Relion® Protection and Control

650 series
DNP3 Communication Protocol Manual

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Document ID: 1MRK 511 224-UEN
Issued: September 2009
Revision: -
Product version: 1.0

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This product is designed and produced for industrial use.

Table of contents

Table of contents

Section 1 Introduction

1.1 This manual

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

1.2 Intended audience

This manual addresses the communication system engineer or system integrator responsible for pre-engineering and engineering for communication setup in a substation from an IED perspective.

The system engineer or system integrator must have a basic knowledge of communication in protection and control systems and thorough knowledge of the specific communication protocol.

1.3 Product documentation

1.3.1 Product documentation set

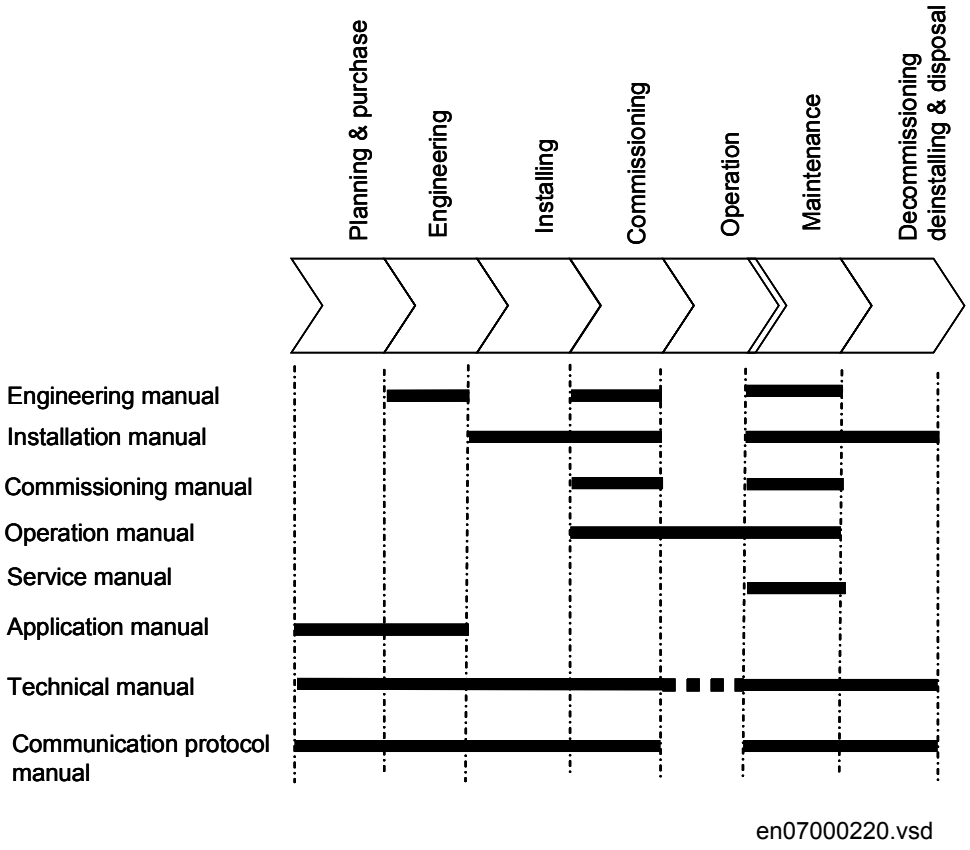

Figure 1: The intended use of manuals in different lifecycles

The engineering manual contains instructions on how to engineer the IEDs using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 61850 and DNP3.

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

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for checking of external circuitry and energizing the IED, parameter setting and configuration as 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 chronological order in which the IED should be commissioned.

The operation manual contains instructions on how to operate the IED once it has been commissioned. The manual provides instructions for monitoring, controlling and setting 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 service manual contains instructions on how to service and maintain the IED. The manual also provides procedures for de-energizing, de-commissioning and disposal of the IED.

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 be used when 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 a communication protocol supported by the IED. The manual concentrates on 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 service manual is not available yet.

