2$.

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

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.

Breaker close/trip circuit monitoring TCSSCBR
The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The trip circuit supervision generates a current of approximately 1 mA through the supervised control circuit. The validity supervision of a control circuit is provided for power output contacts T1, T2 and T3.

The trip circuit supervision operates after a settable definite operating time and resets after a settable definite time when the fault disappears.

8. 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. The synchronizing function evaluates voltage difference, phase angle difference, slip frequency and frequency rate of change before issuing a controlled closing of the circuit breaker. Breaker closing time is a parameter setting.

Autorecloser for 3-phase operation SMBRREC
The autorecloser SMBRREC function provides high-speed and/or delayed auto-reclosing for single breaker applications.

Up to five three-phase reclosing attempts can be included by parameter setting.

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

Autorecloser for 1/3-phase operation STBRREC
The autoreclosing function provides high-speed and/or delayed auto-reclosing for single breaker applications.

Up to five reclosing attempts can be included by parameter setting. The first attempt can be single- 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.

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

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

Each control IED has interlocking functions for different switchyard arrangements, each handling the interlocking of one bay. The interlocking functionality in each IED is not dependent on any central function. For the station-wide interlocking, the IEDs communicate via the station bus or by using hard wired binary inputs/outputs.

The interlocking conditions depend on the primary bus configuration and status of any breaker or switch at any given time.

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

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

Circuit breaker control for circuit breaker. CBC1
The CBC1 consists of 3 functions:

- SCILO - The Logical node for interlocking. SCILO function contains the logic to enable a switching operation, and provides the information to SCSWI wether it is permitted to operate due to actual switchyard topology. The interlocking conditions are generated in separate function blocks containing the interlocking logic.
- SCSWI - The Switch controller initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one-three-phase device.
- SXCBR - The circuit breaker controller SXCBR provides the actual position status and pass the commands to the primary circuit breaker and supervises the switching operation and positions.

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 an enhanced selector switch functionality compared to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The 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 using IEC61850. 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. The commands can be pulsed or steady with a settable pulse time.

AutomationBits AUTOBITS
The Automation bits function AUTOBITS is used to configure the DNP3 protocol command handling. Each of the 3 AUTOBITS available has 32 individual outputs available, each can be mapped as a binary output point in DNP3.

Function commands for IEC60870-5-103, I103CMD, I103IEDCMD, I103URSCMD, I103GENCMD, I103POSCMD
IEC60870-5-103 function and command logic blocks are available for configuration of the IED. The output signals are predefined or user defined depending on selected function block.

9. Logic

Tripping logic common 3-phase output 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 three-phase 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 breaker lock-out.

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Tripping logic phase segregated output SPTPTRC
A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides the settable pulse prolongation to ensure an one- or three-phase trip pulse of sufficient length, as well as all functionality necessary for correct cooperation with autoreclosing and communication logic functions.

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

Trip matrix logic TMAGGIO
The 12 Trip matrix logic TMAGGIO function each with 32 inputs are used to route trip signals and other logical output signals to the tripping logics SMPPTRC and SPTPTRC or to different output contacts on the IED.

TMAGGIO 3 output signals and the physical outputs allows the user to adapt the signals to the physical tripping outputs according to the specific application needs for settable pulse or steady output.

Configurable logic blocks
A number of logic blocks and timers are available for the user to adapt the configuration to the specific application needs.

- OR function block. Each block has 6 inputs and two outputs where one is inverted.
- INVERTER function blocks that inverts the input signal.
- PULSETIMER function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- GATE function block is used for whether or not a signal should be able to pass from the input to the output.
- XOR function block. Each block has two outputs where one is inverted.
- LOOPDELAY function block used to delay the output signal one execution cycle.
- TIMERSET function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay and must be On for the input signal to activate the output with the appropriate time delay.
- AND function block. Each block has four inputs and two outputs where one is inverted
- SRMEMORY function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The SET input has priority if both SET and RESET inputs are operated simultaneously.
- RSMEMORY function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block's output should reset or return to the state it was, after a power interruption. The RESET input has priority if both SET and RESET are operated simultaneously.

Configurable logic Q/T
A number of logic blocks and timers, with the capability to propagate timestamp and quality of the input signals, are available. The function blocks assist the user to adapt the IEDs configuration to the specific application needs.

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

- INDCOMBSPQT combines single input signals to group signal. Single position input is copied to value part of SP_OUT output. TIME input is copied to time part of SP_OUT output. Quality input bits are copied to the corresponding quality part of SP_OUT output.
- INDEXTSPQT extracts individual signals from a group signal input. Value part of single position input is copied to SI_OUT output. Time part of single position input is copied to TIME output. Quality bits in common part and indication part of inputs signal is copied to the corresponding quality output.

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

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

Boolean 16 to Integer conversion with logic node representation B16IFCVI
Boolean 16 to integer conversion with logic node representation function B16IFCVI is used to transform a set of 16 binary (logical) signals into an integer. The block input will freeze the output at the last value.

Integer to Boolean 16 conversion IB16A
Integer to boolean 16 conversion function IB16A is used to transform an integer into a set of 16 binary (logical) signals.

Integer to Boolean 16 conversion with logic node representation IB16FCVB
Integer to boolean conversion with logic node representation function IB16FCVB is used to transform an integer to 16 binary (logic) signals.

- IB16FCVB function can receive remote values over IEC61850 when the operator position input PSTO is in position remote. The block input will freeze the output at the last value.

Elapsed time integrator with limit transgression and overflow supervision TEIGGIO
The function TEIGGIO is used for user defined logics and it can also be used for different purposes internally in the IED . An application example is the integration of elapsed time during the measurement of neutral point voltage or neutral current at earth fault conditions.

Settable time limits for warning and alarm are provided. The time limit for overflow indication is fixed.

10. Monitoring

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 function 16 inputs SP16GGIO
IEC 61850 generic communication I/O functions 16 inputs SP16GGIO function is used to send up to 16 logical signals to other systems or equipment in the substation.

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
- current sequence components
- voltage sequence components

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

Event counter with limit supervison L4UFCNT
The 12 Up limit counter L4UFCNT provides a settable counter with four independent limits where the number of positive and/or negative flanks on the input signal are counted against the setting values for limits. The output for each limit is activated when the counted value reaches that limit.

Overflow indication is included for each up-counter.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance recorder function (maximum 40 analog and 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 9,9 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.

Measured value expander block MVEXP
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 MVEXP has been introduced to

enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

Station battery supervision SPVNZBAT
The station battery supervision function SPVNZBAT is used for monitoring battery terminal voltage.

SPVNZBAT activates the start and alarm outputs when the battery terminal voltage exceeds the set upper limit or drops below the set lower limit. A time delay for the overvoltage and undervoltage alarms can be set according to definite time characteristics.

SPVNZBAT operates after a settable operate time and resets when the battery undervoltage or overvoltage condition disappears after settable reset time.

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

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

Circuit breaker monitoring SSCBR
The circuit breaker condition monitoring function SSCBR is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of I^2t values. Alarms are generated when the calculated values exceed the threshold settings.

The function contains a block alarm functionality.

The supervised and presented breaker functions include
- breaker open and close travel time
- spring charging time
- number of breaker operations
- accumulated I^2t per phase with alarm and lockout
- remaining breaker life per phase
- breaker inactivity

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11. 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 BIO (binary input/output) module and then read by the PCGGIO function. A scaled service value is available over the station bus.

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.

12. Human Machine Interface

Local HMI

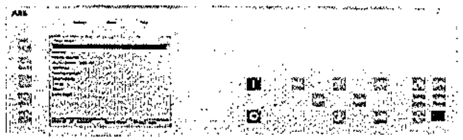

Figure 4. Local human-machine interface

The LHMI of the IED contains the following elements:
- Display (LCD)
- Buttons
- LED indicators
- Communication port for PCM600

The LHMI is used for setting, monitoring and controlling.

The Local human machine interface, LHMI includes a graphical monochrome LCD with a resolution of 320x240 pixels. The character size may vary depending on selected language. The amount of characters and rows fitting the view depends on the character size and the view that is shown.

