Relion® Protection and Control

670 series 2.0 ANSI
DNP3 Communication Protocol Manual

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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 and ANSI C37.90. The DNP protocol implementation in the IED conforms to "DNP3 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2", available at www.dnp.org .

Table of contents

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.

1.3 Product documentation

1.3.1 Product documentation set

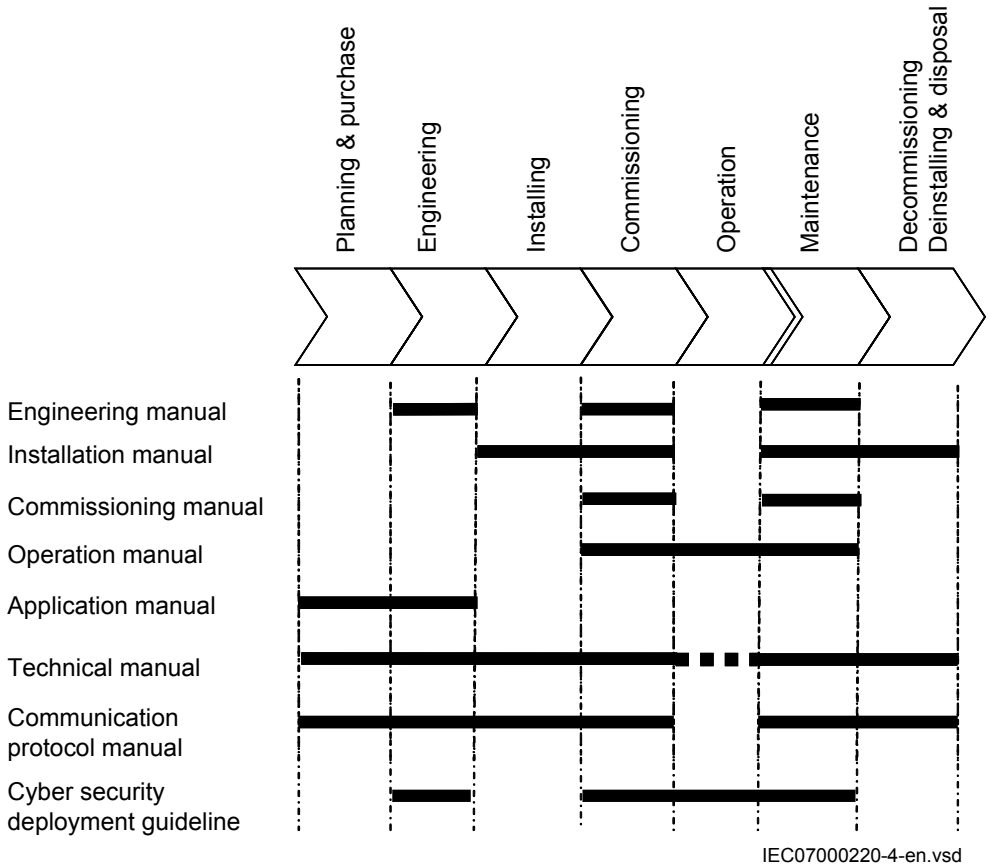

Figure 1: The intended use of manuals throughout the product lifecycle

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 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 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 application and functionality 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
-/May 2014	First release

1.3.3 Related documents

Documents related to REB670	Identify number
Application manual	1MRK 505 302-UUS
Commissioning manual	1MRK 505 304-UUS
Product guide	1MRK 505 305-BUS
Technical manual	1MRK 505 303-UUS
Type test certificate	1MRK 505 305-TUS

Documents related to REC670	Identify number
Application manual	1MRK 511 310-UUS
Commissioning manual	1MRK 511 312-UUS
Product guide	1MRK 511 313-BUS
Technical manual	1MRK 511 311-UUS
Type test certificate	1MRK 511 313-TUS

Documents related to RED670	Identify number
Application manual	1MRK 505 307-UUS
Commissioning manual	1MRK 505 309-UUS
Product guide	1MRK 505 310-BUS
Technical manual	1MRK 505 308-UUS
Type test certificate	1MRK 505 310-TUS

Documents related to REG670	Identify number
Application manual	1MRK 502 051-UUS
Commissioning manual	1MRK 502 053-UUS
Product guide	1MRK 502 054-BUS
Technical manual	1MRK 502 052-UUS
Type test certificate	1MRK 502 054-TUS

Documents related to REL670	Identify number
Application manual	1MRK 506 338-UUS
Commissioning manual	1MRK 506 340-UUS
Product guide	1MRK 506 341-BUS
Technical manual	1MRK 506 339-UUS
Type test certificate	1MRK 506 341-TUS

Documents related to RET670	Identify number
Application manual	1MRK 504 138-UUS
Commissioning manual	1MRK 504 140-UUS
Product guide	1MRK 504 141-BUS
Technical manual	1MRK 504 139-UUS
Type test certificate	1MRK 504 141-TUS

670 series manuals	Identify number
Operation manual	1MRK 500 118-UUS
Engineering manual	1MRK 511 308-UUS
Installation manual	1MRK 514 019-UUS
Communication protocol manual, DNP3	1MRK 511 301-UUS
Communication protocol manual, IEC 61850 Edition 2	1MRK 511 303-UUS
Point list manual, DNP3	1MRK 511 307-UUS
Accessories guide	1MRK 514 012-BUS
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 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/output 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.”
- Dimensions are provided both in inches and mm. If it is not specifically mentioned then the dimension is in mm.

1.4.3 Functions included in 670 series IEDs

Table 1: Main protection functions

IEC 61850 or function name	ANSI	Description
Differential protection		
BBP3PH4B	87B	Busbar differential protection, 2 zones, three phase/4 bays Package including functions BUTPTRC_B1-BUTPTRC_B4, BCZTPDIF, BZNTPDIF_A, BZNTPDIF_B, BZITGGIO, BUTSM4
BBP3PH8B	87B	Busbar differential protection, 2 zones, three phase/8 bays Package including functions BUTPTRC_B1-BUTPTRC_B8, BCZTPDIF, BZNTPDIF_A, BZNTPDIF_B, BZITGGIO, BUTSM8
BBP1PH12B	87B	Busbar differential protection, 2 zones, single phase/12 bays Package including functions BUSPTRC_B1-BUSPTRC_B12, BCZSPDIF, BZNSPDIF_A, BZNSPDIF_B, BZISGGIO, BUSSM12
BBP1PH24B	87B	Busbar differential protection, 2 zones, single phase/24 bays Package including functions BUSPTRC_B1-BUSPTRC_B24, BCZSPDIF, BZNSPDIF_A, BZNSPDIF_B, BZISGGIO, BUSSM24
BDCGAPC	87B	Status of primary switching object for busbar protection zone selection
T2WPDIF	87T	Transformer differential protection, two winding
T3WPDIF	87T	Transformer differential protection, three winding
HZPDIF	87	1Ph High impedance differential protection
GENPDIF	87G	Generator differential protection
REFPDIF	87N	Restricted earth fault protection, low impedance
L3CPDIF	87L	Line differential protection, 3 CT sets, 23 line ends
L6CPDIF	87L	Line differential protection, 6 CT sets, 35 line ends
LT3CPDIF	87LT	Line differential protection 3 CT sets, with inzone transformers, 23 line ends
LT6CPDIF	87LT	Line differential protection 6 CT sets, with inzone transformers, 35 line ends
LDLPSCH	87L	Line differential coordination function
LDRGFC	11REL	Additional security logic for differential protection
Impedance protection		
ZMQAPDIS, ZMQPDIS	21	Distance protection zone, quadrilateral characteristic
ZDRDIR	21D	Directional impedance quadrilateral
ZMCPDIS, ZMCAPDIS	21	Distance measuring zone, quadrilateral characteristic for series compensated lines
ZDSRDIR	21D	Directional impedance quadrilateral, including series compensation
FDPSPDIS	21	Phase selection, quadrilateral characteristic with fixed angle
ZMHPDIS	21	Full-scheme distance protection, mho characteristic
ZMMPDIS, ZMMAPDIS	21	Fullscheme distance protection, quadrilateral for earth faults
ZDMRDIR	21D	Directional impedance element for mho characteristic
ZDARDIR		Additional distance protection directional function for earth faults
ZSMGAPC		Mho Impedance supervision logic

