RELION® PROTECTION AND CONTROL

REX640

IEC 61850 Engineering Guide

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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.

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1 Introduction

1.1 This manual

The engineering guide provides information for IEC 61850 engineering of the protection relays with PCM600. 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

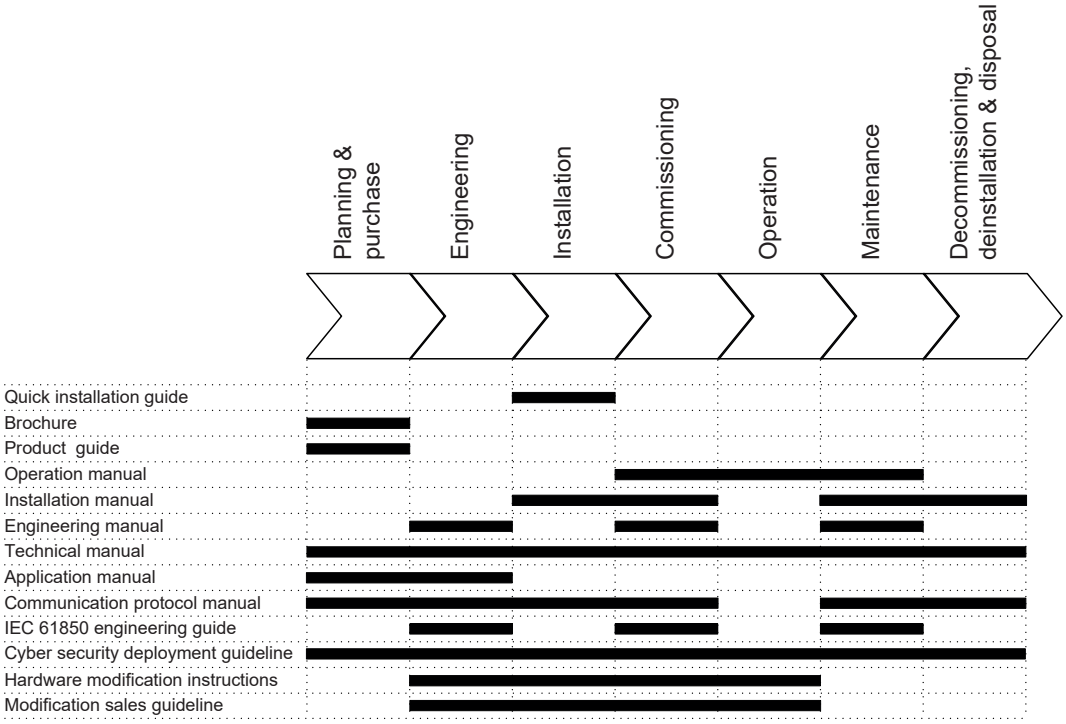

Figure 1: The intended use of documents during the product life cycle

1.3.2 Document revision history

Document revision/ date	Product connectivity level	History
A/2019-04-30	PCL1	First release
B/2020-02-13	PCL2	Content updated to correspond to the product connectivity level
C/2020-12-10	PCL3	Content updated to correspond to the product connectivity level
D/2023-02-10	PCL4	Content updated to correspond to the product connectivity level

1.3.3 Related documentation

Download the latest documents from the ABB Web site *www.abb.com/mediumvoltage*.

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.
- Values of quantities are expressed with a number and an SI unit. The corresponding imperial units may be given in parentheses.
- This document assumes that the parameter setting visibility is "Advanced".

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 2.1.

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.

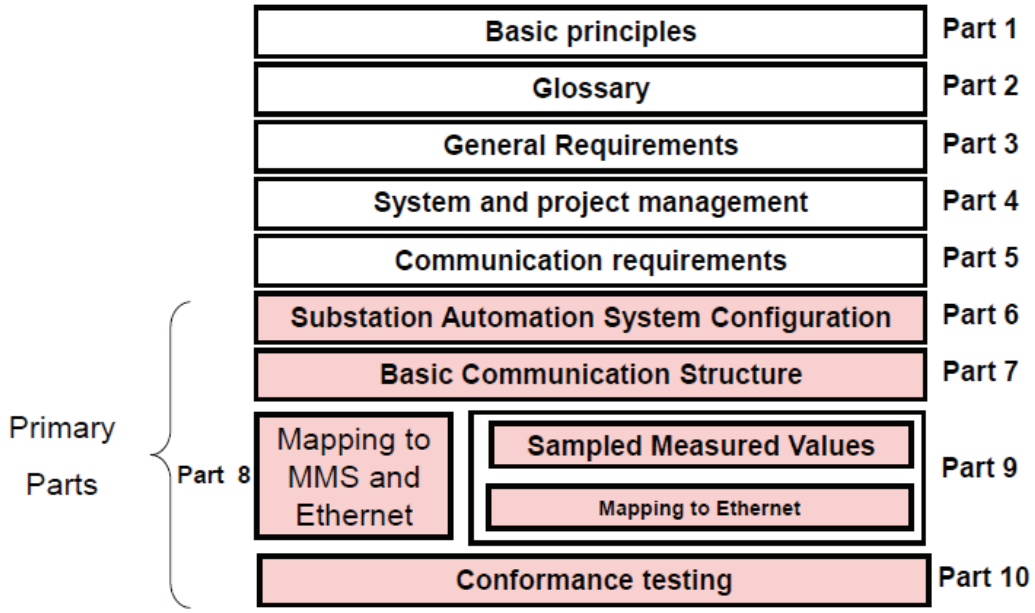

Figure 2: Structure and parts of the IEC 61850 standard

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 horizontal 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.

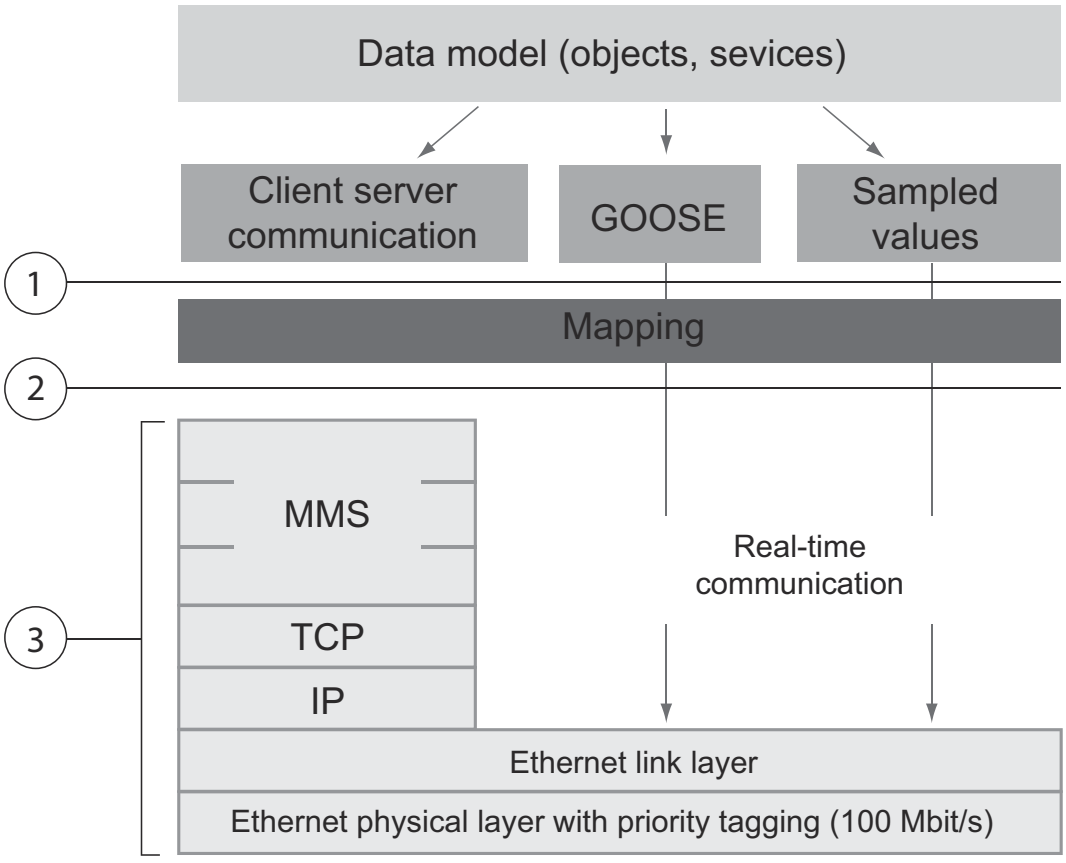

Figure 3: Communication stacks and mapping used in IEC 61850

1 Abstract communication services interface (ACSI)

2 Stack interface

3 ISO/OSI stack

3 PCM600

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. 2.12 or later
- REX640 Connectivity Package Ver. 1.3.0 or later

Download connectivity packages from the ABB Web site *www.abb.com/mediumvoltage* or directly with Update Manager in PCM600.

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 2.1, 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.

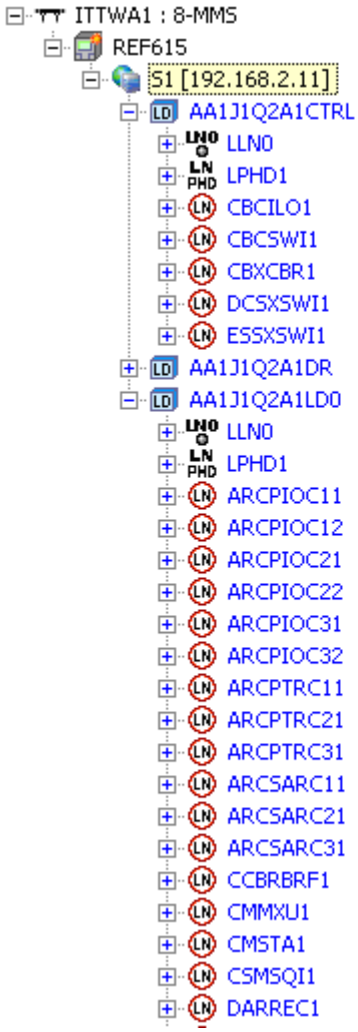

Figure 4: Example of an IEC 61850 data model of a protection relay

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 ZEE600. 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 1: Identification lengths in IEC 61850 versions

Object	Edition 1 length	Edition 2 length	Description
IED name	28 (32-4)	60 (64-4)	Excluding the longest LD name length of 4 characters
Report control block name	14	30	Without a two digit RCB instance number
Data set name	32	32	
RptID	65	129	Report Identifier
GoID	65	129	GOOSE Identifier
MSVID	65	65	Multicast Sampled Value Identifier (length as in 61850-9-2 LE)

Table 2: Number of control block data sets and size of data sets

Control Block	Maximum data sets	Maximum length	Description
GoCB	6	120 data objects or attributes in total 80 data objects or attributes per data set	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.
RCB	27	Edition 1: 256 data attributes Edition 2: When the data attribute level is used, maximum 80	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

Table continues on the next page

Control Block	Maximum data sets	Maximum length	Description
		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.	can be minimum 21 data sets for reporting.
SVCB	1	16 data attributes	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.

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, 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** > **MMSLPRT1**.