1.3.2 Document revision history

Document revision/date	Product series version	History
-/September 2009	1.0	First release

1.3.3 Related documents

Documents related to REC650	Identity number
Commissioning manual	1MRK 511 209-UEN
Technical manual	1MRK 511 204-UEN
Application manual	1MRK 511 203-UEN

Table continues on next page

Documents related to REC650	Identity number
Product Guide, configured	1MRK 511 211-BEN
Type test certificate	1MRK 511 211-TEN

Documents related to REL650	Identity number
Commissioning manual	1MRK 506 307-UEN
Technical manual	1MRK 506 304-UEN
Application manual	1MRK 506 305-UEN
Product Guide, configured	1MRK 506 308-BEN
Type test certificate	1MRK 506 308-TEN

Documents related to RET650	Identity number
Commissioning manual	1MRK 504 109-UEN
Technical manual	1MRK 504 106-UEN
Application manual	1MRK 504 107-UEN
Product Guide, configured	1MRK 504 110-BEN
Type test certificate	1MRK 504 110-TEN

650 series manuals	Identity number
Operation manual	1MRK 500 088-UEN
Communication protocol manual, DNP3	1MRK 511 224-UEN
Communication protocol manual, IEC 61850	1MRK 511 205-UEN
Engineering manual	1MRK 511 206-UEN
Installation manual	1MRK 514 013-UEN
Point list manual, DNP3	1MRK 511 225-UEN

1.4 Symbols and conventions

1.4.1 Safety indication 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 to 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 should be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Manual conventions

Conventions used in IED manuals. A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual are spelled out in Glossary. 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.
- The ^ character in front of an input or output signal name in the function block symbol given for a function, indicates that the user can set an own signal name in PCM600.
- The * character after an input or output signal name in the function block symbol given for a function, indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.

1.4.3 Functions included in 650 series IEDs

Table 1: Main protection functions

IEC 61850	ANSI	Function description
Differential protection		
T2WPDIF	87T	Transformer differential protection, two winding
T3WPDIF	87T	Transformer differential protection, three winding
REFPDIF	87N	Restricted earth fault protection, low impedance
Impedance protection		
ZQDPDIS	21	Five zone distance protection, quadrilateral characteristic
FDPSPDIS	21	Phase selection with load enchroachment, quadrilateral characteristic

Table continues on next page

IEC 61850	ANSI	Function description
ZMOPDIS	21	Five zone distance protection, mho characteristic
FMPSPDIS	21	Faulty phase identification with load enchroachment for mho
ZDNRDIR	21	Directional impedance quadrilateral and mho
PPLPHIZ		Phase preference logic
ZMRPSB	68	Power swing detection
ZCVPSOF		Automatic switch onto fault logic, voltage and current based

Table 2: Back-up protection functions

IEC 61850	ANSI	Function description
Current protection		
PHPIOC	50	Instantaneous phase overcurrent protection
OC4PTOC	51/67	Four step directional phase overcurrent protection
EFPIOC	50N	Instantaneous residual overcurrent protection
EF4PTOC	51N/67N	Four step directional residual overcurrent protection
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection
UC2PTUC	37	Time delayed 2-step undercurrent protection
LPTTR	26	Thermal overload protection, one time constant
TRPTTR	49	Thermal overload protection, two time constants
CCRBRF	50BF	Breaker failure protection
STBPTOC	50STB	Stub protection
CCRPLD	52PD	Pole discordance protection
BRCPTOC	46	Broken conductor check
GUPPDUP	37	Directional underpower protection
GOPPDOP	32	Directional overpower protection
DNSPTOC	46	Negative sequence based overcurrent function
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
LOVPTUV	27	Loss of voltage check
Frequency protection		
SAPTUF	81	Underfrequency function
SAPTOF	81	Overfrequency function
SAPFRC	81	Rate-of-change frequency protection