The LHMI is simple and easy to understand. The whole front plate is divided into zones, each with a well-defined functionality:

- Status indication LEDs
- Alarm indication LEDs which can indicate three states with the colors green, yellow and red, with user defined and also printable label. All LEDs are configurable from the PCM600 tool
- Liquid crystal display (LCD)

- Keypad with push buttons for control and navigation purposes, switch for selection between local and remote control and reset
- Five user programmable function buttons
- An isolated RJ45 communication port for PCM600

13. Basic IED functions

Self supervision with internal event list
The Self supervision with internal event list INTERRSIG and SELFSUPEVLST function reacts to internal system events generated by the different built-in self-supervision elements. The internal events are saved in an internal event list presented on the LHMI and in PCM600 event viewer tool.

Time synchronization
Use a common global source for example GPS time synchronization inside each substation as well as inside the area of the utility responsibility to achieve a common time base for the IEDs in a protection and control system. This makes comparison and analysis of events and disturbance data between all IEDs in the power system possible.

Time-tagging of internal events and disturbances are an excellent help when evaluating faults. Without time synchronization, only the events within the IED can be compared to one another. With time synchronization, events and disturbances within the entire station, and even between line ends, can be compared during evaluation.

In the IED, the internal time can be synchronized from a number of sources:

- SNTP
- IRIG-B
- DNP
- IEC60870-5-103

Parameter setting groups ACTVGRP
Use the four different groups of settings to optimize the IED operation for different power system conditions. Creating and switching between fine-tuned setting sets, either from the local HMI or configurable binary inputs, results in a highly adaptable IED that can be applied to a variety of power system scenarios.

Test mode functionality TESTMODE
The protection and control IEDs may have many included functions. To make the testing procedure easier, the IEDs include the feature that allows individual blocking of all functions except the function(s) the shall be tested.

There are two ways of entering the test mode:

- By configuration, activating an input signal of the function block TESTMODE
- By setting the IED in test mode in the local HMI

While the IED is in test mode, all protection functions are blocked.

Any function can be unblocked individually regarding functionality and event signaling. This enables the user to follow the operation of one or several related functions to check functionality and to check parts of the configuration, and so on.

Forcing of binary outputs, wether from the LHMI or from the PCM600 is only possible when the IED is in test mode.

Change lock function CHNGLCK
Change lock function CHNGLCK is used to block further changes to the IED configuration and settings once the commissioning is complete. The purpose is to block inadvertent IED configuration changes beyond a certain point in time.

The change lock function activation is normally connected to a binary input.

Authorization
The user categories and roles with user rights as defined by IEC 62359-8 for role based access control are pre-defined in the IED.

The IED users can be created, deleted and edited only with PCM600.

Password policies are set in the PCM600 IED user management tool.

At delivery, the IED user has full access as SuperUser until users are created with PCM600.

Authority status ATHSTAT
Authority status ATHSTAT function is an indication function block for user log-on activity.

User denied attempt to log-on and user successful log-on are reported.

Authority check ATHCHCK
To safeguard the interests of our customers, both the IED and the tools that are accessing the IED are protected, by means of authorization handling. The authorization handling of the IED and the PCM600 is implemented at both access points to the IED:

- local, through the local HMI
- remote, through the communication ports

The IED users can be created, deleted and edited only with PCM600 IED user management tool.

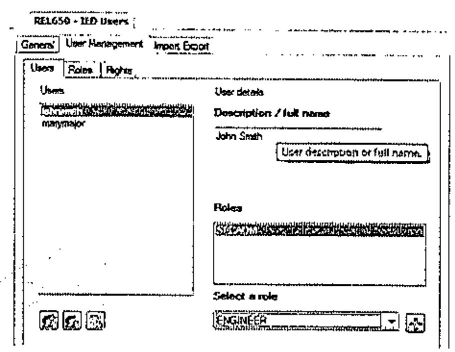

Figure 5. PCM600 user management tool

AUTHMAN
This function enables/disables the maintenance menu. It also controls the maintenance menu log on time out.

FTP access with SSL FTPACCS
The FTP Client defaults to the best possible security mode when trying to negotiate with SSL.

The automatic negotiation mode acts on port number and server features. It tries to immediately activate implicit SSL if the specified port is 990. If the specified port is any other, it tries to negotiate with explicit SSL via AUTH SSL/TLS.

Using FTP without SSL encryption gives the FTP client reduced capabilities. This mode is only for accessing disturbance recorder data from the IED.

Normal FTP is required to read out disturbance recordings, create a specific account for this purpose with rights only to do File transfer. The password of this user will be exposed in clear text on the wire.

Generic security application AGSAL
As a logical node AGSAL is used for monitoring security violation regarding authorization, access control and inactive association including authorization failure. Therefore, all the information in AGSAL can be configured to report to 61850 client.

Activity logging ACTIVLOG
ACTIVLOG contains all settings for activity logging.

There can be 6 external log servers to send syslog events to. Each server can be configured with IP address; IP port number and protocol format. The format can be either syslog (RFC 5424) or Common Event Format (CEF) from ArcSight.

Security alarm SECALARM
The function creates and distributes security events for mapping the security events on protocols such as DNP3.

It is possible to map respective protocol to the signals of interest and configure them for monitoring with the Communication Management tool (CMT) in PCM600. No events are mapped by default.

Parameter names:
- EVENTID: Event ID of the generated security event
- SEQNUMBER: Sequence number of the generated security event

Security events
All user operations are logged as events. These events can be sent to external security log servers using SYSLOG data formats. The log servers can be configured using PCM600.

14. Station communication

IEC 61850-8-1 communication protocol
The IED supports the communication protocols IEC 61850-8-1 and DNP3 over TCP/IP. All operational information and controls are available through these protocols. However, some communication functions, for example, horizontal communication (GOOSE) between the IEDs, is only enabled by the IEC 61850-8-1 communication protocol.

The IED is equipped with optical Ethernet rear port(s) for the substation communication standard IEC 61850-8-1. 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.

Disturbance files are accessed using the IEC 61850-8-1 protocol. Disturbance files are also available to any Ethernet based application via FTP in the standard Comtrade format. Further, the IED can send and receive binary values, double point values and measured values (for example from MMXU functions), together with their quality bit, using the IEC 61850-8-1 GOOSE profile. The IED meets the GOOSE performance requirements for tripping applications in substations, as defined by the IEC 61850 standard. The IED interoperates with other IEC 61850-compliant IEDs, and systems and simultaneously reports events to five different clients on the IEC 61850 station bus.

The Denial of Service functions DOSLAN1 and DOSFRNT are included to limit the inbound network traffic. The communication can thus never compromise the primary functionality of the IED.

The event system has a rate limiter to reduce CPU load. The event channel has a quota of 10 events/second after the initial 30 events/second. If the quota is exceeded the event channel transmission is blocked until the event changes is below the quota, no event is lost.

All communication connectors, except for the front port connector, are placed on integrated communication modules. The IED is connected to Ethernet-based communication systems via the fibre-optic multimode LC connector(s) (100BASE-FX).

The IED supports SNTP and IRIG-B time synchronization methods with a time-stamping accuracy of ±1 ms.

- Ethernet based: SNTP and DNP3
- With time synchronization wiring: IRIG-B

The IED supports IEC 60870-5-103 time synchronization methods with a time stamping accuracy of ±5 ms.

Table 1. Supported station communication interfaces and protocols

Protocol	Ethernet	Serial	
	100BASE-FX LC	Glass fibre (ST connector)	EIA-485
IEC 61850-8-1	•	-	-
DNP3	•	•	•
IEC 60870-5-103	-	•	•

• = Supported

Horizontal communication via GOOSE for interlocking
GOOSE communication can be used for exchanging information between IEDs via the IEC 61850-8-1 station communication bus. This is typically used for sending apparatus position indications for interlocking or reservation signals for 1-of-n control. GOOSE can also be used to exchange any boolean, integer, double point and analog measured values between IEDs.

DNP3 protocol
DNP3 (Distributed Network Protocol) is a set of communications protocols used to communicate data between components in process automation systems. For a detailed description of the DNP3 protocol, see the DNP3 Communication protocol manual.

IEC 60870-5-103 communication protocol
IEC 60870-5-103 is an unbalanced (master-slave) protocol for coded-bit serial communication exchanging information with a control system, and with a data transfer rate up to 19200 bit/s. In IEC terminology, a primary station is a master and a secondary station is a slave. The communication is based on a point-to-point principle. The master must have software that can interpret IEC 60870-5-103 communication messages.

IEC 60870-5-103 protocol can be configured to use either the optical serial or RS485 serial communication interface on the COM03 or the COM05 communication module. The functions Operation selection for optical serial OPTICALPROT and Operation selection for RS485 RS485PROT are used to select the communication interface.