Table 3: Diagnostic data objects

Data object	Description	Diagnostic information
SucConn	Successful connections	Number of succeeded client connection attempts
FailConn	Failed connections	Number of failed client connection attempts
ConcCnt	Concludes	Number of session concludes
TxAbtCnt	Sent aborts	Number of association aborts sent by server
RxAbtCnt	Received aborts	Number of received association aborts by server
TxRejCnt	Sent rejects	Number of sent rejects by server
RxRqCnt	Received request	Number of received client requests
FailRqCnt	Failed requests	Number of failed client requests
SucReadCnt	Reads	Number of variable reads

Table continues on the next page

Data object	Description	Diagnostic information
FailReadCnt	Failed reads	Number of failed variable reads
SucWrCnt	Writes	Number of succeeded variable writes
FailWrCnt	Failed writes	Number of failed variable writes
InfRepCnt	Reports	Number of sent reports
ActConnCnt	Active connections	Number of active client connections

It is possible to reset the vertical diagnostics counters via **Monitoring** > **Communication** > **MMSLPRT1** > **Reset counters** and via the IEC 61850 communication by writing `TRUE` to the *RsCnt.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 FTP.

When setting the parameter **Configuration** > **Communication** > **MMSLPRT1** > **Unit mode** to “Primary”, 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 GOOSE

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 fulfils 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 4: GOOSE control block attributes

GoCB property	Description
GoCB name	GOOSE control block name
Application ID	A unique GOOSE identification string for each GoCB in the system. By default, it is the GoCB identification in the relay data model.
Max Time	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.
Min Time	Indicates the maximum response time to data changes in milliseconds. In the relay, the value is always "10ms" for sent data.
Multicast MAC address	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 01-0CCD- 01-00-00...01-0C-CD-01-01-FF.
Configuration Revision	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.
APPID	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.
Data set	Data content sent in GOOSE messages
VLAN ID	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 nonconfigured 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.
VLAN Priority	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.

5.3 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.

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.

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 5: Message examples

Messages	Description
Information messages	
Increased GOOSE latency might be detected under heavy load.	P3 performance class requirement may not be met.
Increased GOOSE latency will be detected under heavy load.	50% of the packets do not meet the P3 performance class requirement.
Warning messages	
Increased GOOSE latency detected under heavy load. Configuration changes needed.	70% of the packets do not meet the P3 performance class requirement.

5.4 Configuring GOOSE with Application Configuration

To configure GOOSE with Application Configuration, GOOSE configuration must be enabled from options.

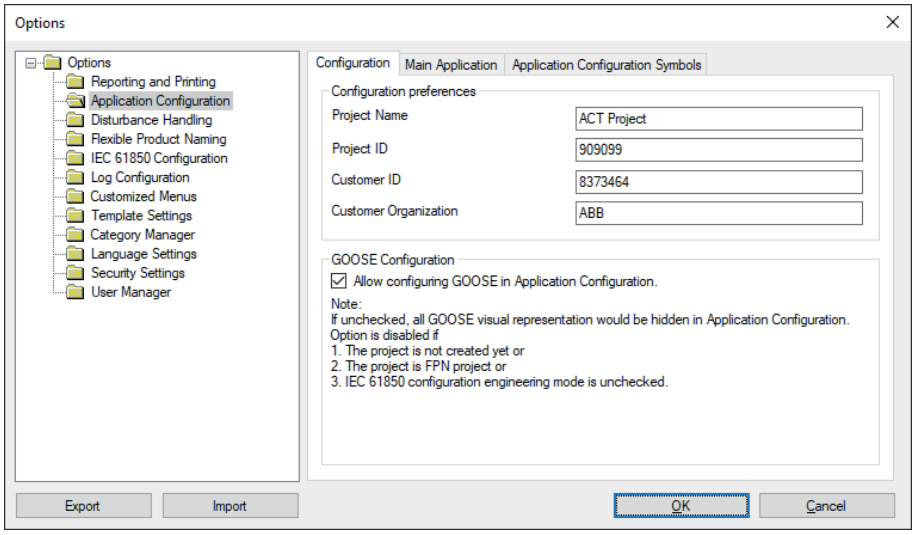

Figure 5: Enabling GOOSE configuration

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 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.

5.4.1 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**.

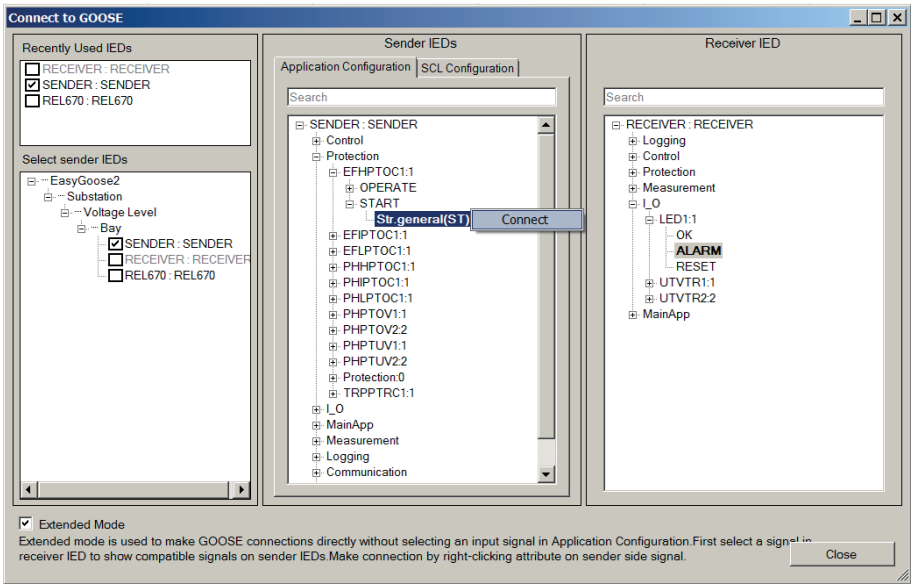

Figure 6: Connecting non-directional earth-fault protection start signal

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.

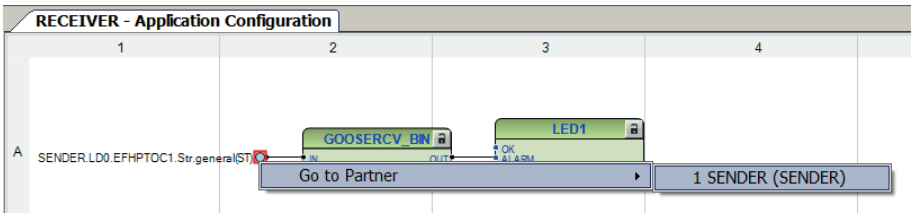

Figure 7: Navigating to the connected sender function block signal

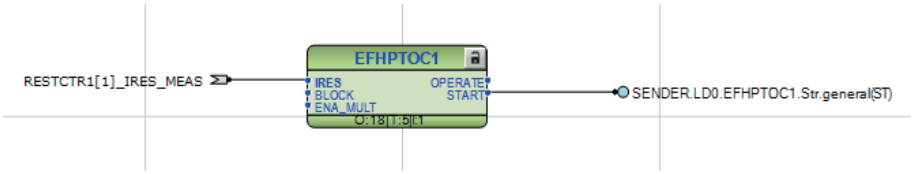

Figure 8: Sender function block signal connected

5.4.2 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.

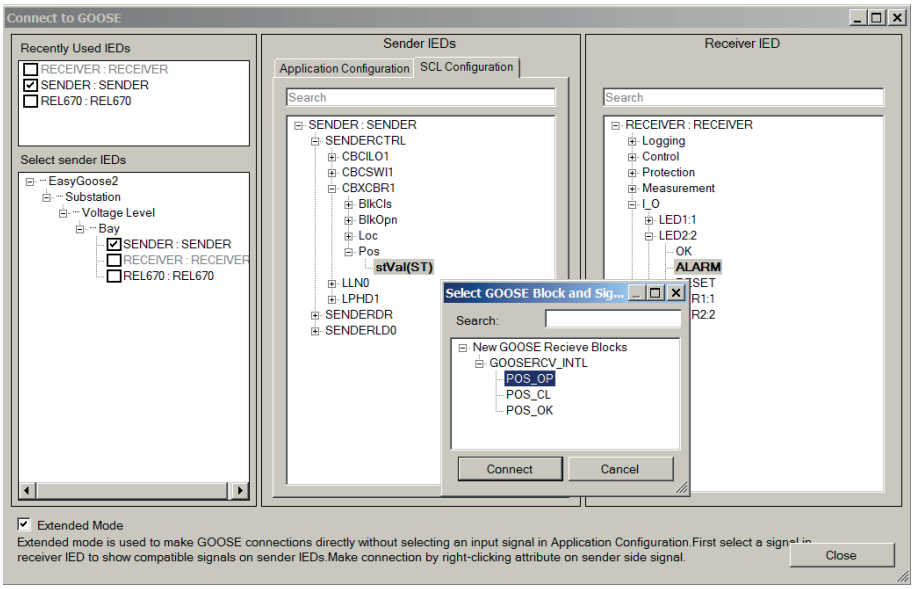

Figure 9: Using SCL to connect the GOOSE sender signal

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.

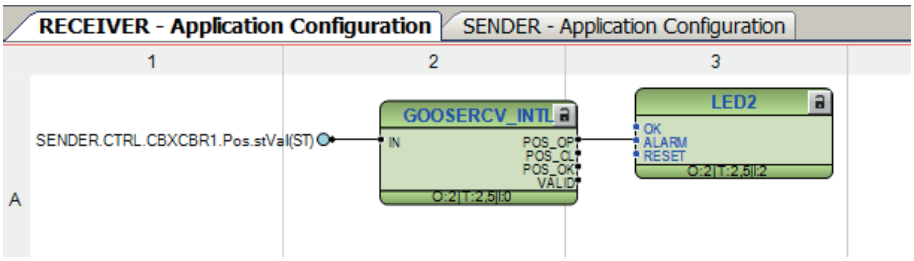

Figure 10: Connected circuit breaker open signal

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.

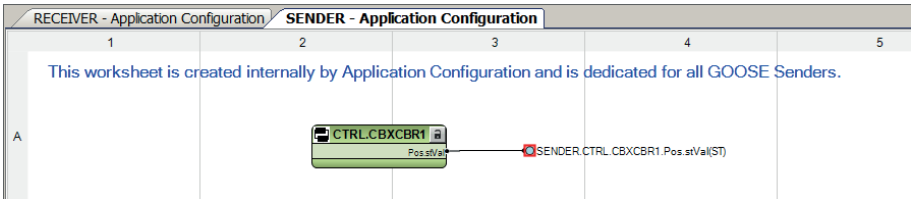

Figure 11: All internal GOOSE sender composite function blocks added to a special worksheet

5.5 Configuring GOOSE with IEC 61850 Configuration

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

5.5.1 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 the IEC 61850 Configuration.

5.5.2 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 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. A quality attribute is used at the receiver side to check data validity.

5.5.2.1 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.

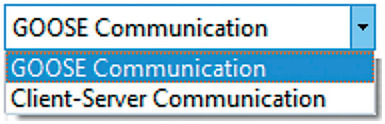

Figure 12: Selecting GOOSE communication

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**.