Table 3: Control and monitoring functions

IEC 61850	ANSI	Function description
Control		
SESRSYN	25	Synchrocheck, energizing check, and synchronizing
SMBRREC	79	Autorecloser
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		Circuit switch
POS_EVAL		Evaluation of position indication
SELGGIO		Select release
QCBAY		Bay control
LOCREM		Handling of LR-switch positions
LOCREMCTRL		LHMI control of PSTO
TR1ATCC	90	Automatic voltage control for tapchanger, single control
TR8ATCC	90	Automatic voltage control for tapchanger, parallell control
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs
SLGGIO		Logic Rotating Switch for function selection and LHMI presentation
VSGGIO		Selector mini switch extension
DPGGIO		IEC61850 generic communication I/O functions double point
SPC8GGIO		Single point generic control 8 signals
AUTOBITS		AutomationBits, command function for DNP3.0
Secondary system supervision		
CCSRDIF	87	Current circuit supervision
SDDRFUF		Fuse failure supervision
TCSSCBR		Breaker close/trip circuit monitoring
Logic		
SMPPTRC	94	Tripping logic

Table continues on next page

IEC 61850	ANSI	Function description
TMAGGIO		Trip matrix logic
OR		Configurable logic blocks, OR
INVERTER		Configurable logic blocks, Inverter
PULSETIMER		Configurable logic blocks, PULSETIMER
GATE		Configurable logic blocks, Controllable gate
XOR		Configurable logic blocks, exclusive OR
LOOPDELAY		Configurable logic blocks, loop delay
TimeSet		Configurable logic blocks, timer
AND		Configurable logic blocks, AND
SRMEMORY		Configurable logic blocks, set-reset memory
RSMEMORY		Configurable logic blocks, reset-set memory
ANDQT		Configurable logic Q/T, ANDQT
ORQT		Configurable logic Q/T, ORQT
INVERTERQT		Configurable logic Q/T, INVERTERQT
XORQT		Configurable logic 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
FSDSIGN		Fixed signal function block
B16I		Boolean 16 to Integer conversion
B16IFCVI		Boolean 16 to integer conversion with logic node representation
IB16A		Integer to Boolean 16 conversion
IB16FCVB		Integer to boolean 16 conversion with logic node representation
Monitoring		
CVMMXN		Measurements
CMMXU		Phase current measurement
VMMXU		Phase-phase voltage measurement
CMSQI		Current sequence component measurement
VMSQI		Voltage sequence measurement
VNMMXU		Phase-neutral voltage measurement
CNTGGIO		Event counter
DRPRDRE		Disturbance report
AxRADR		Analog input signals
BxRBDR		Binary input signals
SPGGIO		IEC61850 generic communication I/O functions

Table continues on next page

IEC 61850	ANSI	Function description
SP16GGIO		IEC61850 generic communication I/O functions 16 inputs
MVGGIO		IEC61850 generic communication I/O functions
MVEXP		Measured value expander block
LMBRFLO		Fault locator
SPVNZBAT		Station battery supervision
SSIMG	63	Insulation gas monitoring function
SSIML	71	Insulation liquid monitoring function
SSCBR		Circuit breaker condition monitoring
Metering		
PCGGIO		Pulse counter logic
ETPMMTR		Function for energy calculation and demand handling

Table 4: Designed to communicate

IEC 61850	ANSI	Function description
Station communication		
		IEC61850 communication protocol
		DNP3.0 for TCP/IP communication protocol
GOOSEINTLKRCV		Horizontal communication via GOOSE for interlocking
GOOSEBINRCV		GOOSE binary receive
Scheme communication		
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection
ZCLCPLAL		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

Table 5: Basic IED functions

IEC 61850	Function description
Basic functions included in all products	
INTERRSIG	Self supervision with internal event list
	Time synchronization
SETGRP	Setting group handling
ACTVGRP	Parameter setting groups
TESTMODE	Test mode functionality
CHNGLCK	Change lock function
ATHSTAT	Authority status
ATHCHCK	Authority check

Section 2 DNP3 overview

DNP3 is a set of communications protocols 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.