Table continues on next page

IEC 61850 or function name	ANSI	Description
FMPSPDIS	21	Faulty phase identification with load enchroachment
ZMRPDIS, ZMRAPDIS	21	Distance protection zone, quadrilateral characteristic, separate settings
FRPSPDIS	21	Phase selection, quadrilateral characteristic with settable angle
ZMFPDIS	21	High speed distance protection
ZMFCPDIS	21	High speed distance protection for series compensated lines
ZMCAPDIS		Additional distance measuring zone, quadrilateral characteristic
ZMRPSB	68	Power swing detection
PSLPSCH		Power swing logic
PSPPPAM	78	Pole slip/out-of-step protection
OOSPPAM	78	Out-of-step protection
ZCVPSOF		Automatic switch onto fault logic, voltage and current based
LEXPDIS	40	Loss of excitation
PPLPHIZ		Phase preference logic
ROTIPHIZ	64R	Sensitive rotor earth fault protection, injection based
STTIPHIZ	64S	100% stator earth fault protection, injection based
ZGVPDIS	21	Underimpedance protection for generators and transformers

Table 2: Backup protection functions

IEC 61850 or function name	ANSI	Description
Current protection		
PHPIOC	50	Instantaneous phase overcurrent protection
OC4PTOC	51_67	Four step phase overcurrent protection
PH4SPTOC	51	Four step single phase overcurrent protection
EFPIOC	50N	Instantaneous residual overcurrent protection
EF4PTOC	51N_67N	Four step residual overcurrent protection
NS4PTOC	46I2	Four step directional negative phase sequence overcurrent protection
SDEPSDE	67N	Sensitive directional residual over current and power protection
LCPTTR	26	Thermal overload protection, one time constant, Celsius
LFPTTR	26	Thermal overload protection, one time constant, Fahrenheit
TRPTTR	49	Thermal overload protection, two time constants
CCRBRF	50BF	Breaker failure protection
CCSRBRF	50BF	Breaker failure protection, single phase version
STBPTOC	50STB	Stub protection
CCPDSC	52PD	Pole discordance protection

Table continues on next page

IEC 61850 or function name	ANSI	Description
GUPPDUP	37	Directional underpower protection
GOPPDOP	32	Directional overpower protection
BRCPTOC	46	Broken conductor check
CBPGAPC		Capacitor bank protection
NS2PTOC	46I2	Negative sequence time overcurrent protection for machines
AEGPVOC	50AE	Accidental energizing protection for synchronous generator
VRPVOC	51V	Voltage restrained overcurrent protection
GSPTTR	49S	Stator overload protection
GRPTTR	49R	Rotor overload protection
Voltage protection		
UV2PTUV	27	Two step undervoltage protection
OV2PTOV	59	Two step overvoltage protection
ROV2PTOV	59N	Two step residual overvoltage protection
OEXPVPH	24	Overexcitation protection
VDCPTOV	60	Voltage differential protection
STEFPHIZ	59THD	100% Stator earth fault protection, 3rd harmonic based
LOVPTUV	27	Loss of voltage check
PAPGAPC	27	Radial feeder protection
Frequency protection		
SAPTUF	81	Underfrequency protection
SAPTOF	81	Overfrequency protection
SAPFRC	81	Rate-of-change frequency protection
FTAQFVR	81A	Frequency time accumulation protection
Multipurpose protection		
CVGAPC		General current and voltage protection

Table 3: Control and monitoring functions

IEC 61850 or function name	ANSI	Description
Control		
SESRSYN	25	Synchrocheck, energizing check, and synchronizing
SMBRREC	79	Autorecloser
TR1ATCC	90	Automatic voltage control for tap changer, single control
TR8ATCC	90	Automatic voltage control for tap changer, parallel control
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs
Table continues on next page		

IEC 61850 or function name	ANSI	Description
TCLYLTC	84	Tap changer control and supervision, 32 binary inputs
SLGAPC		Logic Rotating Switch for function selection and LHMI presentation
VSGAPC		Selector mini switch
DPGAPC		Generic communication function for Double Point indication
SPC8GAPC		Single Point Generic Control 8 signals
AUTOBITS		AutomationBits, command function for DNP3.0
SINGLECMD		Single command, 16 signals Command function block for LON and SPA
VCTRSEND		Horizontal communication via GOOSE for VCTR
GOOSEVCTRRCV		Horizontal communication via GOOSE for VCTR
I103CMD		Function commands for IEC60870-5-103
I103GENCMD		Function commands generic for IEC60870-5-103
I103POSCMD		IED commands with position and select for IEC60870-5-103
I103IEDCMD		IED commands for IEC60870-5-103
I103USRCMD		Function commands user defined for IEC60870-5-103
Apparatus control and interlocking		
SCILO	3	Logical node for interlocking
BB_ES	3	Interlocking for busbar earthing switch
A1A2_BS	3	Interlocking for bus-section breaker
A1A2_DC	3	Interlocking for bus-section disconnector
ABC_BC	3	Interlocking for bus-coupler bay
BH_CONN	3	Interlocking for 1 1/2 breaker diameter
BH_LINE_A	3	Interlocking for 1 1/2 breaker diameter
BH_LINE_B	3	Interlocking for 1 1/2 breaker diameter
DB_BUS_A	3	Interlocking for double CB bay
DB_BUS_B	3	Interlocking for double CB bay
DB_LINE	3	Interlocking for double CB bay
ABC_LINE	3	Interlocking for line bay
AB_TRAFO	3	Interlocking for transformer bay
SCSWI		Switch controller
SXCBR		Circuit breaker
SXSWI		Switch controller
RESIN1		Reservation input 1
RESIN2		Reservation input 2
POS_EVAL		Evaluation of position indication
QCRSV		Bay reservation
Table continues on next page		

IEC 61850 or function name	ANSI	Description
QCBAY		Apparatus control Function for handling the status of Local/Remote switch
LOCREM		Handling of LRswitch positions
LOCREMCTRL		LHMI control of PSTO Function for handling Internal Local/Remote switch
Secondary system supervision		
CCSSPVC	87	Current circuit supervision
FUFSPVC		Fuse failure supervision
VDSPVC	60	Fuse failure supervision based on voltage difference
Logic		
SMPPTRC	94	Tripping logic
TMAGAPC		Trip matrix logic
ALMCALH		Logic for group alarm
WRNCALH		Logic for group warning
INDCALH		Logic for group indication
AND		Configurable logic blocks, AND
OR		Configurable logic blocks, OR
INV		Configurable logic blocks, inverter
PULSETIMER		Configurable logic blocks, PULSETIMER
GATE		Configurable logic blocks, controllable gate
TIMERSET		Configurable logic blocks, timer
XOR		Configurable logic blocks, exclusive OR
LLD		Configurable logic blocks, LLD
SRMEMORY		Configurable logic blocks, set-reset memory
RSMEMORY		Configurable logic blocks, reset-set memory
ANDQT		Configurable logic blocks Q/T, ANDQT
ORQT		Configurable logic blocks Q/T, ORQT
INVERTERQT		Configurable logic blocks Q/T, INVERTERQT
XORQT		Configurable logic blocks Q/T, XORQT
SRMEMORYQT		Configurable logic Q/T, set-reset with memory
RSMEMORYQT		Configurable logic Q/T, reset-set with memory
TIMERSETQT		Configurable logic Q/T, settable timer
PULSETIMERQT		Configurable logic Q/T, pulse timer
INVALIDQT		Configurable logic Q/T, INVALIDQT
INDCOMBSPQT		Configurable logic Q/T, single-indication signal combining
INDEXTSPQT		Configurable logic Q/T, single-indication signal extractor
Table continues on next page		

IEC 61850 or function name	ANSI	Description
FXDSIGN		Fixed signal function block
B16I		Boolean 16 to Integer conversion
BTIGAPC		Boolean 16 to Integer conversion with Logic Node representation
IB16		Integer to Boolean 16 conversion
ITBGAPC		Integer to Boolean 16 conversion with Logic Node representation
TIGAPC		Delay on timer with input signal integration
TEIGAPC		Elapsed time integrator with limit transgression and overflow supervision
Monitoring		
CVMMXN, CMMXU, VMMXU, CMSQI VMSQI, VNMMXU		Measurements
AISVBAS		Function block for service value presentation of secondary analog inputs
SSIMG	63	Gas medium supervision
SSIML	71	Liquid medium supervision
SSCBR		Circuit breaker condition monitoring
EVENT		Event function Function for event reporting for LON and SPA
DRPRDRE, A1RADR-A4RADR, B1RBDR-B6RBDR		Disturbance report
SPGAPC		Generic communication function for Single Point indication
SP16GAPC		Generic communication function for Single Point indication 16 inputs
MVGAPC		Generic communication function for Measured Value
BINSTATREP		Logical signal status report
RANGE_XP		Measured value expander block
LMBRFLO		Fault locator
I103MEAS		Measurands for IEC60870-5-103
I103MEASUSR		Measurands user defined signals for IEC60870-5-103
I103AR		Function status auto-recloser for IEC60870-5-103
I103EF		Function status earth-fault for IEC60870-5-103
I103FLTPROT		Function status fault protection for IEC60870-5-103
I103IED		IED status for IEC60870-5-103
I103SUPERV		Supervison status for IEC60870-5-103
I103USRDEF		Status for user defiend signals for IEC60870-5-103
L4UFCNT		Event counter with limit supervision
Metering		
PCFCNT		Pulse-counter logic