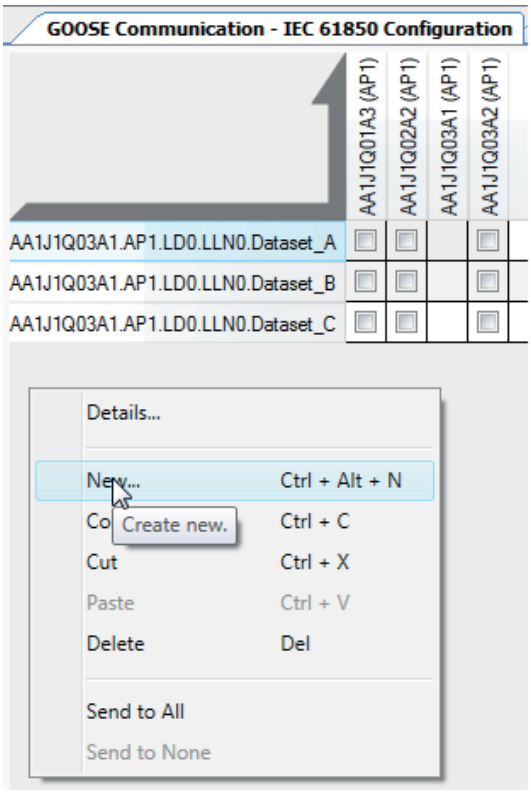

Figure 13: Creating a new data set

5. Define the LN where the data set is to be placed (accept preselected " LD0/ LLN0") and give the data set a unique name.

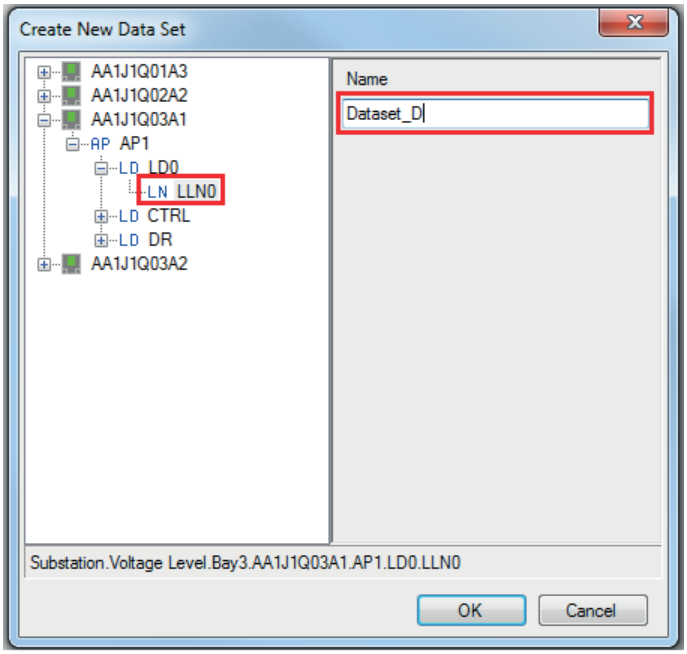

Figure 14: Naming the data set

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 a data from the data set, select the data in the data set entries pane and click **Remove selected**.

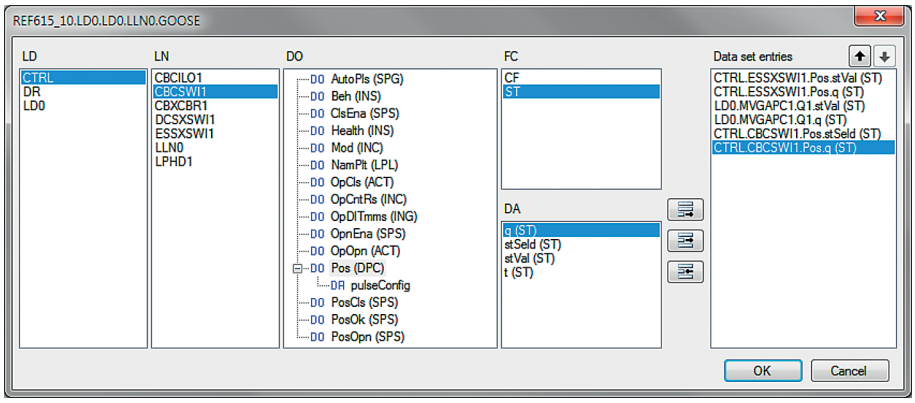

Figure 15: Adding data set entries

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.

5.5.2.2 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**.

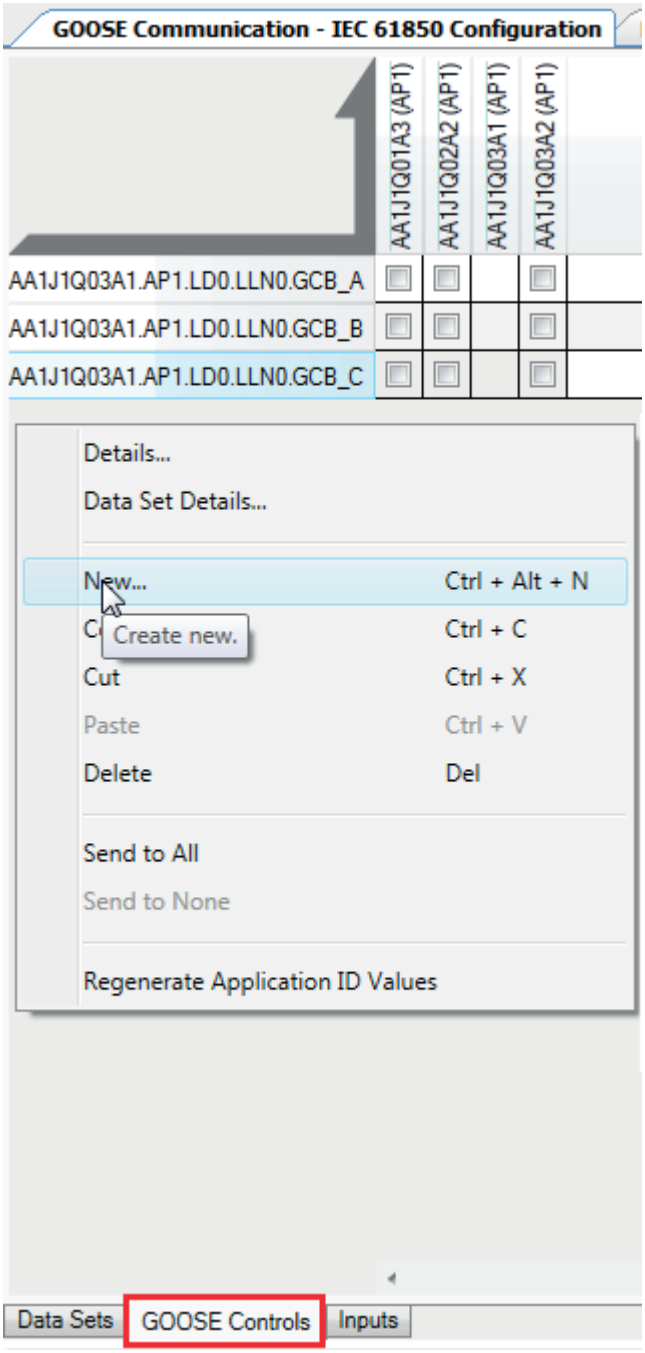

Figure 16: Creating a new GOOSE control block

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.

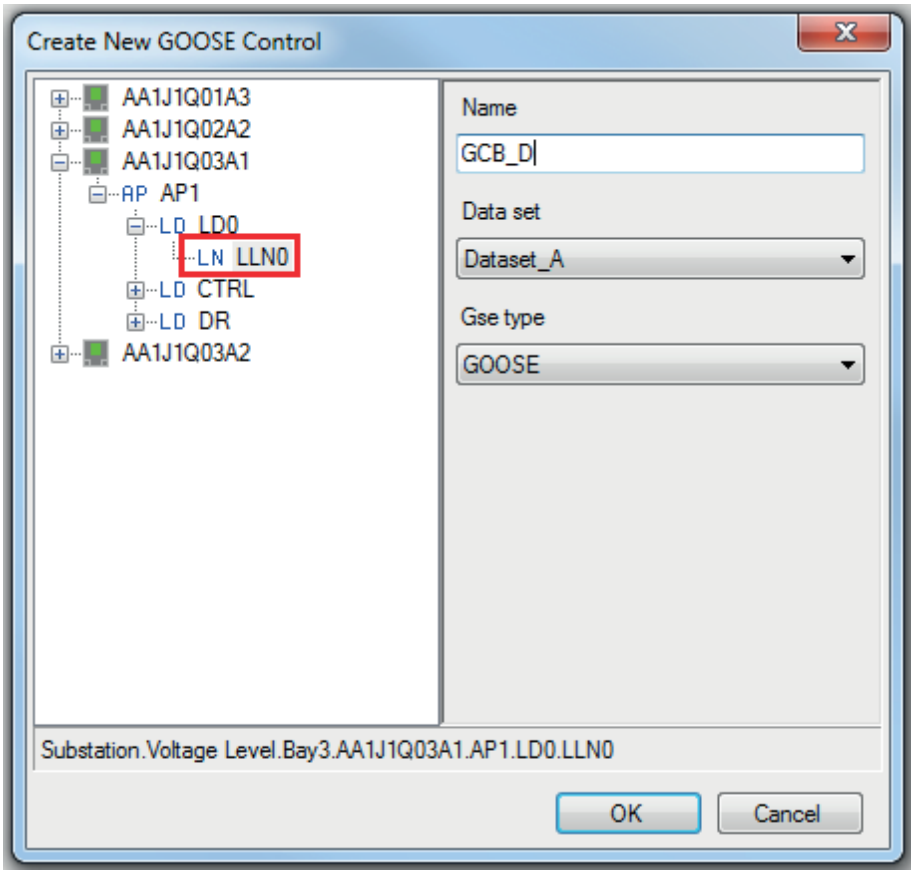

Figure 17: Naming a GOOSE control block

6. In the **Data set** drop-down list, select the previously created data set to link with the GCB.

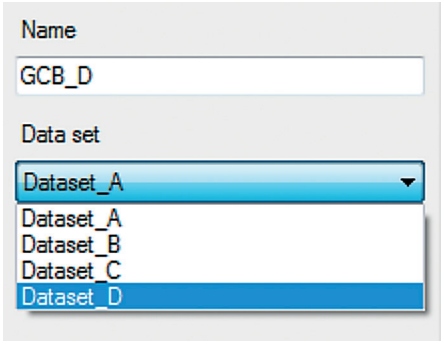

Figure 18: Data set drop-down list

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.