The function IEC60870-5-103 Optical serial communication, OPTICAL103, is used to configure the communication parameters for the optical serial communication interface. The function IEC60870-5-103 serial communication for RS485, RS485103, is used to configure the communication parameters for the RS485 serial communication interface.

IEC 62439-3 Parallel Redundancy Protocol
Redundant station bus communication according to IEC 62439-3 Edition 2 is available as option in the Customized 650 Ver 1.3 series IEDs, and the selection is made at ordering. Redundant station bus communication according to IEC 62439-3 Edition 2 uses both ports LAN1A and LAN1B on the COM03 module.

Select COM03 for redundant station bus according to IEC 62439-3 Edition 2 protocol, at the time of ordering.
IEC 62439-3 Edition 2 is NOT compatible with IEC 62439-3 Edition 1.

15. Hardware description

Layout and dimensions
Mounting alternatives
- 19" rack mounting kit

Rack mounting a single 3U IED

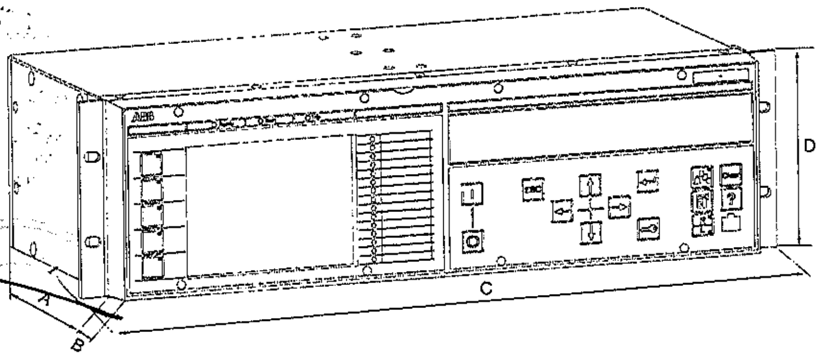

Figure 6. Rack mounted 3U IED

A 224 mm + 12 mm with ring-lug connectors
B 22.5 mm
C 482 mm
D 132 mm, 3U

See ordering for details about available mounting alternatives.

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16. Connection diagrams

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

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

Connection diagrams for Customized products

Connection diagram, 650 series 1.3 1MRK006501-AD

Connection diagrams for Configured products

Connection diagram, REQ650 1.3, (3Ph/1CB/1BB) A01 1MRK006501-LD

Connection diagram, REQ650 1.3, (1Ph/1CB/1BB) A11 1MRK006501-RD

Connection diagram, REQ650 1.3, (1Ph/1CB/2BB) B11 1MRK006501-SD

17. Technical data

General

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

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

- CT and VT ratios in the IED are set in accordance with the associated main instrument transformers. Note that for functions which measure an analogue signal which do not have corresponding primary quantity, the 1:1 ratio shall be set for the used analogue inputs on the IED, For example, HZPDIF.
- Parameter IBase used by the tested function is set equal to the rated CT primary current.
- Parameter UBase used by the tested function is set equal to the rated primary phase-to-phase voltage.
- Parameter SBase used by the tested function is set equal to sqrt(3)* IBase* UBase for three-phase power system.

Energizing quantities, rated values and limits

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Analog inputs

Table 2. TRM — Energizing quantities, rated values and limits for transformer inputs

Description	Value	
Frequency		
Rated frequency f_r	50 or 60 Hz	
Operating range	$f_r \pm 10\%$	
Current inputs		
Rated current I_r	0.1 or 0.5 A[1]	1 or 5 A[2]
Operating range	0 – 50 A	0 – 500 A
Thermal withstand	100 A for 1 s 20 A for 10 s 8 A for 1 min 4 A continuously	500 A for 1 s *) 100 A for 10 s 40 A for 1 min 20 A continuously
Dynamic withstand	250 A one half wave	1250 A one half wave
Burden	< 1 mVA at I_r = 0.1 A < 20 mVA at I_r = 0.5 A	< 10 mVA at I_r = 1 A < 200 mVA at I_r = 5 A
*) max. 350 A for 1 s when COMBITEST test switch is included.		
Voltage inputs**)		
Rated voltage U_r	100 or 220 V	
Operating range	0 – 420 V	
Thermal withstand	450 V for 10 s 420 V continuously	
Burden	< 50 mVA at 100 V < 200 mVA at 220 V	
**) all values for individual voltage inputs		
Note! All current and voltage data are specified as RMS values at rated frequency		

1) Residual current
2) Phase currents or residual current

Auxiliary AC and DC voltage

Table 3. Power supply

Description	PSM01	PSM02	PSM03
U_{aux} nominal	24, 30V DC	48, 60, 110, 125 V DC	100, 110, 120, 220, 240 V AC, 50 and 60 Hz
			110, 125, 220, 250 V DC
U_{aux} variation	80...120% of U_n (19.2...36 V DC)	80...120% of U_n (38.4...150 V DC)	80...110% of U_n (80...264 V AC)
			80...120% of U_n (88...300 V DC)
Maximum load of auxiliary voltage supply	35 W for DC 40 VA for AC		
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 and 120 Hz)		
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux}		
Resolution of the voltage measurement in PSM module	1 bit represents 0,5 V (+/- 1 VDC)	1 bit represents 1 V (+/- 1 VDC)	1 bit represents 2 V (+/- 1 VDC)

Binary inputs and outputs

Table 4. Binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.38 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)

Table 5. Signal output and IRF output

IRF relay change over - type signal output relay

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤0.5 A/≤0.1 A/≤0.04 A

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Table 6. Power output relays without TCS function

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A

Table 7. Power output relays with TCS function

Description	Value
Rated voltage	250 V DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A
Control voltage range	20...250 V DC
Current drain through the supervision circuit	~1.0 mA
Minimum voltage over the TCS contact	20 V DC

Table 8. Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
100BASE-TX	-	CAT 6 S/FTP or better	100 MBits/s
100BASE-FX	TCP/IP protocol	Fibre-optic cable with LC connector	100 MBits/s

Table 9. Fibre-optic communication link

Wave length	Fibre type	Connector	Permitted path attenuation[1]	Distance
1300 nm	MM 62.5/125 µm glass fibre core	LC	<8 dB	2 km

1) Maximum allowed attenuation caused by connectors and cable together

Table 10. X8/IRIG-B and EIA-485 interface

Type	Protocol	Cable
Tension clamp connection	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841- 9844) or Alpha Wire (Alpha 6222-6230)
Tension clamp connection	IEC 68070-5-103 DNP3.0	Shielded twisted pair cable Recommended: DESCAFLEX RD-H(ST)H-2x2x0.22mm², Belden 9729, Belden 9829

Table 11. IRIG-B

Type	Value	Accuracy
Input impedance	430 Ohm	-
Minimum input voltage HIGH	4.3 V	-
Maximum input voltage LOW	0.8 V	-

Table 12. EIA-485 interface

Type	Value	Conditions
Minimum differential driver output voltage	1.5 V	–
Maximum output current	60 mA	-
Minimum differential receiver input voltage	0.2 V	-
Supported bit rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	-
Maximum number of 650 IEDs supported on the same bus	32	-
Max. cable length	925 m (3000 ft)	Cable: AWG24 or better, stub lines shall be avoided

Table 13. Serial rear interface

Type	Counter connector
Serial port (X9)	Optical serial port, type ST for IEC 60870-5-103 and DNP serial

Table 14. Optical serial port (X9)

Wave length	Fibre type	Connector	Permitted path attenuation[1]
820 nm	MM 62,5/125 µm glass fibre core	ST	6.8 dB (approx. 1700m length with 4 db / km fibre attenuation)
820 nm	MM 50/125 µm glass fibre core	ST	2.4 dB (approx. 600m length with 4 db / km fibre attenuation)

1) Maximum allowed attenuation caused by fibre

Influencing factors

Ingress protection

Table 15. Ingress protection

Description	Value
IED front	IP 54
IED rear	IP 20
IED sides	IP 40
IED top	IP 40
IED bottom	IP 20

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Table 16. Environmental conditions

