Disclaimer

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

This product has been designed to be connected and communicate data and information via a network interface which should be connected to a secure network. It is the sole responsibility of the person or entity responsible for network administration to ensure a secure connection to the network and to take the necessary measures (such as, but not limited to, installation of firewalls, application of authentication measures, encryption of data, installation of anti virus programs, etc.) to protect the product and the network, its system and interface included, against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB is not liable for any such damages and/or losses.

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

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2014/35/EU). This conformity is the result of tests conducted by the third party testing laboratory Intertek 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.
Safety information

⚠️ Dangerous voltages can occur on the connectors, even though the auxiliary voltage has been disconnected.

⚠️ Non-observance can result in death, personal injury or substantial property damage.

⚠️ Only a competent electrician is allowed to carry out the electrical installation.

⚠️ National and local electrical safety regulations must always be followed.

⚠️ The frame of the protection relay has to be carefully earthed.

❗️ The protection relay contains components which are sensitive to electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.

❗️ Whenever changes are made in the protection relay, measures should be taken to avoid inadvertent tripping.
# Table of contents

## Section 1 Introduction
- This manual.................................................................5
- Intended audience..........................................................5
- Product documentation....................................................6
  - Product documentation set..............................................6
  - Document revision history..............................................6
- Related documentation....................................................6
- Symbols and conventions...............................................7
  - Symbols........................................................................7
  - Document conventions................................................7

## Section 2 IEC 61850 overview...........................................9

## Section 3 PCM600.........................................................13
- Connectivity packages..................................................13
  - PCM600 and relay connectivity package version...............13

## Section 4 REX640 data model..........................................15
- REX640 implementation................................................15
- Information model.......................................................15
  - Vertical and horizontal communication........................17
  - Predefined vertical communication data sets.....................18
  - Predefined horizontal communication data sets.................19
  - Vertical communication diagnostic counters....................19
- Parameter setting and disturbance recorder.......................20

## Section 5 GOOSE........................................................21
- Horizontal communication.............................................21
- GOOSE publishing properties.........................................21
- Configuring GOOSE with Application Configuration...........22
  - GOOSE load estimations..............................................23
  - Connecting sender function block signal to GOOSE receiver
    block using Application Configuration tab........................24
  - Connecting sender function block signal to GOOSE receiver
    block using SCL Configuration tab...................................26
- Configuring GOOSE with IEC 61850 Configuration................27
  - Defining IEDs and starting IEC 61850 Configuration...........27
  - Configuring a GOOSE publisher with IEC 61850 Configuration..28
    - Creating a GOOSE data set with IEC 61850 Configuration...28
    - Configuring a GOOSE control block with IEC 61850
      Configuration.............................................................31
<table>
<thead>
<tr>
<th>Section 6</th>
<th>Process bus and IEEE 1588 time synchronization</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sampled measured values and IEEE 1588 v2 time synchronization</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>System building</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>High-availability seamless redundancy HSR</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Parallel redundancy protocol PRP</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Intelink port</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Performance optimization</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Requirements for third-party devices</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>SMV system configuration</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>SMVSENDER ACT configuration</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>SMVRCVx ACT configuration</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Configuring SMV with IEC 61850 Configuration</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Configuring SMV receiver with Signal Matrix’s SMV tool</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Bay level configuration</td>
<td>72</td>
</tr>
</tbody>
</table>
Section 7 Engineering of event reporting with PCM600.............85
IEC 61850 client management with IEC 61850 Configuration........85
Adding new IEC 61850 clients for IEC 61850 Configuration........85
IEC 61850 Configuration user interface.................................88
Creating data sets with IEC 61850 Configuration.......................90
Defining data set entries with IEC 61850 Configuration.............91
Creating report control blocks with IEC 61850 Configuration........93
Configuring report control block clients with IEC 61850
Configuration........................................................................96
Substation section configuration in IEC 61850 Configuration........97

Section 8 Engineering of event reporting with IET600.............99
Managing IEC 61850 clients with IET600.................................99
Adding new IEC 61850 clients for IET600...............................99
Attaching IEC 61850 clients to a bus with IET600....................102
IET600 user interface..............................................................103
Setting visibility of columns in grid editors............................105
Substation section configuration in IET600...............................105
Creating data sets with IET600..............................................107
Creating report control blocks with IET600............................109
Report control block client configuration with IET600..............110
Configuring report control block clients semi-automatically........111

Section 9 Flexible product naming.........................................113
Flexible product naming concept.............................................113
Mapping examples...............................................................113
Import scenarios.....................................................................114
Network configuration............................................................115
Defining subnetwork.............................................................116
Mapping access points............................................................118
Engineering..........................................................................119
IEC 61850 edition selection...................................................119
Parameter setting.................................................................119
IED identification.................................................................119
Table of contents

Configuration size.................................................................................. 120
Functional naming.................................................................................. 120
Name space definition files................................................................. 121
Data model................................................................................................. 121
Logical device division........................................................................ 121
Data protection........................................................................................ 121
Functional constraints.......................................................................... 121
Data types.................................................................................................. 122
Standard compatibility........................................................................ 122
Primary values........................................................................................ 123
Substitution............................................................................................... 123
Settings......................................................................................................... 123
Device menu............................................................................................. 124
Function mode handling.......................................................................... 124
Setting group parameters........................................................................ 128
Setting group control............................................................................. 129
Control......................................................................................................... 129
Local/remote handling............................................................................ 129
Control model.......................................................................................... 129
Data sets.................................................................................................... 129
Supported data types in data sets.......................................................... 130
Editing data sets in IEC 61850 Configuration......................................... 130
Sampled measured values....................................................................... 133
SCL configuration checklist for sampled measured values.................. 133
GOOSE.................................................................................................... 133
SCL configuration checklist for GOOSE............................................... 134
Editing GOOSE control blocks in IEC 61850 Configuration................. 134
Reporting.................................................................................................. 136
SCL configuration checklist for ReportControl...................................... 136
Editing ReportControl blocks in IEC 61850 Configuration.................... 136
Logging...................................................................................................... 138
Service tracking...................................................................................... 138

Section 10 Glossary.................................................................................. 139
Section 1  Introduction

1.1  This manual

The engineering guide provides information for IEC 61850 engineering of the protection relays with PCM600 and IET600. The guide can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service. For more details on tool usage, see the PCM600 documentation.

1.2  Intended audience

This manual addresses the system engineers and installation and commissioning personnel.

The system engineer must have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logic in the protection relays. The installation and commissioning personnel must have basic knowledge of how to handle the electronic equipment.
1.3 Product documentation

1.3.1 Product documentation set

Planning & purchase
- Quick installation guide
- Brochure
- Product guide
- Operation manual

Installation
- Installation manual
- Engineering manual
- Technical manual
- Application manual

Commissioning
- Communication protocol manual
- IEC 61850 engineering guide

Operation
- Cyber security deployment guideline
- Hardware modification instructions

Maintenance
- Modification sales guideline

Decommissioning, deinstallation & disposal

Figure 1: The intended use of documents during the product life cycle

1.3.2 Document revision history

<table>
<thead>
<tr>
<th>Document revision/date</th>
<th>Product connectivity level</th>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/2019-04-30</td>
<td>PCL1</td>
<td>First release</td>
</tr>
<tr>
<td>B/2020-02-13</td>
<td>PCL2</td>
<td>Content updated to correspond to the product connectivity level</td>
</tr>
</tbody>
</table>

1.3.3 Related documentation

1.4 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. Therefore, comply fully with all warning and caution notices.

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold. Select Main menu/Settings.
- Parameter names are shown in italics. The function can be enabled and disabled with the Operation setting.
- Parameter values are indicated with quotation marks. The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font. When the function starts, the START output is set to TRUE.
- This document assumes that the parameter setting visibility is "Advanced".
Section 2  IEC 61850 overview

The international IEC 61850 standard defines a framework for substation communication networks and systems. The standard consists of several parts ranging from the requirements on substation automation systems to the details of a communication protocol. Its main goal is interoperability; the ability for IEDs from one or different manufacturers to exchange information and use the information for their own functions.

This standard has been out since 2005 and used successfully in ABB products. It is updated with a new version, Edition 2, which extends to new application areas in transmission and distribution power systems and also defines a new functionality to Edition 1 functionality. This product supports both IEC 61850 versions, Edition 1 and Edition 2.

IEC 61850 Edition 2 adds new functionality which is not supported by the Edition 1 devices. Therefore it is recommended to always use the same standard version in all devices and not to mix different versions in the same project.

A major difference between the other communication protocols applied in substation automation and IEC 61850 is that the latter is not only a communication protocol, but a whole framework for specifying, engineering and operating substation automation systems. The communication part covers the connection between the IEDs and the substation clients, for example, SCADA and gateways.

![Structure and parts of the IEC 61850 standard](image)

**Figure 2:** Structure and parts of the IEC 61850 standard
The IEC 61850 standard specifies an expandable object-oriented data model and a wide set of protocol services for substation automation (standard parts 7-x). The standard does not specify any protection or control functions, but specifies how the functions expose their information to a communication network.

The standard supports free allocation of functions to devices. With efficient communication facilities, the functions can be located anywhere in the system, that is, an interlocking function can reside in the IED or on the station level. Additionally, the standard is open for different system implementations, that is, different integration levels and allocation of functions to different devices are supported.

The standard defines a system configuration description language (SCL) for substation automation systems. The language facilitates efficient automated integration of devices into systems. Additionally the standard supports a comprehensive and consistent system definition and engineering, which makes not only the devices, but also their tools and systems interoperable (standard part 6).

The standard uses Ethernet and TCP/IP for communication. Since Ethernet and TCP/IP are widely accepted and used, the application of these technologies provides a broad range of features from mainstream communication (standard parts 8-1, 9-2). The communication profiles in IEC 61850 can be divided into vertical and horizontal. The vertical profile uses MMS over TCP/IP and vertical communication Layer 2 Ethernet multicast messages. The standard separates the functionality represented by the data model and the related communication services from the communication implementation thus being open for new communication concepts in the future.
Figure 3: Communication stacks and mapping used in IEC 61850

1. Abstract communication services interface (ACSI)
2. Stack interface
3. ISO/OSI stack
Protection and Control IED Manager PCM600 offers all the necessary functionality to work throughout all stages of the protection relay's life cycle.

- Planning
- Engineering
- Commissioning
- Operation and disturbance handling
- Functional analysis

The whole substation configuration can be controlled and different tasks and functions can be performed with the individual tool components. PCM600 can operate with many different topologies, depending on the project needs.

For more information, see the PCM600 documentation.

3.1 Connectivity packages

A connectivity package is a software component that consists of executable code and data which enable system tools to communicate with a protection relay. Connectivity packages are used to create configuration structures in PCM600. The latest PCM600 and connectivity packages are backward compatible with older protection relay versions.

A connectivity package includes all the data which is used to describe the protection relay. For example, it contains a list of the existing parameters, data format used, units, setting range, access rights and visibility of the parameters. In addition, it contains code which allows the software packages that use the connectivity package to properly communicate with the protection relay.

3.2 PCM600 and relay connectivity package version

- Protection and Control IED Manager PCM600 Ver.2.10 or later
- REX640 Connectivity Package Ver.1.1 or later
Download connectivity packages from the ABB Web site
www.abb.com/mediumvoltage or directly with Update Manager in
PCM600.
Section 4  REX640 data model

4.1  REX640 implementation

The protection relay is modelled according to IEC 61850. This means that the functionality of the protection relay is represented in a data model in accordance with the standard and the protection relay supports a wide range of the services provided by the standard.

- Process data: monitoring of statuses and measurements
- Application data: protection activation, tripping, fault recordings
- Disturbance records
- Control commands
- Protection settings
- Settings and setting groups
- Configuration data
- Diagnostics and self-supervision
- Fast horizontal communication between devices
- Time synchronization
- File transfer

As this protection relay supports both versions of IEC 61850, Edition 1 and Edition 2, there are small differences in the IEC 61850 data models depending on the used version. Generally the relay’s protection and control functionality is independent of the IEC 61850 version used. Any differences between data model versions are documented.

It is possible to have Edition 1 and Edition 2 relays configured in the same PCM600 project. The PCM600 project's SCL edition is the highest SCL edition of the relays in the project, but if IEC 61850 is not used for the station bus, either version can be applied. The protection relay's IEC 61850 version is by default Edition 2. See Table 1 for the limitations in identification lengths in IEC 61850 versions and, in case of a mixed system, consider them when engineering. Edition 2 introduces new common data classes, which work only with Edition 2 capable devices.

4.2  Information model

The IEC 61850 data model can include up to four logical devices where different logical nodes, representing protection and control functionality, are located. Depending on the selected functionality in the protection relay, different configurations have different sets of logical devices and logical nodes. Data models
also include modelling and functionality of settings, setting groups and configuration according to the IEC 61850 concept.

- Control logical device, CTRL
- Disturbance recorder logical device, DR
- Protection logical device, LD0
- Sampled measured values sending logical device, MU01

All generic functionality, such as modelling of physical inputs and outputs as well as the alarming LED functionality, resides under logical device LD0. A full description of the protection relay's data model is available in the parameter list.

During system engineering in the system configuration tool, do not delete or rename logical devices, logical nodes, data objects or data attributes in the IEC 61850 data model.

---

**Figure 4:** Example of an IEC 61850 data model of a protection relay

In the IEC 61850 standard, communication services are configured through a number of data structures including data sets, report control blocks, GOOSE control blocks and setting group control blocks. As these data structures pertain to the entire logical device, the standard indicates that they are to be modeled under LLN0, which is a
special logical node that describes the common functionality of the logical device. All these data structures are located in logical device LD0 logical node LLN0.

The data model can be exported from PCM600 to an SCL file.

4.3 Vertical and horizontal communication

The protection relays are capable of vertical communication between the protection relay and monitoring and control systems (clients) such as PCM600 or MicroSCADA. Each protection relay can communicate to five separate clients to receive events, read or write data (an active PCM600 connection is considered to be a client). The protection relay can report data in either buffered or unbuffered mode and execute direct or select-before-operate control sequences according to the control commands sent by the client.

The protection relays are also capable of horizontal or peer-to-peer communication. They can be programmed to publish (send) information to and subscribe (receive) information from other devices according to IEC 61850-8-1 and IEC 61850-9-2 LE.

IEC 61850 standard Edition 2 increased several identification string lengths which affects communication engineering and interoperability. Table 1 lists the identification length values to be considered especially with third-party tools. ABB tools generally check the length values.

<table>
<thead>
<tr>
<th>Object</th>
<th>Edition 1 length</th>
<th>Edition 2 length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IED name</td>
<td>28 (32-4)</td>
<td>60 (64-4)</td>
<td>Excluding the longest LD name length of 4 characters</td>
</tr>
<tr>
<td>Report control block name</td>
<td>14</td>
<td>30</td>
<td>Without a two-digit RCB instance number</td>
</tr>
<tr>
<td>Data set name</td>
<td>32</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>RptID</td>
<td>65</td>
<td>129</td>
<td>Report Identifier</td>
</tr>
<tr>
<td>GoID</td>
<td>65</td>
<td>129</td>
<td>GOOSE Identifier</td>
</tr>
<tr>
<td>MSVID</td>
<td>65</td>
<td>65</td>
<td>Multicast Sampled Value Identifier (length as in IEC 61850-9-2 LE)</td>
</tr>
</tbody>
</table>
Table 2: Number of control block data sets and size of data sets

<table>
<thead>
<tr>
<th>Control block</th>
<th>Maximum data sets</th>
<th>Maximum length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoCB</td>
<td>6</td>
<td>120 data objects or attributes</td>
<td>The sending GOOSE data sets can have in total 120 data objects or attributes in the GOOSE data sets. To minimize the message-handling load in the receiving and sending protection relays, it is recommended to limit the data object and attribute amount to 20 per data set.</td>
</tr>
<tr>
<td>RCB</td>
<td>27</td>
<td>Edition 1: 256 data attributes Edition 2: When the data attribute level is used, maximum 80 data attributes can be configured per data set. When the data object level is used, maximum 80 data objects can be configured if the limit of 300 attributes per data set is not reached before that. Structured data objects contain more data attributes.</td>
<td>The recommendation is to use data objects when creating reporting data sets. The maximum number of reporting data sets is affected by the used GOOSE data sets. The number of data sets is shared with GOOSE meaning that there can be minimum 21 data sets for reporting.</td>
</tr>
<tr>
<td>SVCB</td>
<td>1</td>
<td>16 data attributes</td>
<td>The sending sampled value data set has a fixed set of 16 data attributes, as defined in IEC 61850-9-2 LE, with four current and four voltage measurement values with corresponding quality attributes.</td>
</tr>
</tbody>
</table>

4.3.1 Predefined vertical communication data sets

In vertical communications, the protection relay can generate events that are automatically reported to any listening clients. These communications are configured via a series of predefined data sets and corresponding report control blocks. The data sets are used to configure what data is sent and the report control block is used to configure when data is sent.