Table continues on next page

IEC 61850 or function name	ANSI	Description
ETPMMTR		Function for energy calculation and demand handling
System protection and control		
SMAIHPAC		Multipurpose filter

Table 4: Station communication functions

IEC 61850 or function name	ANSI	Description
Station communication		
SPA		SPA communication protocol
ADE		LON communciation protocol
PROTOCOL		Operation selection between SPA and IEC60870-5-103 for SLM
CHSERRS485		DNP3.0 for TCP/IP and EIA-485 communication protocol
DNPFREC		DNP3.0 fault records for TCP/IP and EIA-485 communication protocol
IEC61850-8-1		Parameter setting function for IEC61850
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking
GOOSEBINRCV		Goose binary receive
GOOSEDPRCV		GOOSE function block to receive a double point value
GOOSEINTRCV		GOOSE function block to receive an integer value
GOOSEMVRCV		GOOSE function block to receive a measurand value
GOOSESPRCV		GOOSE function block to receive a single point value
GOOSEVCTRCONF		GOOSE VCTR configuration for send and receive
VCTRSEND		Horizontal communication via GOOSE for VCTR
GOOSEVCTRRCV		Horizontal communication via GOOSE for VCTR
MULTICMDRCV, MULTICMDSND		Multiple command and transmit
FRONT, LANABI, LANAB, LANCDI, LANCD		Ethernet configuration of links
MU1_4I_4U MU2_4I_4U MU3_4I_4U MU4_4I_4U MU5_4I_4U MU6_4I_4U		Process bus communication IEC61850-9-2
PRP		Duo driver configuration
Scheme communication		
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection
ZC1PPSCH	85	Phase segregated Scheme communication logic for distance protection
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection
ZC1WPSCH	85	Current reversal and weak-end infeed logic for phase segregated communication
Table continues on next page		

IEC 61850 or function name	ANSI	Description
ZCLCPSCH		Local acceleration logic
ECPSCH	85	Scheme communication logic for residual overcurrent protection
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection
Direct transfer trip		
LAPPGAPC	37_55	Low active power and power factor protection
COUVGAPC	59_27	Compensated over- and undervoltage protection
SCCVPTOC	51	Sudden change in current variation
LCCRPTRC	94	Carrier receive logic
LCNSPTOV	47	Negative sequence overvoltage protection
LCZSPTOV	59N	Zero sequence overvoltage protection
LCNSPTOC	46	Negative sequence overcurrent protection
LCZSPTOC	51N	Zero sequence overcurrent protection
LCP3PTOC	51	Three phase overcurrent
LCP3PTUC	37	Three phase undercurrent

Table 5: Basic IED functions

IEC 61850 or function name	Description
INTERRSIG	Self supervision with internal event list
SELFSUPEVLST	Self supervision with internal event list
TIMESYNCHGEN	Time synchronization module
SYNCHBIN, SYNCHCAN, SYNCHCMPPS, SYNCHLON, SYNCHPPH, SYNCHPPS, SYNCHSNTP, SYNCHSPA, SYNCHCMPPS	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
LONGEN	Misc Base Common
Table continues on next page	

IEC 61850 or function name	Description
SMBI	Signal matrix for binary inputs
SMBO	Signal matrix for binary outputs
SMMI	Signal matrix for mA inputs
SMAI1 - SMAI20	Signal matrix for analog inputs
3PHSUM	Summation block 3 phase
ATHSTAT	Authority status
ATHCHCK	Authority check
AUTHMAN	Authority management
FTPACCS	FTP access with password
SPACOMMMAP	SPA communication mapping
SPATD	Date and time via SPA protocol
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
ALTRK	Service tracking
ACTIVLOG	Activity logging parameters
FSTACCS	Field service tool access via SPA protocol over ethernet communication
PCMACCS	IED Configuration Protocol
SECALARM	Component for mapping security events on protocols such as DNP3 and IEC103
DNPGEN	DNP3.0 communication general protocol
DNPGENTCP	DNP3.0 communication general TCP protocol
CHSEROPT	DNP3.0 for TCP/IP and EIA-485 communication protocol
MSTSER	DNP3.0 for serial communication protocol
OPTICAL103	IEC60870-5-103 Optical serial communication
RS485103	IEC60870-5-103 serial communication for RS485
IEC61850-8-1	Parameter setting function for IEC61850
HORZCOMM	Network variables via LON
LONSPA	SPA communication protocol
LEDGEN	General LED indication part for LHMI

Section 2 DNP3 overview

DNP3 is a communication protocol used between components in process automation systems. Its main use is in utilities such as electric and water companies. Usage in other industries is not common, although technically possible. Specifically, it was developed to facilitate communications between various types of data acquisition and control equipment. It plays a crucial role in SCADA systems, where it is used by SCADA master stations (aka Control Centers), RTUs, and IEDs.

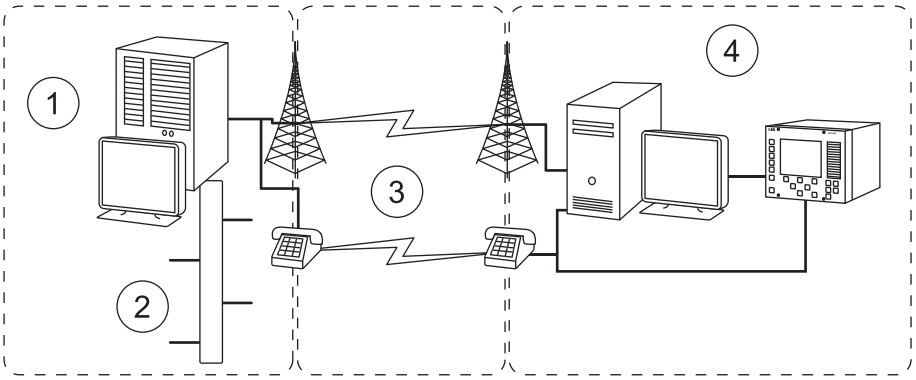

Figure 2: DNP3 communication schematic representation

1 SCADA master station / control center

2 External control points

3 Communication links (radio, microwave, spread-spectrum, twisted-pair, fibre-optics, dial-up, leased line)

4 Remote substation (station computer and IED)

2.1 DNP3 standard

The DNP3 protocol was developed by Westronic based on the early versions of the IEC 60870-5 standard telecontrol protocol specifications. DNP is now governed by IEEE Std 1815-2012 IEEE Standard for Electric Power Systems Communications — Distributed Network Protocol (DNP3) www.dnp.org.

The protocol is based on the EPA, a simplified model of the ISO/OSI model. It specifies the data link layer, the application layer and a transport pseudo-layer. To

support advanced RTU functions and messages larger than the maximum frame length as defined by the IEC document 60870-5-1, the DNP3 data link is intended to be used with the mentioned transport pseudo-layer. As a minimum, this transport layer implements message assembly and disassembly services.

Physical layer

Even though the standard does not specify the physical layer, it does however specify how to operate in a networked environment and also suggests how to avoid collisions between simultaneously sending devices.

Many implementations use serial communication based on RS-232, RS-485 or even fibre optics.

DNP3 can also be used over packet-oriented networks such as TCP/IP and UDP in which, for example, Ethernet may be used. In this case DNP3 can be said to be tunneled over TCP/IP or UDP.

Additional information on the DNP3 physical layer is available at the DNP Users Group at www.dnp.org.

Data link layer

The DNP3 data link layer is designed to operate with asynchronous or synchronous bit serial physical layers. Fully balanced transmission procedures were adopted to support spontaneous transmissions from remotes.

Data link functions include:

- Performing message data link retransmissions.
- Packing user data into the defined frame format includes CRC and transmitting the data to the physical layer.
- Unpacking the data link frame received from the physical layer into user data, checking and removing CRC.
- Controlling the physical layer.
- In unsolicited reporting mode, performing collision avoidance/detection procedures to ensure reliable transfer of data across the physical link.
- Responding to all valid frames received from the physical layer.

Data link responsibilities:

- Exchange of Service data units (SDUs) between peer DNP3 data links
- Error notification to data link user
- Sequencing of SDUs
- SDU delivery quality.