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

Table 17. Environmental tests

Description		Type test value	Reference
Cold tests	operation	96 h at -25°C 16 h at -40°C	IEC 60068-2-1/ANSI C37.90-2005 (chapter 4)
	storage	96 h at -40°C	
Dry heat tests	operation	16 h at +70°C	IEC 60068-2-2/ANSI C37.90-2005 (chapter 4)
	storage	96 h at +85°C	
Damp heat tests	steady state	240 h at +40°C humidity 93%	IEC 60068-2-78
	cyclic	6 cycles at +25 to +55°C humidity 93...95%	IEC 60068-2-30

Type tests according to standards

Table 18. Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test		IEC 61000-4-18, level 3 IEC 60255-22-1 ANSI C37.90.1-2012
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2, level 4 IEC 60255-22-2 ANSI C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode	10 V (emf), f=150 kHz...80 MHz	IEC 61000-4-6 , level 3 IEC 60255-22-6
• Radiated, amplitude-modulated	20 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz	IEC 61000-4-3, level 3 IEC 60255-22-3 ANSI C37.90.2-2004
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A ANSI C37.90.1-2012
• Communication ports	4 kV	
• Other ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-22-5
• Communication	1 kV line-to-earth	
• Other ports	2 kV line-to-earth, 1 kV line-to-line	
• Power supply	4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8, level 5
• 3 s	1000 A/m	
• Continuous	100 A/m	
Pulse magnetic field immunity test	1000A/m	IEC 61000–4–9, level 5
Damped oscillatory magnetic field	100A/m, 100 kHz and 1MHz	IEC 6100–4–10, level 5
Power frequency immunity test		IEC 60255-22-7, class A IEC 61000-4-16
• Common mode	300 V rms	
• Differential mode	150 V rms	
Voltage dips and short interruptions on DC power supply	Dips: 40%/200 ms 70%/500 ms Interruptions: 0-50 ms: No restart 0...∞ s : Correct behaviour at power down	IEC 60255-11 IEC 61000-4-11

Table 18. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Voltage dips and interruptions on AC power supply	Dips: 40% 10/12 cycles at 50/60 Hz 70% 25/30 cycles at 50/60 Hz Interruptions: 0–50 ms: No restart 0...∞ s: Correct behaviour at power down	IEC 60255-11 IEC 61000–4–11
Electromagnetic emission tests		EN 55011, class A IEC 60255-25 ANSI C63.4, FCC
• Conducted, RF-emission (mains terminal)		
0.15...0.50 MHz	< 79 dB(µV) quasi peak < 66 dB(µV) average	
0.5...30 MHz	< 73 dB(µV) quasi peak < 60 dB(µV) average	
• Radiated RF-emission, IEC		
30...230 MHz	< 40 dB(µV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	< 47 dB(µV/m) quasi peak, measured at 10 m distance	

Table 19. Insulation tests

Description	Type test value	Reference
Dielectric tests:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1 min, communication	
Impulse voltage test:		IEC 60255-5 ANSI C37.90-2005
• Test voltage	5 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J 1 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J, communication	
Insulation resistance measurements		IEC 60255-5 ANSI C37.90-2005
• Isolation resistance	>100 MΩ, 500 V DC	
Protective bonding resistance		IEC 60255-27
• Resistance	<0.1 Ω (60 s)	

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Table 20. Mechanical tests

Description	Reference	Requirement
Vibration response tests (sinusoidal)	IEC 60255-21-1	Class 1
Vibration endurance test	IEC60255-21-1	Class 1
Shock response test	IEC 60255-21-2	Class 1
Shock withstand test	IEC 60255-21-2	Class 1
Bump test	IEC 60255-21-2	Class 1
Seismic test	IEC 60255-21-3	Class 2

Product safety

Table 21. Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005)

EMC compliance

Table 22. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Current protection

Table 23. Instantaneous phase overcurrent protection, 3-phase output PHPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 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 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

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Table 24. Instantaneous phase overcurrent protection, phase segregated output SPTPIOC

Function	Range or value	Accuracy
Operate current	(5-2500)% of IBase	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 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 5 x I_{set}	-
Reset time	40 ms typically at 5 to 0 x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	< 5% at τ = 100 ms	-

Table 25. Four step phase overcurrent protection, 3-phase output OC4PTOC

Function	Setting range	Accuracy
Operate current	(5-2500)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95% at (50–2500)% of *IBase*	-
Min. operating current	(5-10000)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ±1.0% of I at $I > I_r$
2nd harmonic blocking	(5–100)% of fundamental	± 2.0% of I_r
Independent time delay	(0.000-60.000) s	± 0.5% ±25 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	[1] ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \le k \le 3.00$ $1.5 \times I_{set} \le I \le 20 \times I_{set}$
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 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	-

[1] Note: Timing accuracy only valid when 2nd harmonic blocking is turned off

Table 26. Four step phase overcurrent protection, phase segregated output OC4SPTOC

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%	-
Min. operating current	(5-10000)% of *IBase*	± 1.0% of I_r at $I < I_r$ ±1.0% of I at $I > I_r$
Independent time delay	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	[1] ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Operate time, nondirectional start function	25 ms typically at 0 to 2 x I_{set}	-
Reset time, nondirectional start function	35 ms typically at 2 to 0 x I_{set}	-
Operate time, directional start function	50 ms typically at 0 to 2 x I_{set}	-
Reset time, directional start function	35 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	-

[1] Note: Timing accuracy only valid when 2nd harmonic blocking is turned off.

Table 27. 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	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 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 5x I_{set}	-
Reset time	40 ms typically at 5 to 0x I_{set}	-
Critical impulse time	2 ms typically at 0 to 5 x I_{set}	-
Dynamic overreach	<5% at τ = 100 ms	-

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Table 28. 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, Zero sequence	(1–100)% of *IBase*	± 2.0% of I_r
Operate current for directional comparison, Negative sequence	(1–100)% of *IBase*	± 2.0% of I_r
Min. operating current	(1-10000)% of *IBase*	± 1.0% of I_r at $I < I_r$ ± 1.0% of I at $I > I_r$
Minimum operate time for inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Timers	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	[1] ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms $0.10 \leq k \leq 3.00$ $1.5 \times I_{set} \leq I \leq 20 \times I_{set}$
Minimum polarizing voltage, Zero sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing voltage, Negative sequence	(1–100)% of *UBase*	± 0.5% of U_r
Minimum polarizing current, Zero sequence	(2–100)% of *IBase*	±1.0% of I_r
Minimum polarizing current, Negative sequence	(2–100)% of *IBase*	±1.0% of I_r
Real part of source Z used for current polarization	(0.50-1000.00) Ω/phase	-
Imaginary part of source Z used for current polarization	(0.50–3000.00) Ω/phase	-
Operate time, non-directional start function	30 ms typically at 0.5 to 2 x I_{set}	-
Reset time, non-directional start function	30 ms typically at 2 to 0.5 x I_{set}	-
Operate time, directional start function	30 ms typically at 0,5 to 2 x I_N	-
Reset time, directional start function	30 ms typically at 2 to 0,5 x I_N	-

[1] Note: Timing accuracy only valid when 2nd harmonic blocking is turned off.

Table 29. Sensitive directional residual overcurrent and power protection SDEPSDE

Function	Range or value	Accuracy
Operate level for $3I_0 \cdot \cos\varphi$ directional residual overcurrent	(0.25-200.00)% of *IBase*	± 1.0% of I_r at I ≤ 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*	± 2.0% of S_r at S ≤ S_r ± 2.0% 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 ≤ 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 ≤ 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≤U_r ± 0.5% of U at U > U_r
Residual release current for all directional modes	(0.25-200.00)% of *IBase*	± 1.0% of I_r at I ≤ I_r ± 1.0% of I at I > I_r 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	(1.00 - 300.00)% of *UBase*	± 0.5% of U_r at U≤U_r ± 0.5% of U at U > U_r
Reset ratio	> 95%	-
Timers	(0.000-60.000) s	± 0.5% ±25 ms
Inverse characteristics, see table 73, table 74 and table 75	15 curve types	ANSI/IEEE C37.112 IEC 60255–151 ±3.0% or±90 ms 0.10 ≤ k ≤ 3.00 1.5 x I_{set} ≤ I ≤ 20 x I_{set}
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}	60 ms typically at 0 to 2 x I_{set}
Reset time, non-directional residual over current	65 ms typically at 2 to 0 x I_{set}	65 ms typically at 2 to 0 x I_{set}

Table 29. Sensitive directional residual overcurrent and power protection SDEPSDE, continued