The relay's connectivity package includes predefined data sets and control blocks for vertical MMS event reporting. These data sets are used in predefined reporting control blocks for five clients. The selected data in the data sets is suitable to most applications and the selected default data automatically considers the used protection relay type and options.

The data sets and report control blocks can be modified using IEC 61850 Configuration in PCM600 or IET600, however, this should only be done by users that are familiar with both the protection relays and IEC 61850. Inappropriate modifications can result in malfunction of the protection relay.

- StatIed – generic status information of IEDs
- StatIo – inputs, outputs, LEDs
- StatUrg – measurement limit supervision, control feedback
- StatNrml – protection start and trip signals, autoreclosing status
- StatDR – digital fault recorder status
- MeasReg – registered measurement values at faults
- MeasFlt – measurements

When function blocks are added to or removed from an application configuration also the default data sets and the content of data sets are automatically modified to follow the IED data model. If all data does not fit into one data set, two data sets with suffixes "A" and "B" are created.

The protection relays support both buffered and unbuffered event reporting. In the predefined configuration all report control blocks are configured to use buffered reporting. The benefit of buffered reporting is that it buffers events during communication breaks and thus no events are lost. A data set can only be used by one report control block and the same data set entry cannot be used in different event reporting data sets.

The default values for the data sets and control blocks are suitable for most applications. The protection relay allows free renaming and editing of report control blocks and data sets. Only users who have an in-depth understanding of the protection relay and IEC 61850 should modify the default configuration. Description of the data in default data sets is available in the parameter list.

4.3.2 Predefined horizontal communication data sets

In horizontal communication the user normally has to engineer IEC 61850-8-1 GOOSE data sets. When IEC 61850-9-2 is used, the connectivity package automatically creates a data set including data as defined in 9-2 LE: four currents and four voltages with quality attributes.

It is not allowed to engineer or modify the predefined 9-2 LE data set. Together with the 9-2 LE data sets, the connectivity package also creates a default SMV control block. The SVCB configuration needs to be finalized in the tool before connecting the sent 9-2 LE data to the receiver IEDs.

4.3.3 Vertical communication diagnostic counters

The IEDs' IEC 61850 data model includes a logical node LD0.MMSLPRT1 for IEC 61850 vertical communication diagnostic. The counters are available via the HMI or PCM600 path Monitoring/Communication/Protocols/MMSLPRT1.

Table 3: Diagnostic data objects

<table>
<thead>
<tr>
<th>Data object</th>
<th>Description</th>
<th>Diagnostic information</th>
</tr>
</thead>
<tbody>
<tr>
<td>SucConn</td>
<td>Successful connections</td>
<td>Number of succeeded client connection attempts</td>
</tr>
<tr>
<td>FailConn</td>
<td>Failed connections</td>
<td>Number of failed client connection attempts</td>
</tr>
<tr>
<td>ConcCnt</td>
<td>Concludes</td>
<td>Number of session conclusions</td>
</tr>
<tr>
<td>TxAbtCnt</td>
<td>Sent aborts</td>
<td>Number of association aborts sent by server</td>
</tr>
</tbody>
</table>

Table continues on next page
<table>
<thead>
<tr>
<th>Data object</th>
<th>Description</th>
<th>Diagnostic information</th>
</tr>
</thead>
<tbody>
<tr>
<td>RxAbtCnt</td>
<td>Received aborts</td>
<td>Number of received association aborts by server</td>
</tr>
<tr>
<td>TxRejCnt</td>
<td>Sent rejects</td>
<td>Number of sent rejects by server</td>
</tr>
<tr>
<td>RxRqCnt</td>
<td>Received request</td>
<td>Number of received client requests</td>
</tr>
<tr>
<td>FailRqCnt</td>
<td>Failed requests</td>
<td>Number of failed client requests</td>
</tr>
<tr>
<td>SucRqCnt</td>
<td>Reads</td>
<td>Number of variable reads</td>
</tr>
<tr>
<td>FailRqCnt</td>
<td>Failed reads</td>
<td>Number of failed variable reads</td>
</tr>
<tr>
<td>SucWrCnt</td>
<td>Writes</td>
<td>Number of succeeded variable writes</td>
</tr>
<tr>
<td>FailWrCnt</td>
<td>Failed writes</td>
<td>Number of failed variable writes</td>
</tr>
<tr>
<td>InfRpCnt</td>
<td>Reports</td>
<td>Number of sent reports</td>
</tr>
<tr>
<td>ActConnCnt</td>
<td>Active connections</td>
<td>Number of active client connections</td>
</tr>
<tr>
<td>CntRs</td>
<td>Counter reset</td>
<td>Reset above diagnostic counters</td>
</tr>
</tbody>
</table>

It is possible to reset the vertical diagnostic counters via Monitoring/Communication/Protocols/MMSLPRT1/Reset counters and via the IEC 61850 communication by writing TRUE to the CntRs.Oper.ctlVal attribute under MMSLPRT1.

### 4.4 Parameter setting and disturbance recorder

The relay's protection function parameters can be set and the active setting groups can be changed by a IEC 61850 client using the standard IEC 61850 services. The disturbance recorder and load profile files in COMTRADE format are retrieved from the \COMTRADE\ and \LPD\COMTRADE\ directories by using PCM600 or any other client supporting IEC 61850 file transfer service or FTPS.

When setting the parameter Unit Mode to "Primary" via the menu path Configuration/Communication/Protocols/MMS, the values sent over IEC 61850 are scaled according to the CT and VT settings.

Restart the protection relay after changing the parameter. This feature is needed if the SCADA system or substation gateway does not handle scaling from nominal values.
5.1 Horizontal communication

GOOSE is used in substation automation for fast horizontal communication between protection relays. GOOSE can be used for direct data exchange, for example, of interlocking and blocking information between protection relays. According to the IEC 61850-8-1 standard, GOOSE uses a publisher/subscriber profile in which information is shared from one device to one or several devices by using Ethernet multicast messages. A message is an image of a sent IEC 61850 data set that is defined in the configuration.

The protection relay can send any type of status or measurement data in the GOOSE messages from its IEC 61850 data model. The status data response time, that is, the time it takes the application to handle a received GOOSE message and to send the data back to the network, is below 3 ms. The response time fulfills the type 1A and performance class P1 requirements of IEC 61850-5 Edition 2.

When the protection relay is configured to send measurements, the analog, integer or counter type data should be placed in its own data set to minimize the bandwidth consumption in the network and to avoid unnecessary publishing of unchanged status data. The triggering of analog data sending is controlled by deadband handling, zero-point clamping and limit supervision.

The horizontal communication configuration consists of the protection relays' GOOSE control block, data set and GOOSE input configuration. The result of the configuration work is a system configuration which is used for the protection relays. The used files in the workflow are IEC 61850 standard format SCL files.

5.2 GOOSE publishing properties

GOOSE data is transmitted event based and at regular intervals in 802.1Q multicast frames over Network1. Peer devices can determine the state of the communications by listening for the transmissions. When a data value changes, the GOOSE message with the latest data values is transmitted multiple times for a few milliseconds to ensure the reception of the changed data. After fast retransmission, the GOOSE retransmission scheme moves to use the heartbeat cycle time.

In GOOSE, data sending is based on data sets and GOOSE control blocks. The data set defines what device data is used in the GOOSE service and sent to the local Ethernet subnetwork in a GOOSE message.
<table>
<thead>
<tr>
<th>GoCB property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoCB name</td>
<td>GOOSE control block name</td>
</tr>
<tr>
<td>Application ID</td>
<td>A unique GOOSE identification string for each GoCB in the system. By default, it is the GoCB identification in the relay data model.</td>
</tr>
<tr>
<td>Max Time</td>
<td>Indicates the background “heartbeat” cycle time in milliseconds; the default value is “10 000 ms”. If there are no data changes, the relay still resends the last message content with the heartbeat cycle. Communication supervision is based on this idle sending mechanism.</td>
</tr>
<tr>
<td>Min Time</td>
<td>Indicates the maximum response time to data changes in milliseconds. In the relay, the value is always “10ms” for sent data.</td>
</tr>
<tr>
<td>Multicast MAC address</td>
<td>A multicast addressing scheme is used when sending GOOSE messages. A multicast address can be shared by several GoCBs but to enable the multicast message filtering of the devices and a properly working network, it is recommended to use unique multicast addresses in each GoCB. The multicast MAC address is the address to which the GOOSE data is sent. The receiving relay filters the frames and starts to process them if a multicast address is subscribed in the configuration. The range for GOOSE multicast addresses is 01-0C-CD-01-00-00...01-0C-CD-01-01-FF.</td>
</tr>
<tr>
<td>Configuration Revision</td>
<td>Integer value indicating the revision of the GOOSE configuration. It is sent in every GOOSE message. The integer indicates the number of changes in the sent GOOSE data set; the receiver checks the value to detect possible configuration mismatches. Both the GOOSE sender and the receiver must use the same ConfRev value from configuration. This ensures that both devices have the same configuration level in the substation configuration. ConfRev updates are done automatically by tools. If the latest system configuration is not downloaded to all required devices, the configuration revision may differ between the receiver and sender and data exchange does not work.</td>
</tr>
<tr>
<td>APPID</td>
<td>A hexadecimal application identifier value for the published GoCB. It needs to be a unique value within the system. It identifies the purpose of a data set. The value range is 0000...3FFF.</td>
</tr>
<tr>
<td>Data set</td>
<td>Data content sent in GOOSE messages</td>
</tr>
<tr>
<td>VLAN ID</td>
<td>The VLAN group can be used when configuring the Ethernet network topology's virtual LANs for routing and segmenting. Configuration is done in managed Ethernet switches. If static VLAN identifiers are defined, it also affects the switch port configuration. Value “000” indicates a non-configured VLAN; in this case, switches do not filter these messages on a port basis. This is recommended if there is no need to split the logical network. The VLAN identifier is a three-character hexadecimal value with range 000...FFF.</td>
</tr>
<tr>
<td>VLAN Priority</td>
<td>Used in networks supporting VLANs. The priority is used with network switches. The default value for GOOSE is “4” and the value range is 0...7.</td>
</tr>
</tbody>
</table>

### 5.3 Configuring GOOSE with Application Configuration

GOOSE can handle horizontal communication of time-critical events, such as triggers, interlocking, disturbance recording, and autoreclosing, between the IEDs in a substation. Typically, engineering involves several PCM600 tools (ICE, ACT, SMT) and, optionally, a separate tool such as IET600 for the GOOSE configuration.
With easy GOOSE, horizontal communication can be configured using only Application Configuration in PCM600. Knowledge of configuration details is not needed.

1. To create horizontal communication between function block signals of two different IEDs, open Application Configuration of the receiving IED.
2. Locate the function block input and right-click the input.
3. Point to Connect and select GOOSE.
4. In the Connect to Goose dialog box, connect GOOSE by selecting the function block output of the sender application or the signal of the sender logical node.

5.3.1 GOOSE load estimations

GOOSE performance classes are defined in standard part IEC 61850-5 Edition 2. For trip signals, there are several performance classes.

- P1 = quarter of the electrical network sinus waveform cycle
- P2 = in the order of half of the electrical network sinus waveform cycle

For other fast messages, there is one performance class.

- P3 = in the order of one cycle of the electrical network sinus waveform

For the medium-speed messages, there is one performance class.

- P4 = transfer times under 100 ms

Configuration load calculation ensures that the relay's application configuration is within the allowed limits. GOOSE load estimation is calculated independently and uses the remaining system capacity. The process bus load is handled by hardware. For more information on the configuration load calculation, see the engineering manual.

To have optimal GOOSE performance in the P1...P3 performance classes, several configuration aspects should be considered.

1. Minimizing the overall configuration load (ACT configuration) since the remaining time is available for GOOSE
   Unused function blocks should be removed.
2. Minimizing the received and sent GOOSE data set sizes
   - It is optimal to have smaller data sets.
   - Each received data set needs to be decoded before the attribute content can be used. Thus all attributes are counted in load estimations. For example, 20 received data sets having 20 attributes results in a 400-attribute load.
   - Minimizing the number of measurement values in GOOSE data sets
3. Designing the station level data flows and bay function allocation
• Good basic understanding of the system data flows helps keeping the concepts clear and minimizes the traffic.
• It may be good to use some configurations for collecting and grouping global states. For example, the busbar state is collected in a sectionalizer and sent to other bays.

In REX640, GOOSE load estimations are based on the worst case measured values. The performance class met by the configuration is expressed by information and warning messages. The tool does not produce messages for performance classes above P3.

<table>
<thead>
<tr>
<th>Messages</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information messages</strong></td>
<td></td>
</tr>
<tr>
<td>Increased GOOSE latency might be detected under heavy load.</td>
<td>P3 performance class requirement may not be met.</td>
</tr>
<tr>
<td>Increased GOOSE latency will be detected under heavy load.</td>
<td>50% of the packets do not meet the P3 performance class requirement.</td>
</tr>
<tr>
<td><strong>Warning messages</strong></td>
<td></td>
</tr>
<tr>
<td>Increased GOOSE latency detected under heavy load. Configuration changes needed.</td>
<td>70% of the packets do not meet the P3 performance class requirement.</td>
</tr>
</tbody>
</table>

All the above configuration loads are feasible, but in different application types. If the configuration exceeds the above time categories, it is not possible to use it. The tool does not download the configuration to the relay and error message “Increased GOOSE latency detected under heavy load. Configuration changes needed” is shown.

5.3.2 Connecting sender function block signal to GOOSE receiver block using Application Configuration tab

1. On the **Application Configuration** tab, select the sender IED function block signal and click **Connect**.
Figure 5: Connecting non-directional earth-fault protection start signal

The needed horizontal communication function block and input variable are created automatically.

It is also possible to create the GOOSE receiver function block separately and connect it to the receiver and sender function block signals.

2. Right-click the created input connection variable to navigate to the connected sender function block signal.

Figure 6: Navigating to the connected sender function block signal

Figure 7: Sender function block signal connected
### 5.3.3 Connecting sender function block signal to GOOSE receiver block using SCL Configuration tab

1. On the **SCL Configuration** tab, select a data attribute of the sender logical node to connect. Depending on the attribute, an input of the GOOSE receiver block may also need to be selected. This configuration method requires some insight into the underlying data model.

![Using SCL to connect the GOOSE sender signal](image)

*Figure 8: Using SCL to connect the GOOSE sender signal*

The needed horizontal communication function block and input variable are created automatically.

2. Right-click the created input connection variable to navigate to the connected sender function block's signal.

![Connected circuit breaker open signal](image)

*Figure 9: Connected circuit breaker open signal*

A separate internal GOOSE sender application worksheet is created for the sender IED. On this worksheet, function blocks can be moved, but they cannot be edited. Also, picture texts can be added.
5.4 Configuring GOOSE with IEC 61850 Configuration

1. Add devices to a PCM600 project.
2. Engineer the GOOSE connections between the devices.
   2.1. Define the published GOOSE data and control blocks.
   2.2. Define the subscribing IEDs for the GOOSE data.
3. Connect the GOOSE inputs in the IED applications.

5.4.1 Defining IEDs and starting IEC 61850 Configuration

Use PCM600 to define the substation and the IEDs. Before starting the system engineering, configure the IED settings and logic in PCM600.

For more information, see PCM600 documentation.

1. Create a PCM600 project with all the needed IEDs.

   If the substation includes third-party IEDs requiring configuring for horizontal GOOSE communication, instantiate a generic IEC 61850 IED under the substation in the plant structure and import the SCL files (ICD/CID) holding the information on those IEDs. The third-party IEDs have separate tools for creating the ICD/CID/SCD file.

2. Start IEC 61850 Configuration.
5.4.2 Configuring a GOOSE publisher with IEC 61850 Configuration

To control the GOOSE data publishing, such as addressing, every publisher IED must have at least one data set for GOOSE data and one GOOSE control block.

1. Group the data to a data set sent to the IEC 61850 station bus.
2. Define the GOOSE control block.

The IED can send single binary, double binary, integer and floating point data values with a quality attribute. The quality attribute is used at the receiver side to check data validity.

5.4.2.1 Creating a GOOSE data set with IEC 61850 Configuration

The sending data set is defined with the GOOSE control block. A maximum of 120 data attributes can be added to the IED's GOOSE data sets. The recommendation is to divide the attribute amount to 20 per GOOSE data set, for maximum performance in sender and receiver.

All data sets must be configured under the logical node LLN0 and must be provided with unique names in the relay. For more information on GOOSE data sets, see Table 2. In simple GOOSE applications it is often sufficient to define a single data set and control block for an application. However, it is recommended to use a separate data set and corresponding control block for analog values.

1. Select the target IED in the Plant Structure view.
2. Select GOOSE Communication in the drop-down box on the toolbar.

![Selecting GOOSE communication](image)

3. Select the Data Sets tab.
4. To add a new data set, right-click the area containing the data set names and select New.
5. Define the LN where the data set is to be placed (accept preselected “LD0/LLN0”) and give the data set a unique name.