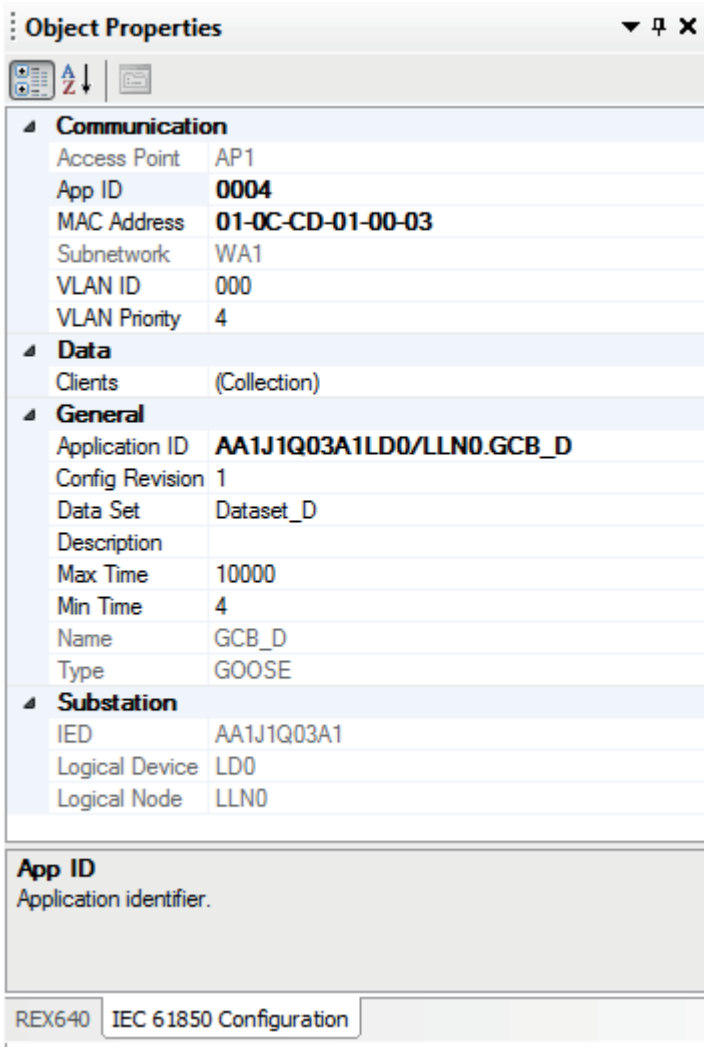

Figure 19: GOOSE control block properties

With this protection relay, only *t(max)* is configurable, not *t(min)*.

The multicast *MAC Address* is usually unique, and *App ID* must be unique.

5.5.3 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.

5.5.3.1 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.

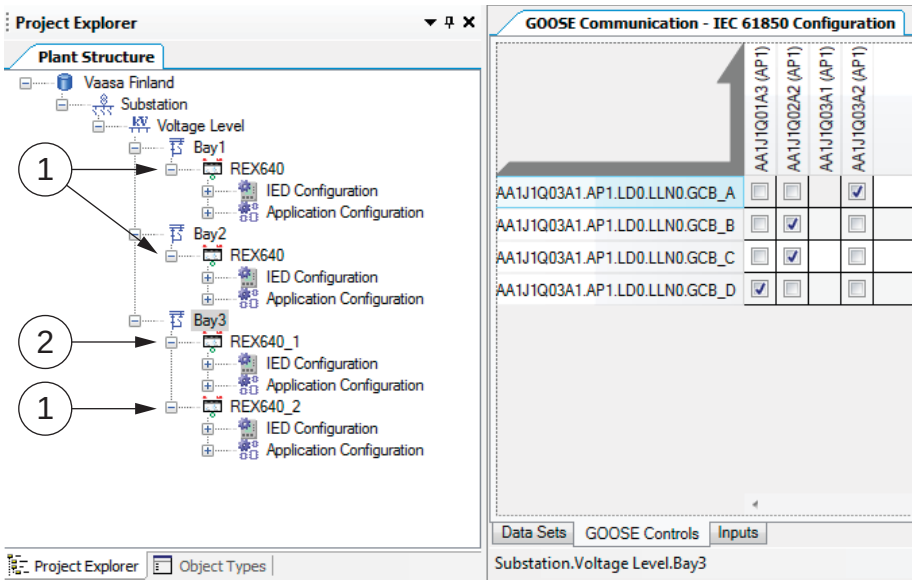

Figure 20: GCB client editor showing the senders and receivers

1 Subscriber

3 Publisher

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.

5.6 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.

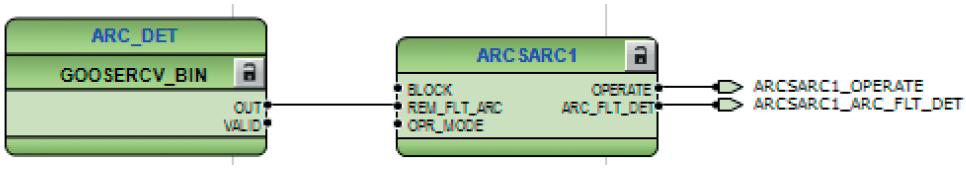

Figure 21: Adding the GOOSERCV function block

3. Create the connection in the application.
   a) Create the connection.
   b) Click **Calculate execution order**.
   c) Click **Validate configuration**.
   d) 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.

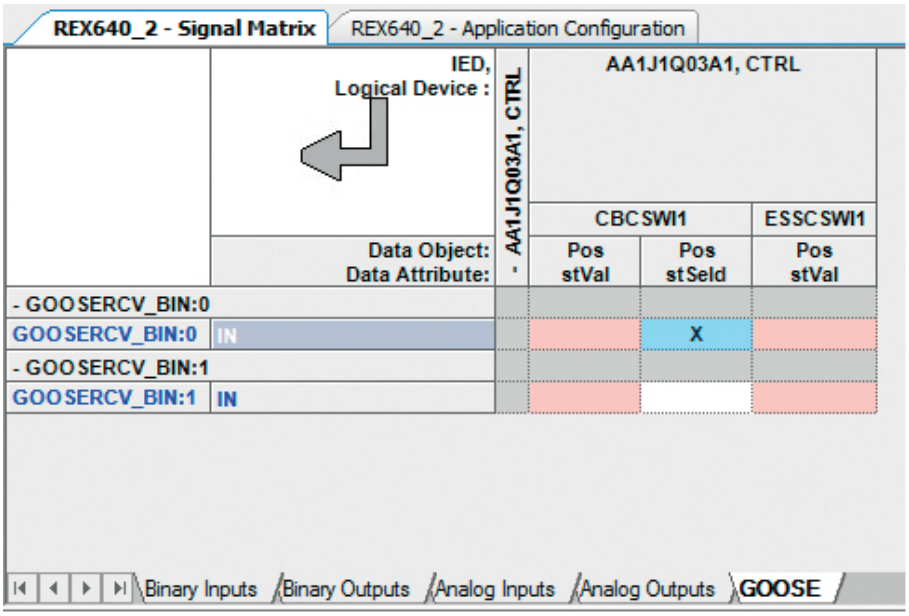

Figure 22: GOOSE tab in Signal Matrix

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 quality attribute is missing from the received GOOSE data set, the GOOSE receiver block output VALID is always "1" (GOOD).

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.

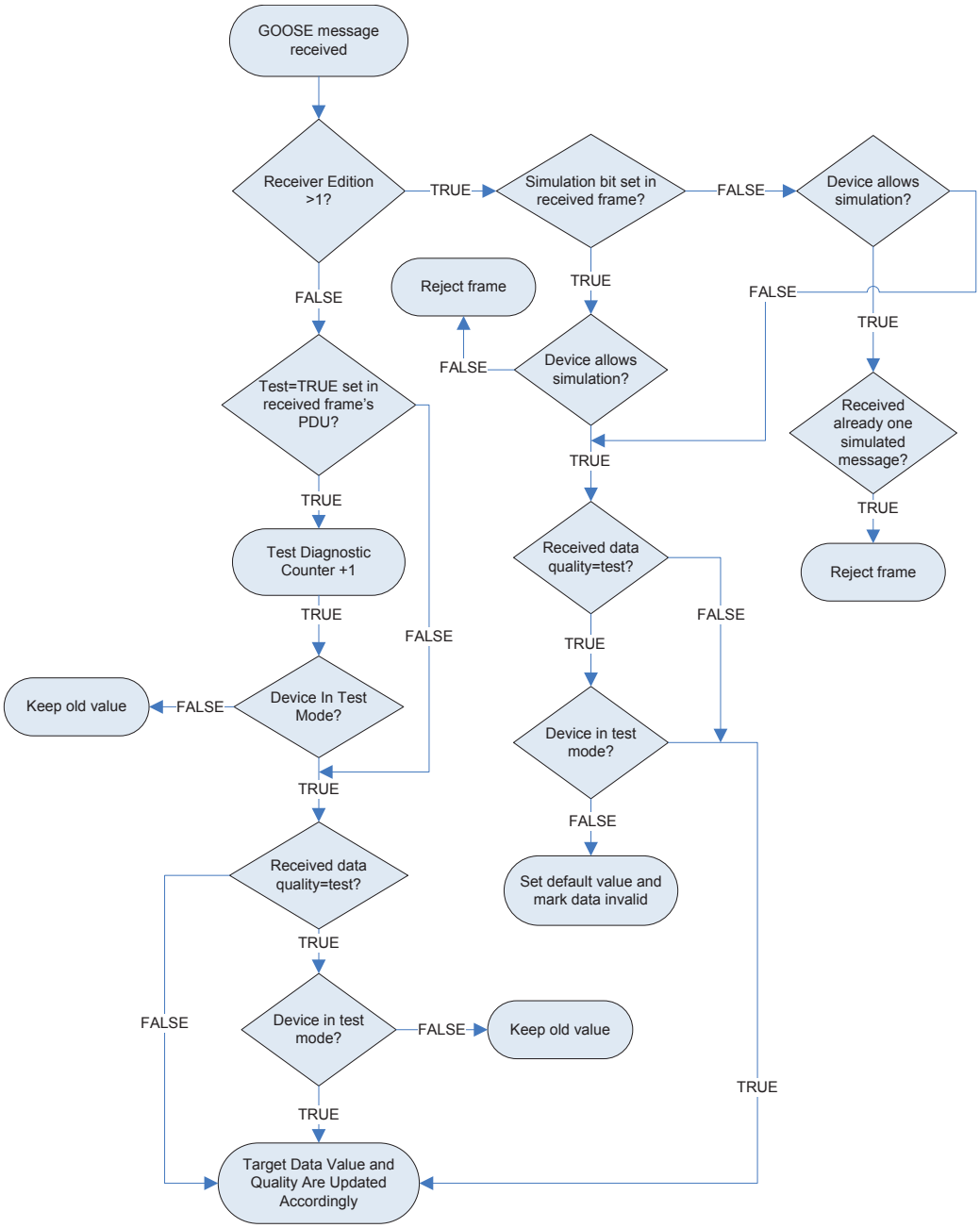

Figure 23: Receiving of GOOSE data in case of simulation or test mode

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".