Link-layer confirm usage is not recommended and the implementation is optional. The IED does not request data-link layer confirmations for TCP/IP communication.

See the DNP technical bulletin TB1998-0402, section 3 for details at www.dnp.org.

Transport pseudo-layer

To support advanced RTU functions and messages exceeding the maximum data link frame length, a transport pseudo-layer which implements message assembly and disassembly services was adopted.

Transport functions:

- Fragmenting user data into one or more data link frames and transmitting the data to the data link layer
- Assembling the data link frames received from the data link layer into user data
- Controlling all aspects of the data link excluding data link configuration

Transport responsibilities:

- Exchange of SDUs between peer DNP3 transport pseudo layers
- Error notification to transport users
- Sequencing of SDUs

Application layer

The application layer is responsible for performing operations on data objects defined by the device or on the device itself. These operations include returning actual values (read function), assigning new values (write function) if the object represents control points, arming and energizing the output point (select, operate or direct operate functions) and if counters are used, reading actual values and clearing the counters. DNP3 uses the term point to identify an entity, and these entities can be categorized into point-types, such as analogs or binaries. Points are addressed by giving them an index number and an object is a formatted representation of data from a point. These objects can be assigned to classes in order to organize events and current values into categories. The DNP3 protocol defines four data classes to organize data reporting.

Communication modes

The IED supports four DNP3 communication modes.

- Quiescent operation
- Unsolicited report-by-exception operation
- Polled report-by-exception operation
- Polled static operation

2.2 Documentation

This implementation of DNP3 is fully compliant with DNP3 Subset Definition Level 2, and contains significant functionality beyond Subset Level 2. See the device profile for further information.

Section 3 Vendor-specific implementation

3.1 DNP3 link modes

3.1.1 DNP3 TCP/IP mode

DNP3 TCP/IP link mode is supported by the IED. This implementation supports up to four different masters communicating simultaneously with the IED. The IED is a listening endpoint implementation and listens for connections from DNP3 masters on a configurable port, *TCPIPLisPort*. The IED does not connect to masters, meaning that it is not a dual-endpoint implementation.

It is possible to use both the connection establishment method based on the master IP address, and the connection establishment method based on the port number. The identification and association of the master is based both on the IP address of the master and the port number it connects to. It is essential to make sure that the parameters *TCPIPLisPort*, *MasterIP-Addr*, *MasterIPNetMask*, *SlaveAddress* and *MasterAddress* uniquely identifies one master from the other masters.

The above is an important concept to grasp during commissioning so that no conflicts occur. Therefore, it is strongly recommended not to change the *MasterIPNetMask* parameter to anything else than its default 255.255.255.255 unless necessary. The parameter should not be mixed up with the subnet mask of the IP configuration. The *MasterIPNetMask* can be used to allow to accept connections from masters that do have dynamic IP addresses within a known range.

For example, if a master changes its IP address dynamically in the range of 10.10.10.1 and 10.10.10.254, the *MasterIPNetMask* could be set to 255.255.255.0 to allow for connections from this range. If two masters share this dynamic range or share the same IP address, it is necessary to separate them by having them connect to separate ports, for example, 20000 and 20001 respectively.

Also, *SlaveAddress* and *MasterAddress* must be correctly configured for each master. Otherwise, the previously accepted connection is closed upon the reception of the first DNP3 message.

The IED supports the requirements of the standard to receive UDP broadcast messages on the ports configured by *UDPPortAccData*. When operating in UDP-only mode, *UDPPortInitNUL* and *UDPPortCliMast* need to be configured as well.

As a default, the IED sends a keep-alive message in every 10 seconds according to the value of the *tKeepAliveT* parameter. The time can be changed, and setting it to zero means that no keep-alive messages are sent. It is important to know the hazards of disabling the keep-alive, and it is not recommended to do so unless necessary. If the keep-alive messages are unwanted, it is better to increase the value of *tKeepAliveT* so that it exceeds the master's poll rate.

If a master crashes or the communication links are broken and the master restarts, the TCP/IP makes the IED believe that the connection still exists. Since the IED conforms to the recommendations of the standard not to accept new connections when a connection already exists to the particular master, the master will never be allowed to connect again. Another parameter that concerns the TCP/IP connection status is *tBrokenConTout*. It determines how long a session is active after a TCP/IP connection has been broken. After the time period, the session becomes inactive and events are not stored. If the parameter is set to 0, events are stored until the sequential buffers overflow. Note that if the parameter is set to zero, all events from start-up until the sequential buffers overflow are saved even though no connection would have been established.

Further documentation concerning DNP3 TCP/IP communication is available in the IP Networking document Volume 7, from www.dnp.org.

3.2 Internal indications

Internal indications give information on certain status and error conditions within the outstation. They contain 2 octets of data and are found in the application layer on an outstation response.

Each octet has 8 bit fields numbered 0 through 7 where bit 0 is the least significant bit. A code is used to reference or specify a particular bit:

IINx.b - where x is a 1 for the first octet and x is a 2 for the second. b identifies the bit number.

Thus, IIN2.0 refers to the first bit in the second octet.

See the DNP3 Specification Volume 3 Application Layer (Section 5 Detailed IIN Bit Descriptions) for more detailed descriptions of IIN bits.

Table 6: Default class assignment for internal indications

Bit index	Descriptions and conditions	Writable
IIN1.0	All stations – set after a broadcast message (any message using a destination address of 0xfff0 or above) has been received. Does not indicate an error condition	No
IIN1.1	Class 1 event data available. Can be set at any time and does not indicate an error condition.	No
IIN1.2	Class 2 event data available. Can be set at any time and does not indicate an error condition	No
IIN1.3	Class 3 event data available. Can be set at any time and does not indicate an error condition	No
IIN1.4	Time synchronization required from master. Can be set at any time and does not indicate an error condition. This bit is set according to the PST setting “tSyncTimeout” when time synchronization is via DNP3.	No
IIN1.5	Local mode. Set if some points are uncontrollable via DNP3.	No
IIN1.6	Device trouble. Set if the IED has detected device problems. This bit is set when the IED’s “Internal Fail” flag is set.	No
IIN1.7	Device restart. Set only under specific conditions. Does not indicate an error condition	Yes
IIN2.0	Function unknown. Generally means that the function code (octet 2 of the request header) cannot be processed.	No
IIN2.1	Object unknown. Generally means that the function code could be processed but the object group / variation could not be processed	No
IIN2.2	Parameter error. Generally indicates that both function code and object group / variation could be processed but that the qualifier / range field is in error.	No
IIN2.3	Buffer overflow. Indicates that an event buffer has overflowed, and that change events, of at least one type, have been lost. Binary event buffer size is 1000. Counter event buffer size is 1000. Frozen event counter event are not supported. Analog event buffer size is 1000.	No
IIN2.4	Requested operation is already executing.	No
IIN2.5	Configuration corrupted.	No
IIN2.6	Reserved. Always 0.	No
IIN2.7	Reserved. Always 0.	No

3.3 Event reporting

The IED supports unsolicited reports. Given the parameters *UREvCntThold1*, *tUREvBufTout1*, *UREvCntThold2*, *tUREvBufTout2*, *UREvCntThold3* and *tUREvBufTout3*, the IED can be configured to report events either after a number of events of a certain class have been generated or when at least one event of the class has been generated and the configured time-span has elapsed.

The event system has a rate limiter to reduce CPU load. Each channel has a quota of 10 events/second. If the quota is exceeded the event channel is blocked until the event changes is below the quota.

3.3.1 Event buffers

Binary input points, double-bit input points, counters and analog input points each have buffer sizes of 1000 events.

3.4 Command handling

DNP3 allows for operation on binary outputs via CROB. Direct Operate, Direct Operate with No Acknowledgement as well as Select/Operate pairs are allowed. The protocol requires that a pair of select and operate messages is completely alike and only one sequence number apart. This in turn requires masters not to send any requests between the selected message and the operate message, otherwise the operate request will be denied.

Select and Operate requests may contain multiple objects. The select/control buffer size is large enough to hold 10 of the largest select requests possible.

3.4.1 Automation bits

Automation bit signals can be used to interpret and execute the count, on-time and off-time parameters of a CROB. Thereby pulse trains of different characteristics and lengths can be generated, and the outputs from the automation bits component can be connected to other function blocks in PCM600.

3.4.2 Apparatus control

Apparatuses can be controlled via DNP3. Open and close points to SCSWI are available for mapping in PCM600. These points can then be written to by as CROBs, thereby opening or closing the breaker. It is important to note that the control model, *ctlModel*, of the SCSWI is respected when set to *SBO Enh*. If *ctlModel* is set to *SBO Enh*, direct operate commands from DNP3 are not allowed. On the other hand, if *ctlModel* is set to *Dir Norm*, *SBO* commands from DNP3 are allowed.