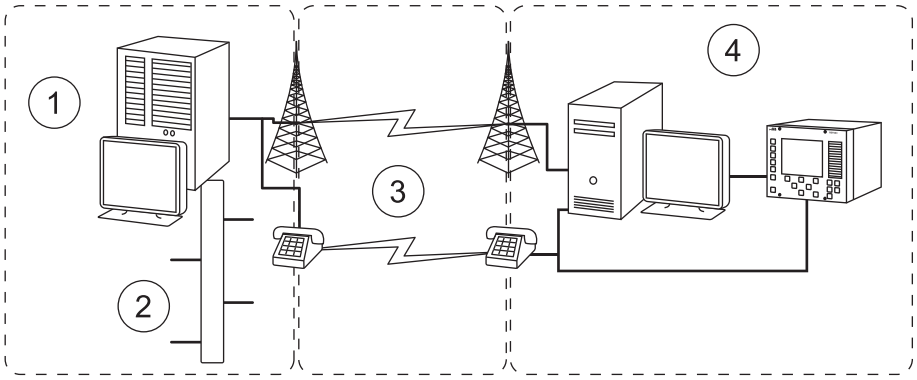

Figure 2: DNP3 communication schematic representation

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. Now the protocol specification is controlled by the DNP Users Group at 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.

DNP 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 DNP 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 outstations.

Data link functions include:

- Performing message data link retransmissions.
- Synchronizing and handling the FCB in the control octet.
- Setting and clearing the DFC bit based on buffer availability.
- Packing user data into the defined frame format, include CRC and transmitting the data to the physical layer.
- Unpacking the data link frame received from the physical layer into user data, check and remove CRC.
- Controlling the physical layer.
- Responding to all valid frames received from the physical layer.

Data link responsibilities:

- Exchange of 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. DNP uses the term point do 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 classes; 0 for static data (current value) and 1, 2 and 3 for event data.

Communication modes

The IED supports four DNP 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 DNP 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, *UDPPortInitNULL* 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.

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 DNP. This bit is set when the IED is selected to Local control.	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

Table continues on next page

Bit index	Descriptions and conditions	Writable
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 spontaneous reporting, that is, unsolicited reporting, of events. 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.

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

DNP 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 select 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 DNP. 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. This means that if *ctlModel* is set to *SBO Enh*, direct operate commands from DNP are not allowed. This means that if *ctlModel* is set to *SBO Enh*, direct operate commands from DNP are not allowed.

Furthermore, the select timeout parameter *tSelectTimeout* in DNP 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/operate.

3.4.3 Binary output status points and control relay output blocks

While 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 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

DNP supports time synchronization of the IED via object numbers 50...52. Time synchronization via DNP 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 DNP masters.

DNP can be set for a coarse synchronization source under **Configuration/Time/Synchronisation/1:TSYNCGEN/CoarseSyncSrc** in the LHMI tree. Note that when DNP 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 DNP master configuration block has a number of parameters that affect the time synchronization. Only one master at a time shall be configured to set the time in the IED. Therefore, only one master configuration block should enable the *DNPToSetTime* parameter.

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.

3.5.1 Analog inputs

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

3.5.1.1 Analog data scaling

The four scaling options associated with analog input data reporting are None, Ratio, Multiplicative and Divisor. The selection *None* means that no scaling is performed on the source IEC 61850 value. The value is reported as such to DNP.

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 DNP value.

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

(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)

3.5.1.2 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, U, I, P, Q, for example. The RMS values are available in floating point presentation as output signals of function blocks of type MMXU.

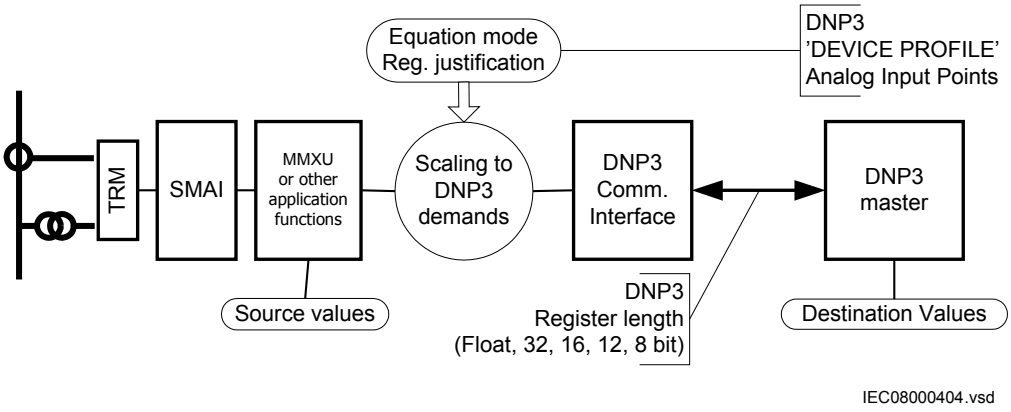

Figure 3: PCM600: Typical example of DNP3 scaling

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).