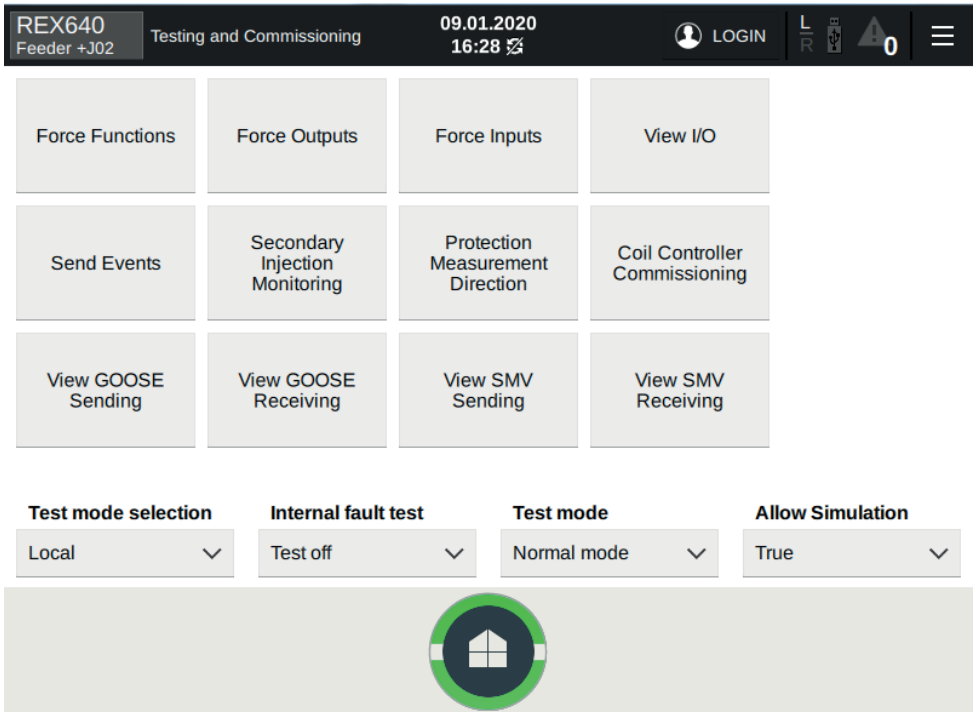

Figure 24: Setting of the Allow simulation parameter via the Testing and Commissioning page

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.

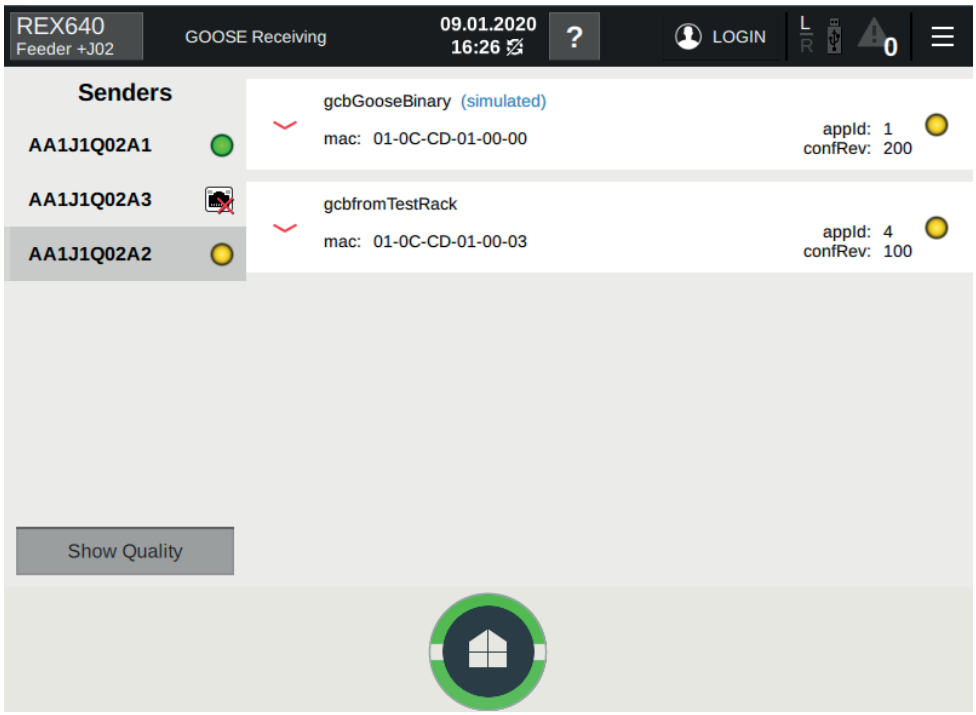

Figure 25: Subscribed GOOSE publishers on the LHMI during the simulation

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.

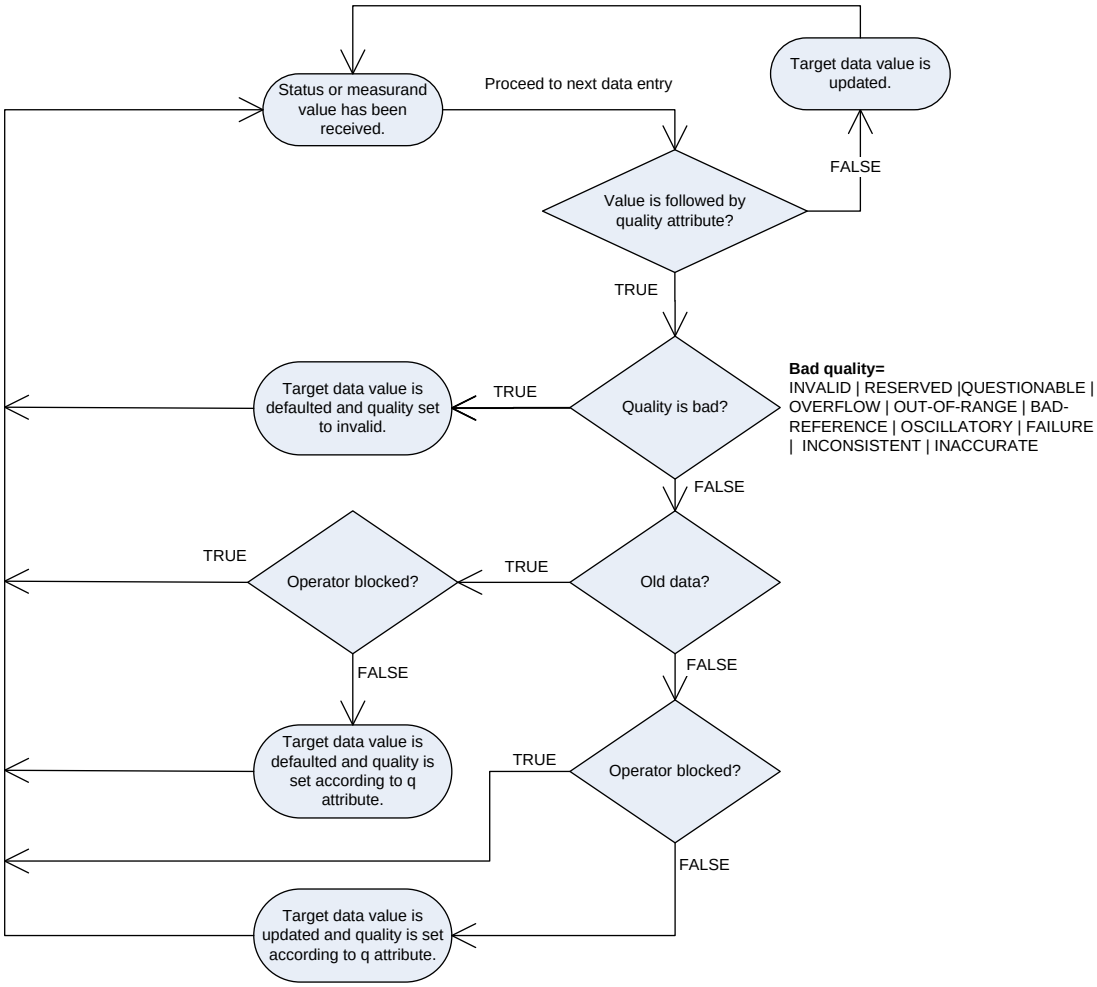

Figure 26: Receiving of GOOSE data with quality in protection relays

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×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 signaling 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 GSELPRT1.Alm data object for IEC 61850 event clients.

GSELPRT1.Alm can also be used on the application side as an input in the Signal Matrix's Binary Outputs sheet (signal GSELPRT 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.GSELPRT1 for the GOOSE communication diagnostic. The counters are also available via the HMI or PCM600 path**Monitoring** > **I/O Status** > **Communication** > **GSELPRT1** > **Monitoring**.

It is possible to reset the GOOSE communication diagnostics counters via **Monitoring** > **I/O Status** > **Communication** > **GSELPRT1** > **Monitoring** > **Reset counters** and via the IEC 61850 communication by writing `TRUE` to the RsCnt.Oper.ctlVal attribute under GSELPRT1.

Table 6: Diagnostics data objects

Data object	Description	Diagnostic information
FrRxCnt	Received messages	When increasing, the protection relay is receiving GOOSE messages.
FrTxCnt	Transmitted messages	When increasing, the protection relay is sending GOOSE messages.
RxStCnt	Received state changes	Received GOOSE messages with a new stNum value
RxSeqCnt	Received sequence number	Received GOOSE retransmissions or heartbeat cycle messages with a new sequence number
RxTestCnt	Received frames with test bit	Received GOOSE frames with the test flag on. Incremented only in Edition 1 mode
StWrnCnt	State warnings	Number of detected state number jumps
SeqWrnCnt	Sequence warnings	Number of detected sequence number jumps
RxTmOutC nt	Receiver time-outs	Number of detected peer device time-outs
ConfErrCnt	Received ConfRev mismatches	When increasing, there is a mismatch between the received GOOSE frame information and configured GOOSE.
NdsComCnt	Received frames with Needs Commissioning bit	One or many peer devices indicate that their configuration is not valid or up-to-date.
DSErrCnt	Errors in received data set	Received data is syntactically incorrect, or the amount of data in the data set is not as expected.
Alm	Receiver alarm	Alarm signal value connected to the event and application logic. It is active when one or many peer devices are in time-out.
RptProtCnt	Replay protection warnings	Number of detected message replays

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.

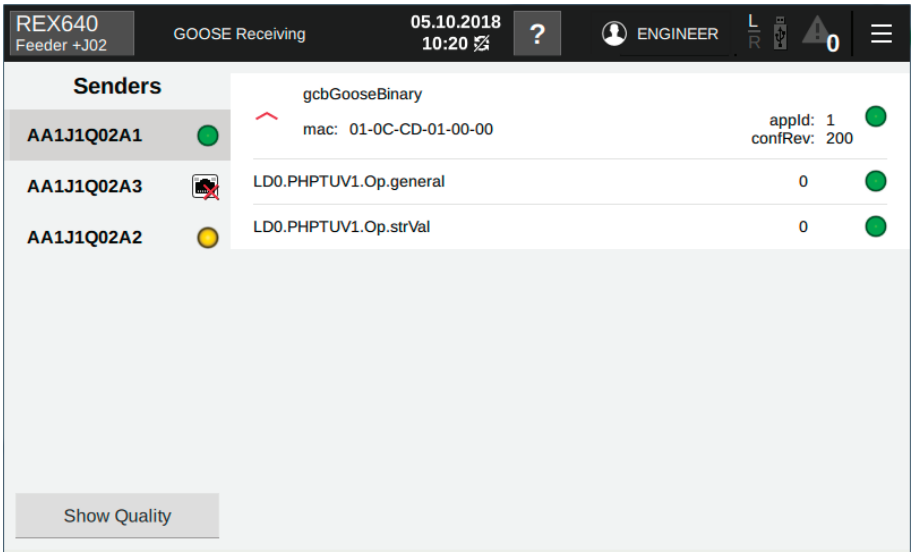

Figure 27: GOOSE Receiving page

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.