Furthermore, the select timeout parameter *tSelectTimeout* in DNP3 should be set so that it harmonizes with the *tSelect* parameter of the SCSWI. The shortest of the two parameters dictates the timing of select/execute.

3.4.3 Binary output status points and control relay output blocks

While binary outputs status (BOS) points are included here for completeness, they are not often polled by DNP3 masters. BOS points represent the most recent value from a command operation for the corresponding control relay output block (CROB) point. BOS points are not recommended to be included in class 0 polls.

As an alternative, it is recommended that actual status values affected by CROB points should be mapped as BI or DI. Requesting CROBs on the Open and Close points of SCSWI operate the breaker. The operation may take several seconds to complete. This means that a success response from the operate command may have been returned from the CROB even though the operation is still in progress. Therefore, the mentioned outputs from, for example, SCSWI need to be monitored as a complement.

This implies that the binary output object should not be assigned to classes 1, 2 or 3. A read of the binary outputs returns the last value written to that output.

3.5 Time synchronization

DNP3 supports time synchronization of the IED via object numbers 50...52. Time synchronization via DNP3 should only be used if time source with better accuracy is not available, for example, IRIG-B, GPS or SNTP. For TCP/IP channels, the LAN procedure should be used, in which two separate messages are transmitted from the master, record current time and write, see DNP3 Specification Volume 5 for more information.

Parameters have to be set among the system wide time parameters as well as among the individual DNP3 masters.

DNP3 can be set for a coarse synchronization source under **Configuration/Time/Synchronisation/TIMESYNCHGEN:1/CoarseSyncSrc** in the LHMI tree. Note that when DNP3 is set as coarse synchronization source, no fine synchronization source shall be configured. Otherwise, the time will jump between the fine and the coarse synchronization time sources.

Each DNP3 master configuration block has a number of parameters that affect the time synchronization. Only one master at a time is configured to set the time in the IED. Therefore, only one master configuration block enables the *DNPToSetTime* and *TSyncReqAfTout* parameter. That is, both parameters must have the same value and should only be set for one master at a time.

The *tSyncTimeout* parameter defines how long after a successful time synchronization the NeedTime IIN bit has to be set. The *tSyncReqAfTout* parameter defines if the

tSyncTimeout should be used or not. Also, the IED supports both the new standard directive of use of UTC and local time for backward compatibility (*ExtTimeFormat*). If UTC is selected, the time in the time synchronization messages is expected to be in UTC, and vice versa.

3.6 Analog inputs

It is important to note that 16-bit and 32-bit variations of analog inputs are transmitted through DNP3 as signed numbers. The default analog input event buffer size is set 1000.

3.6.1 Analog data scaling

The four scaling options associated with analog input data reporting are None, Ratio, Multiplicative and Divisor.

Ratio, multiplicative and divisor scaling methods

The PCM600 tool contains four value arguments related to the scaling methods: *sourceMinVal*, *sourceMaxVal*, *destMinVal* and *destMaxVal*. The use of these arguments differs depending on the scaling method.

The ratio, multiplicative and divisor scaling methods use the first two arguments, *souceMinVal* and *sourceMaxVal*, to define the source value range inside which the object is to be used. The complete value range of the object is usually wanted even though the user could freely define the source range.

Arguments three and four, *destMinVal* and *destMaxVal*, define the destination value range. In ratio scaling, arguments *destMinVal* and *destMaxVal* define the corresponding range of the scaled, reported DNP3 value.

$$DNPvalue = (sourceValue - sourceMinVal) \left[\frac{(destMaxVal - destMinVal)}{(sourceMaxVal - sourceMinVal)} \right] + destMinVal$$

(Equation 1)

In multiplicative scaling, argument four *destMaxVal* becomes a scale constant.

$$DNPvalue = sourceValue \times destMaxVal$$

(Equation 2)

In divisor scaling, argument four *destMaxVal* becomes a scale constant.

$$DNPvalue = \frac{sourceValue}{destMaxVal}$$

(Equation 3)

3.6.2 Analog input signal scaling for DNP3 master presentation

The presentation of an analog value in a telecontrol protocol varies between the different protocols and also with the age of the used protocol version. The range is from a simple 8 bit integer up to a double precision floating point. Internally in the IED many calculations are floating points.

PCM600 supports the re-scaling and the justification to the register presentation given by the project demands.

Figure 3 presents a typical example of a signal flow in the IED from the CTs, VTs to the DNP3 master. The CT, VT is connected to the IED by the transformer module TRM. The SMAI function block is a preprocessor to calculate, check the signals for further use in application function blocks of type MMXU. MMXU calculates the RMS values for the most used analog signals like, V, I, P, Q, for example. The RMS values are available in floating point presentation as output signals of function blocks of type MMXU.

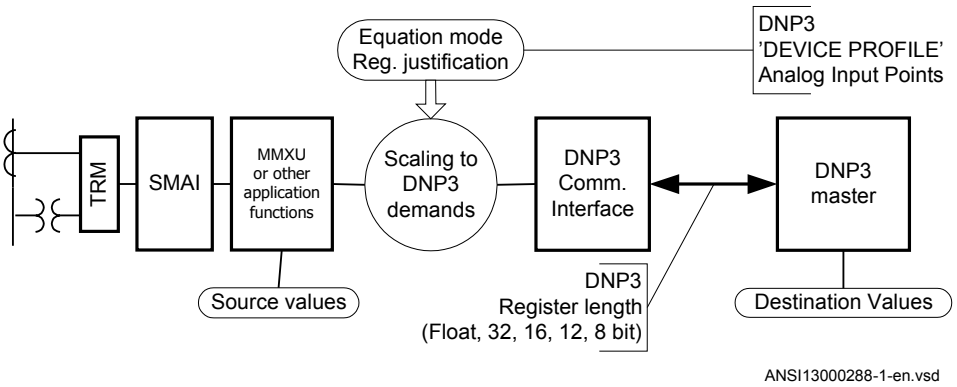

Figure 3: PCM600: Typical example of DNP3 scaling

The actual DNP3 specification defines 6 variations for the presentation of an analog value:

- Variation 1 - 32-bit with flag
- Variation 2 - 16-bit with flag
- Variation 3 - 32-bit without flag
- Variation 4 - 16-bit without flag
- Variation 5 - single-precision floating point with flag
- Variation 6 - double-precision floating point with flag

The IED supports all 32-bit and floating point variants without any additional scaling configuration. This is given as long as the *MaxSourceVal* (as it is given in the IED as floating point) is in the range of a 32-bit signed integer value (max. 32-bit = 2 147 483 648).