Function	Range or value	Accuracy
Operate time, non-directional residual overvoltage	45 ms typically at 0.8 to 1.5 x U_{set}	45 ms typically at 0.8 to 1.5 x U_{set}
Reset time, non-directional residual overvoltage	85 ms typically at 1.2 to 0.8 x U_{set}	85 ms typically at 1.2 to 0.8 x U_{set}
Operate time, directional residual over current	140 ms typically at 0.5 to 2 x I_{set}	-
Reset time, directional residual over current	85 ms typically at 2 to 0.5 x I_{set}	-
Critical impulse time non-directional residual over current	35 ms typically at 0 to 2 x I_{set}	-
Impulse margin time non-directional residual over current	25 ms typically	-

Table 30. 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	(0-300)°C, (0 - 600)°F	± 2.0°C, ±2.0°F
Operate time: $t = \tau \cdot \ln\left(\frac{I^2 - I_p^2}{I^2 - I_{ref}^2}\right)$ (Equation 1) I = actual measured current I_p = load current before overload occurs I_{ref} = reference load current	Time constant τ = (0–1000) minutes	IEC 60255-8, ±5% + 200 ms
Alarm temperature	(0-200)°C, (0-400)°F	± 2.0°C ± 2.0°F
Trip temperature	(0-300)°C, (0-600)°F	± 2.0°C ± 2.0°F
Reset level temperature	(0-300)°C, (0-600)°F	± 2.0°C ± 2.0°F

Table 31. Breaker failure protection, 3-phase activation and output 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	20 ms typically	-
Reset time for current detection	10 ms maximum	-

Table 32. Breaker failure protection, phase segregated activation and output CSPRBRF

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	20 ms typically	-
Reset time for current detection	10 ms maximum	-

Table 33. Stub protection STBPTOC

Function	Range or value	Accuracy
Operating current	(1-2500)% of *IBase*	± 1.0% of I_r at $I \le I_r$ ± 1.0% of I at $I > I_r$
Reset ratio	> 95%	-
Operate time	20 ms typically at 0 to 2 x I_{set}	-
Reset time	30 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	-

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Table 34. Pole discordance protection CCRPLD

Function	Range or value	Accuracy
Operate value, current asymmetry level	(0-100) %	± 1.0% of I_r
Reset ratio	>95%	-
Time delay	(0.000-60.000) s	± 0.5% ± 25 ms

Table 35. Broken conductor check BRCPTOC

Function	Range or value	Accuracy
Minimum phase current for operation	(5–100)% of *IBase*	± 1.0% of I_r
Unbalance current operation	(50-90)% of maximum current	± 2.0% of I_r
Timer	(0.00-60.000) s	± 0.5% ± 25 ms
Operate time for start function	35 ms typically	-
Reset time for start function	30 ms typically	-
Critical impulse time	15 ms typically	-
Impulse margin time	10 ms typically	-

Table 36. Directional over/underpower protection GOPPDOP, GUPPDUP

Function	Range or value	Accuracy
Power level	(0.0–500.0)% of *SBase*	± 1.0% of S_r at $S < S_r$ ± 1.0% of S at $S > S_r$
	(1.0-2.0)% of *SBase*	< ± 50% of set value
	(2.0-10)% of *SBase*	< ± 20% of set value
Characteristic angle	(-180.0–180.0) degrees	2 degrees
Timers	(0.010 - 6000.000) s	± 0.5% ± 25 ms

Table 37. Negative sequence based overcurrent function DNSPTOC

Function	Range or value	Accuracy
Operate current	(2.0 - 200.0) % of *IBase*	± 1.0% of I_r at I <I_r ± 1.0% of I at I > I_r
Reset ratio	> 95 %	-
Low polarizing voltage level	(0.0 - 5.0) % of *UBase*	< ± 0.5% of U_r
Relay characteristic angle	(-180 - 180) degrees	± 2.0 degrees
Relay operate angle	(1 - 90) degrees	± 2.0 degrees
Timers	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Operate time, non-directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, non-directional	40 ms typically at 2 to 0 x I_{set}	-
Operate time, directional	30 ms typically at 0 to 2 x I_{set} 20 ms typically at 0 to 10 x I_{set}	-
Reset time, directional	40 ms typically at 2 to 0 x I_{set}	-
Critical impulse time	10 ms typically at 0 to 2 x I_{set} 2 ms typically at 0 to 10 x I_{set}	-
Impulse margin time	15 ms typically	-
Dynamic overreach	< 10% at t = 300 ms	-

Voltage protection

Table 38. 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
Reset ratio	<102%	-
Inverse time characteristics for low and high step, see table 77	-	See table 77
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ±25 ms
Minimum operate time, inverse characteristics	(0.000–60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 1.2 to 0.5U_{set}	-
Reset time, start function	40 ms typically at 0.5 to 1.2 xU_{set}	-
Critical impulse time	10 ms typically at 1.2 to 0.8 x U_{set}	-
Impulse margin time	15 ms typically	-

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Table 39. 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
Reset ratio	>98%	-
Inverse time characteristics for steps 1 and 2, see table 76	-	See table 76
Definite time delay, step 1	(0.00 - 6000.00) s	± 0.5% ± 25 ms
Definite time delays, step 2	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum operate time, Inverse characteristics	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	40 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 40. Two step residual overvoltage protection ROV2PTOV

Function	Range or value	Accuracy
Operate voltage, step 1	(1-200)% of *UBase*	± 0.5% of U_r at U < U_r ± 0.5% of U at U > U_r
Operate voltage, step 2	(1–100)% of *UBase*	± 0.5% of U_r at U < U_r ± 0.5% of U at U > U_r
Reset ratio	> 98%	-
Inverse time characteristics for low and high step, see table 78	-	See table 78
Definite time setting, step 1	(0.00–6000.00) s	± 0.5% ± 25 ms
Definite time setting, step 2	(0.000–60.000) s	± 0.5% ± 25 ms
Minimum operate time for step 1 inverse characteristic	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time, start function	30 ms typically at 0 to 2 x U_{set}	-
Reset time, start function	40 ms typically at 2 to 0 x U_{set}	-
Critical impulse time	10 ms typically at 0 to 1.2 xU_{set}	-
Impulse margin time	15 ms typically	-

Table 41. Loss of voltage check LOVPTUV

Function	Range or value	Accuracy
Operate voltage	(0–100)% of UBase	± 0.5% of U_r
Reset ratio	<105%	-
Pulse timer	(0.050–60.000) s	± 0.5% ± 25 ms
Timers	(0.000–60.000) s	± 0.5% ± 25 ms

Frequency protection

Table 42. Under frequency protection SAPTUF

Function	Range or value	Accuracy
Operate value, start function	(35.00-75.00) Hz	± 2.0 mHz at symmetrical three-phase voltage
Operate value, restore frequency	(45 - 65) Hz	± 2.0 mHz
Reset ratio	<1.001	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz At 60 Hz: 170 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz	-
Reset time, start function	At 50 Hz: 60 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 50 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Operate time delay	(0.000-60.000)s	<250 ms
Restore time delay	(0.000-60.000)s	<150 ms

Table 43. 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
Reset ratio	>0.999	-
Operate time, start function	At 50 Hz: 200 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 170 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz	-
Reset time, start function	At 50 and 60 Hz: 55 ms typically at f_{set} +0.5 Hz to f_{set}-0.5 Hz	-
Timer	(0.000-60.000)s	<250 ms

Table 44. 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, restore enable frequency	(45.00 - 65.00) Hz	± 2.0 mHz
Timers	(0.000 - 60.000) s	<130 ms
Operate time, start function	At 50 Hz: 100 ms typically At 60 Hz: 80 ms typically	-

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Secondary system supervision

Table 45. 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 46. 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

Table 47. Breaker close/trip circuit monitoring TCSSCBR

Function	Range or value	Accuracy
Operate time delay	(0.020 - 300.000) s	± 0,5% ± 110 ms

Control

Table 48. Synchronizing, synchrocheck and energizing check SESRSYN

Function	Range or value	Accuracy
Phase shift, $\varphi_{line} - \varphi_{bus}$	(-180 to 180) degrees	-
Voltage ratio, U_{bus}/U_{line}	0.500 - 2.000	-
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	0.03-0.50 p.u	± 0.5% of U_r
Time delay output for synchrocheck	(0.000-60.000) s	± 0.5% ± 25 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% ± 25 ms
Breaker closing pulse duration	(0.050-60.000) s	± 0.5% ± 25 ms
tMaxSynch, which resets synchronizing function if no close has been made before set time	(0.000-60.000) s	± 0.5% ± 25 ms
Minimum time to accept synchronizing conditions	(0.000-60.000) s	± 0.5% ± 25 ms
Time delay output for energizing check	(0.000-60.000) s	± 0.5% ± 25 ms
Operate time for synchrocheck function	40 ms typically	-
Operate time for energizing function	100 ms typically	-