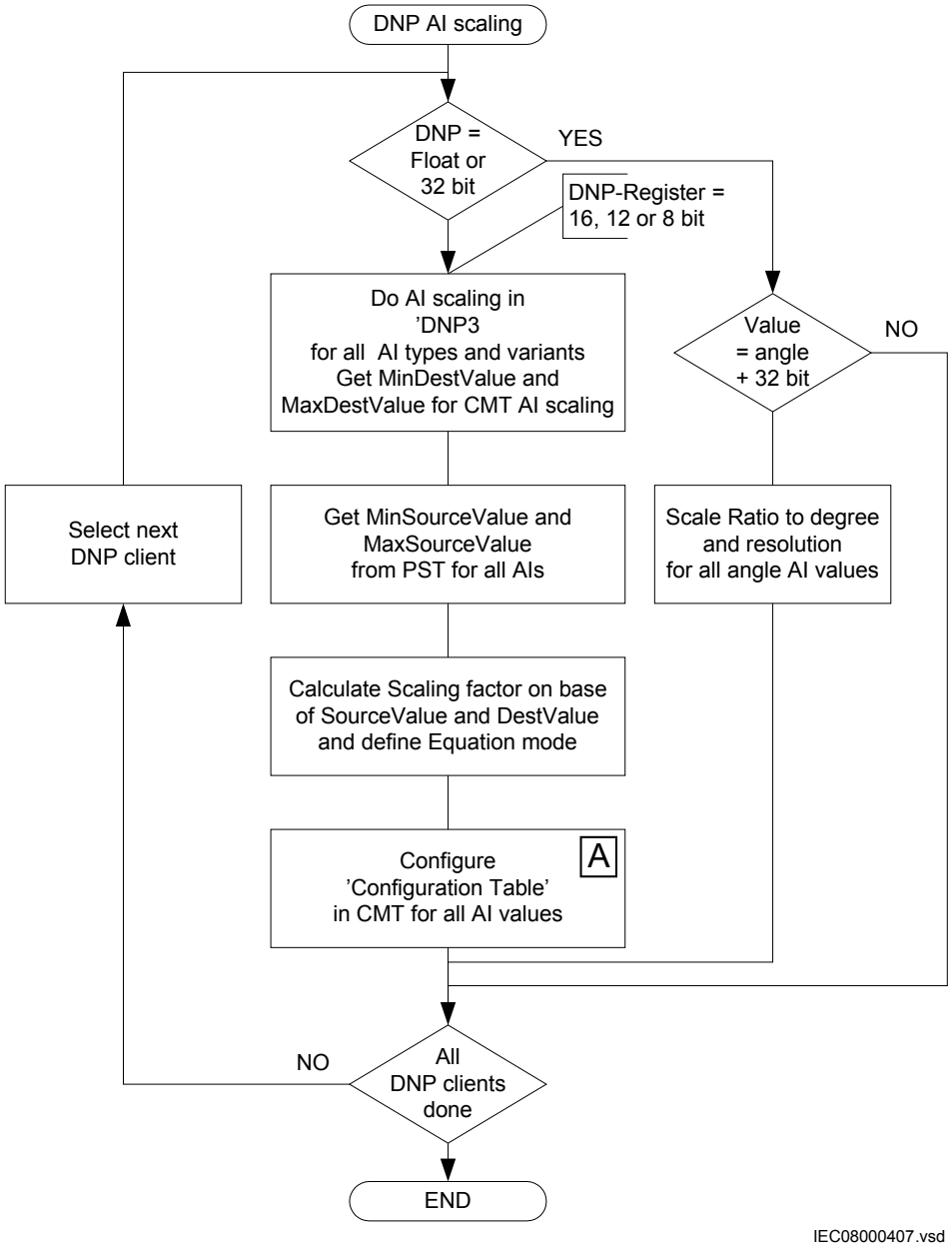

Figure 4: CMT: Configuration Flowchart

3.6 DNP points

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

3.6.1 Point configuration

The DNP3 point map is configurable in PCM600. All points in the IED are unmapped as default. 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. Point gaps cannot be read by the client.