Figure 12: Creating a new data set
After creating the GOOSE data sets, define the data set entries (data attributes or data objects) for the data sets.

If quality data attributes are added to a data set, they should be located after the status value of the corresponding data object. The reason for this is compatibility with other devices.

The received GOOSE data set can contain signals on the data attribute or data object level. However, it is strongly recommended that GOOSE data sets be made on the data attribute level for faster data processing.

Access point based transmitting and receiving of GOOSE to a specific network or port is not supported by the protection relay. By default, GOOSE is transmitted to and received from all Network1 ports. Network2 ports do not support GOOSE or SMV. Port-based filters can be used if the transmitting or receiving of GOOSE must be limited to specific Ethernet ports. See the technical manual for more information.
Defining GOOSE data set entries with IEC 61850 Configuration

1. Select the **Data Sets** tab.
2. Right-click a data set and select **Details** to add data attributes.
3. In the **Data Set Entry** window, select the data attribute or data object present in the data set.
   - Click **Append selected** to add the data to the end of the data set. To add a data object level entry, select it from the FC section. To add a data attribute level entry, select it from the DA section.
   - Click **Insert selected** to add the data above the selected row in the data set entries list.
   - To remove data from the data set, select the data in the data set entries pane and click **Remove selected**.

![Figure 14: Adding data set entries](image)

If a data set has quality attributes, the attributes must be located after the status value of the same data object.

After defining the data entries for the data sets, configure the GOOSE control block properties.

### 5.4.2.2 Configuring a GOOSE control block with IEC 61850 Configuration

1. Select the IED in the **Plant Structure** view.
2. Select the **GOOSE Controls** tab in the tool pane.
3. To add a new GOOSE control block, right-click the area containing the existing GOOSE control blocks and select **New**.
Figure 15: Creating a new GOOSE control block

4. Browse to LLN0 under LD0 to define where the GOOSE control block must be placed.

5. Give a unique name to the GOOSE control block.
6. In the **Data set** drop-down list, select the previously created data set to link with the GCB.

---

**Figure 16:** Naming a GOOSE control block

**Figure 17:** Data set drop-down list
Data set entries in a data set linked to the GCB can be modified from the **GOOSE control block** tab by selecting **Data Set details** in the shortcut menu.

7. Edit the properties and addresses of the created GOOSE control block. Edit at least MAC Address and App ID.

With this protection relay, only $t_{(max)}$ is configurable, not $t_{(min)}$. 
5.4.3 Configuring a GOOSE subscriber with IEC 61850 Configuration

The IED application can receive and use single binary, double binary, integer and floating point values with attached quality information. A quality attribute is received and processed automatically.

5.4.3.1 Configuring GOOSE inputs with IEC 61850 Configuration

1. Select the IED node from the plant structure in the Project Explorer window.
2. Click the GOOSE Controls tab in the tool pane.
   The rows of the GCB client editor show GCBs, the so-called senders, and the columns show the IEDs available as the GOOSE clients, the so-called receivers. All IEDs that are configured in the plant structure automatically appear in the clients column.
3. To add or remove clients for a GOOSE control block, click the check box in the grid corresponding to the IEDs.
   When adding or removing clients, the input sections of the corresponding IEDs are updated.
On the **Data Sets** tab and the **GOOSE Controls** tab, the clients column shows all the configured IEDs. For the IED without data sets and GCBs, however, there is no check box in the grid matrix since the IED publishes the GOOSE control block to the network.

On the **Data Sets** tab, the clients are mapped automatically to the corresponding data sets based on the configuration done on the **GOOSE Controls** tab and vice versa.

### 5.5 Configuring GOOSE with IET600

1. Add devices to a PCM600 project.
2. Export the SCD file.
3. Import the SCD file to IET600.
4. Engineer the GOOSE connections between the devices.
4.1. Define the published GOOSE data and control blocks.
4.2. Define the subscribing IEDs for the GOOSE data.

5. Export the SCD file back to PCM600.
6. In PCM600, engineer the IED applications with GOOSE inputs.

Before any configuration, create backups of the PCM600 and IET600 projects. For example, once an SCD file is imported into PCM600, the changes cannot be undone except by restoring the backup.

**Figure 20:** Configuring horizontal communication

### 5.5.1 Defining devices and exporting SCD file for IET600

Use PCM600 to define the substation and the devices. Before starting the system engineering, configure the device in PCM600.

For more information, see the PCM600 documentation.
1. Create a PCM600 project with all the needed devices.
2. To export the SCD file, click the **Plant Structure** tab, right-click the substation node in the submenu and select **Export**. The file includes the whole substation configuration in SCL format for other tools.

![Plant Structure](image)

**Figure 21:** Exporting an SCD file from PCM600

3. In the SCL **Export Options** dialog, click **Export**.

![SCL Export Options](image)

**Figure 22:** Confirming export
5.5.2 Creating an empty project with IET600

1. Open IET600.
2. To create an empty project, click the round button on the upper-left corner of the IET600 tool.
3. Click Manage Projects.
4. In the Projects dialog, click New.
5. Name the project.

![Projects dialog with New Project option](image)

Figure 23: Naming a project

6. Click Browse to select the destination folder for the project.
7. Click OK.

After creating an empty project, import the SCD file from PCM600 to the project.

5.5.3 Importing SCD file into IET600

1. Import the SCD file from PCM600 to the empty project in one of the alternative ways.
   - Click Import SCL File on the shortcut menu of the project object.
   - Click Import.
2. Locate the SCL file and click **Open**.

If the substation includes third-party devices which need to be configured for horizontal GOOSE communication, the SCL files holding the information on those devices must be imported as well. The third-party devices have separate tools for creating the ICD/CID/SCD file.

SCD files can be imported to a project only once. If a new device needs to be added later to the configuration, it must be first created using the **Create New IED** function after which the **Update IED** function can be used to import the related CID or ICD file. Another alternative is to create a new project in IET600 and import the whole SCD file from PCM600. The existing IEC 61850 configuration including GOOSE remains if the changes made in IET600 have been already imported to PCM600.
5.5.4 Configuring a GOOSE publisher with IET600

To control the GOOSE data publishing, such as addressing, every publisher device must have at least one data set for GOOSE data and one GOOSE control block.

1. Group the data to a data set sent to the IEC 61850 station bus.
2. Define the GOOSE control block.

The protection relay can send single binary, double binary, integer and floating point data values with a quality attribute. The quality attribute is used at the receiver side to check data validity.

5.5.4.1 Creating a GOOSE data set with IET600

All data sets must be configured under the logical node LLN0 and must be provided with names unique within the device. The protection relays allow a maximum of four GOOSE control blocks, which effectively limits the protection relay to four data sets for GOOSE as there is a one-to-one correspondence between the GOOSE control blocks and GOOSE data sets. In simple GOOSE applications it is often sufficient to define a single data set and control block for an application. However, it is recommended to use a separate data set and corresponding control block for analog values.

1. Select the IEDs tab in the navigation pane.
2. Click the IED node.
3. Click the Datasets tab in the editor pane.
4. To add a new data set, right-click the area containing the data set names and select **Insert new row**.
5. Define the LN where the data set is to be placed (accept preselected “LD0/LLN0”) and give the data set a unique name.

After creating the GOOSE data sets, define the data attributes for the data sets.
If quality data attributes are added to a data set, they must be located after the status value of the corresponding data object.

The received GOOSE data set can contain signals on the data attribute or data object level. Data object level GOOSE entries can only be received of the following CDC types: SPS, SPC, ACD, ACT, DPS, DPC, INC, INS, ENC and ENS. Other CDC types can be connected to application only when dataset is defined in attribute level.

**Defining data entries with IET600**

1. Select the **Datasets** tab on the editor pane.
2. Select a GOOSE data set.
3. Using the selection lists below the data set grid, select a data attribute or data object to be used.
   - Click **Append >>** to add the data attribute to the end of the data set.
   - Click **Insert >** to add the data attribute above the selected row in the data set entries list.

![Adding data set entries](image)

**Figure 27:** Adding data set entries

The possible number of attributes that can be added to a data set and the amount of already added attributes are shown above the data set entries list. However, since IET600 cannot distinguish between the maximum data attribute count of a data set for vertical reporting and a GOOSE data set, too high a maximum value is shown for a GOOSE data set.
If a data set has quality attributes, the attributes must be located after the status value of the same data object.

Data set entries for vertical reporting are selected using the data object level, and entries for GOOSE using the data attribute or data object level.

After the installation of the connectivity package documentation add-on, a full list of the available signals with descriptions and IEC 61850 names is available in PCM600 under the Documentation menu of the IED node. The document name in PCM600 is Parameter List.

After defining the data entries for the data sets, configure the GOOSE control block properties.

5.5.4.2 Configuring a GOOSE control block with IET600

1. Select the IED node on the IEDs tab in the navigation pane.
2. Select the GCB Data tab in the editor pane.
3. To add a new GOOSE control block, right-click the area containing the existing GOOSE control blocks and select Insert new row.
4. Browse to LLN0 under LD0 to define where the GOOSE control block is to be placed.
5. Give a unique name to the GOOSE control block and click **OK**.
6. In the **Attached Dataset** drop-down list, select the previously created data set.
7. Edit the GOOSE control block properties and addresses. Edit at least **MAC Address** and **APP-ID**.

To set the visibility of the GoCB columns, click the upper-left icon of the table and select or clear the check boxes in the **Field Chooser** dialog.
With this protection relay, only $t(\text{max})$ is configurable, not $t(\text{min})$.

IET600 updates $\text{Conf.Rev.}$ automatically to the next multiple of 100 when the configuration changes.

The multicast $\text{MAC address}$ is usually unique, and $\text{APP-ID}$ must be unique.

## 5.5.5 Configuring a GOOSE subscriber with IET600

The relay application can receive and use single binary, double binary, integer and floating point values with attached quality information. A quality attribute is received and processed automatically.

### 5.5.5.1 Configuring GOOSE inputs with IET600

1. Select the root node on the IEDs tab in the navigation pane.
2. Click the GCB Clients tab in the editor pane.
   The rows of the GCB client editor show GoCBs, that is, “senders”, and the columns show the devices available as GOOSE clients, that is, “receivers”. If the
client device is not on the same subnetwork as the GoCB sender, it cannot be configured as a client.

![GCB client editor](image1)

**Figure 32:** GCB client editor

3. To add or to delete clients, double-click the cell. Upon adding or removing clients, the corresponding input sections are updated.

![GOOSE inputs](image2)

**Figure 33:** GOOSE inputs

### 5.5.6 Finalizing GOOSE configuration with IET600

#### 5.5.6.1 Exporting SCL files

1. Export the SCL file in one of the alternative ways.
   - Click **Export SCD File** on the shortcut menu of the project object.
   - Under the **Home** tab, click **Export**.
2. Select the file destination and click **Save**.
   It is recommended to leave the SCD file exported from PCM600 as a backup.

5.5.6.2 **Importing SCL files**

1. Open PCM600 and ensure the original project is open.
2. Switch off the engineering mode.
3. Go to the Project Explorer view and select the Plant Structure tab.
4. Right-click the project and select Import.

Figure 35: Switching off the engineering mode

Figure 36: Importing an SCD file to PCM600
5. Open the SCL file exported from IET600.
6. In the **SCL Import Options** dialog box under **IED Types**, select **Don't import IEDs of unknown type** if the GOOSE configuration does not include third-party devices.

![SCL Import Options](image)

**Figure 37: Selecting SCL import options in PCM600**

**Table 6: Import options**

<table>
<thead>
<tr>
<th>Import option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don’t import IEDs of unknown type</td>
<td>If PCM600 cannot recognize the IED type or the connectivity package is not activated, the IED object is not created in the Plant Structure during the import. The SCL IED is still imported to the project SCL data.</td>
</tr>
<tr>
<td>Replace unknown IED types with generic IEC 61850 object type</td>
<td>If PCM600 cannot recognize the IED type or the connectivity package is not activated, a generic IEC 61850 IED object is created in the Plant Structure during the import. The SCL IED is imported to the project SCL data.</td>
</tr>
<tr>
<td>Ignore PCM Object Type</td>
<td>If the IED type in the SCL file IED does not match the corresponding PCM600 project SCL IED, the IED is still imported from the file. This can be used, for example, when importing the IED from a CID/ICD/IID file to a generic IEC 61850 IED object.</td>
</tr>
</tbody>
</table>

Table continues on next page
<table>
<thead>
<tr>
<th>Import option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignore Substation Section</td>
<td>Updates the SCL IEDs in the project, but the SCL substation section is not updated. This also means that the IED locations in the Plant Structure are not updated during the SCD import.</td>
</tr>
<tr>
<td>Import Short Addresses</td>
<td>Overwrites the existing logical nodes' short addresses in the project SCL with the short addresses from the imported SCL file</td>
</tr>
<tr>
<td>Include IED Name in Caption</td>
<td>Adds the IED name in the imported file to the IED object's caption in the Plant Structure. Without this option, the caption contains the IED desc attribute value in the SCL file.</td>
</tr>
</tbody>
</table>

7. Click **Import**.

For more information, see the PCM600 documentation.

## 5.6 Connecting GOOSE inputs to a relay application

1. In PCM600, open **Project Explorer** and select the **Plant Structure** tab.
2. Add the GOOSERCV function block with Application Configuration.

   The GOOSERCV function block can only be added with Application Configuration.

   Give the GOOSERCV block application-specific user-defined names to distinguish between different blocks when making GOOSE connections in Signal Matrix.

   ![Figure 38: Adding the GOOSERCV function block](image)

3. Create the connection in the application.
   3.1. Create the connection.
   3.2. Click **Calculate execution order**.
   3.3. Click **Validate configuration**.
   3.4. Save the connection to the application.
4. To open Signal Matrix, right-click the protection relay, and select **Signal Matrix**.

5. To map the input points to the receiving input data, click the cell. To expand the source field, drag the edge of the field to expand it until the whole GOOSE source address is visible.

6. In Signal Matrix on the **GOOSE** tab, map the GOOSE publisher data to the corresponding GOOSERCV function block. The columns on the GOOSE tab represent publisher data and the rows represent the possible subscriber input points.

![Figure 39: GOOSE tab in Signal Matrix](image)

The GOOSE receiver block output **VALID** defines the validity for the received data. The value is based on the received quality attribute value or communication status. This validity information can be used in the application to build the validity logic in addition to the GOOSE default supervision information.

During the protection relay start-up phase, the protection relay keeps the value of the output **VALID** as “1” (GOOD) until the communication is activated. After the communication is activated, the value of the output **VALID** is updated by the value received via the communication.
If the data type does not match with the GOOSERCV function block, the attribute cell is red.

In Signal Matrix, the received GOOSE data can be directly connected to the relay application. The GOOSE inputs are shown on the Binary or Analog Inputs sheets and they can be connected to the application receiver function blocks. The columns represent publisher data and the rows represent the possible subscriber input points.

If the data type, for example timestamp, is not supported by the relay application, the attribute column is red. The quality attribute is automatically incorporated in the application with the status value, and it is not seen in Signal Matrix.

7. Save the changes made in Signal Matrix.
8. Write to the IED.

5.7 GOOSE simulation

When the IEC 61850 Edition 2 configuration has been selected for the protection relay, it is capable of processing simulated messages. The switchover to simulated messages requires that the relay is set to allow simulated messages and that it receives the first simulated message. Detection of simulated messages is separated per GOOSE publisher. Therefore, one GOOSE input may receive a simulated message while another input receives a real GOOSE message.
To set the protection relay to allow simulated GOOSE, either LD0.LPHD1.Sim is set to true via the IEC 61850 protocol or the Allow simulation parameter is set via the WHMI or the LHMI to "Yes".

Figure 40: Receiving of GOOSE data in case of simulation or test mode
Figure 41: Setting of the Allow simulation parameter via the Testing and Commissioning page

Switching back to receiving real GOOSE messages requires that the Allow simulation parameter is set to "No" (or LD0.LPHD1.Sim = false). The values change to real ones after the first received real GOOSE message.

The LHMI can be used to verify that a simulated GOOSE is received. The publisher is marked with the “(simulated)” text when simulated messages are received.
5.8 Received GOOSE message handling

A GOOSE frame is not accepted if the Needs Commission bit is set. When the protection relay uses IEC 61850 Edition 2, data with the Test quality bit set is accepted only if the receiving device is also in the test mode. When the relay uses IEC 61850 Edition 1, the Test field in the GOOSE message is also used. For more information about GOOSE quality handling, see the corresponding flowcharts.

When the protection relay uses IEC 61850 Edition 2, the Test quality bit is active in the sender if the relay is set to test mode. When the relay uses IEC 61850 Edition 1, the Test field in the GOOSE message is also set when the relay is in test mode.

When the GOOSE sender is in test mode and the GOOSE receiver is not, in Edition 1 mode the GOOSE receiver freezes to its previous valid state, and in Edition 2 mode the data value is defaulted and the quality is set to invalid.