Table 49. Autorecloser for 3-phase operation SMBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1 - 5	-
Autoreclosing open time: shot 1 - t1 3Ph	(0.000-60.000) s	± 0.5% ± 25 ms
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) 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	
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	

Table 50. Autorecloser for 1/3-phase operation STBRREC

Function	Range or value	Accuracy
Number of autoreclosing shots	1-5	-
Autoreclosing open time: Shot 1 - t1 3Ph Shot 1 - t1 1Ph	(0.000-60.000) s	± 0.5% ± 25 ms
shot 2 - t2 3Ph shot 3 - t3 3Ph shot 4 - t4 3Ph shot 5 - t5 3Ph	(0.00-6000.00) s	
Autorecloser maximum wait time for sync	(0.00-6000.00) s	
Open time extension for long trip time	(0.000-60.000) 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	
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	

Logic

Table 51. Tripping logic common 3-phase output SMPPTRC

Function	Range or value	Accuracy
Trip action	3-ph	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

Table 52. Tripping logic phase segregated output SPTPTRC

Function	Range or value	Accuracy
Trip action	3-Ph, 1/3-Ph	-
Timers	(0.000-60.000) s	± 0.5% ± 10 ms

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Table 53. Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	5 ms	20 ms	100 ms		
AND	60	60	160	-	-
OR	60	60	160	-	-
XOR	10	10	20	-	-
INVERTER	30	30	80	-	-
SRMEMORY	10	10	20	-	-
RSMEMORY	10	10	20	-	-
GATE	10	10	20	-	-
PULSETIMER	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSET	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
LOOPDELAY	10	10	20		

Table 54. Configurable logic Q/T

Logic block	Quantity with cycle time		Range or value	Accuracy
	20 ms	100 ms		
ANDQT	20	100	-	-
ORQT	20	100	-	-
XORQT	10	30	-	-
INVERTERQT	20	100	-	-
RSMEMORYQT	10	30	-	-
SRMEMORYQT	15	10	-	-
PULSETIMERQT	10	30	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
TIMERSETQT	10	30	(0.000–90000.000) s	± 0.5% ± 25 ms for 20 ms cycle time
INVALIDQT	6	6	-	-
INDCOMBSPQT	10	10	-	-
INDEXTSPQT	10	10	-	-

Table 55. Elapsed time integrator with limit transgression and overflow supervision TEIGGIO

Function	Cycle time (ms)	Range or value	Accuracy
Elapsed time integration	5	0 – 999999.9 s	±0.05% or ±0.01 s
	20	0 – 999999.9 s	±0.05% or ±0.04 s
	100	0 – 999999.9 s	±0.05% or ±0.2 s

Monitoring

Table 56. Technical data covering measurement functions: CVMMXN, CMMXU, VMMXU, CMSQI, VMSQI, VNMMXU

Function	Range or value	Accuracy
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
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	± 1.0% of S_r at S ≤ S_r ± 1.0% of S at S > S_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	± 1.0% of S_r at S ≤ S_r ± 1.0% of S at S > S_r
Apparent power, S Three phase settings	cos phi = 1	± 0.5% of S at S > S_r ± 0.5% of S_r at S ≤ S_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 57. Event counter CNTGGIO

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

Table 58. Limit counter L4UFCNT

Function	Range or value	Accuracy
Counter value	0-65535	-
Max. count up speed	5-160 pulses/s	-

Table 59. Disturbance report DRPRDRE

Function	Range or value	Accuracy
Current recording	-	± 1,0% of I_r at $I \leq I_r$ ± 1,0% of I at I > Ir
Voltage recording	-	± 1,0% of U_r at $U \leq U_r$ ± 1,0% of U at $U > U_r$
Pre-fault time	(0.05–3.00) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–8.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See time synchronization technical data
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 60. Event list DRPRDRE

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

Table 61. Indications DRPRDRE

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

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Table 62. Event recorder DRPRDRE

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 63. Trip value recorder DRPRDRE

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

Table 64. Disturbance recorder DRPRDRE

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

Table 65. Station battery supervision SPVNZBAT

Function	Range or value	Accuracy
Lower limit for the battery terminal voltage	(60-140) % of Ubat	± 1.0% of set battery voltage
Reset ratio, lower limit	<105 %	-
Upper limit for the battery terminal voltage	(60-140) % of Ubat	± 1.0% of set battery voltage
Reset ratio, upper limit	>95 %	-
Timers	(0.000-60.000) s	± 0.5% ± 110 ms
Battery rated voltage	20-250V	-

Table 66. Insulation gas monitoring function SSIMG

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms

Table 67. Insulation liquid monitoring function SSIML

Function	Range or value	Accuracy
Timers	(0.000-60.000) s	± 0.5% ± 110 ms

Table 68. Circuit breaker condition monitoring SSCBR

Function	Range or value	Accuracy
Alarm levels for open and close travel time	(0-200) ms	± 0.5% ± 25 ms
Alarm levels for number of operations	(0 - 9999)	-
Setting of alarm for spring charging time	(0.00-60.00) s	± 0.5% ± 25 ms
Time delay for gas pressure alarm	(0.00-60.00) s	± 0.5% ± 25 ms
Time delay for gas pressure lockout	(0.00-60.00) s	± 0.5% ± 25 ms

Metering

Table 69. Pulse counter PCGGIO

Function	Setting range	Accuracy
Cycle time for report of counter value	(1–3600) s	-

Table 70. Function for energy calculation and demand handling ETPMMTR

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

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Station communication

Table 71. Communication protocol

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

Hardware

IED

Dimensions

Table 72. Dimensions of the IED - 3U full 19" rack

Description	Value
Width	444 mm (17.48 inches)
Height	132 mm (5.20 inches), 3U
Depth	249.5 mm (9.82 inches)
Weight box	10 kg (<22.04 lbs)

Inverse time characteristics

Table 73. ANSI Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{(I^P - 1)} + B \right) \cdot k + tDef$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	-
ANSI Extremely Inverse	A=28.2, B=0.1217, P=2.0	
ANSI Very inverse	A=19.61, B=0.491, P=2.0	
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	
ANSI Long Time Extremely Inverse	A=64.07, B=0.250, P=2.0	
ANSI Long Time Very Inverse	A=28.55, B=0.712, P=2.0	
ANSI Long Time Inverse	A=0.086, B=0.185, P=0.02	

Table 74. IEC Inverse time characteristics

Function	Range or value	Accuracy
Operating characteristic: $t = \left(\frac{A}{(I^P - 1)} \right) \cdot k$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	-
IEC Normal Inverse	A=0.14, P=0.02	
IEC Very inverse	A=13.5, P=1.0	
IEC Inverse	A=0.14, P=0.02	
IEC Extremely inverse	A=80.0, P=2.0	
IEC Short time inverse	A=0.05, P=0.04	
IEC Long time inverse	A=120, P=1.0	

The parameter setting *Characterist1 and 4/ Reserved* shall not be used, since this parameter setting is for future use and not implemented yet.

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Table 75. 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	
RD type logarithmic inverse characteristic $t = 5.8 - \left(1.35 \cdot \ln \frac{I}{k}\right)$ $I = I_{measured}/I_{set}$	k = (0.05-999) in steps of 0.01	

Table 76. 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% +60 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	

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Table 77. 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% +60 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	

Table 78. 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% +70 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	

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18. Ordering for Customized IED

Guidelines

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

Product specification

Basic IED 650 platform and common functions housed in 3U 1/1 sized 19" casing

REQ650 — Quantity: ☐ — 1MRK 006 518-AD

Option:

Customer specific configuration — On request

Connection type for Analog modules

Rule: One connection type must be selected

Compression terminals	☐	1MRK 002 960-CA
Ring lug terminals	☐	1MRK 002 960-DA

Connection type for Power supply, Input/Output and communication modules

Rule: One connection type must be selected

Compression terminals	☐	1MRK 002 960-EA
Ring lug terminals	☐	1MRK 002 960-FA

Power supply module

Rule: One Power supply module must be specified

Power supply module	PSM01	24–30V DC, 9BO	☐	1KHL178029R0001
	PSM02	48-125V DC, 9BO	☐	1KHL178073R0001
	PSM03	110-250V DC, 100–240V AC, 9BO	☐	1KHL178082R0001

Communication and processing modules

Rule: One Communication and processing module must be selected
For redundant station communication PRP, COM03 must be selected.