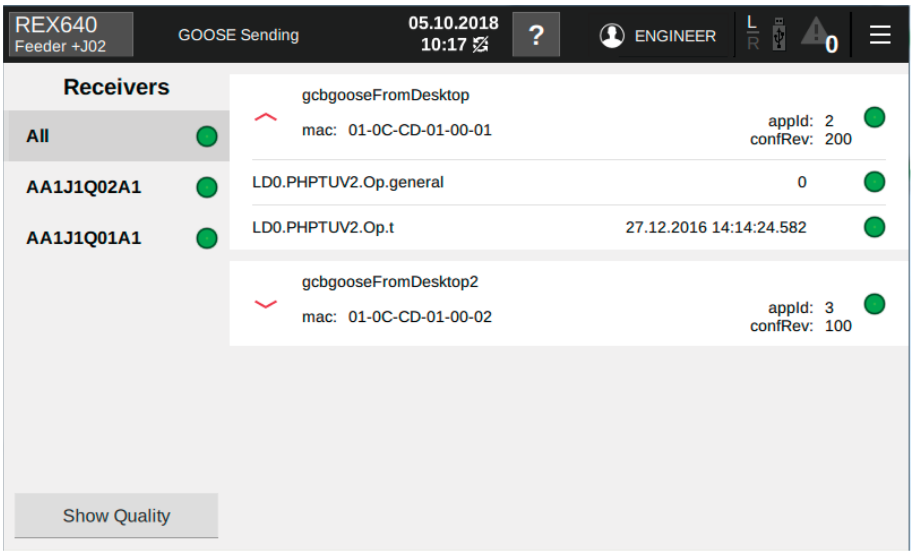

Figure 28: GOOSE Sending page

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.

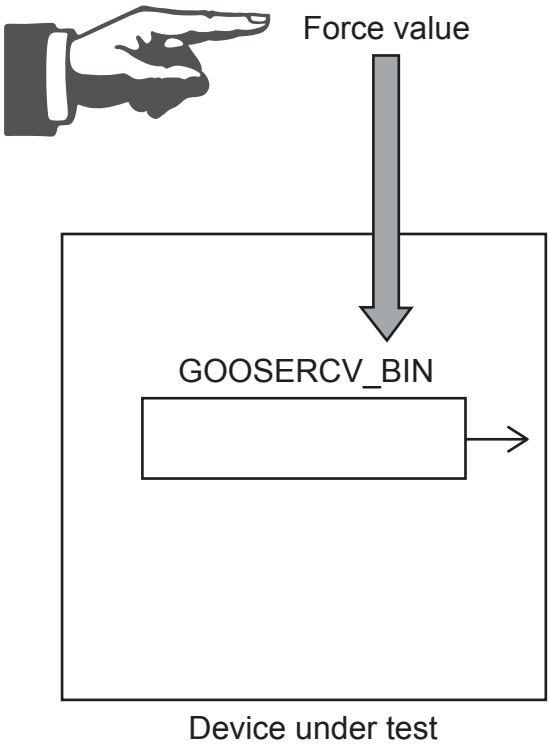

Figure 29: Testing of one device

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.

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 sampled values protocol. By default, if sampled values sending is enabled, relay sends 9-2LE conformant sampled values data. However, if modifying specific SV options or attributes, the SV data might not be according to 9-2LE specification anymore. PCM Tool gives user a warning if the SV stream configured is not accorgin to 9-2LE. If SV data is sent to e.g. 3rd party device, system engineer must ensure is the SV receiving device is capable to e.g. handle specific SV options.

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.

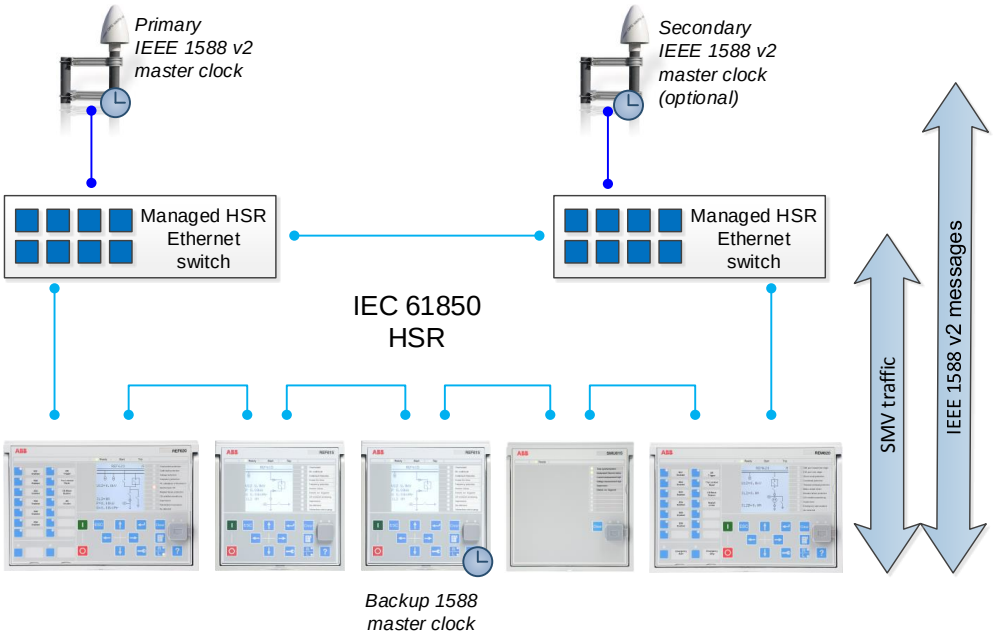

Figure 30: Recommended HSR reference topology with SMV and IEEE 1588 v2

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.

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

6.2.2 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.

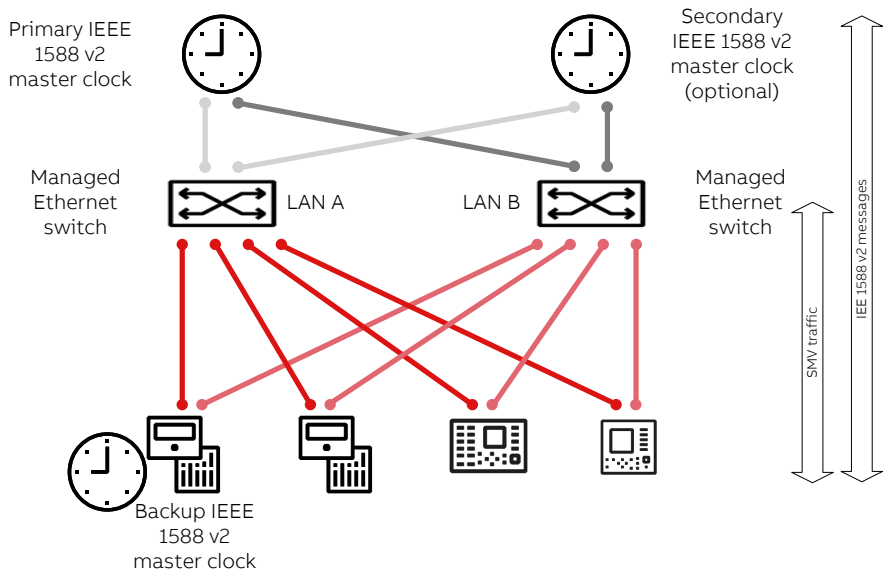

Figure 31: Recommended PRP reference topology with SMV and IEEE 1588 v2

6.2.3 Interlink 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 or Utility profile IEC 61850-9-3
- 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
- IEEE Std C37.238-2011 or IEC/IEEE 61850-9-3:2016 PTP profile support

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. Relay supports 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.

Scaling of SMV currents is standardized to 1 mA/bit (IEC 61850-9-2LE and IEC 61869-9). In the case of calculated I0 (-3I0) the measured value can exceed the maximum 32 bit number reserved for measurements in IEC 61850-9-2. If the calculated I0 value exceeds 1518,5 kA RMS it will saturate (clip).

REX640 however also calculates the I0 from individual phase current when received over SMV, using this calculated I0 instead (`ILTCTR IRES_CLK` output) is a possible workaround.

Additionally when sending calculated I0 over SMV the maximum usable primary current setting is 11,8 kA in the sender IED. Exceeding this setting value results in zero amplitude for calculated I0 in SMV stream. Workaround for this is also to use calculated I0 in calculated in receiver instead (`ILTCTR IRES_CLK` output).

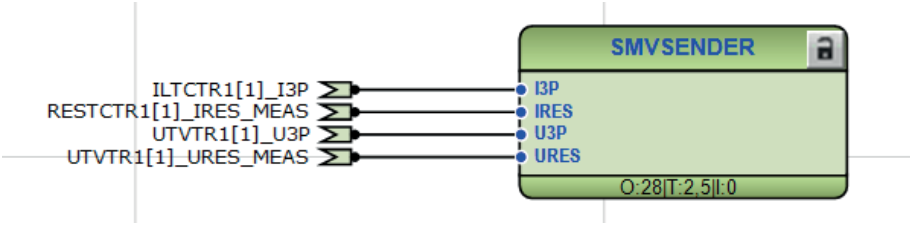

Figure 32: SMVSENDER block in Application Configuration

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.

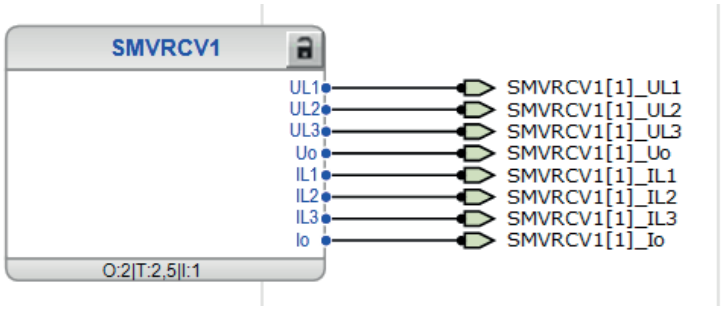

Figure 33: SMVRCVx block in Application Configuration

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.

Figure 34: 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.