The Test bit is active in the sender if the protection relay is set to test mode.

See the technical manual for more information on the test mode.
The GOOSE frame is not accepted either if ConfRev deviates from the one in the configuration. These error situations can be observed in the GSELPRT1 diagnostic counters.

The default GOOSE input value is “0” for all the data types. The functionality is analogous to physically wired galvanic Normally Open (NO) contacts where the disconnected signal gives value “0” of FALSE to relay application. The application must be designed to withstand the default value. This value is used when the subscribed GOOSE data is not valid, or it is not received from the network and the peer device is considered to be in a time-out state.

If a peer device sends the data including the quality attribute, the receiver device input object is not updated according to the received status value if the data quality is bad, questionable or blocked. The default value is also used in this case.

![Diagram of GOOSE data receiving with quality in protection relays]

**Figure 43:** Receiving of GOOSE data with quality in protection relays
5.9 GOOSE supervision

5.9.1 Background sending

To ensure reliability and availability of the application, the GOOSE communication must be supervised. The application should handle communication losses, for example, when a peer device is not available or there are communication time-outs.

If there are no GOOSE-related data changes, the protection relay resends the last GOOSE message with a heartbeat cycle to enable the receiver to detect communication losses. The heartbeat cycle is defined by modifying the MaxTime property on the GOOSE control block.

Every GOOSE frame has a TAL field which shows how long the frame is valid until the next heartbeat frame. Other devices may have their own TAL values. Nevertheless, all the TAL values under 1000 ms are rounded up to 1000 ms on the receiving side.

If no frames are received during $2 \times \text{TAL}$, that is, if at least two consecutive frames are lost, then the receiver considers the whole data set as invalid. The quality attribute for the entire data set is set to "bad" and the values are set to their default values. This is an important consideration when designing the application as the default values need to be fail-safe values. For example, the protection relay should use an enabled signal for interlocking and a blocking-type signal for protection.

5.9.2 Default value handling

The information is of point-to-point type which means that there is only one signal connected to the function block input.

The default value of the GOOSE receiver blocks output (OUT) is FALSE (0) if there is a communication error. This is applicable for all signal types (binary, integer, enum and floating point). In addition to the default value handling, the value output signal automatically carries validity information to the application function blocks. Validity information can be used in application by adding the quality function blocks.

In communication disturbance cases, GOOSE receiver blocks use default values. Application function blocks using these signals have their own handling for propagated quality information and fail-safe functionality, especially when receiving analog data. For more information on the fail-safe functionality, see the function block description in the technical manual.

If one relay application function block input receives signals from several protection relays, the input value is calculated in OR or AND operation (configured in Application Configuration) from several inputs. In this case, one default signal is treated as logical FALSE (0), but the other signals can keep the function block input value active. It works similarly to the traditional galvanic signal wires connected between protection relays. The advantage in the GOOSE-based signalling is that the
application always detects faulty connections, unlike the Normally Open (NO) type of physically wired galvanic contacts.

In all cases, however, a separate alarm event is generated by the GSELPR1.Alm data object for IEC 61850 event clients.

GSELPR1.Alm can also be used on the application side as an input in the Signal Matrix's Binary Outputs sheet (signal GSELPR1 ALARM).

### 5.9.3 Alarm supervision in application

In a communication time-out situation, all the peer devices receive information about the problem. The system does not tolerate single failures or non-existing devices, for example, in service situations. This should be considered when designing an application.

Disable GOOSE sending by writing “false” from IEC 61850 clients to the GoEna attribute under the GOOSE control block. Use this feature carefully, and for test purposes only.

### 5.9.4 Diagnostic counters

The protection relays' IEC 61850 data model includes a logical node LD0.GSELPR1 for the GOOSE communication diagnostic. The counters are also available via the HMI or PCM600 path Monitoring/I/O Status/Communication/GSELPR1/Monitoring.

It is possible to reset the GOOSE communication diagnostic counters via Monitoring/I/O Status/Communication/GSELPR1/Monitoring/Reset counters and via the IEC 61850 communication by writing TRUE to the CntRs.Oper.ctlVal attribute under GSELPR1.

<table>
<thead>
<tr>
<th>Data object</th>
<th>Description</th>
<th>Diagnostic Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>FrRxCnt</td>
<td>Received messages</td>
<td>When increasing, the protection relay is receiving GOOSE messages.</td>
</tr>
<tr>
<td>FrTxCnt</td>
<td>Transmitted messages</td>
<td>When increasing, the protection relay is sending GOOSE messages.</td>
</tr>
<tr>
<td>RxStCnt</td>
<td>Received state changes</td>
<td>Received GOOSE messages with a new stNum value</td>
</tr>
<tr>
<td>RxSeqCnt</td>
<td>Received sequence number</td>
<td>Received GOOSE retransmissions or heartbeat cycle messages with a new sequence number</td>
</tr>
<tr>
<td>RxTestCnt</td>
<td>Received frames with test bit</td>
<td>Received GOOSE frames with the test flag on. Incremented only in Edition 1 mode</td>
</tr>
<tr>
<td>StWrnCnt</td>
<td>State warnings</td>
<td>Number of detected state number jumps</td>
</tr>
<tr>
<td>SeqWrnCnt</td>
<td>Sequence warnings</td>
<td>Number of detected sequence number jumps</td>
</tr>
</tbody>
</table>

Table continues on next page
<table>
<thead>
<tr>
<th>Data object</th>
<th>Description</th>
<th>Diagnostic information</th>
</tr>
</thead>
<tbody>
<tr>
<td>RxTmOutCnt</td>
<td>Receiver time-outs</td>
<td>Number of detected peer device time-outs</td>
</tr>
<tr>
<td>ConfErrCnt</td>
<td>Received ConfRev mismatches</td>
<td>When increasing, there is a mismatch between the received GOOSE frame information and configured GOOSE.</td>
</tr>
<tr>
<td>NdsComCnt</td>
<td>Received frames with Needs Commissioning bit</td>
<td>One or many peer devices indicate that their configuration is not valid or up-to-date.</td>
</tr>
<tr>
<td>DSErrCnt</td>
<td>Errors in received data set</td>
<td>Received data is syntactically incorrect, or the amount of data in the data set is not as expected.</td>
</tr>
<tr>
<td>Alm</td>
<td>Receiver alarm</td>
<td>Alarm signal value connected to the event and application logic. It is active when one or many peer devices are in time-out.</td>
</tr>
<tr>
<td>RptProtCnt</td>
<td>Replay protection warnings</td>
<td>Number of detected message replays</td>
</tr>
</tbody>
</table>

**GOOSE Alarm** is activated in the receiver device in certain situations.

- Time-out
- Configuration revision mismatch
- Error in the received data set
- The Needs Commissioning bit is active in the received message.

### 5.9.5 Checking GOOSE data with LHMI's Test and Commissioning pages

1. On the **GOOSE Receiving** page, check the GOOSE data that the relay subscribes from the Ethernet network.

   The left side of this page shows a list of devices that send GOOSE messages to the relay. These devices that publish data for the relay are defined in the relay configuration. The right side of the page shows the GOOSE data the relay receives from the network. The data set consists of value and quality attributes. The received data has status indicators where green means all OK, yellow warning and red error.
2. On the **GOOSE Sending** page, check the status of the relay's configured GOOSE control blocks and the values of the sent data. The left side of this page shows a list of the devices where the relay sends GOOSE messages. In the system there may be more devices, but these devices are according to relay configuration the ones subscribing the data from the relay. The right side of the page shows the GOOSE data that the relay sends to the network. The data set consists of value and quality attributes. The sent data has status indicators where green means all OK, yellow warning and red error.
5.10 Forcing of GOOSE signals

Application Configuration in PCM600 is used for configuring the IED.

5.10.1 Testing of one device

Configuration logic testing is done for individual configurations. GOOSE signals can be forced using Signal Monitoring or Testing and Commissioning pages of 640 LHMI.

![Diagram of GOOSE signal forcing](image)

Figure 46: Testing of one device

The device must be in test mode.

5.10.2 Testing of several devices in a system

Any status data can be sent through GOOSE communication. Horizontal communication can be tested by forcing the outputs of the sender device using Testing and Commissioning pages of 640 LHMI and observing the results in the receiving device.
Both devices must be in test mode.
Section 6 Process bus and IEEE 1588 time synchronization

6.1 Sampled measured values and IEEE 1588 v2 time synchronization

The protection relay supports the IEC 61850 process bus with the IEC 61850-9-2 LE protocol. It can send sampled values of analog neutral and phase currents and voltages. IEDs with process bus based applications use IEEE 1588 v2 Precision Time Protocol (PTP) according to IEEE C37.238-2011 Power Profile for high-accuracy time synchronization.

Configure IEC 61850-9-2 LE with IEC 61850 Configuration in PCM600 or with the separate IET600 tool. PCM600 interacts with IET600 by importing and exporting SCL files.

6.2 System building

Redundant Ethernet topologies (HSR/PRP) are recommended to be used in the sampled measured values applications and with GOOSE to ensure the highest availability.

6.2.1 High-availability seamless redundancy HSR

The HSR topology presented here is a reference system for process bus usage with switches supporting HSR and IEEE 1588 v2. This topology includes an HSR ring with protection relays where IEEE 1588 v2 clock masters are connected to the ring using Ethernet switches. The HSR ring is presented with light blue lines and normal Ethernet connections with dark blue.

Each connected node in the HSR ring must support the HSR protocol. Single attached nodes can be connected to an HSR ring with a separate redundancy box (RedBox).

Use correct Ethernet ports in the protection relay with HSR. Protection relays with HSR support have three Ethernet ports and redundant Ethernet ports are marked as X1/LAN A and X2/LAN B. The X3 Ethernet port is an interlink port which is used as a redundancy box connector.
The maximum number of IEDs supported in the HSR ring is 30. This is to keep the ring delay as small as possible for protection applications using the communication channel. When using IEEE 1588 time synchronization and IEC 61850-9-2 LE, 15 hops from the clock master to the IED is the maximum to reach 1 μs accuracy in measurements according to the IEEE 1588 v2 standard.

The HSR bandwidth is 50 Mbit/s as all messages are doubled for both directions of the ring.

### Parallel redundancy protocol PRP

The PRP topology presented here is a reference system for process bus usage with switches supporting IEEE 1588 v2. This topology includes duplicated star networks which are called LAN A and LAN B. IEEE 1588 v2 clock masters are connected to the network using Ethernet switches. LAN A is presented with dark blue lines and LAN B with light blue.

In PRP, LAN A and LAN B must be connected only to end devices supporting PRP otherwise Ethernet communication is disturbed and might not work. All devices connected to both LAN A and LAN B must support the PRP protocol. Single attached nodes can be connected directly to LAN A or LAN B, in which case there is no redundancy for these nodes, or with a separate redundancy box (RedBox).
Use correct Ethernet ports in the protection relay with PRP. Protection relays with PRP support have three Ethernet ports and redundant Ethernet ports are marked as X1/LAN A and X2/LAN B. The X3 Ethernet port is an interlink port which is used as a redundancy box connector.

Do not mix different PRP LANs. Ensure that the LAN A port is always connected to LAN A only and the LAN B port is connected to LAN B.

**Figure 48:** Recommended PRP reference topology with SMV and IEEE 1588 v2

### 6.2.3 Intelink port

The relay communication card has an X3 Ethernet port which is an interlink port that can be used to connect other relays or devices to the HSR or PRP station bus. This port works as a redundancy box (RedBox) port for other devices. It also supports IEEE 1588 making it possible to connect the PTP grandmaster clock to the station bus using it. Additionally, single attached nodes connected to the interlink port can receive 1588 time synchronization over this port.

### 6.2.4 Performance optimization

- As the SMV messages cause high traffic in the network, they should be filtered out from the local subnetwork part not using them. Otherwise, the SMV messages
reach also those network devices that do not subscribe them. Managed Ethernet switches can be configured to perform the filtering operation.

- IEEE 1588 v2 network devices complying with Power Profile are highly recommended to simplify the settings and to ensure compatibility. Power Profile and the HSR standard recommend implementation according to the one-step mode.
- It is recommended to use IEEE 1588 v2 devices with the same clock mode (one-step or two-step) within one network. Ethernet switches performing one-step to two-step conversions should be avoided due to additional inaccuracy.
- One SMV publisher generates around 5 Mbit/s traffic to the network. This is about 5% of bandwidth in PRP and 10% in HSR when the bandwidth of the used network is 100 Mb/s.

### 6.2.5 Requirements for third-party devices

#### System and setting requirements

- Support for the IEEE 1588 v2 time synchronization
- Preferably IEEE 1588 v2 according to Power Profile and implementation according to the one-step mode
- All network devices between the IEEE 1588 v2 clock master and the IED must support IEEE 1588 v2

#### Ethernet switch requirements

- Support for the IEEE 1588 v2 transparent clock operation mode to enable accurate time synchronization in the system
- Managed switch with optional capabilities for SMV filtering and VLAN to restrict the SMV flow only to devices using it
- Switches that support IEEE 802.1D with LLDP enabled

#### IEEE 1588 v2 master clock requirements

- Support for IEEE 1588 v2 Grand Master operation mode
- TC time inaccuracy to comply with IEEE Std C37.238-2011 annex B

### 6.3 SMV system configuration

#### 6.3.1 SMVSENDER ACT configuration

The SMVSENDER function block must be added to the ACT configuration and connected to at least one triplet or residual channel to activate SMV sending. Unused channels in SMVSENDER must be connected to GRPOFF. As a result, the sampled value control block and the related data set are automatically added to the protection
relay configuration. IEC 61850-9-2 LE defines a sample rate of 4000 samples per second in a 50 Hz system.

A maximum of 16 SMV channels can be received. Different combinations of these channels, such as two SMVRCV blocks using eight channels each or four SMVRCV blocks using four channels each, are possible as long as the number of used SMV channels does not exceed 16. The total number of channels that the relay can process is 64 including local, remote and calculated channels. Forwarding of received SMV channels through SMVSENDER is not supported.

Figure 49: SMVSENDER block in Application Configuration

6.3.2 SMVRCVx ACT configuration

At least one SMVRCVx function block must be added to the ACT configuration of the SMV receiver protection relay to enable SMV receiving. One protection relay can have a maximum of four SMVRCVx blocks and up to 16 individual measurement channels.

Figure 50: SMVRCVx block in Application Configuration

6.3.3 Configuring SMV with IEC 61850 Configuration

The connection between the SMV sender and receiver is handled using IEC 61850 Configuration.

1. In the Plant Structure view, right-click the correct sender IED and select IEC 61850 Configuration.
2. Select Process Bus Communication in the drop-down box on the toolbar.
Section 6
Process bus and IEEE 1588 time synchronization

Figure 51: Selecting Process Bus Communication

The SMV sender and the possible SMV receiver IEDs become visible.

3. On the Sampled Value Controls tab, edit the properties and addresses of the sampled value control block.

Figure 52: Changing the VLAN ID

Some switches do not support multicast filtering with VLAN ID value “0” because it means “no VLAN” and VLAN ID “1” has a special purpose as the management VLAN for switches. The recommended value for VLAN ID is 2...1001.

Use a unique multicast address for each SVCB. The address range for sampled values multicast addresses is 01-0C-CD-04-00-00…01-0C-CD-04-01-FF.

4. Connect the SMV sender to the receivers.
5. In PCM600, select Write to IED.
6.3.4 Configuring SMV receiver with Signal Matrix’s SMV tool

The connection between the SMV receiver and sender is handled using the Signal Matrix’s SMV tool. If the receiver IED’s ACT configuration includes multiple SMVRCVx blocks, the SMV tool can also be used to specify which sender is connected to which receiver.

1. In the Plant Structure view, right-click the correct receiver IED and select Signal Matrix.
2. Select the SMV tab.
3. Connect the SMV receiver with the sender.

If the configuration is updated in a manner that affects the Conf.Rev value of SVCB, configurations of both SMV sender and all receivers must be rewritten from PCM600.
6.4 Bay level configuration

6.4.1 Application configuration of SMV receiver

The SMV receiver application configuration is done with Application Configuration in PCM600. TxTR function blocks are used in the receiver application to supervise the sampled values and to connect the received analog inputs to the application. The SMVRCV function block outputs need to be connected according to the SMV application requirements. Typically, all three analog phase voltages are connected, for example, to UTVTR1. When voltages are used, the VT connection analog input setting parameter for phase voltages must be set to "Wye" for IEC 61850-9-2 LE compliancy.

The synchrocheck function requires only one analog phase voltage (UL1).
**Figure 57:** Receiving one line voltage for synchrocheck functionality using SMV

The **WARNING** output of TxTR should be connected in the SMV applications to perform the necessary actions if the SMV angle information is out of the accuracy range. Depending on the protection function operation principle, inaccurate angle information is also seen in the protection function operation inaccuracy. Additionally, the **ALARM** output of TxTR should be connected to ensure fail-safe operation in all circumstances. The **WARNING** output is internally active whenever the **ALARM** output is active.