3.6.2 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.

BOS points exist only if the corresponding CROB point has been inserted in the active point list.

3.7 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 DNP 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 DNP 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 **Settings/General/Settings/Station Communication/DNP3.0**. There is one general setting for DNP3 (Disabled/Enabled) and specific settings for each communication TCP/IP channel, for example, CH1TCP and MST1TCP.

The DNP3 block contains one single parameter that controls the operation of DNP. This parameter must be turned on for the other parameters to have effect. 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 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.

UDP is not supported in the first release. Do not use "UDP-only" for setting *Operation*.

Master session settings for a specific communication channel

Operation determines the operation of the master session. 0 = Off. 1 = On.

SlaveAddress defines the DNP address of this master session.

MasterAddress defines the DNP 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.

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.

ApplConfTout 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 DNP 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.

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

tSTsynchTimeout 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.

TsyncReqAfToutTSyncReqAfTout 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.

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.

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.

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.

4.2 Parameter list

Table 8: DNPGEN Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation mode Off / On

Table 9: CH1TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only[1)]	-	-	Off	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

1) Not supported in the first release

Table 10: 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 11: CH2TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only[1)]	-	-	Off	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

1) Not supported in the first release

Table 12: 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 13: CH3TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only[1)]	-	-	Off	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

1) Not supported in the first release

Table 14: 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 15: CH4TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off TCP/IP UDP-Only[1)]	-	-	Off	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

1) Not supported in the first release

Table 16: 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 17: MST1TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	Master IP-address				
MasterIPNetMsk	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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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 18: 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	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROffIRtryDel	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
tUREvBufTout1	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
tUREvBufTout2	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
tUREvBufTout3	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 19: MST2TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	Master IP-address				
MasterIPNetMsk	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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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 20: 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	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	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
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	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
tUREvBufTout1	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
tUREvBufTout2	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
tUREvBufTout3	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 21: MST3TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	Master IP-address				
MasterIPNetMsk	Master IP net mask				

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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 22: 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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	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
tUREvBufTout1	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
tUREvBufTout2	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
tUREvBufTout3	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 23: MST4TCP Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off / On
SlaveAddress	0 - 65519	-	1	1	Slave address
MasterAddres	0 - 65519	-	1	1	Master address
ValMasterAddr	No Yes	-	-	Yes	Validate source (master) address
MasterIP-Addr	Master IP-address				
MasterIPNetMsk	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 24: 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
ConfMultFrag	No Yes	-	-	Yes	Confirm each multiple fragment
UREnable	No Yes	-	-	Yes	Unsolicited response enabled
UREvClassMask	Off Class 1 Class 2 Class 1 and 2 Class 3 Class 1 and 3 Class 2 and 3 Class 1, 2 and 3	-	-	Off	Unsolicited response, event class mask
UROfflineRetry	0 - 10	-	1	5	Unsolicited response retries before off-line retry mode
tURRetryDelay	0.00 - 60.00	s	0.01	5.00	Unsolicited response retry delay in s
tUROfflRtryDel	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
tUREvBufTout1	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
tUREvBufTout2	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
tUREvBufTout3	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

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
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