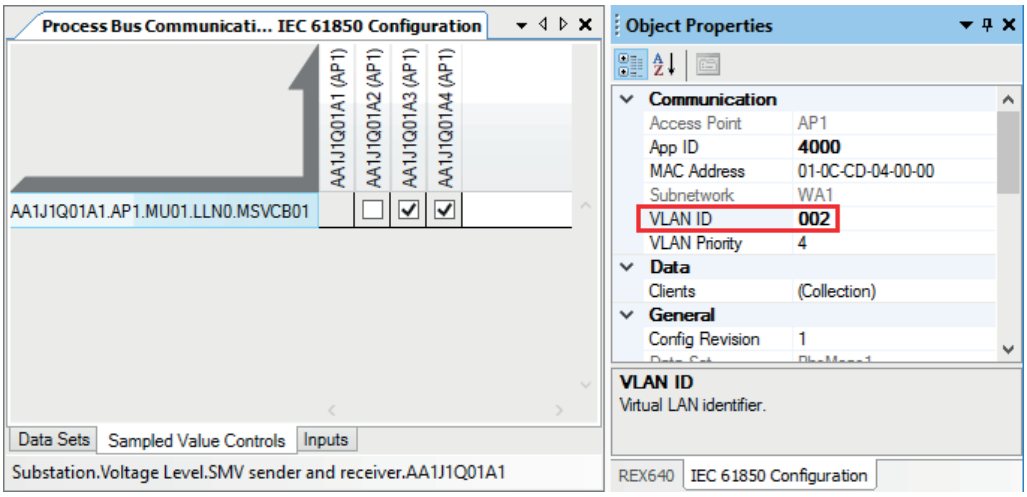

Figure 35: Changing the VLAN ID

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

Sampled value control name defines the frame format of the sampled value. Selected IEC 61850 edition is followed by default. Samples Synchronized behavior can be controlled usign *Smv SmpSynch format* parameter in SMVSENDER function.

4. Connect the SMV sender to the receivers.

5. In PCM600, select **Write to IED**.

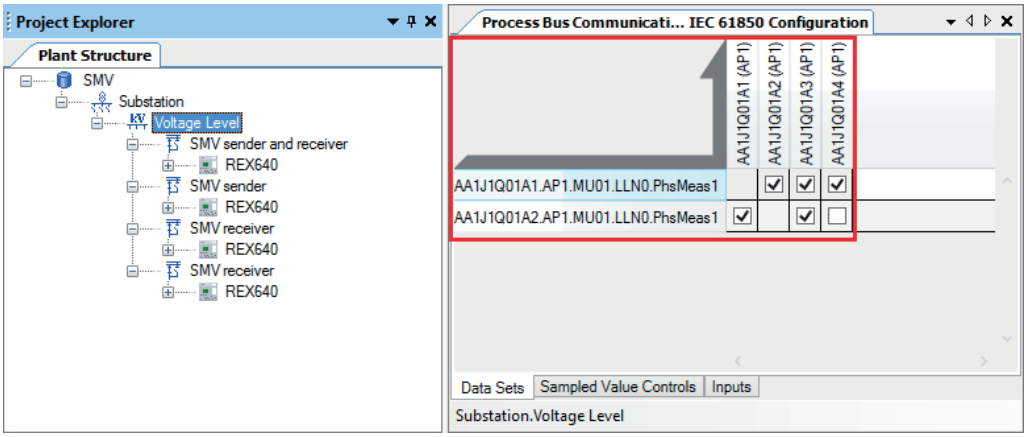

Figure 36: Configuring the SMV sender and receivers

If the configuration is updated in a manner that affects the SV frame content, e.g. options, SVID, *Conf.Rev*, dst MAC change, configurations of both SMV sender and all receivers must be rewritten from PCM600 to the relays.

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.

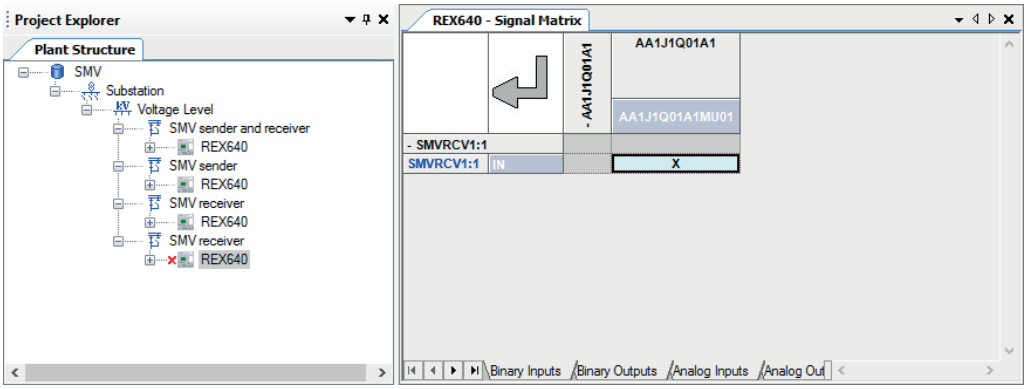

Figure 37: Configuring the SMV receiver

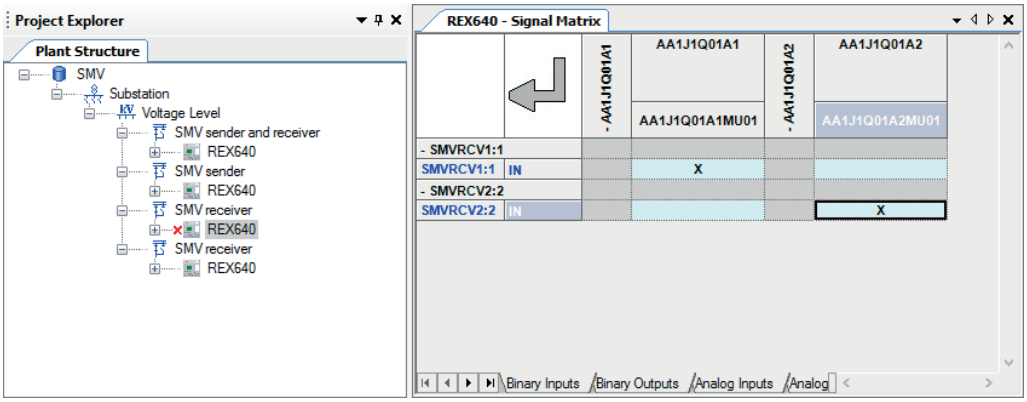

Figure 38: Configuring the SMV receiver in case of multiple SMVRCVx blocks

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.

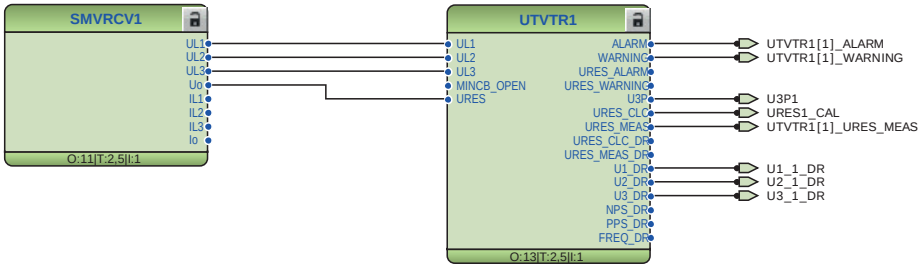

Figure 39: Receiving all phase voltages and residual voltage using SMV

The synchrocheck function requires only one analog phase voltage (UL1).

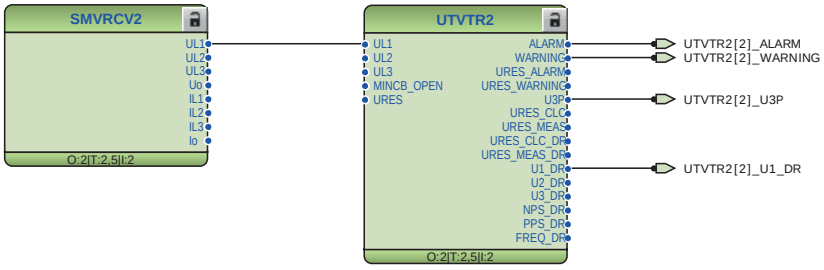

Figure 40: Receiving one line voltage for synchrocheck functionality using SMV

ALARM and WARNING outputs are active during the configuration writing. In case of unsupported configuration, an SMV error is indicated.

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.

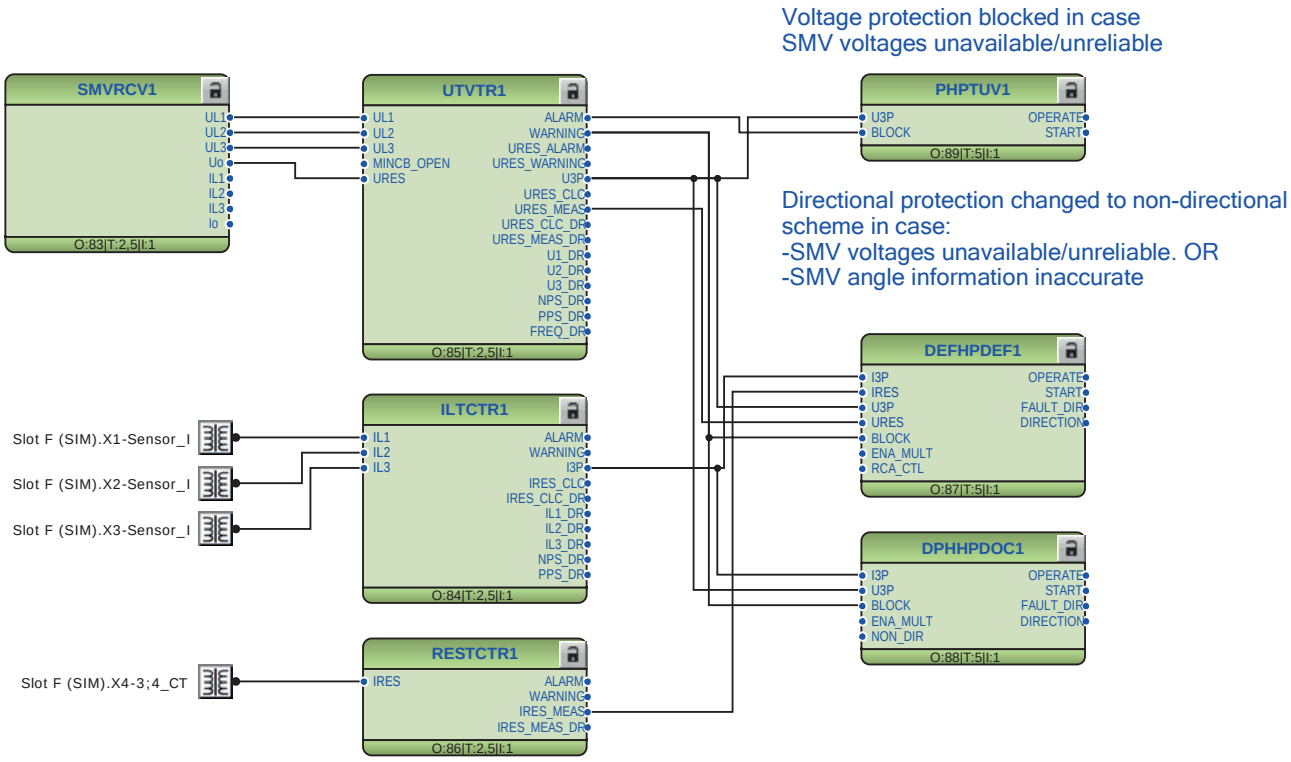

Figure 41: Application Configuration tool logic example for the SMV applications

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 7: Sampled value control block attributes

SVCB attribute	Description
SVID	A SVCB-specific string. The default value is <ledName>MU01. Maximum SVID length is 129 characters, as defined in IEC 61850-9-2 Ed 2.1.
Multicast address	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.
SVCB name	The name of the SVCB structure seen by the IEC 61850/MMS client
Data set	Data sent in sampled values messages to the network. Default data-set PhsMeas1 should not be changed.
ConfRev	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.
MAC Address	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.
App ID	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.
VLAN-ID	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.
VLAN Priority	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.
Sample Rate	Amount of samples per period
NoAsdu	Number of ASDUs, which are concatenated into one APDU

Table continues on the next page

SVCB attribute	Description
IncludeSampleRate	If selected SV buffer contains the attribute “SmpRate”
Master Clock ID	If selected SV frame contains the grandmaster id of the SMV sender. That is, the IEC 61850-9-2 option "gmIdentity".