**WARNING** and **ALARM** information is internally propagated to the measurement functions. Thus, measurement functions can update the measured value quality information accordingly without any additional connections.

**Figure 58:** Application Configuration logic example for the SMV applications

The receiver activates the TxTR **WARNING** and **ALARM** outputs if any of the quality bits, except for the derived bit, is activated. When the receiver is in the test mode, it
accepts SMV frames with a test bit without activating the TxTR WARNING and ALARM outputs.

The TxTR WARNING in the receiver is activated if the synchronization accuracy of the sender or the receiver is worse than 4 μs. The output is held on for 10 seconds after the synchronization accuracy returns within limits.

The TxTR ALARM in the receiver is activated if the synchronization accuracy of the sender or the receiver is unknown, the difference between the received samples' time stamp and the protection relay's time is more than 8 ms, the SMV frame is delayed more than SMV Max Delay or two or more consecutive SMV frames are lost. The output is held on for 10 seconds after the synchronization accuracy returns within limits.

The quality of received SMV is available as outputs in TxTR function blocks and is not propagated directly to protection function blocks along with the SMV measurement values. To handle situations where SMV is not available, its quality is not good or there is an issue with time synchronization, the WARNING and ALARM outputs of SMV measurement function blocks must be connected to the application, for example to block directional protection.

### 6.4.2 SMV control block

<table>
<thead>
<tr>
<th>SVCB attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SviD</td>
<td>A SVCB-specific string. The default value is &lt;ledName&gt;MU01.</td>
</tr>
<tr>
<td>Multicast address</td>
<td>A multicast addressing scheme is used when sending sampled values messages. A multicast address can be shared by several sending devices or it can be IED specific. To keep the multicast message filtering of the devices working, it is recommended to use unique multicast addresses.</td>
</tr>
<tr>
<td>SVCB name</td>
<td>The name of the SVCB structure seen by the IEC 61850/MMS client</td>
</tr>
<tr>
<td>Data set</td>
<td>Data sent in sampled values messages to the network</td>
</tr>
<tr>
<td>ConfRev</td>
<td>ConfRev increases when the referenced data set is modified. Both the sampled values sender and the receiver must have the same ConfRev value. This ensures that both IEDs have the same configuration level in the substation configuration. ConfRev usage is done automatically by the tools. If the latest system configuration is not downloaded into all required IEDs, the configuration revision may differ between the receiver and sender.</td>
</tr>
</tbody>
</table>

Table continues on next page
### SVCB attribute

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC Address</td>
<td>Multicast MAC address to which the sampled values data is sent. The receiving IED filters the frames and starts to process them if a multicast address is defined in the configuration. It is recommended to have one unique multicast address per SVCB. The address range for sampled values multicast addresses is 01-0C-CD-04-00-00...01-0C-CD-04-01-FF.</td>
</tr>
<tr>
<td>App ID</td>
<td>Unique HEX value application identifier for sending the SVCB within the system. It identifies the purpose of a data set. The value range for sampled values is 0x4000...0x7FFF.</td>
</tr>
<tr>
<td>VLAN-ID</td>
<td>Used if the Ethernet switches in a station bus support VLAN. If static VLAN identifiers are defined, it also affects the switch port configuration. Value “000” indicates a non-configured VLAN and switches do not filter these messages on a port basis. This is recommended if there is no need to split the logical network. The VLAN identifier is a three-character HEX value with range 000...FFF. The recommended values are 2...1001.</td>
</tr>
<tr>
<td>VLAN Priority</td>
<td>Used in networks supporting VLANs. The priority is used with network switches. The default value for sampled values is “4” and the value range is 0...7.</td>
</tr>
<tr>
<td>Sample Rate</td>
<td>Amount of samples per period</td>
</tr>
<tr>
<td>NoAsdu</td>
<td>Number of ASDUs, which are concatenated into one APDU</td>
</tr>
<tr>
<td>IncludeRefreshTime</td>
<td>If selected SV buffer contains the attribute “RefrTm”</td>
</tr>
<tr>
<td>IncludeSampleRate</td>
<td>If selected SV buffer contains the attribute “SmpRate”</td>
</tr>
</tbody>
</table>

Modify only MAC address, VLAN ID and sampled value ID to keep the 9-2 LE compliancy. Leave the others as default.

Use a unique AppID for each SMV stream to ensure that always the correct SMV stream is received and used by the application. It is also highly recommended to use unique MAC addresses to fully benefit from the network filters.

### 6.4.3 Angle and amplitude corrections

The TxTR instrument transformer amplitude and angle correction factors also affect the scaling in SMV frames. Thus, it is sufficient to configure these correction factors in the sender only.
6.4.4 SMV delay

The SMV Max Delay parameter, found via menu path Configuration/System, defines how long the receiver waits for the SMV frames before activating the TxTR ALARM output. This setting also delays the local measurements of the receiver to keep them correctly time aligned. The SMV Max Delay values include sampling, processing and network delay.

For best performance, the SMV Max Delay value should not be set needlessly high since this delays the protection by an equal amount of time (Table 10). Setting it too low can cause SMV samples to arrive after the set deadline and thus make SMV-based protection inoperable. To determine suitable SMV Max Delay values, see Table 9.

TxTR ALARM activates when two or more consecutive SMV frames are lost or late. A single loss of frame is corrected with a zero-order hold scheme. The effect on protection is considered negligible in this case and it does not activate the TxTR WARNING or ALARM outputs.

Table 9: Topology-dependent SMV max delay setting

<table>
<thead>
<tr>
<th>Number of hops in network</th>
<th>Internal application delay (µs)</th>
<th>Internal switch latency (µs)(^1)</th>
<th>Store and forward latency (µs)(^1)</th>
<th>Queue latency (µs)(^1)(^2)</th>
<th>Additional tolerance (µs)(^3)</th>
<th>Theoretical max delay (µs)</th>
<th>Recommended max delay setting (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1728</td>
<td>20</td>
<td>24</td>
<td>240</td>
<td>80</td>
<td>2092</td>
<td>1814 2 2</td>
</tr>
<tr>
<td>5</td>
<td>1728</td>
<td>1450</td>
<td>50</td>
<td>600</td>
<td>200</td>
<td>2638</td>
<td>2360 3 3</td>
</tr>
<tr>
<td>10</td>
<td>1728</td>
<td>1450</td>
<td>100</td>
<td>1200</td>
<td>250</td>
<td>3398</td>
<td>3120 5 4</td>
</tr>
<tr>
<td>15</td>
<td>1728</td>
<td>1450</td>
<td>150</td>
<td>1800</td>
<td>300</td>
<td>4158</td>
<td>3800 5 4</td>
</tr>
</tbody>
</table>

Table continues on next page
### 6.4.5 IEEE 1588 v2 parameters and status information

#### Time

The time parameters are found via menu path `Configuration/Time/Time synchronization`.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synch source</td>
<td>IEEE 1588</td>
<td></td>
</tr>
<tr>
<td>PTP Domain ID</td>
<td>0</td>
<td>0...255</td>
</tr>
<tr>
<td>PTP priority 1(^1)</td>
<td>128</td>
<td>0...255</td>
</tr>
<tr>
<td>PTP priority 2(^1)</td>
<td>128</td>
<td>0...255</td>
</tr>
<tr>
<td>PTP announce mode</td>
<td>Basic IEEE1588</td>
<td>1 = Basic IEEE1588</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = Power Profile</td>
</tr>
<tr>
<td>Clear clock list</td>
<td>False</td>
<td>False</td>
</tr>
<tr>
<td></td>
<td></td>
<td>True</td>
</tr>
</tbody>
</table>

\(^1\) Smaller value has higher priority.
In IEEE 1588 v2, the PTP domain is a logical grouping of clocks that synchronize to each other using the protocol but that are not necessarily synchronized to clocks in another domain.

*PTP priority 1* and *PTP priority 2* are used in the execution of the best master clock algorithm in which lower values take precedence. Priority 1 is the first one used to decide the clock master.

*PTP announce mode* is used to select the announce frame format: "Basic IEEE1588" enables sending the IEEE 1588 v2 announce frame format and "Power Profile" enables sending the IEEE C37.238-2011 Power Profile announce frame format.

*Clear clock list* is used to clear the stored master clock list. For more information, see time synchronization in the technical manual.

**Best master clock algorithm**

The best master clock algorithm compares data describing two clocks to determine which data describes the better clock. This algorithm is used to determine which of the described clocks in several announce messages received by the local clock port is the best clock. It is also used to determine whether a newly discovered clock is better than the local clock.

The comparison algorithm is based on pair-wise comparisons of attributes with the following precedence.

- Priority 1
- Clock class
- Clock accuracy
- Clock stability
- Priority 2
- Clock identity: A tiebreaker based on unique identifiers

The TxTR ALARM output activates in the SMV receiver if transfer is made to a IEEE 1588 v2 master that has 8 ms or more offset compared to the previous master. The ALARM output stays on for a period of 11...33 s.

**Time synchronization monitoring values**

The time synchronization monitoring values are found via menu path Monitoring/IED status/Time synchronization.

**Table 12: Time synchronization monitoring values**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synch source</td>
<td>IEEE 1588 master</td>
</tr>
<tr>
<td></td>
<td>IEEE 1588 slave</td>
</tr>
<tr>
<td>Synch status</td>
<td>Up</td>
</tr>
<tr>
<td></td>
<td>Down</td>
</tr>
<tr>
<td>Synch accuracy</td>
<td>0...26 bits</td>
</tr>
</tbody>
</table>
Synch accuracy indicates the synchronization accuracy in number of fractional bits and can be calculated from the number of bits according to a formula.

\[ \text{Synch accuracy} = 2^{- \text{bits}} \text{ seconds} \]

(Equation 1)

**Table 13: Synch accuracy values and corresponding accuracies**

<table>
<thead>
<tr>
<th>Bits</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>8 µs</td>
</tr>
<tr>
<td>18</td>
<td>4 µs</td>
</tr>
<tr>
<td>19</td>
<td>2 µs</td>
</tr>
<tr>
<td>20</td>
<td>1 µs</td>
</tr>
<tr>
<td>21</td>
<td>500 ns</td>
</tr>
<tr>
<td>22</td>
<td>250 ns</td>
</tr>
<tr>
<td>23</td>
<td>125 ns</td>
</tr>
<tr>
<td>24</td>
<td>62.5 ns</td>
</tr>
<tr>
<td>25</td>
<td>31.25 ns</td>
</tr>
</tbody>
</table>

The time synchronization accuracy is rounded to the next worse accuracy, for example, if the accuracy is 2.3 ms, it is shown as 8 bits (4 ms).

**IEEE 1588 v2 monitoring values**

The IEEE 1588 v2 monitoring values are found via menu path Monitoring/IED status/Time synchronization.

**Table 14: IEEE 1588 v2 monitoring values**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTP gm identity</td>
<td></td>
</tr>
<tr>
<td>PTP gm time Src</td>
<td>Atomic clock</td>
</tr>
<tr>
<td></td>
<td>GPS</td>
</tr>
<tr>
<td></td>
<td>Terrestrial radio</td>
</tr>
<tr>
<td></td>
<td>PTP</td>
</tr>
<tr>
<td></td>
<td>NTP</td>
</tr>
<tr>
<td></td>
<td>Hand set</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td>Internal oscil.</td>
</tr>
<tr>
<td>PTP gm accuracy</td>
<td></td>
</tr>
</tbody>
</table>

Within a domain, grandmaster is the clock that is the ultimate source of time for clock synchronization using the PTP protocol.
PTP gm identity indicates the identity of the master clock.

PTP gm time Src indicates the source of time announced by the grandmaster clock.

PTP gm accuracy indicates the accuracy announced by the grandmaster clock.

SMV accuracy monitoring values

The SMV accuracy monitoring values are found via menu path Monitoring/IED status/SMV accuracy.

Table 15: SMV accuracy monitoring values

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMV synch accuracy</td>
<td>No sync</td>
</tr>
<tr>
<td></td>
<td>Local clock</td>
</tr>
<tr>
<td></td>
<td>Global clock</td>
</tr>
<tr>
<td>Local synch accuracy</td>
<td></td>
</tr>
<tr>
<td>Max Dev Sync Acc</td>
<td></td>
</tr>
</tbody>
</table>

SMV synch accuracy value "No sync" indicates that the SMV is either not in use or it does not use IEEE 1588 v2. The clock synchronization is locally synchronized to the grandmaster clock with parameter value "Local clock" and to the GPS clock with parameter value "Global clock".

Local synch accuracy indicates the time synchronization accuracy in microseconds.

Max Dev Sync Acc indicates the maximum clock deviation when the clock accuracy was over 4 µs.

6.4.6 Power Profile parameters

The IED's IEEE 1588 v2 time synchronization complies with IEEE C37.238-2011 Power Profile.

For best interoperability, third-party devices in the same IEEE 1588 v2 time domain network must be set according to Power Profile either via the power profile parameter or by individually setting the parameters according to Power Profile.

Table 16: IEEE C37.238-2011 Power Profile key parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay Mechanism</td>
<td>P2P</td>
</tr>
<tr>
<td>VLAN priority</td>
<td>mandatory (default=4)</td>
</tr>
<tr>
<td>Ethertype</td>
<td>0x88f7</td>
</tr>
<tr>
<td>Announce period</td>
<td>1 s</td>
</tr>
</tbody>
</table>

Table continues on next page
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sync period</td>
<td>1 s</td>
</tr>
<tr>
<td>Pdelay period</td>
<td>1 s</td>
</tr>
<tr>
<td>PTP mode</td>
<td>transparent</td>
</tr>
</tbody>
</table>

1) Some devices use the standard notation format 2^n[s] of IEEE 1588 v2 intervals. The values in this table are in [s] format.

### 6.4.7 Quality bits in SMV frames

**Table 17: Explanation of quality bits**

<table>
<thead>
<tr>
<th>Quality bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>smpSynch</td>
<td>Synchronization accuracy for all channels in the SMV frame. 0: less than 4 µs synchronization accuracy 1: within 4 µs synchronization accuracy</td>
</tr>
<tr>
<td>test bit</td>
<td>The sender IED is in test mode.</td>
</tr>
<tr>
<td>invalid 01 &amp; bad reference</td>
<td>The sender time synchronization is uninitialized (accuracy unknown).</td>
</tr>
<tr>
<td>invalid 01</td>
<td>The sender's time accuracy is less than 100 ms.</td>
</tr>
<tr>
<td>questionable 11 &amp; inaccurate</td>
<td>The accuracy of the measurement value is inaccurate or not supported.</td>
</tr>
<tr>
<td>derived</td>
<td>The channel is derived from other channels, for example, calculated residual voltage.</td>
</tr>
</tbody>
</table>

### 6.5 Engineering verification

This chapter gives a checklist of items to check and confirm during the engineering phase. The complete test specification depends on the network topology and used system components.

- Check the configuration and settings with real system load and topology.

- In the Measurement view of the SMV receiver, the voltage values in brackets indicate an invalid or a questionable measurement.
Table 18: SMV sender

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing sender</td>
<td>Disable the SMV sender via Configuration/Communication/Ethernet/SMVSENDER and verify the expected handling in receivers. In the SMV receivers’ Measurement view, the voltage values should be in brackets indicating invalid or questionable measurement. If SMVSENDER is disabled from the LHMI, it can only be enabled from the LHMI. Thus, in this situation a configuration write from PCM600 does not enable SMVSENDER.</td>
<td></td>
</tr>
<tr>
<td>Internal fault test</td>
<td>Force internal fault in the sender via Tests/IED test and check that the receiving devices behave as expected.</td>
<td></td>
</tr>
</tbody>
</table>

SMV receiver monitored data is available in three locations.

- Monitoring/I/O status/Analog inputs
- Monitoring/IED status/SMV traffic
- Monitoring/IED status/SMV accuracy

Table 19: SMV receiver

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARNING</td>
<td>WARNING (Monitoring/I/O status/Analog inputs/Voltage(3U,VT)) works as specified in Application Configuration. Necessary special handling considered in the Application Configuration tool logics. WARNING is active when the IED starts.</td>
<td></td>
</tr>
<tr>
<td>ALARM</td>
<td>ALARM (Monitoring/I/O status/Analog inputs/Voltage(3U,VT)) works as specified in the Application Configuration tool. Necessary special handling considered in the Application Configuration tool logics. ALARM is active when the IED starts.</td>
<td></td>
</tr>
<tr>
<td>Max delay</td>
<td>The maximum delay (Monitoring/IED status/SMV traffic) must be always smaller than the SMV Max Delay parameter (Configuration/System). Larger values indicate configuration problems in the network or the need to change SMV Max Delay.</td>
<td></td>
</tr>
<tr>
<td>Average delay</td>
<td>The average delay (Monitoring/IED status/SMV traffic) variation is small in different network traffic setups. A large variation may indicate configuration problems in the network.</td>
<td></td>
</tr>
<tr>
<td>Measurement</td>
<td>In the SMV receivers’ Measurement view, the voltage values should be without brackets indicating good status. Brackets indicate questionable or invalid values. The SMV traffic delay (Monitoring/IED status/SMV traffic) value should be lower than the value of SMV Max delay (Max 6.48 ms).</td>
<td></td>
</tr>
</tbody>
</table>

Table 20: Time synchronization

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time quality</td>
<td>Observe the grandmaster accuracy (Monitoring/IED status/Time Synchronization). The IED GNRLTMS1 WARNING signal is activated if the accuracy is not within the specified limits.</td>
<td></td>
</tr>
<tr>
<td>Missing clock</td>
<td>Disable the clock master and check that one IED takes the clock master role.</td>
<td></td>
</tr>
<tr>
<td>SMV Synch accuracy</td>
<td>The global clock is seen when the clock master is present.</td>
<td></td>
</tr>
</tbody>
</table>

Table continues on next page
Local sync accuracy

According to 9-2 LE the synchronization accuracy needs to be better than 4 μs which is the defined supervision limit.  