Communication and processing module COM05, 12BI, IRIG-B, RS485, Ethernet LC optical, ST serial	☐	1MRK 002 346-AA
Communication and processing module COM03, IRIG-B, RS485, 3 Ethernet LC optical, ST serial, ST PPS Slave *The 3rd Ethernet port and PPS Slave is not supported in this release.*	☐	1MRK 002 346-BA

Current protection

Rule: One Breaker failure protection must be ordered

Rule: If 3 ph tripping logic has been selected only CCRBRF can be selected. If Phase segregated tripping logic has been selected only CSPRBRF can be selected.

Breaker failure protection, 3-phase activation and output CCRBRF	Qty:	☐	1MRK 004 908-LA
Breaker failure protection, phase segregated activation and output CSPRBRF	Qty	☐	1MRK 004 908-UA

Logic

Rule: One tripping logic type only must be ordered
Note: Selection of Tripping Logic type rules the selection of Instantaneous phase Overcurrent protection, Four step phase Overcurrent protection, Breaker Failure protection and Autorecloser.

Tripping logic, common 3-phase output SMPPTRC	Qty:	☐	1MRK 004 922-AA
Tripping logic, phase segregated output SPTPTRC	Qty:	☐	1MRK 004 922-UA

Optional functions
Current protection

Rule: Only one Instantaneous phase overcurrent protection can be ordered

Rule: If 3 ph tripping logic has been selected only PHPIOC can be selected. If Phase segregated tripping logic has been selected only SPTPIOC can be selected.

Instantaneous phase overcurrent protection, 3-phase output PHPIOC	Qty:	☐	1MRK 004 908-AA
Instantaneous phase overcurrent protection, phase segregated output SPTPIOC	Qty:	☐	1MRK 004 908-XA

Rule: Only one Four step phase overcurrent protection can be ordered.
Rule: If 3 ph tripping logic has been selected only OC4PTOC can be selected. If Phase segregated tripping logic has been selected only OC4SPTOC can be selected.

Four step phase overcurrent protection, 3-phase output OC4PTOC	Qty:	☐	1MRK 004 908-BC
Four step phase overcurrent protection, phase segregated output OC4SPTOC	Qty:	☐	1MRK 004 908-VC
Instantaneous residual overcurrent protection EFPIOC	Qty:	☐	1MRK 004 908-CA
Four step residual overcurrent protection, zero/negative sequence direction EF4PTOC	Qty:	☐	1MRK 004 908-FA
Sensitive directional residual overcurrent and power protection SDEPSDE	Qty:	☐	1MRK 004 908-EB
Thermal overload protection, one time constant, Celsius LCPTTR	Qty:	☐	1MRK 004 908-HC
Thermal overload protection, one time constant, Fahrenheit LFPTTR	Qty:	☐	1MRK 004 908-HD
Stub protection STBPTOC	Qty:	☐	1MRK 004 908-MA
Pole discordance protection CCRPLD	Qty:	☐	1MRK 004 908-NA
Broken conductor check BRCPTOC	Qty:	☐	1MRK 004 908-PA
Directional underpower protection GUPPDUP	Qty:	☐	1MRK 004 908-RB
Directional overpower protection GOPPDOP	Qty:	☐	1MRK 004 908-SB
Negative sequence based overcurrent function DNSPTOC	Qty:	☐	1MRK 004 908-TB

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Voltage protection

Two step undervoltage protection UV2PTUV	Qty:	☐	1MRK 004 910-AB
Two step overvoltage protection OV2PTOV	Qty:	☐	1MRK 004 910-BB
Two step residual overvoltage protection ROV2PTOV	Qty:	☐	1MRK 004 910-CB
Loss of voltage check LOVPTUV	Qty:	☐	1MRK 004 910-EA

Frequency protection

Underfrequency protection SAPTUF	Qty:	1 ☐ 2 ☐	1MRK 004 912-AA
Overfrequency protection SAPTOF	Qty:	1 ☐ 2 ☐	1MRK 004 912-BA
Rate-of-change frequency protection SAPFRC	Qty:	1 ☐ 2 ☐	1MRK 004 912-CA

Secondary system supervision

Current circuit supervision CCSRDIF	Qty:	☐	1MRK 004 914-AA
Fuse failure supervision SDDRFUF	Qty:	☐	1MRK 004 914-BA

Control

Synchrocheck, energizing check and synchronizing SESRSYN	Qty:	☐	1MRK 004 917-AC

Rule: Only one of Autorecloser can be ordered
Rule: If 3 ph tripping logic has been selected only SMBRREC can be selected. If Phase segregated tripping logic has been selected only STBRREC can be selected.

Autorecloser for 3-phase operation SMBRREC	Qty:	☐	1MRK 004 917-BA
Autorecloser for 1/3-phase operation STBRREC	Qty:	☐	1MRK 004 917-SA

Logic

Configurable logic blocks Q/T		☐	1MRK 002 917-MK

Monitoring

Station battery supervision SPVNZBAT	Qty:	☐	1MRK 004 925-HB
Insulation gas monitoring function SSIMG	Qty:	☐	1MRK 004 925-KA
Insulation liquid monitoring function SSIML	Qty:	☐	1MRK 004 925-LA
Circuit breaker condition monitoring SSCBR	Qty:	☐	1MRK 004 925-MA

First local HMI user dialogue language

HMI language, English IEC			Always included

Additional local HMI user dialogue language

HMI language, English US		☐	1MRK 002 940-MA

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Optional hardware

Human machine interface

Rule: One must be ordered.

Display type	Keypad symbol	Case size		
Local human machine interface LHMI01	IEC	3U 1/1 19"	☐	1KHL160055R0001
Local human machine interface LHMI01	ANSI	3U 1/1 19"	☐	1KHL160042R0001

Analog system

Rule: One Transformer input module must be ordered

Transformer module TRM01	6I 1/5A + 4U 100/220V, 50/60Hz	Qty:	☐	1KHL178083R0001
Transformer module TRM01	8I 1/5A + 2U, 100/220V, 50/60Hz	Qty:	☐	1KHL178083R0013
Transformer module TRM01	4I 1/5A + 1I 0.1/0.5A + 5U 100/220V, 50/60Hz	Qty:	☐	1KHL178083R0016
Transformer module TRM01	4I 1/5A + 6U 100/220V, 50/60Hz	Qty:	☐	1KHL178083R0003

Rule: Only one Analog input module can be ordered

Analog input module AIM01	6I 1/5A + 4U 100/220V, 50/60Hz	Qty:	☐	1KHL178083R5001
Analog input module AIM01	4I 1/5A + 1I 0.1/0.5A + 5U 100/220V, 50/60Hz	Qty:	☐	1KHL178083R5016

Binary input/output modules

Note: If analog input module AIM is ordered only 2 BIO modules can be ordered

Binary input/output module BIO01 — Qty: 1 ☐ 2 ☐ 3 ☐ 4 ☐ — 1KHL178074R0001

Rack mounting kit

Rack mounting kit for 3U 1/1 x 19" case — Quantity: ☐ — 1KHL400352R0001

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19. Ordering for Configured IED

Guidelines
Carefully read and follow the set of rules to ensure order management.
Please refer to the available functions table for included application functions.

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

Example code: REQ650*1.3-A01X00-X00-B1X0-D-H-SA-E-SA3-AXXX-F. Using the code of each position #1-11 specified as REQ650*1-2 2-3-4 4-5-6-7 7-8-9 9-10 10 10 10-11

#	1	-	2		-	3	-	4		-	5	-	6	-	7		-	8	-	9		-	10				-	11
REQ650*		-			-		-			-		-		-			-		-			-					-	

	Position	
SOFTWARE	#1	Notes and Rules
Version number		
Version no	1.3	
Selection for position #1.	1.3	

Configuration alternatives		#2	Notes and Rules
Single breaker, 3-phase, 1 busbar	A01		
Single breaker, single phase, 1 busbar	A11		
Single breaker, single phase, 2 busbars	B11		
ACT configuration			
ABB standard configuration		X00	
Selection for position #2.		X00	

Software options	#3	Notes and Rules
No option	X00	
Selection for position #3	X00	

First HMI language		#4	Notes and Rules
English IEC	B1		
Selection for position #4.			
Additional HMI language		#4	
No second HMI language		X0	
Selection for position #4.	B1	X0	

Casing	#5	Notes and Rules
Rack casing, 3U 1/1 x 19"	D	
Selection for position #5.	D	

Mounting details	#6	Notes and Rules
No mounting kit included	X	
Rack mounting kit for 3U 1/1 x 19"	H	
Selection for position #6.		