AC	Alternating current
ACT	Application configuration tool within PCM600
A/D converter	Analog to digital converter
ADBS	Amplitude dead-band supervision
ANSI	American National Standards Institute
AR	Autoreclosing
ASCT	Auxiliary summation current transformer
ASD	Adaptive signal detection
AWG	American Wire Gauge standard
BR	External bi-stable relay
BS	British standard
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication
CB	Circuit breaker
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations sponsored standards body within the International Telecommunications Union.
CCVT	Capacitive Coupled Voltage Transformer
Class C	Protection Current Transformer class as per IEEE/ ANSI
CMPPS	Combined mega pulses per second
CO cycle	Close-open cycle
Co-directional	Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions
COMTRADE	Standard format according to IEC 60255-24
Contra-directional	Way of transmitting G.703 over a balanced line. Involves four twisted pairs of with two are used for transmitting data in both directions, and two pairs for transmitting clock signals
CPU	Central processor unit
CR	Carrier receive
CRC	Cyclic redundancy check
CS	Carrier send

CT	Current transformer
CVT	Capacitive voltage transformer
DAR	Delayed auto-reclosing
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
DFT	Discrete Fourier transform
DIP-switch	Small switch mounted on a printed circuit board
DLLB	Dead line live bus
DNP	Distributed Network Protocol as per IEEE/ANSI Std. 1379-2000
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	Electro magnetic compatibility
EMF	Electro motive force
EMI	Electro magnetic interference
EnFP	End fault protection
ESD	Electrostatic discharge
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
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
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 auto reclosing
HV	High voltage
HVDC	High voltage direct current
IDBS	Integrating dead band supervision
IEC	International Electrical Committee
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
IEC 61850	Substation Automation communication 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 Electro Motive Force.
IED	Intelligent electronic device
I-GIS	Intelligent gas insulated switchgear
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 will have 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 re-assembly through the data link layer.
	2. Ingression protection according to IEC standard
IP 20	Ingression protection, according to IEC standard, level 20
IP 40	Ingression protection, according to IEC standard, level 40
IP 54	Ingression protection, according to IEC standard, level 54
IRF	Internal fail 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
LDD	Local detection device
LED	Light emitting diode
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.
NCC	National Control Centre
OCO cycle	Open-close-open cycle
OCP	Overcurrent protection
OLTC	On load tap changer
OV	Over voltage
Overreach	A term used to describe how the relay behaves during a fault condition. For example a distance relay is over-reaching when the impedance presented to it is smaller than the apparent impedance to the fault applied to the balance point, i.e. 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
PISA	Process interface for sensors & actuators
PMC	PCI Mezzanine card
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
REVAL	Evaluation software
RFPP	Resistance for phase-to-phase faults
RFPE	Resistance for phase-to-earth faults
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
SC	Switch or push-button to close
SCS	Station control system
SCT	System configuration tool according to standard IEC 61850
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.
SRY	Switch for CB ready condition
ST	Switch or push-button to trip
Starpoint	Neutral point of transformer or generator
SVC	Static VAr compensation
TC	Trip coil

TCS	Trip circuit supervision
TCP	Transmission control protocol. The most common transport layer protocol used on Ethernet and the Internet.
TCP/IP	Transmission control protocol over Internet Protocol. The de facto standard Ethernet protocols incorporated into 4.2BSD Unix. TCP/IP was developed by DARPA for internet working and encompasses both network layer and transport layer protocols. While TCP and IP specify two protocols at specific protocol layers, TCP/IP is often used to refer to the entire US Department of Defense protocol suite based upon these, including Telnet, FTP, UDP and RDP.
TNC connector	Threaded Neill Concelman, A threaded constant impedance version of a BNC connector
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
Underreach	A term used to describe how the relay behaves during a fault condition. For example a distance relay is under-reaching when the impedance presented to it is greater than the apparent impedance to the fault applied to the balance point, i.e. the set reach. The relay does not “see” the fault but perhaps it should have seen it. See also Overreach.
U/I-PISA	Process interface components that deliver measured voltage and current values
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 also sometimes known by the military name, "Zulu time". "Zulu" in the phonetic alphabet stands for "Z" which stands for longitude zero.
UV	Undervoltage
WEI	Weak end infeed logic
VT	Voltage transformer
X.21	A digital signalling interface primarily used for telecom equipment

$3I_O$	Three times zero-sequence current. Often referred to as the residual or the earth-fault current
$3U_O$	Three times the zero sequence voltage. Often referred to as the residual voltage or the neutral point voltage

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