Max Dev sync Accuracy

According to 9-2 LE the synchronization accuracy needs to be better than 4 μs which is the defined supervision limit.  

Grandmaster

Check the grandmaster monitoring from the master configuration via the LHMI path Monitoring/IED status/Time synchronization/IEEE 1588. Check that all IEDs are synchronized to the same PTP master.

1) 4 μs corresponds to approximately 0.07 degrees in 50 Hz systems

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local sync accuracy</td>
<td>According to 9-2 LE the synchronization accuracy needs to be better than 4 μs which is the defined supervision limit.</td>
<td></td>
</tr>
<tr>
<td>Max Dev sync Accuracy</td>
<td>According to 9-2 LE the synchronization accuracy needs to be better than 4 μs which is the defined supervision limit.</td>
<td></td>
</tr>
<tr>
<td>Grandmaster</td>
<td>Check the grandmaster monitoring from the master configuration via the LHMI path Monitoring/IED status/Time synchronization/IEEE 1588. Check that all IEDs are synchronized to the same PTP master.</td>
<td></td>
</tr>
</tbody>
</table>

Table 21: Network

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max HSR loop size</td>
<td>Maximum supported HSR loop size is 30. Consider applying a different topology if a larger system is needed.</td>
<td></td>
</tr>
<tr>
<td>Redundancy</td>
<td>Check the maximum delays in different network setups.</td>
<td></td>
</tr>
</tbody>
</table>

6.5.1 Checking SMV data with LHMI's Test and Commissioning pages

1. On the SMV Receiving page, check the sampled values data that the relay subscribes from the Ethernet network.

   The left side of this page shows a list of devices that send SMV messages to the relay. These devices that publish data for the relay are defined in the relay configuration. The right side of the page shows the SMV data that the relay receives from the network. The data set consists of value and quality attributes. The received data has status indicators where green means all OK, yellow warning and red error.
2. On the SMV Sending page, check the status of the relay's configured SMV control blocks and the values of the sent IEC 61850-9-2 sampled value data. The left side of this page shows a list of the devices where the relay sends SMV messages. In the system there may be more devices, but these devices are according to relay configuration the ones subscribing the data from the relay. The right side of the page shows the SMV data the relay sends to the network. The sent data has status indicators where green means all OK, yellow warning and red error.
Section 7  Engineering of event reporting with PCM600

7.1  IEC 61850 client management with IEC 61850 Configuration

The default IED SCL contains five default client definitions, “Client1”...”Client5”, which are used by all the RCBs. PCM600 does not show these clients in the plant structure, but IEC 61850 Configuration shows the clients in the client-server communication.

MicroSCADA and COM600S clients can use the client definitions directly. If other clients need to be added to the project, the ICD file describing the client data model should be imported to PCM600.

7.1.1  Adding new IEC 61850 clients for IEC 61850 Configuration

Adding a new IEC 61850 client to a PCM600 project is a two-step operation. First, a new generic IEC 61850 IED object must be created under the plant structure and then the relevant client ICD or CID file must be imported to the generic IEC 61850 IED.

1. Right-click a bay node in the project plant structure, point to New, then point to Generic IEC61850 IEC and select IEC61850 IED.
Figure 62: Creating a generic IEC 61850 IED

2. Rename the IED object as “Client_G”.
3. Right-click the IED and select **Import**.

Figure 63: Selecting Import on the shortcut menu

4. Select a valid client SCL file (ICD or CID) and click **Open** in the file selection dialog box.
5. In the **SCL Import Options** dialog box, select **Ignore PCM Object Type** and click **Import**.
6. Start IEC 61850 Configuration and select **Client-Server communication** as engineering mode.

The newly added client should be present in the Clients column along with other clients on both the Data Set tab and the Report Controls tab.
7.2 IEC 61850 Configuration user interface

1. Engineering mode selection
   The communication mode can be selected from the drop-down list on the toolbar.
   Four modes are available: “GOOSE Communication”, “Client-Server Communication”, “Process Bus Communication” and “Subnetwork Configuration”.

2. Switching engineering mode on and off
   The button switches between engineering and view mode. The configuration can be edited only in the engineering mode.
When the engineering mode is enabled, SCD files from external IEC 61850 engineering tools cannot be imported into PCM600.

3. Switching IEC 61850 IED naming on and off
   The button switches between IEC 61850 and PCM600 IED naming.

4. Create new object
   The button opens a window to create a new object. The type of object depends on the currently selected engineering type.

5. Selection details
   The button opens the Editor window for the data currently selected in the mapping grid. The same editor can also be opened by double-clicking the data.

6. Receiving access points
   All IEDs that have access points capable of receiving the kind of data according to the currently selected engineering type and engineering mode are displayed as columns in the mapping grid. A check mark in a column means that the access point is receiving the data.

7. Mapping grid
   The mapping grid consists of check boxes for configuring what data is sent to or received by an access point. A check mark in the grid means that the data on the row is sent to the receiver in the column.

8. Data to send/receive
   The data available for sending or receiving in the selected engineering mode and its type are displayed as rows in the mapping grid. The data is context-sensitive with the current selection in the PCM600 plant structure. A check mark on the row means that the data is sent to or received by an access point. The data editor is opened by double-clicking the data.

9. Engineering type selection
   Each engineering mode has several engineering types. Engineering type means the type of data to configure. The types can be selected by clicking the tab page on the bottom of the tool window. The available engineering types depend on the selected engineering mode.
   • Data sets: Create, delete, modify or send data sets
   • GOOSE controls: Create, delete, modify or send GOOSE controls
   • Sampled value controls: Create, delete, modify or send sampled value controls
   • Report controls: Create, delete, modify or send report controls
   • Inputs: View inputs (external references)

10. Object properties
    The Object Properties window displays the properties of the currently selected data. Different data properties are edited in this window.
7.3 Creating data sets with IEC 61850 Configuration

1. Select Plant Structure in the Project Explorer window.
2. Right-click the IED node.
3. Select Client-Server Communication in the drop-down box on the toolbar.

![Selecting Client-Server Communication](image1)

4. Select the Data Sets tab.
5. Right-click the area containing the data set names and select New to add a new data set.

![Creating a new data set](image2)

6. In the Create New Data Set dialog box, define the LN where to place the data set (accept preselected “LD0/LLN0”) and give the data set a unique name.
After creating the GOOSE data sets, define the data set entries (data attributes or data objects) for the data sets.

### 7.3.1 Defining data set entries with IEC 61850 Configuration

1. Select the **Data Sets** tab.
2. Right-click a data set and select **Details** to add data attributes.
3. In the data set entry window, select the data attribute to be contained in the data set.
   - Click **Append selected** to add the data attribute to the end of the data set.
   - Click **Insert selected** to add the data attribute above the selected row in the data set entries list.
   - To remove a data attribute from the data set, select the data attribute in the data set entries pane and click **Remove selected**.

Reporting data sets can include status and measurement data. Also configuration and setting values can be added to data sets.

Data set entries for vertical reporting are selected using the data object level, and entries for GOOSE are selected using the data attribute or data object level.

The default data set for SMV sending is fixed and may not be modified.
7.4 Creating report control blocks with IEC 61850 Configuration

1. Select the IED node in **Plant Structure** in **Project Explorer**.
2. Click the **Report Controls** tab.
3. Right-click the area containing the existing RCBs and select **New** to add a new RCB.
4. Browse to LLN0 under LD0 to define where to place the RCB.
5. Give a unique name to the RCB.
6. In the drop-down list, select the previously created data set to link with the RCB.

![Figure 71: Adding a new report control block](image_url)
7. Edit the properties and options of the created RCB.
Data set entries in a data set linked to the RCB can be modified from the RCB Control Block tab by selecting Data Set Details in the shortcut menu.
7.5 Configuring report control block clients with IEC 61850 Configuration

Add and configure the IEDs before configuring the RCB client. The potential clients and their communication configuration should be known for a successful RCB client configuration.

1. In Plant Structure, click the IED node which is the RCB server.
2. Click the Report Controls tab. The rows of the Report Controls window show the RCBs configured for the IED. The columns of the Report Controls window show the RCB clients configured in the PCM600.
3. To add or remove clients for an RCB, click the check box in the grid, corresponding to the client and RCB. Five clients at a maximum can be connected to an RCB.

![Figure 74: RCB clients](image)

1. RCBs configured for the IED
2. RCB clients
The clients are automatically added to or removed from the corresponding data sets on the **Data Sets** tab. Date sets are based on the configuration done on the **Reports Controls** tab and vice versa.

7.6 Substation section configuration in IEC 61850 Configuration

The substation topology consists of the substation, voltage level and bay nodes. The bay nodes also include the conducting (primary) equipment, which corresponds to the switches, that is, the circuit breakers, disconnectors, and earth switch, of the configured IED. In addition to the substation topology configuration, logical nodes of the IEDs are mapped to proper objects, for example, to support the automatic bay configuration via SCL files in the SCADA system.

At the moment, IEC 61850 Configuration does not support engineering of the substation section. Instead, for example, IET600 can be used for engineering, if needed.
Managing IEC 61850 clients with IET600

When the relay configurations are changed using IET600, some preparations are required when a project is started and the protection relay's data model is imported to the tool for the first time.

- The default IED SCL export from PCM600 contains five default client definitions, “Client1”...”Client5”, which are used by all the RCBs. MicroSCADA and COM600S clients can use the client definitions directly. If other clients need to be added to the IET600 project, import the ICD file describing the client data model to the project and attach the file to the same IEC 61850 subnetwork in the Communication tab.
- Create the bus connections for the IEC 61850 clients.

Adding new IEC 61850 clients for IET600

Adding a new IEC 61850 client to an IET600 project is a two-step operation. The client must be first created using the Create New IED function, after which the Update IED function can be used to import the related ICD or CID file.

1. To create an IED, click the IEDs tab in the navigation pane.
2. Click the root node in the IED tree.
3. Right-click the node and click Create New IED.
4. Type the name of the client IED as it is in the file to be imported. Click **OK**.
5. Right-click the created IED and click **Update IED**.
6. In the file selection dialog box, select any valid SCL file that is SCD, ICD, CID or IID, and click **Open**.
   IET600 automatically matches IEDs with the same name in IET600 and in the file.

7. Click **OK** to import the IED from the file.
The procedure for configuring IEC 61850 clients can be used to create or update any IED or several IEDs at the same time.

### 8.1.2 Attaching IEC 61850 clients to a bus with IET600

1. Click the **Communication** tab in the navigation pane.
2. Click the **Subnetworks** tab in the editor pane.
3. In the Subnetworks grid, select the bus from the Subnetwork list to attach the IEC 61850 client to the bus.
   An alternative way is to drag the client in the **Communication** tab to the correct subnetwork.
Figure 78: Defining bus connection properties for IEC 61850 clients

4. Repeat the steps to attach all five default clients in the project to the bus.

By default, the IEDs’ bus connections are ready-made when the configuration work is started and need not be set separately. After the client bus connections are created, the event clients appear on the RCB Clients tab.

8.2 IET600 user interface

The IET600 user interface is divided into sections, that is, panes for navigating and displaying the project data.
Figure 79: IET600 user interface

1 Menu on the top of the user interface
2 Navigation pane for context-oriented navigation and filtering the various editors
3 Properties pane for detailed properties of the selected element in the navigation pane
4 Editors for detailed design and engineering of the substation, IEDs and IEC 61850 communication
5 Logging and messaging (output) pane

The navigation pane provides context-oriented navigation of the editors. It has three tabs, which correspond to three different context views.

- **Substation** – Full substation topology and primary equipment nodes
- **IEDs** – IED nodes and corresponding functionality
- **Communication** – Subnetworks and connected IED access points

The editor pane is the main working area of the IET600 user interface. It is organized in various tabs for detailed substation design and engineering. The visible tabs depend on the node type selected in the navigation pane.

Available editor tabs depend on the selected node type, not on the selected navigation tab. Choose any available context view to do the engineering tasks.
Choose upper or lower level in the structure to see the data of single, many or all IEDs at the same time in the editor pane.

### 8.2.1 Setting visibility of columns in grid editors

Most editors are implemented as tables. These grid editors provide features like setting column visibility, filtering, sorting, automatic data filling, copying and pasting, finding and replacing and exporting to Excel.

Most tables include columns which are hidden by default.

1. To set the visibility of the columns, click the upper-left icon of the table.

   ![Field Chooser](image)

   *Figure 80: Setting column visibility in a grid editor*

2. Select or clear the check boxes from the **Field Chooser** dialog box.

### 8.3 Substation section configuration in IET600

Substation topology consists of the substation, voltage level and bay nodes. Bay nodes also include the conducting (primary) equipment, which corresponds to the switches, that is, the circuit breakers, disconnectors, earth switch, of the configured protection relay. Substation topology is initially built by importing the SCD file from PCM600.

The SLD editor is a graphical editor for the configuration of the substation section in IET600. It provides tools to draw the primary equipment and the interconnection between the equipment in the bay.
Figure 81: **SLD Editor**

SLD in the protection relay is configured using the Graphical Display Editor of PCM600, not in IET600.

In addition to the substation topology configuration, logical nodes of IEDs need to be mapped to proper objects, for example, to support the automatic bay configuration via SCL files in the SCADA system. Logical nodes are mapped with LN Mapping Editor.
8.4 Creating data sets with IET600

Data sets are created or modified using the Dataset editor, which consists of three parts.

- Grid for existing data sets (data set creating, deleting and renaming)
- Selection lists for adding new entries to a selected data set
- List of data set entries for a selected data set (viewing, deleting)
1. Select an IED node in the IEDs navigation pane.
2. Click the **Datasets** tab in the editor pane.
3. Right-click the area containing data set names and select **Insert new row**.
4. Define the LN where the data set is to be placed (preselected **LD0/LLN0** is recommended) and the name for the new data set.
5. Click **Append>>** to add data items to the end of the data set or click **Insert>** to add data items above the selected row in the data set entries list.

Reporting data sets can include status and measurement data. Also configuration and setting values can be added to data sets.

Above the data set entries list it is shown how many attributes can be added to the data set and how many are already added.

Select a proper FC (functional constraint) value for the data attributes to be added to a data set. If none is selected, that is “(all)” is shown on the list, it is not possible to add attributes to the data set.
Data set entries for vertical reporting are selected using the data object level, and entries for GOOSE are selected using the data attribute or data object level.

8.5 Creating report control blocks with IET600

Configuration properties, such as the attached data set and the buffering and triggering options of the RCBs are defined in the RCB editor. A predefined RCB configuration of a preconfigured IED is a default configuration which can be adapted according to the requirements.

1. Click an IED node in the IEDs navigation pane.
2. Click the RCB Data tab in the editor pane.
3. Right-click the area containing RCB names and select Insert new row.
4. Define the LN where the RCB is to be placed (preselected LD0/LLN0 is recommended) and the name for the new RCB. Use the field chooser to show or hide the properties. For example, the SeqNum, Entry ID and Reason Code options (set by default in the IED) are hidden by default.

![Figure 84: RCB editor]

IET600 updates Conf.Rev automatically to the next multiple of 100 when the configuration changes.

Deleting an RCB does not remove it from IET600. Instead, its status is set to “Deleted” and it is not exported to SCL files. Removing a data set automatically puts the related RCB to the “Deleted” state.
An RCB cannot be renamed. To rename an RCB, delete it and create a new RCB with a new name.

8.6 Report control block client configuration with IET600

Before the RCB client configuration, the potential clients and their communication configuration should be known. Therefore, the IEDs must be added and configured to the subnetwork before configuring the RCB client.

The rows of the RCB client editor show IEDs and RCBs and the columns show the available client IEDs.

If a client IED is not on the same subnetwork as a server IED or RCB, it cannot be configured as a client.

![Figure 85: RCB client editor](image)

Different keys can be used when editing the cells.