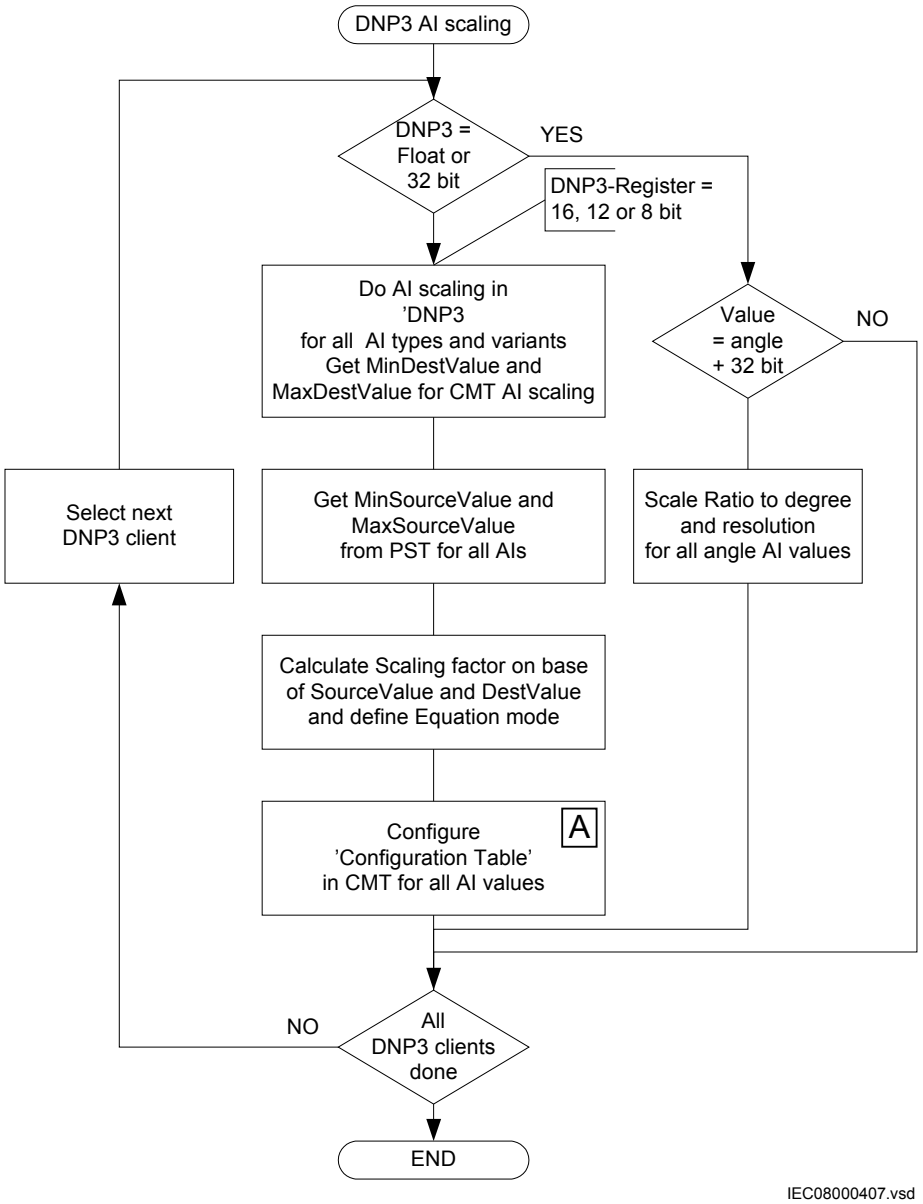

Figure 4: CMT: Configuration Flowchart

3.7 DNP3 points

See the engineering manual for instructions on how to configure DNP3 with PCM600.

3.7.1 Point configuration

The DNP3 point map is configurable in PCM600. All points in the IED may be remapped. In PCM600, the unmapped points in the variables list on the left may be inserted to the active point list on the right.

Point gaps may be inserted if wanted. However, too many and too big gaps are not recommended. Point gaps cannot be read by the client.

3.7.2 Class assignment

Class assignment allows the events generated in the IED to be reported as DNP3 events. Some configurations exceed the class assignment possibilities defined by the standard.

Table 7: DNP3 point map configuration

Configuration	Description
None	Integrity class 0 scan returns gap. Value is available only via static scan. Point does not generate events.
Class 0	Point is returned in the class 0 scan. Point does not generate events.
Class 0 and any class 1,2,3 combination	Point is returned in the class 0 scan. Point generates events for the selected class or classes.
Class 1, 2 or 3 combination	Point is not returned in the class 0 scan. Point generates events for the selected class or classes.

Binary outputs status (BOS) points exist only if the corresponding control relay output block (CROB) point has been inserted in the active point list.

3.8 Fault record

Fault record is a mechanism to browse through disturbance records. It shows a snapshot of important information from each existing disturbance record.

Fault record contains signals that provide information on the current disturbance that the user of the *FaultRecord* has selected. It provides signals that help the user to iterate and browse through the existing disturbances. All the signals that can be used to iterate the fault records can be mapped as binary outputs in PCM600 and operated on with CROBs. All signals that provide information on the current disturbance can be mapped as analog inputs and read by the master. The DNP3 master navigates through the *FaultRecord* using the three signals:

- *GetFirstRec* fetches the oldest record in the *FaultRecord*.
- *GetNextRec* fetches the next record in time in the *FaultRecord* relative to the previously fetched record. If the previously fetched record is the newest, no fetch is done.
- *GetPrevRec* fetches the previous record in time in the *FaultRecord* relative to the previously fetched record. If the previously fetched record is the oldest, no fetch is done.

When a new disturbance is recorded, and the outputs are mapped to one of the event classes, events are generated, but the navigation in the *FaultRecord* is not affected. Hence, when the next command is sent from the DNP3 master, the fetched position is relative to the last fetch done; the position in the *FaultRecord* before the new disturbance occurred.

The output signals provide the fault record number, which is the number of the disturbance in the LHMI or PCM600, the number of faults in the IED, the active setting group at the time of the disturbance recording, the trigger signal identity, the time stamp at the trigger time as well as the fault location and the fault type. In addition, the magnitude, angle, fault magnitude and fault angle are provided for up to 30 of the analog channels connected to the disturbance recorder, and for the last 10 analog channels, the calculated value at the trigger time is provided.

Section 4 DNP3 parameters

4.1 Parameter descriptions

The DNP3 parameters for a specific IED can be accessed with PCM600 via **Configuration/Communication/Station Communication/DNP3.0**. There is one general setting for DNP3 (*Disabled/Enabled*), available in function DNPGEN:1. This parameter must be *Enabled* for the other parameters to have effect. Each communication channel has specific settings.

Function OPTICALPROT:1 is used to arbitrate between communication protocols such as DNP3 or IEC60870-5-103 on the optical port. Function RS485PROT:1 is used to select if DNP3 or IEC60870-5-103 communication protocol shall be used for the RS485 serial port. When RS485 serial port is selected, also settings in function RS485GEN:1 must be considered.

There are specific settings for the serial channel depending on if the serial optical or RS485 interface is used. Communication specific settings for the serial optical interface are available in function OPTICALDNP:1 and communication specific settings for the RS485 interface are available in function RS485DNP:1. There are specific settings for the master sessions, available in function MSTSERIAL:1, when a master session occurs on the serial channel.

In function DNPGENTCP:1 the selection of physical ports for the protocol is configured. There are specific settings for the TCP/IP channel, available in functions CH1TCP to CH4TCP and MST1TCP to MS4TCP.

The channel blocks and the master blocks are separate but should be treated as pairs grouped together with a number. For example, CH1TCP and MST1TCP should be treated as an entity during engineering. The reason for this division is that it is conceptually possible to have multiple masters talking on the same channel, for example, a serial link, and it is also possible to imagine a single master switching between different channels, for example, different serial links.

TCP/IP communication, CH1TCP - CH4TCP channels settings

TCPIPLisPort defines the listen port if the channel is configured for TCP/IP. Default is 20000.

UDPPortAccData defines the port on which the UDP datagrams should be accepted if the channel is configured for networking. Default is 20000.

UDPPortInitNUL defines the master's destination port to which the initial NULL response should be sent if the channel is configured for networking. Default is 20000.

UDPPortCliMast defines the master's destination port to which responses should be sent if the channel is configured for networking. If the parameter is set to 0, the port number is taken from the previous request. Default is 0. There are specific settings for the master sessions if the master session occurs on the serial channel or on the TCP/IP channels.

ApLayMaxRxSize specifies the maximum application fragment size received in octets.

ApLayMaxTxSize specifies the maximum application fragment size transmitted in octets.

UDP is not supported in this release of 670 series. Do not use "UDP-only" for setting *Operation*.

Master session settings for a specific communication channel ,MST1TCP - MST4TCP

Operation determines the operation of the master session. 0 = *Disabled*. 1 = *Enabled*.

SlaveAddress defines the DNP3 address of this master session.

MasterAddress defines the DNP3 address that this master session uses for communication.

ValMasterAddr determines if the stack should validate the source address in receive frames. DNP3 frames contain both a source address field and a destination address field. If this parameter is set to 0, the stack does not validate the source address and thus the frames whose destination address matches the configured slave session are accepted. If this parameter is set to 1, both the source and the destination addresses have to match before the frame is accepted.

When going down in baudrate, the size of the configuration on DNP must be considered.

MasterIP-Addr defines the master's IP address.

MasterIPNetMsk determines the subnet mask that should be used to mask with the IP address.

Obj1DefVar determines the default variation for Object 1, Binary Inputs.

Obj2DefVar determines the default variation for Object 2, Binary Input Change Events.

Obj3DefVar determines the default variation for Object 3, Double Bit Inputs.

Obj4DefVar determines the default variation for Object 4, Double Bit Input Change Events.

Obj10DefVar determines the default variation for Object 10, Binary Output Status.

Obj20DefVar determines the default variation for Object 20, Binary Counters.

Obj22DefVar determines the default variation for Object 22, Binary Counter Change Events.

Obj30DefVar determines the default variation for Object 30, Analog Inputs.

Obj32DefVar determines the default variation for Object 32, Analog Change Events.

AddrQueryEnbl determines whether to enable self-address functionality on this master session (slave) as specified by the DNP Technical Bulletin 2003-003. Self-Address Reservation. The master session (Slave) responds to the address 0xfffc as if it had received a request for its configured address. It responds with its own address so that the master can automatically discover the slave address.

tApplConfTout specifies how long the slave waits for the application layer confirmation from the master. This in combination with *unsolRetryDelay* or *unsolOfflineRetryDelay* determines how frequently an unsolicited response is resent.