Connection type for Power supply, Input/output and Communication modules		#7	Notes and Rules
Compression terminals	S		
Ringlug terminals	R		
Power supply			
Slot position:		pPSM	
100-240V AC, 110-250V DC, 9BO, PSM03		A	
48-125V DC, 9BO, PSM02		B	
24-30V DC, 9BO, PSM01		C	
Selection for position #7.			

Human machine interface	#8	Notes and Rules
Local human machine interface LHMI01, OL8000, IEC 3U 1/1 x 19", Basic	E	
Selection for position #8.	E	

Connection type for Analog modules		#9	Notes and Rules
Compression terminals	S		
Ringlug terminals	R		
Analog system			
Slot position:		p2	
Transformer module TRM01, 4I 1/5A + 1I 0.1/0.5A + 5U 100/220V, 50/60Hz		A3	
Selection for position #9.		A3	

Binary input/output module	#10				Notes and Rules
Slot position (rear view)	p3	p4	p5	p6	
No board in slot		X	X	X	
Binary input/output module BIO01, 9 BI, 3 NO Trip, 5 NO Signal, 1 CO Signal	A	A	A	A	p4, p5, p6 optional for A01 p4 basic, p5, p6 optional for A11/B11
Selection for position #10.	A				

Communication and processing module	#11	Notes and Rules
Slot position (rear view)	pCOM	
12BI, IRIG-B, RS485, Ethernet, LC optical, ST serial	F	
Selection for position #11.	F	

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20. Ordering for Accessories

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 DVD containing user documentation
Operation manual
Technical manual
Installation manual
Commissioning manual
Application manual
Communication protocol manual, DNP3
Communication protocol manual, IEC61850-8-1
Communication protocol manual, IEC60870-5-103
Cyber security deployment guidelines
Type test certificate
Engineering manual
Point list manual, DNP3
Connectivity packages and LED label template is always included for each IED

Rule: Specify additional quantity of IED Connect DVD requested

User documentation	Quantity:	☐	1MRK 003 500-AA

Rule: Specify the number of printed manuals requested

Operation manual	IEC	Quantity:	☐	1MRK 500 096-UEN
Technical manual	IEC	Quantity:	☐	1MRK 505 292-UEN
Commissioning manual	IEC	Quantity:	☐	1MRK 505 293-UEN
Application manual	IEC	Quantity:	☐	1MRK 505 291-UEN
Communication protocol manual, DNP3	IEC	Quantity:	☐	1MRK 511 280-UEN
Communication protocol manual, IEC 61850-8-1	IEC	Quantity:	☐	1MRK 511 281-UEN
Communication protocol manual, IEC 60870-5-103	IEC	Quantity:	☐	1MRK 511 282-UEN
Engineering manual	IEC	Quantity:	☐	1MRK 511 284-UEN
Installation manual	IEC	Quantity:	☐	1MRK 514 016-UEN
Point list manual, DNP3	IEC	Quantity:	☐	1MRK 511 283-UEN
Cyber Security deployment guidelines	IEC	Quantity:	☐	1MRK 511 285-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

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Related documents

Documents related to REQ650	Identity number
Application manual	1MRK 505 291-UEN
Technical manual	1MRK 505 292-UEN
Commissioning manual	1MRK 505 293-UEN
Product Guide	1MRK 505 294-BEN
Type test certificate	1MRK 505 294-TEN
Application notes for Circuit Breaker Control	1MRG006806

650 series manuals	Identity number
Communication protocol manual, DNP 3.0	1MRK 511 280-UEN
Communication protocol manual, IEC 61850–8–1	1MRK 511 281-UEN
Communication protocol manual, IEC 60870-5-103	1MRK 511 282-UEN
Cyber Security deployment guidelines	1MRK 511 285-UEN
Point list manual, DNP 3.0	1MRK 511 283-UEN
Engineering manual	1MRK 511 284-UEN
Operation manual	1MRK 500 096-UEN
Installation manual	1MRK 514 016-UEN
Accessories, 650 series	1MRK 513 023-BEN
MICS	1MRG 010 656
PICS	1MRG 010 660
PIXIT	1MRG 010 658

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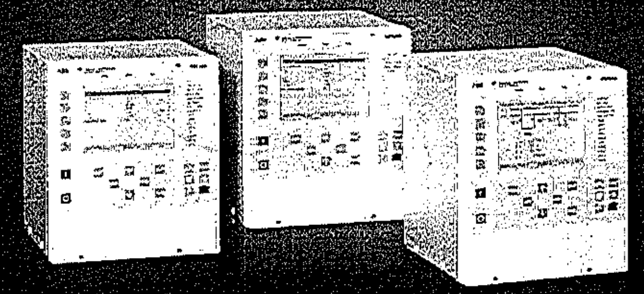

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IEC 60870-5-103 Communication Protocol
Manual

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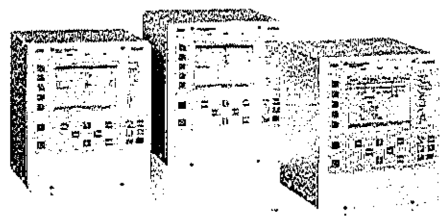

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Warranty

Please inquire about the terms of warranty from your nearest ABB representative.

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Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not to be deemed as a statement of guaranteed properties. All persons responsible for applying the equipment addressed in this manual must satisfy themselves that each intended application is suitable and acceptable, including that any applicable safety or other operational requirements are complied with. In particular, any risks in applications where a system failure and/or product failure would create a risk for harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity applying the equipment, and those so responsible are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This document has been carefully checked by ABB but deviations cannot be completely ruled out. In case any errors are detected, the reader is kindly requested to notify the manufacturer. Other than under explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from the use of this manual or the application of the equipment.

Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The IED is designed in accordance with the international standards of the IEC 60255 series.

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Section 1 Introduction

1.1 This manual

The communication protocol manual describes a communication protocol supported by the IED. The manual concentrates on vendor-specific implementations.

1.2 Intended audience

This manual addresses the communication system engineer or system integrator responsible for pre-engineering and engineering for communication setup in a substation from an IED perspective.

The system engineer or system integrator must have a basic knowledge of communication in protection and control systems and thorough knowledge of the specific communication protocol.

1.3 Product documentation

1.3.1 Product documentation set

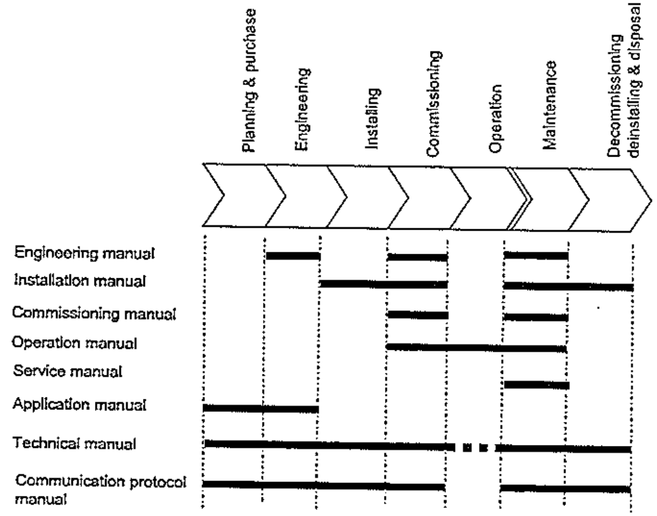

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Figure 1: The intended use of manuals in different lifecycles

The engineering manual contains instructions on how to engineer the IEDs using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 60870-5-103, IEC 61850 and DNP3.

The installation manual contains instructions on how to install the IED. The manual provides procedures for mechanical and electrical installation. The chapters are organized in chronological order in which the IED should be installed.

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for checking of external circuitry and energizing the IED, parameter setting and configuration as