- PLUS SIGN (+), asterisk (*) or X to add a client to the existing ones
- Numbers to change the client sequence or add clients
- MINUS SIGN (-), SPACEBAR or DELETE to delete existing clients
- Double-clicking with the mouse to add or delete clients

The RCB client editor supports both manual and semi-automatic client configuration.
8.6.1 Configuring report control block clients semi-automatically

On the right in the RCB client editor there are option buttons to choose whether to show IEDs (for defining default clients), RCBs or both.

There are also buttons for semi-automatic configuration of default clients and RCB clients.

![Semi-automatic configuring of RCB clients](image)

1. Configure the default clients which are used by the rule-based RCB generation to automatically configure RCB clients.
   Use the buttons on the RCB client editor.
   - **Clear All** removes all default clients.
   - **Configure Empty** fills out only default clients for those IEDs that have no clients configured yet.
   - **Configure All** deletes all existing default clients and fills them out afterwards.

2. Configure the RCB clients.
   The default clients must be configured before configuring RCB clients otherwise the automatic RCB client configuration does not work. Use the buttons on the RCB client editor.
• **Clear All** removes all RCB clients.
• **Configure Empty** copies the default client configuration of this IED to its RCBs (only for those RCBs that have no clients configured yet).
• **Configure All** deletes the existing RCB clients and copies the default client configuration of this IED to its RCBs.

IET600 updates the *Enabled Clients* configuration value of the RCBs automatically based on the configuration made in the RCB client editor. In addition, IET600 always reserves one extra engineering client. For example, when configuring three RCB clients, the *Enabled Clients* value of that RCB is “4”.

---

Section 8
Engineering of event reporting with IET600
Section 9 Flexible product naming

9.1 Flexible product naming concept

Flexible Product Naming in PCM600 allows the use of a vendor-independent IEC 61850 model of the IED. This model is exposed in all IEC 61850 communication, but all other aspects of the IED remain unchanged (for example, names on the local HMI and names in the tools). This offers significant flexibility to adapt the IED to the customers’ system and standard solution.

There are several benefits.

- IEDs use the customer model for communication.
- Customer-specific naming convention for communication can be used.
- Other IEDs and station-level equipment can be defined from the customer-specific communication model.
- Error tracing of communication can be the same between different installations.

9.2 Mapping examples

![Diagram](image)

*Figure 87: L1PTOC in the customer model mapped to BPTOC in the IED model and L2PTOC mapped to APTOC*

The mapping shown in Figure 87 results in the mapping shown in Figure 88.
Figure 88: L1PTOC mapped to FunctionB and L2PTOC mapped to FunctionA

Mapping possibilities and requirements

The mapping is possible at several levels in the structure.

- Logical node level (LN to LN)
- Data object level (DO to DO)
- Data attribute level (DA to DA)

Custom logical device name (LDName) can be used for addressing.

When the mapping is performed, there are some requirements that must be fulfilled.

- Used system configuration files must be standard compatible.
- One attribute in the customer model can be mapped only to one attribute in the IED model. However, one attribute in the IED model can be mapped to several attributes in the customer model.
- The versions of the IEC 61850 standard must match.
- Number of data sets must not exceed the maximum number of data sets that the IED supports.

There are also some consequences that must be considered.

- If two DOs in one LN in the customer model are mapped to DOs in different LNs in the IED model, the DOs in the customer model might have inconsistent quality in case of different operational states of the IED functions.
- When several LNs in the customer model are mapped to one function in the IED, the Mod of the function affects all the customer LNs.

9.3 Import scenarios

The IEC 61850 model provides extensive information tagging for substation automation. The IED data model can be browsed through MMS, and the SCL file
provides additional tagging description information. It is possible to have flexible tools which understand the modeling details. PCM600 and ABB-defined data models are recommended for engineering.

On the other hand, if the SCADA/client configuration cannot be changed, for example, in retrofitting and for some standardization changes, there is a need to support IED 61850 configuration changes through FPN.

Figure 89: Retrofit workflow for an existing IED

IEC 61850 allows usage of templates in engineering. If customer specification defines system configuration (SCD), it is possible to use it and continue engineering in PCM600.

Figure 90: Customer-specification based workflow

9.4 Network configuration

Access point configuration facilitates usage of different IP addresses in Network1 and Network2.
Basic IEC 61850 configurations support one server data model (SCL/IED/AccessPoint/Server) in the defined network address.

The relay also supports a second access point with a ServerAt definition (SCL/IED/AccessPoint/ServerAt). In this case, the same data model is visible on both access points.

Most FPN configurations contain only one access point. If the template project contains multiple access points for one relay, the unnecessary extra access points need to be filtered away in the tool.

**SCL configuration checklist**

FPN configuration cannot exceed the ABB relay's capabilities. When not matching, the FPN system configuration needs to be adjusted in the system tool or manually in SCL.

One standard rule needs to be considered in exiting SCD files.

- SCL/Communicate/Subnetwork/@type must be “8-MMS”.

One ABB-specific limitation must also be considered.

- SCL/IED/Accesspoint/@name must not exceed the ABB device limit of 20.

**9.4.1 Defining subnetwork**

Before starting the FPN configuration of the relay, the ABB-specific configuration must be correct.

- Potential additional subnetwork must be configured using PCM600 configuration.
- The IED’s access point must be defined using Ethernet Configuration in PCM600.

1. In PCM600, right-click an IED in the plant structure and select **Options**.
2. Enable the IEC 61850 configuration engineering mode.
3. On the toolbar, select **Subnetwork configuration** from the drop-down list.

4. Configure Ethernet ports in Ethernet Configuration.
9.4.2 Mapping access points

1. Right-click one of the nodes and point to **Flexible Product Naming**.
2. Click **IEC 61850 Structure Mapping**.
3. On the **Access Point Mapping** tab, map access points to define the relations between REX640 internal access points and customer access points.
In the above example, REX640 access point AP1 is in subnetwork WA1, while access point AP2 is in subnetwork WA2. The configuration is created using Ethernet configuration.

The network configuration must be correct before the flexible product mapping is started.

REX640 supports one access point for the data model. A second access point AP2 is based on the ServerAt concept and has the same data model in different IP addresses.

The REX640 access points are mapped to FPN project access points IED1_AP1 and IED_AP2. The third access point IED1_AP3_UNDESIRED is excluded from the mapping since it does not have a network interface.

9.5 Engineering

9.5.1 IEC 61850 edition selection

The IEC 61850 edition selection is done in the system configuration phase before importing the FPN data model.

The relay determines the data model / SCL version from the configuration file. This has impact, for example, on the used control blocks.

9.5.2 Parameter setting

The relay's parameter setting in PCM600 and on the relay's HMI is independent of the FPN configuration. PCM600 uses FTPS by default but offers FTP as an optional choice. FTP may be useful for passing traffic through a router with the help of an FTP ALG.

9.5.3 IED identification

FPN configuration defines the relay.

- name: technical key
- type: Instead of REX640, the imported version is used, for example, REF615, SPAZC40x.
- manufacturer: Instead of ABB, the imported version is used, for example, GENERIC. ABB Inc.
- configVersion: Instead of the REX640 specific value, the imported project-specific value is used.
- desc: The imported project-specific value is used.
The project needs to adjust the IED configuration details according to the client (SCADA) requirements to minimize the changes in retrofit projects, for example.

9.5.4 Configuration size

FPN replaces the existing MMS configuration. The relay's booting time is longer due to processing of project-specific configuration. The configuration size is compared to the maximum recommended configuration size and a warning is given if the configuration size exceeds the recommended maximum.

The tool does not download the configuration if the relay's capabilities are exceeded. The configuration size warning is given when the project is larger than verified in ABB. In this case, it is recommended to check and minimize unnecessary options.

The configuration size can be minimized in several ways.

- Decrease the number of RCB clients per control block. This can be checked from //ReportControl/RptEnabled/@max.
- Decrease the number of report controls and data sets
- Remove the unnecessary logical nodes from configuration. The data model size can be minimized if a replaced relay is configured with a default configuration or a configuration which contains unused functions.

9.5.5 Functional naming

FPN allows customer definition of the IEC 61850-8-1 data model. It is possible to have multiple logical devices and their data attribute tagging indicating functions and subfunctions.

The test mode and setting group handling in the IED is global.

If the project contains functional naming, it is possible to have explicit LD name in /LD/@LDName attribute. Functional naming affects the MMS domain name and it changes the data set referencing objects of RCBs and GOOSE control blocks.

Functional naming cannot be used for the REX640 SMV model in MU01 because this is based on the IEC 61850-9-2 LE edition 1 specification.

Functional naming can be used for the LD’s necessary subset.
PCM600 does not support functional naming configuration in an ABB-specific project, but it is possible to configure functional naming for REX640 by importing the SCD project.

9.5.6 Name space definition files

System engineering rules may use only data objects defined in IEC 61850-7-4. Name space definition files can be used by tools to check the data object extension's origin. For REX640, extension data can be found in the IEC 61850 MICS document and it is also defined by name space attributes in the CID file, which can be exported.

9.6 Data model

9.6.1 Logical device division

It is possible to have maximum 45 logical devices. Function designs consisting of multiple logical nodes should be mapped under the same logical device.

9.6.2 Data protection

In data type templates, the valKind attribute defines data access.

- RO=Read only
- Set=Settable
- Conf=Configuration time

It is possible to have customer-specific valKind in SCL, but the REX640-specific access rights cannot be overridden and thus data is protected. A warning message is given in mapping in such cases. When aiming to monitoring, it is typically ok to ignore that warning.

9.6.3 Functional constraints

From the IEC 61850 point of view, functional constraints should match between the ABB model and the FPN model. It is possible to map data between known predefined functional constraints. For example, different devices may have different requirements of setting group handling. When the FPN model is used for monitoring, a warning message can be ignored.
### 9.6.4 Data types

From the IEC 61850 point of view, the data types of common data classes should match. Data mapping between different types is possible, but a warning is given. The engineer must understand the possible loss of precision when mapping between types.

### 9.6.5 Standard compatibility

For structural types like CMV, it is important to have SCL data in correct order in the SCD file's data type template section. The IEC 61850-8-1 part suggests that the functional constraints are in consecutive order. If the order is different than specified in the standard, the data attribute locations in the data objects may be interpreted differently in the received and sent GOOSE.

Table 22: Examples of functional constraint rules

<table>
<thead>
<tr>
<th>FPN model</th>
<th>ABB model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>SG</td>
<td>See the <a href="#">Setting group parameters</a> chapter.</td>
</tr>
<tr>
<td>SG</td>
<td>SP</td>
<td>See the <a href="#">Setting group parameters</a> chapter.</td>
</tr>
<tr>
<td>SV</td>
<td>ST, MX, DC</td>
<td>REX640 does not support substitution. It is, however, possible to have substation data in the FPN data model and map it to the REX640 application data.</td>
</tr>
<tr>
<td>BL</td>
<td>ST</td>
<td>Not supported by REX640 directly, but it is possible to map to generic data.</td>
</tr>
<tr>
<td>OR</td>
<td>ST</td>
<td>Not supported by REX640 directly, but it is possible to map to generic data.</td>
</tr>
<tr>
<td>SR</td>
<td>ST, DC</td>
<td>Not supported by REX640 directly, but it is possible to map to generic data.</td>
</tr>
</tbody>
</table>

Table 23: Example of the SCL data order

<table>
<thead>
<tr>
<th>DA fc</th>
<th>DA name</th>
<th>DA bType</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX</td>
<td>instCVal</td>
<td>Struct</td>
<td>MyVector</td>
</tr>
<tr>
<td>MX</td>
<td>cVal</td>
<td>Struct</td>
<td>MyVector</td>
</tr>
<tr>
<td>MX</td>
<td>range</td>
<td>Enum</td>
<td>MyRangeConfig</td>
</tr>
<tr>
<td>MX</td>
<td>rangeAng</td>
<td>Enum</td>
<td>MyRangeConfig</td>
</tr>
<tr>
<td>MX</td>
<td>q</td>
<td>Quality</td>
<td></td>
</tr>
<tr>
<td>MX</td>
<td>t</td>
<td>Timestamp</td>
<td></td>
</tr>
<tr>
<td>SV</td>
<td>subEna</td>
<td>BOOLEAN</td>
<td></td>
</tr>
<tr>
<td>SV</td>
<td>subCVal</td>
<td>Struct</td>
<td>MyVector</td>
</tr>
<tr>
<td>SV</td>
<td>subQ</td>
<td>Struct</td>
<td>MyVector</td>
</tr>
</tbody>
</table>

Table continues on next page
### 9.6.6 Primary values

By default, the relay is in nominal mode. If system engineering requires it, MMS monitoring can be set to primary mode.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
<th>Menu path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit mode</td>
<td>1=Primary; 0=Nominal</td>
<td>Configuration/Communication/Protocols/MMS</td>
</tr>
</tbody>
</table>

### 9.6.7 Substitution

REX640 does not support substitution. It is, however, possible to have substation data in the FPN data model and map it to the REX640 application data.

### 9.7 Settings

In IEC 61850, function mode handing is defined in control model. In REX640, function mode parameters are not changed during normal operation, but they are set up during the engineering phase. Therefore, the most relevant of the “Operation” parameters are defined in the Settings menu.
For instant change of the configuration scenario, the setting group concept with blocking signals is recommended. Another alternative for the operator role is to use the controllable single- and double-point status from relevant application functions.

9.7.1 Device menu

Menus are the same regardless of the FPN. Thus the function's IEC 61850 name is default due to manual reference. The functions' IEC, ANSI and user-defined naming is settable with parameter \(<place>\).

9.7.2 Function mode handling

Parameter Setting is the primary tool for changing the function's operation mode. IEC 61850 defines the logical node's common behavior. Each logical device (LD) must contain standard data objects LLN0.Mod and LLN0.Beh which can be status-only or controllable.

Due to security and limited visibility in the menu, several mapping rules apply to Mod data objects.

- Mod data objects are mapped to existing Mod parameters which are visible in the menu.
- If Mod is unmapped, the functionality is always “on”.
- If the intention is to turn the function off, the behavior (Beh) data must be in the menu.
- Status-only must be used for the FPN control model when the intention is not to write the data. It is possible to override the ABB direct-with-normal-security by status-only in control model (ctlModel).

There are some recommendations for the menu parameters.

- \(Test \text{ mode} = "LD0.LLN0.Mod"\) via Tests/IED test
- \(Device \text{ state} = "LD0.LLN0.Beh"\) via Monitoring/IED status/Self-supervision
- \(Control \text{ mode} = "CTRL.LLN0.Mod"\) via Configuration/Control/General
- \(Operation = "Function \text{ block master Mod}"\) via Settings/Settings/<Category>/<Function name>
- \(<\text{Function name}>\) Function block Beh via Monitoring/FB status

Mapping example 1

All FPN mode parameters are mapped to the existing ABB model. The global mode parameter of the logical device (LLN0.Mod) is mapped to the ABB-specific LD0.LLN0.Mod.
### Mapping example 1

<table>
<thead>
<tr>
<th>FPN model</th>
<th>ABB model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LD</strong></td>
<td><strong>LD0</strong></td>
</tr>
<tr>
<td><strong>LN</strong></td>
<td><strong>LLN0</strong></td>
</tr>
<tr>
<td><strong>DO</strong></td>
<td><strong>Mod</strong></td>
</tr>
<tr>
<td><strong>DA</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>Default</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>Oper.ctlVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>ctlModel</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>Beh</strong></td>
<td><strong>Beh</strong></td>
</tr>
<tr>
<td><strong>stVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>HIPTOC1</strong></td>
<td><strong>PHIPTOC1</strong></td>
</tr>
<tr>
<td><strong>Mod</strong></td>
<td><strong>Mod</strong></td>
</tr>
<tr>
<td><strong>stsVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>Oper.ctlVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>ctlModel</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>Beh</strong></td>
<td><strong>Beh</strong></td>
</tr>
<tr>
<td><strong>stsVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
</tbody>
</table>

### Mapping example 2

The FPN model's global mode is set to the default value. The behavior indicates the IED's global test mode regardless of the mapping.

<table>
<thead>
<tr>
<th>FPN model</th>
<th>ABB model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LD</strong></td>
<td><strong>LD0</strong></td>
</tr>
<tr>
<td><strong>LN</strong></td>
<td><strong>(NONE)</strong></td>
</tr>
<tr>
<td><strong>DO</strong></td>
<td><strong>on</strong></td>
</tr>
<tr>
<td><strong>DA</strong></td>
<td><strong>(NONE)</strong></td>
</tr>
<tr>
<td><strong>Default</strong></td>
<td><strong>(NONE)</strong></td>
</tr>
<tr>
<td><strong>Oper.ctlVal</strong></td>
<td><strong>(NONE)</strong></td>
</tr>
<tr>
<td><strong>ctlModel</strong></td>
<td><strong>(NONE)</strong></td>
</tr>
<tr>
<td><strong>Beh</strong></td>
<td><strong>(NONE)</strong></td>
</tr>
<tr>
<td><strong>stsVal</strong></td>
<td><strong>(NONE)</strong></td>
</tr>
<tr>
<td><strong>HIPTOC1</strong></td>
<td><strong>PHIPTOC1</strong></td>
</tr>
<tr>
<td><strong>Mod</strong></td>
<td><strong>Mod</strong></td>
</tr>
<tr>
<td><strong>stsVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>Oper.ctlVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>ctlModel</strong></td>
<td><strong>stsVal</strong></td>
</tr>
<tr>
<td><strong>Beh</strong></td>
<td><strong>Beh</strong></td>
</tr>
<tr>
<td><strong>stsVal</strong></td>
<td><strong>stsVal</strong></td>
</tr>
</tbody>
</table>

### Mapping example 3

DARREC1 is moved logically under control functions and existing ABB data LD0.DARREC1.Mod.stsVal is explicitly mapped to new Control.Q1RREC1.Mod.stsVal.
When the IEC 61850 MMS client writes Control.LLN0.Mod.Oper ctlVal value "off", DARREC1 is switched off.