ApplMultFrgRes determines if the application layer of this master session in the slave is allowed to send multi fragment responses.

ConfMultFrag determines if application layer confirmations are requested for non-final fragments of a multi-fragment response. Application layer confirmations are always requested for responses that contain events.

UREnable determines if unsolicited responses are allowed. If set to 0, no unsolicited responses are generated and requests to enable or disable unsolicited responses fail.

UREvClassMask specifies the initial or new state of the unsolicited event mask. This mask is used to determine which event class or classes generate unsolicited responses. According to the DNP3 specification, unsolicited responses should be disabled until an Enable Unsolicited Response request is received from the master. Thus, this value should generally be 0. However, some masters do not generate the Enable Unsolicited Response message, in which case they must be enabled here. Keep the value to 0 for all other purposes.

UROfflineRetry specifies the maximum number of unsolicited retries before changing to the offline retry period. Up to 65535 retries can be specified. Set *UROfflRetryDel* to the same value as *URRetryDelay* to define an infinite number of retries.

tURRetryDelay specifies in seconds the time to delay after an unsolicited confirm timeout before retrying the unsolicited response.

tUROfflRtryDel specifies in seconds the time to delay after an unsolicited timeout before retrying the unsolicited response if *URO**fflineRetry* has been attempted. To disable retries after *URO**fflineRetry*, set this value to the maximum value of a stack timer: 31 days. This limits the retries to one in every 31 days.

UREvCntThold1 If unsolicited responses are enabled, this parameter specifies the maximum number of events in class 1 to be allowed before an unsolicited response is generated.

tUREvBufTout1 If unsolicited responses are enabled (UREnable), this parameter specifies the maximum amount of time in seconds before an unsolicited response is generated after an event in class 1 has been received.

UREvCntThold2 If unsolicited responses are enabled (UREnable), this parameter specifies the maximum number of allowed class 2 events before an unsolicited response is generated.

tUREvBufTout2 If unsolicited responses are enabled (UREnable), this parameter specifies the maximum amount of time in seconds before an unsolicited response is generated after an event in class 2 has been received.

UREvCntThold3 If unsolicited responses are enabled (UREnable), this parameter specifies the maximum number of allowed class 3 events before an unsolicited response will be generated.

tUREvBufTout3 If unsolicited responses are enabled (UREnable), this parameter specifies the maximum amount of time in seconds before an unsolicited response is generated after an event in class 3 has been received .

DelOldBufFull If this parameter is set to 1, the event with the earliest timeStamp is deleted when a new event is added to the full event queue.

ExtTimeFormat 0 = LocalTime. 1 = UTC.

DNPToSetTime determines if time synch messages received for this master session (slave) are allowed to set the local time in the IED.

tSynchTimeout sets the periodicity for time requests. That is, it defines how long after a succeeded time synch message from the master, the IIN.4 bit should be set.

TsyncReqAfTout determines if the stack should start with the IIN.4 bit set.

Averag3TimeReq determines if the IED needs three time synch messages to set the time. If set, the IIN.4 bit is high until three time synch messages are received. The average of the two best messages are used to set the time.

PairedPoint enables the Object12 Close request on an even-index point to access the next-index point.

tSelectTimeout specifies the maximum amount of time that a select remains valid before the corresponding operate is received.

The master subnet mask must not be changed unless the master gets its IP-address dynamically assigned via, for example, DHCP. For details see, DNP3 TCP/IP mode

tBrokenConTout determines how long a session is active after a TCP/IP connection has been broken. After that time period the master session becomes inactive and events are not stored. If the parameter is set to 0, events are stored until the buffers overflow.

tKeepAliveT determines, in seconds, how often the DNP3 master session sends keep-alive messages. Default is 10s.

4.1.1 Serial optical and RS485 communication channel settings

RS485 specific communication channel settings, RS485GEN

Wiremode determines the wire mode if the device is configured for RS485. RS485 is a balanced serial communication that can be used in two ways:

- Two-wire
- Four-wire

A two-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 four-wire connection has separate 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.

BIAS sets the bus bias to *Enabled* or *Disabled*.

Operation selection for RS485 and optical serial communication, OPTICALPROT and RS485PROT

ProtocolSel selects if the communication in RS485 and optical serial modes happens via *DNP* or *IEC 103* communication protocol. It can be *Disabled* via Parameter Setting tool or local HMI.

DNP3.0 for optical RS-232 and EIA-485 communication protocol, OPTICALDNP and RS485DNP

BaudRate specifies the baud rate on the serial.

DLinkConfirm determines when the stack should ask for link layer confirmations. Since DNP3 supports breaking an application layer message into multiple link layer

frames, set to the following based on the desired operation for a specific communication session:

- *Never* - not for any frame
- *Sometimes* - only for multiframe message fragments
- *Always* - for all frames

tDLinkTimeout specifies the maximum amount of time to wait for a link level confirm if requested (that is, if *DLinkConfirm* is *Enabled*). Even if *DLinkConfirm* is set to *Never*, this will be used for linktest frame and request link status if they are sent.

DLinkRetries is the maximum number of link layer retries if data-link layer confirms time up.

tRxToTxMinDel is the minimum time (in seconds) after receiving a character, before another attempt to transmit a character on this channel. This is generally useful when using a modem or some other communication device that requires a minimum time between receive and transmit.

ApLayMaxRxSize specifies the maximum application fragment size received in octets.

ApLayMaxTxSize specifies the maximum application fragment size transmitted in octets.

Stopbit defines the number of stop bits for the serial port.

Parity defines the parity to use for the serial port it can be set to:

- *None* - no parity used
- *Even* - even parity used
- *Odd* - odd parity used

tRTSWarmUp configures transmitter warm-up and warm-down delay times (in milliseconds). If warm-up is configured to non-zero then at start of the send, the transmitter is *Enabled*. This means that the line is driven but the data send of the start is delayed by the warm-up delay time.

tRTSWarmDown specifies that if warm-down is configured to non zero then at end of the send, the transmitter deactivation is delayed by the warm-down time.

tBackOffDelay specifies that if the data send is started, a check is made if data is being received at that time. If yes, a back-off timer is started and when it times out, a check is made again to see if line is idle. If no, a new back-off timer is started. This is repeated until the line is idle and send can start. Line idle is determined when nothing is received for more than a character time. The back-off time consists of a configurable fixed time and a random time where the maximum random time is also configurable. The back-off feature is always on.

tMaxRndDelBkOf specifies the configurable RS485 maximum back-off random time delay in seconds.

HWCollisionDetect, a new collision detect feature in hardware is implemented to improve the sensitivity for collision detection. The performance of this feature depends on parameters of the RS485 network as well as the protocol behaviour. It can even have negative impact on performance in some circumstances, therefore usage of the feature should be tested and adapted for each specific installation.

HWCollisionDetect is only used for RS485 networks, thus is only available in RS485DNP function.

Master session settings for RS485 communication channel, MSTSERIAL

ChToAssociate defines the channel, to which this master session should be associated to.

The MSTSERIAL function includes the same settings as the MS1TCP to MS4TCP functions, except the *ChToAssociate* setting which is used to select either the serial optical or RS485 communication interface on hardware modules.

4.2 Parameter list

4.2.1 Parameter list for optical and RS485 communication channel

Table 8: RS485GEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
WireMode	Four-wire Two-wire	-	-	Four-wire	Two or four wire mode

Table 9: RS485PROT Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
ProtocolSel	Disabled DNP IEC103	-	-	Disabled	Protocol selection

Table 10: OPTICAL103 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SlaveAddress	1 - 254	-	1	1	Slave address
BaudRate	9600 Bd 19200 Bd	-	-	9600 Bd	Baudrate on serial line
RevPolarity	Disabled Enabled	-	-	Enabled	Invert polarity
CycMeasRepTime	1.0 - 1800.0	s	0.1	5.0	Cyclic reporting time of measurments
MasterTimeDomain	UTC Local without DST Local with DST	-	-	UTC	Master time domain
TimeSyncMode	IEDTime LinMastTime IEDTimeSkew	-	-	IEDTime	Time synchronization mode
EvalTimeAccuracy	Disabled 5ms 10ms 20ms 40ms	-	-	5ms	Evaluate time accuracy for invalid time
EventRepMode	SeqOfEvent HiPriSpont	-	-	SeqOfEvent	Event reporting mode
CmdMode	MultiCmd SingleCmd	-	-	SingleCmd	Command handling mode

Table 11: DNPGEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled Enabled	-	-	Disabled	Operation Disabled/Enabled