- According to data model inheritance, MMS data Control.Q1RREC1.Beh.stVal indicates "off".
- Existing menu parameter “Monitoring\FB status\Control\DARREC1”, which is actually LD0.DARREC1.Beh.stVal, indicates "off".

<table>
<thead>
<tr>
<th>Table 27: Mapping example 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FPN model</strong></td>
</tr>
<tr>
<td>LD</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>Oper.ctlVal</td>
</tr>
<tr>
<td>Beh</td>
</tr>
<tr>
<td>Q1CSWI</td>
</tr>
<tr>
<td>Beh</td>
</tr>
<tr>
<td>LD0</td>
</tr>
<tr>
<td>Beh</td>
</tr>
</tbody>
</table>

Table 28: Mapping example 4

DARREC1 is moved visually under control functions. Since the engineer has not mapped DARREC1.Mod.stVal, the function still belongs logically under LD0.LLN0.Mod.

<table>
<thead>
<tr>
<th>Table 28: Mapping example 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FPN model</strong></td>
</tr>
<tr>
<td>LD</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>Oper.ctlVal</td>
</tr>
<tr>
<td>Beh</td>
</tr>
<tr>
<td>Table continues on next page</td>
</tr>
</tbody>
</table>
Mapping example 5

It is possible to have multiple logical devices. Global modes LLN0.Mod should typically be mapped to global test mode LD0.LLN0.Mod. However, it is also possible to map the Mode parameter to existing ABB data in a more demanding way.

In the example below, ABB Operation parameters of protection trip conditioning (LD0.TPRPPT1/2.Mod) are allocated to different logical devices of the FPN project (LLN.Mod). If the user writes "Off" to Prot2.LLN0.Mod.Oper.ctlVal, the following happens:

- Relay's DEFPTOC1 is turned off.
- FPN model's Control.DEFTOC1.Beh indicates “off”.
- In the relay's menu, LD0.DEFPTOC1.Beh indicates “off”.

<table>
<thead>
<tr>
<th>Table 29: Mapping example 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FPN model</strong></td>
</tr>
<tr>
<td>LD</td>
</tr>
<tr>
<td>Beh</td>
</tr>
</tbody>
</table>

| Q1CSWI | CBCSWI1 |
| Mod | Mod |
| stVal | stVal |
| Oper.ctlVal | Oper.ctlVal |
| ctModel | ctModel |

| LD0 | DARREC |
| Mod | (NONE) |
| stVal | on |
| Oper.ctlVal | (NONE) |
| ctModel | (NONE) |

| Beh | (NONE) |
| stVal | Beh |

| OCPTRC1 | PHIPTOC1 |
| Op | Op |
| general | general |

Table continues on next page
### Setting group parameters

ABB product's settings are divided into setting group (SG) and non-group settings (SP) as needed.

If the division differs in the engineered case, it is possible to map SG and SP settings. In this case, the device functionality is not altered and group 1 is only visible through MMS.

#### Table 30: Mapping of setting group parameters

<table>
<thead>
<tr>
<th>Access</th>
<th>FPN data</th>
<th>ABB data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>SG</td>
<td>SP</td>
<td>Returning same SP value for all SG groups</td>
</tr>
<tr>
<td>W</td>
<td>SG</td>
<td>SP</td>
<td>It is only allowed to write group 1. Writing other groups results in error.</td>
</tr>
<tr>
<td>R/W</td>
<td>SP</td>
<td>SG</td>
<td>The value is always redirected to group 1. Other SG group values are set via Parameter Setting in PCM600 or the LHMI menu.</td>
</tr>
</tbody>
</table>

However, it is possible to edit the group settings from PCM600 and the LHMI menu.
9.7.4 Setting group control

Setting group control is global for the device. In the ABB engineering mode, it is possible to use six groups and handle them by binary input.

In the FPN mode, the number of setting groups is taken from the project SCD file. Since the relay has global setting group control for all logical devices, the biggest value is taken.

9.8 Control

The FPN model does not extend the device's services, so existing PIXIT defines the supported services and capabilities.

9.8.1 Local/remote handling

Local/remote handling is defined in the device data model. The engineer needs to map the correct data object according to the used client application. Since the existing local/remote data is a superset of all choices, a reduced FPN model may help the SCADA engineering.

9.8.2 Control model

The product-specific default data model members are visible in parameter tables and details of function features can be found in the technical manual.

It is possible to use the customer data model, but the control model (ctlModel) allows only product-dependent choices. The control model can be status-only or direct-with-normal-security. For DPC, sbo-with-enhanced-security is also supported. The engineer can map the control model directly to the product data object or restrict the FPN model's default value to "status-only".

Time-activated control is not supported, but if the controllable objects contain additional optional attributes, it is possible to write the command structures. Optional attributes must then have default values.

9.9 Data sets

Data sets and control blocks must be defined in the SCL configuration phase under one LLN0. Dynamic creation is not supported.

The number of data set members and report controls should be kept within the limits of standard configuration offering. When adding data set members above the recommended defaults, the IED configuration may have different data priority/speed.
Table 31: Possible errors if the imported FPN SCD file contains invalid data sets

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The customer IED contains [xx] data sets. The internal IED allows 27 data sets at maximum.</td>
<td>There are too many data sets in the configuration.</td>
<td>Combine or remove some data sets.</td>
</tr>
<tr>
<td>The customer IED contains one or more data sets having [xx] entries. The internal IED allows 80 entries at maximum.</td>
<td>One or more data sets in the imported configuration are too big.</td>
<td>Check the data set sizes on the editing dialog box for data set entries. Remove some entries or split data sets into multiple data sets if possible.</td>
</tr>
</tbody>
</table>

9.9.1 Supported data types in data sets

Table 32: Supported data types in data sets

<table>
<thead>
<tr>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST and MX</td>
<td>Partly supported</td>
</tr>
<tr>
<td>CF, SG and SP</td>
<td>Supported but not recommended</td>
</tr>
<tr>
<td>CO</td>
<td>Not supported According to the standard, it is write-only.</td>
</tr>
<tr>
<td>OR and BL</td>
<td>Supported However, since the relay does not natively support the types, the engineer needs to define the used ST data behavior in Application Configuration.</td>
</tr>
<tr>
<td>Array</td>
<td>Not supported</td>
</tr>
<tr>
<td>VisString</td>
<td>Not supported The data is not operational.</td>
</tr>
</tbody>
</table>

9.9.2 Editing data sets in IEC 61850 Configuration

To edit data sets, IEC 61850 configuration engineering mode must be enabled from options.
1. To open IEC 61850 Configuration, right-click an IED and select IEC 61850 Configuration.

2. On the toolbar, select the communication mode for which data sets are managed.
3. Manage data sets on the **Data Sets** tab.
   - To add new data sets, right-click and select **New**.
   - To delete data sets, select the data sets to be deleted, right-click and select **Delete**.
   - To edit entries in a data set, select the data set and open **Entries** from **Object Properties**.

**Figure 97:** Selecting the type of the data sets to be edited

**Figure 98:** Adding, deleting or editing a data set

This opens a dialog box where entries can be added or removed.
9.10 Sampled measured values

The relay supports one IEC 61850-9-2 LE stream having four currents and four voltages.

9.10.1 SCL configuration checklist for sampled measured values

Sampled measured value data sets must be defined according to IEC 61850-9-2 LE.

- Data set name must be PhsMeas1.
- SampledValueControl name must be MSVCB01 or MSVCB02.
- Order of data in the data set must be according to IEC 61850-9-2 LE.

9.11 GOOSE

In FPN configuration, sent GOOSE data sets refer to the FPN configuration data while the received GOOSE data refers to the internal data of REX640.

It is strongly recommended that GOOSE data sets should be on data attribute level. Both DA level and DO level definitions work, however. Reasons for that are:
• Different optional attributes can exist in the data model.
• The used SCL file may contain data attributes in non-standard order (standard does not state this) and thus the tool interprets the data order differently than the IED. See the Standard compatibility chapter.

### 9.11.1 SCL configuration checklist for GOOSE

REX640 supports six GOOSE send data sets so `/SCL/IED/Services/GOOSE/@max` should not exceed 6. It may be easiest to replace the Services section by the section in the REX640 type data files.

In receiving REX640 device uses APPID in packet detection. It is a standard way, however in some template projects, APPID is not set for send GOOSE. Variable `/SCL/Communication/SubNetwork/ConnectedAP/GSE/Address/P/@type` for APPID must be defined for each GSE element.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The customer IED contains [xx] GOOSE control blocks. The internal IED allows 6 GOOSE control blocks at maximum</td>
<td>There are too many GOOSE control blocks in the imported configuration.</td>
<td>Check the GOOSE control blocks using IEC 61850 Configuration.</td>
</tr>
</tbody>
</table>

### 9.11.2 Editing GOOSE control blocks in IEC 61850 Configuration

To edit GOOSE control blocks, IEC 61850 configuration engineering mode must be enabled from options.

*Figure 100: Enabling IEC 61850 configuration engineering mode*
1. To open IEC 61850 Configuration, right-click an IED and select IEC 61850 Configuration.

Figure 101: Opening IEC 61850 Configuration

2. On the toolbar, select GOOSE Communication from the drop-down menu.

Figure 102: Editing GOOSE control blocks

Use the Data Sets tab for editing data sets for GOOSE control blocks and the GOOSE Controls tab for editing GOOSE control blocks.
9.12 Reporting

9.12.1 SCL configuration checklist for ReportControl

REX640 supports 27 data sets out of which six can be defined for GOOSE. For reporting, the total number of ReportControl blocks is 105 (//Services&/ConfReportControl/@max), which typically means that 21 report data sets can have five clients (//ReportControl/RptEnabled/@max). It may be easiest to replace the Services section by the section in the REX640 type data files.

Table 34: Possible errors if imported FPN SCD file contains invalid ReportControl blocks

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The customer IED contains one or more report control blocks having [xx] instantiated clients. The internal IED allows 5 instantiated report clients per report control block at maximum.</td>
<td>Some of the report controls have too many clients.</td>
<td>Check the report control blocks using IEC 61850 Configuration.</td>
</tr>
<tr>
<td>Too many reporting clients</td>
<td>Enabled clients are out of valid range for some of the report control blocks.</td>
<td>Using IEC 61850 Configuration, check the enabled clients from Object Properties for all the ReportControl blocks. This must be in the range of 2...5.</td>
</tr>
</tbody>
</table>

9.12.2 Editing ReportControl blocks in IEC 61850 Configuration

To edit ReportControl blocks, IEC 61850 configuration engineering mode must be enabled from options.
1. To open IEC 61850 Configuration, right-click an IED and select **IEC 61850 Configuration**.

   ![Opening IEC 61850 Configuration](image1)

   **Figure 104:** Opening IEC 61850 Configuration

2. On the toolbar, select **Client-Server Communication** from the drop-down menu.

   ![Selecting client-server communication](image2)

   **Figure 105:** Selecting client-server communication

3. Click the **Data Sets** tab to edit data sets for report controls and the **Report Controls** tab to edit ReportControl blocks.

4. To edit the clients for each ReportControl block, select a ReportControl block and open **Clients** from **Object Properties**.
One ReportControl block can have a maximum of five clients.

9.13 Logging

IEC 61850 logging is not supported by the relay. REX640 central activity logging and audit trail is a recommended system solution. For more information on security logging, see the cyber security deployment guideline.

9.14 Service tracking

IEC 61850 service tracking is not supported by the relay.

The relay, however, supports service tracking of logical nodes and data object creation due to the SCL data type support.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access point</td>
<td>The connection that ties wireless communication devices into a network</td>
</tr>
<tr>
<td>ACSI</td>
<td>Abstract communication service interface</td>
</tr>
</tbody>
</table>
| ACT        | 1. Application Configuration tool in PCM600  
             2. Trip status in IEC 61850                                                                                                          |
<p>| ALG        | Application level gateway                                                                                                               |
| APDU       | Application protocol data unit                                                                                                          |
| APPID      | Application identifier                                                                                                                  |
| ASDU       | Application-layer service data unit                                                                                                      |
| CID        | Configured IED description                                                                                                               |
| COM600S    | Substation Management Unit. An all-in-one communication gateway, automation platform and user interface solution for utility and industrial distribution substations. |
| COMTRADE   | Common format for transient data exchange for power systems. Defined by the IEEE Standard.                                              |
| Connectivity package | A collection of software and information related to a specific protection and control IED, providing system products and tools to connect and interact with the IED |
| CT         | Current transformer                                                                                                                     |
| CTRL       | Control logical device                                                                                                                   |
| DA         | Data attribute                                                                                                                          |
| Data attribute | Defines the name, format, range of possible values and representation of values while being communicated                               |
| Data object | Also known as DO. Part of a logical node object representing specific information, for example status or measurement. From an object-oriented point of view, a data object is an instance of a class data object. DOs are normally used as transaction objects; that is, they are data structures. |
| Data set   | The content basis for reporting and logging containing references to the data and data attribute values                                |
| DO         | Data object                                                                                                                             |
| DPC        | Double-point control                                                                                                                     |</p>
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR</td>
<td>Disturbance recorder</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic compatibility</td>
</tr>
<tr>
<td>Ethernet</td>
<td>A standard for connecting a family of frame-based computer networking technologies into a LAN</td>
</tr>
<tr>
<td>FC</td>
<td>Functional constraint</td>
</tr>
<tr>
<td>FPN</td>
<td>Flexible product naming</td>
</tr>
<tr>
<td>FTP</td>
<td>File transfer protocol</td>
</tr>
<tr>
<td>FTPS</td>
<td>FTP Secure</td>
</tr>
</tbody>
</table>
| GCB          | 1. GOOSE control block  
               2. Generator circuit breaker |
| GoCB         | GOOSE control block |
| GOOSE        | Generic Object-Oriented Substation Event |
| GPS          | Global Positioning System |
| GSE          | Generic substation event |
| HMI          | Human-machine interface |
| HSR          | High-availability seamless redundancy |
| ICD          | IED capability description |
| IEC          | International Electrotechnical Commission |
| IEC 61850    | International standard for substation communication and modeling |
| IEC 61850-8-1| A communication protocol based on the IEC 61850 standard series |
| IEC 61850-9-2| A communication protocol based on the IEC 61850 standard series |
| IEC 61850-9-2 LE | Lite Edition of IEC 61850-9-2 offering process bus interface |
| IED          | Intelligent electronic device |
| IEEE 1588    | Standard for a Precision Clock Synchronization Protocol for networked measurement and control systems |
| IET600       | Integrated Engineering Toolbox |
| IID          | Instantiated IED description |
| LD           | Logical device |
| LD0          | Logical device zero (0) |
| LED          | Light-emitting diode |
| LHMI         | Local human-machine interface |
| **LLDP** | Link Layer Discovery Protocol |
| **LLN0** | Logical node zero (0) |
| **LN** | Logical node |
| **Logical device** | Also known as LD. Representation of a group of functions. Each function is defined as a logical node. A physical device has one or several LDs. |
| **Logical node** | Also known as LN. The smallest part of a function that exchanges data. An LN is an object defined by its data and methods. |
| **MAC** | Media access control |
| **MicroSCADA** | Substation automation system |
| **MICS** | Model implementation conformance statement |
| **MMS** | 1. Manufacturing message specification  
2. Metering management system |
| **NTP** | Network time protocol |
| **P2P** | peer-to-peer |
| **PCM600** | Protection and Control IED Manager |
| **PIXIT** | Protocol implementation extra information for testing |
| **PRP** | Parallel redundancy protocol |
| **PTP** | Precision Time Protocol |
| **RCB** | Report control block |
| **SCADA** | Supervision, control and data acquisition |
| **SCD** | Substation configuration description |
| **SCL** | XML-based system configuration description language defined by IEC 61850 |
| **SMV** | Sampled measured values |
| **SVCB** | Sampled value control block |
| **TAL** | Time allowed to live |
| **TCP/IP** | Transmission Control Protocol/Internet Protocol |
| **VLAN** | Virtual LAN |
| **VT** | Voltage transformer |
| **WHMI** | Web human-machine interface |