Table 12: MSTSER Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled Enabled	-	-	Disabled	Operation Disabled/Enabled
ChToAssociate	RS485 Optical	-	-	RS485	Channel to associate to
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 13: MSTSER Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Disabled Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Disabled	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tVRRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tVROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tVREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tVREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tVREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	Yes	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout

Table 14: CHSEROPT Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BaudRate	300 Bd 600 Bd 1200 Bd 2400 Bd 4800 Bd 9600 Bd 19200 Bd 38400 Bd 57600 Bd 115200 Bd	-	-	9600 Bd	Baud-rate for serial port

Table 15: CHSEROPT Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
DLinkConfirm	Never Sometimes Always	-	-	Never	Data-link confirm
tDLinkTimeout	0.000 - 60.000	s	0.001	2.000	Data-link confirm timeout in s
DLinkRetries	0 - 255	-	1	3	Data-link maximum retries
tRxToTxMinDel	0.000 - 60.000	s	0.001	0.000	Rx to Tx minimum delay in s
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size
StopBits	1 - 2	-	1	1	Stop bits
Parity	No Even Odd	-	-	Even	Parity

Table 16: CHSERRS485 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
BaudRate	300 Bd 600 Bd 1200 Bd 2400 Bd 4800 Bd 9600 Bd 19200 Bd 38400 Bd 57600 Bd 115200 Bd	-	-	9600 Bd	Baud-rate for serial port

Table 17: CHSERRS485 Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
DLinkConfirm	Never Sometimes Always	-	-	Never	Data-link confirm
tDLinkTimeout	0.000 - 60.000	s	0.001	2.000	Data-link confirm timeout in s
DLinkRetries	0 - 255	-	1	3	Data-link maximum retries
tRxToTxMinDel	0.000 - 60.000	s	0.001	0.000	Rx to Tx minimum delay in s
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size
StopBits	1 - 2	-	1	1	Stop bits
Parity	No Even Odd	-	-	Even	Parity
tRTSWarmUp	0.000 - 60.000	s	0.001	0.000	RTS warm-up in s
tRTSWarmDown	0.000 - 60.000	s	0.001	0.000	RTS warm-down in s
tBackOffDelay	0.000 - 60.000	s	0.001	0.050	RS485 back-off delay in s
tMaxRndDelBkOf	0.000 - 60.000	s	0.001	0.100	RS485 maximum back-off random delay in s

4.2.2 Parameter list for TCP/IP

Table 18: DNPGENTCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
PortSelection	None Front LANAB LANCD Any	-	-	Any	Port selection for communiction

Table 19: CH1TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled TCP/IP UDP-Only	-	-	Disabled	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP portfor initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 20: CH1TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 21: CH2TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled TCP/IP UDP-Only	-	-	Disabled	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP port for initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 22: CH2TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 23: CH3TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled TCP/IP UDP-Only	-	-	Disabled	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP port for initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 24: CH3TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 25: CH4TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled TCP/IP UDP-Only	-	-	Disabled	Operation mode
TCPIPLisPort	1 - 65535	-	1	20000	TCP/IP listen port
UDPPortAccData	1 - 65535	-	1	20000	UDP port to accept UDP datagrams from master
UDPPortInitNUL	1 - 65535	-	1	20000	UDP port for initial NULL response
UDPPortCliMast	0 - 65535	-	1	0	UDP port to remote client/master

Table 26: CH4TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
ApLayMaxRxSize	20 - 2048	-	1	2048	Application layer maximum Rx fragment size
ApLayMaxTxSize	20 - 2048	-	1	2048	Application layer maximum Tx fragment size

Table 27: MST1TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled Enabled	-	-	Disabled	Operation Disabled/Enabled
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 28: MST1TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Disabled Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Disabled	Unsolicited response, event class mask

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tVRRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tVROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tVREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tVREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tVREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

Table 29: MST2TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled Enabled	-	-	Disabled	Operation Disabled/Enabled
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 30: MST2TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Disabled Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Disabled	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tVRRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tVROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tVREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tVREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tVREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

Table 31: MST3TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled Enabled	-	-	Disabled	Operation Disabled/Enabled
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 32: MST3TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Disabled Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Disabled	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tVRRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tVROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
tVREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tVREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tVREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

Table 33: MST4TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Disabled Enabled	-	-	Disabled	Operation Disabled/Enabled
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	0 - 18	IP Address	1	0.0.0.0	Master IP-address
MasterIPNetMsk	0 - 18	IP Address	1	255.255.255.255	Master IP net mask
Obj1DefVar	1:BISingleBit 2:BIWithStatus	-	-	1:BISingleBit	Object 1, default variation

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Obj2DefVar	1:BIChWithoutTime 2:BIChWithTime 3:BIChWithRelTime	-	-	3:BIChWithRelTime	Object 2, default variation
Obj3DefVar	1:DIWithoutFlag 2:DIWithFlag	-	-	1:DIWithoutFlag	Object 3, default variation
Obj4DefVar	1:DIChWithoutTime 2:DIChWithTime 3:DIChWithRelTime	-	-	3:DIChWithRelTime	Object 4, default variation
Obj10DefVar	1:BO 2:BOStatus	-	-	2:BOStatus	Object 10, default variation
Obj20DefVar	1:BinCnt32 2:BinCnt16 5:BinCnt32WoutF 6:BinCnt16WoutF	-	-	5:BinCnt32WoutF	Object 20, default variation
Obj22DefVar	1:BinCnt32EvWoutT 2:BinCnt16EvWoutT 5:BinCnt32EvWithT 6:BinCnt16EvWithT	-	-	1:BinCnt32EvWoutT	Object 22, default variation
Obj30DefVar	1:AI32Int 2:AI16Int 3:AI32IntWithoutF 4:AI16IntWithoutF 5:AI32FltWithF 6:AI64FltWithF	-	-	3:AI32IntWithoutF	Object 30, default variation
Obj32DefVar	1:AI32IntEvWoutF 2:AI16IntEvWoutF 3:AI32IntEvWithFT 4:AI16IntEvWithFT 5:AI32FltEvWithF 6:AI64FltEvWithF 7:AI32FltEvWithFT 8:AI64FltEvWithFT	-	-	1:AI32IntEvWoutF	Object 32, default variation

Table 34: MST4TCP Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
AddrQueryEnbl	No Yes	-	-	Yes	Address query enable
tApplConfTout	0.00 - 300.00	s	0.01	10.00	Application layer confim timeout
ApplMultFrgRes	No Yes	-	-	Yes	Enable application for multiple fragment response

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Disabled Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Disabled	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tVRRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tVROfflRtryDel	0.00 - 60.00	s	0.01	30.00	Unsolicited response off-line retry delay in s
UREvCntThold1	1 - 100	-	1	5	Unsolicited response class 1 event count report treshold
tVREvBufTout1	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 1 event buffer timeout
UREvCntThold2	1 - 100	-	1	5	Unsolicited response class 2 event count report treshold
tVREvBufTout2	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 2 event buffer timeout
UREvCntThold3	1 - 100	-	1	5	Unsolicited response class 3 event count report treshold
tVREvBufTout3	0.00 - 60.00	s	0.01	5.00	Unsolicited response class 3 event buffer timeout
DelOldBufFull	No Yes	-	-	No	Delete oldest event when buffer is full
ExtTimeFormat	LocalTime UTC	-	-	UTC	External time format
DNPToSetTime	No Yes	-	-	No	Allow DNP to set time in IED
tSynchTimeout	30 - 3600	s	1	1800	Time synch timeout before error status is generated
TSyncReqAfTout	No Yes	-	-	No	Time synchronization request after timeout
Averag3TimeReq	No Yes	-	-	No	Use average of 3 time requests
PairedPoint	No Yes	-	-	Yes	Enable paired point
tSelectTimeout	1.0 - 60.0	s	0.1	30.0	Select timeout
tBrokenConTout	0 - 3600	s	1	0	Broken connection timeout
tKeepAliveT	0 - 3600	s	1	10	Keep-Alive timer

Section 5 Glossary

5.1 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
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
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
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
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
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 IP20- Protected against solid foreign objects of 12.5mm diameter and greater.
IP 40	Ingression protection, according to IEC 60529, level IP40- Protected against solid foreign objects of 1mm diameter and greater.
IP 54	Ingression protection, according to IEC 60529, level IP54-Dust-protected, protected against splashing water.
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 communication
SRY	Switch for CB ready condition
ST	Switch or push button to trip
Starpoint	Neutral/Wye 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 gound-fault protection function
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 ground-fault current
$3V_O$	Three times the zero sequence voltage. Often referred to as the residual voltage or the neutral point voltage

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