Modify only MAC address, VLAN ID and sampled value ID to keep the 9-2 LE compliancy. Default SMV properties are 9-2 LE compliant.

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. Having multiple SMV streams with the same destination MAC+APPID in the system, can result in faulty SMV handling in the devices.

IEC61850-9-2 SV option "Samples synchronized" is mandatory for proper operation if SV cannot be disabled.

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.

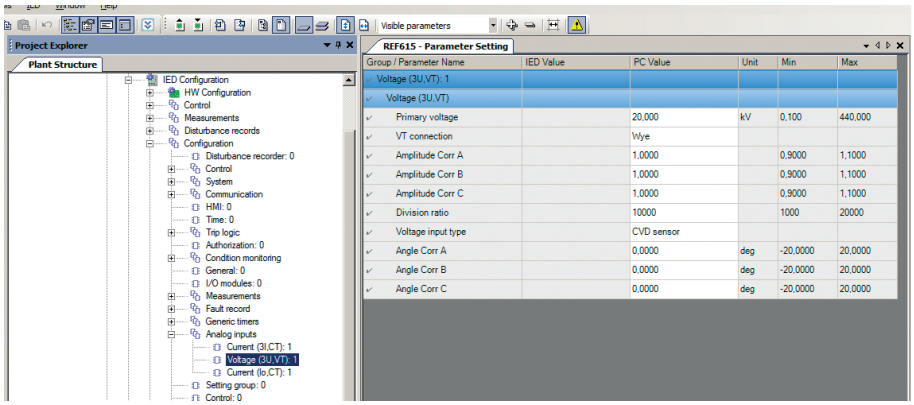

Figure 42: Amplitude and angle correction

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 9*. 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 8*.

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 8: Topology-dependent SMV max delay setting

Number of hops in network	Internal application delay (µs) [1, 2]		Internal switch latency (µs) [3]	Store and forward latency (µs) [3]	Queue latency (µs) [3], [4]	Additional tolerance (µs) [5]	Theoretical max sum of delays (us)		Recommended max delay setting (ms)	
	50 Hz	60 Hz					50 Hz	60 Hz	50 Hz	60 Hz
2	1728	1450	20	24	240	80	2092	1814	2	2
5	1728	1450	50	60	600	200	2638	2360	3	3
10	1728	1450	100	120	1200	250	3398	3120	5	4
15	1728	1450	150	180	1800	300	4158	3880	5	4
20	1728	1450	200	240	2400	350	4918	4640	5	5
25	1728	1450	250	300	3000	400	5678	5400	6	6
30	1728	1450	300	360	3600	450	6438	6160	7	6

Table 9: Protection delays and network margins

System frequency (Hz)	SMV max delay setting (ms)	Ethernet network margin (ms) [6]	Protection delay (ms)
50	2	0.25	0.94
	3	1.5	2.19
	5	2.75	3.44
	6	3	4.69
	7	4.25	5.94
60	2	0.25	0.78
	3	1.5	1.82
	4	2.75	2.86
	5	3	3.91
	6	4.25	4.95

6.4.5 SMV additional settings and backward compatibility

The SMV SmpSynch field is defined to operate in different way in IEC 61850-9-2 Ed 1 and Ed 2.1 standard versions. By default the behavior of this field follows the IEC 61850 edition that is selected in PCM600 tool.

To override the SmpSynch behavior, for backward compatibility reasons, parameter "Smv SmpSynch" format can be used. In Ed 1 mode the SmpSynch values are FALSE/TRUE and in Ed 2.1 mode SmpSynch values are: 0=none, 1=local, 2=global. The relay SMV receiver decoder can accept both however properly. Thus backwards compatibility might be needed for example for older 3rd party devices.

[1] Processing delay of SMV sender, REX640 FP3 values used as example. Depends on merging unit used.
[2] Maximum processing delay time for 50Hz column is 2000us and for 60Hz column 1720us
[3] Latencies are totals over the number of hops and they are calculated for 100 Mbit full-duplex Ethernet network.
[4] Queue latency calculated when the port has started to send a full-sized frame (1500 bytes) before the SMV frame and the switch has been configured to prioritize SMV
[5] Additional tolerance in case of long wires or disturbance in network
[6] Average values, variation is ±0.1 ms.

6.4.6 IEEE 1588 v2 parameters and status information

Time

The time parameters are found via menu path **Configuration** > **Time**.

Table 10: Time parameters

Parameter	Value	Range
Synch source	IEEE 1588	
PTP Domain ID	0	0...255
PTP priority 1 [1]	128	0...255
PTP priority 2 [1]	128	0...255
PTP Profile	IEEE C37.238-2011	1 = IEEE C37.238-2011 2 = IEC 61850-9-3
Clear clock list	False	False True

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 profile is used to select the profile which affects *PTP announce* frame format. Possible selection are "IEEE C37.238-2011" which is often referred as old Power profile and "IEC 61850-9-3" which is a profile for power utility automation.

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 tie-breaker based on unique identifiers

[1] Smaller value has higher priority

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 11: Time synchronization monitoring values

Description	Value
Synch source	IEEE 1588 master
	IEEE 1588 slave
Synch status	Up
	Down
Synch accuracy	0...26 bits

Sync accuracy indicates the synchronization accuracy in number of fractional bits and can be calculated from the number of bits according to a formula.

$$Synch\_accuracy = 2^{-bits} \text{ seconds}$$

(Equation 1)

Table 12: Synch accuracy values and corresponding accuracies

Bits	Accuracy
17	8 µs
18	4 µs
19	2 µs
20	1 µs
21	500 ns
22	250 ns
23	125 ns
24	62.5 ns
25	31.25 ns

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**.

IEEE 1588 v2 monitoring values

Table 13: IEEE 1588 v2 monitoring values

Description	Value
PTP gm identity	
PTP gm time Src	Atomic clock
	GPS
	Terrestrial radio
	PTP
	NTP
	Hand set
	Other
	Internal oscil.
PTP gm accuracy	

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 14: SMV accuracy monitoring values

Description	Value
SMV synch accuracy	No sync
	Local clock
	Global clock
Local synch accuracy	
Max Dev Sync Acc	

SMV synch accuracy value "No sync" indicates that the SMV is either not in use or it is not synchronized with IEEE 1588 v2. "Local clock" indicates that SMV is synchronized to a local area clock and "Global clock" indicates that SMV is synchronized to a global time reference such as GPS.

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.

6.4.7 Power profile parameters

The IEDs' IEEE 1588 v2 time synchronization complies with the 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 15: IEEE C37.238-2011 Power Profile key parameters

Parameter	Value [5]
Delay Mechanism	P2P
VLAN priority	mandatory (default=4)
Ethertype	0x88f7
Announce period	1 s
Sync period	1 s
Pdelay period	1 s
PTP mode	transparent

6.4.8 Quality bits in SMV frames

Table 16: Explanation of quality bits

Quality bit	Description
smpSynch	Synchronization accuracy for all channels in the SMV frame. 0: less than 4 µs synchronization accuracy 1: within 4 µs synchronization accuracy
test bit	The sender IED is in test mode.
invalid 01 & bad reference	The sender time synchronization is uninitialized (accuracy unknown).
	The sender has time accuracy less than 100 ms.
invalid 01	The channel is not available.
questionable 11 & inaccurate	The accuracy of the measurement value is inaccurate or not supported.
derived	The channel is derived from other channels, for example, calculated residual voltage.

6.4.9 SMV Simulation

Relay is capable of processing simulated messages. The switchover to simulated messages requires that the relay is set to allow simulated messages and that it

[5] Some devices use the standard notation format 2x[s] of IEEE 1588 v2 intervals. The values in this table are in [s] format.

receives the first simulated message. Detection of simulated messages is separated per SMV publisher. Therefore, one SMV stream may receive as simulated while another stream is received as a non-simulated one.

To set the protection relay to allow simulated SMV, 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".

Switching back to receiving only non-simulated normal SMV stream 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 normal SMV packet after simulation mode has been disabled.

The HMI can be used to verify that a simulated SMV stream is received. The publisher is marked with the “(simulated)” text when simulated stream is received. This can be observed in the Testing and Commissioning "Show SMV receiver" section.

The simulation mode behavior is described in more detail in IEC 61850-7-1 standard section.

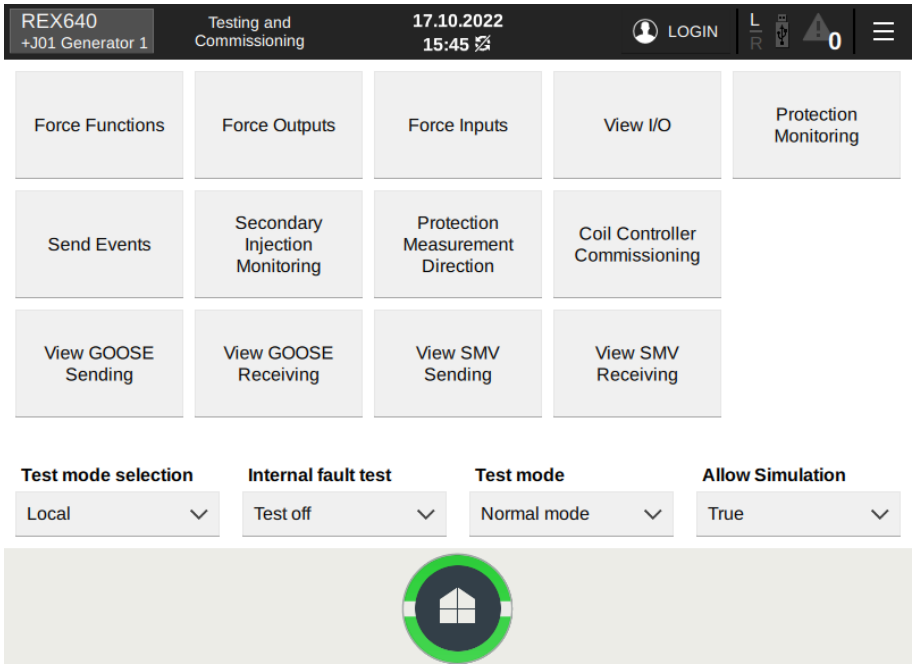

Figure 43: Setting of the Allow simulation parameter via the Testing and Commissioning page

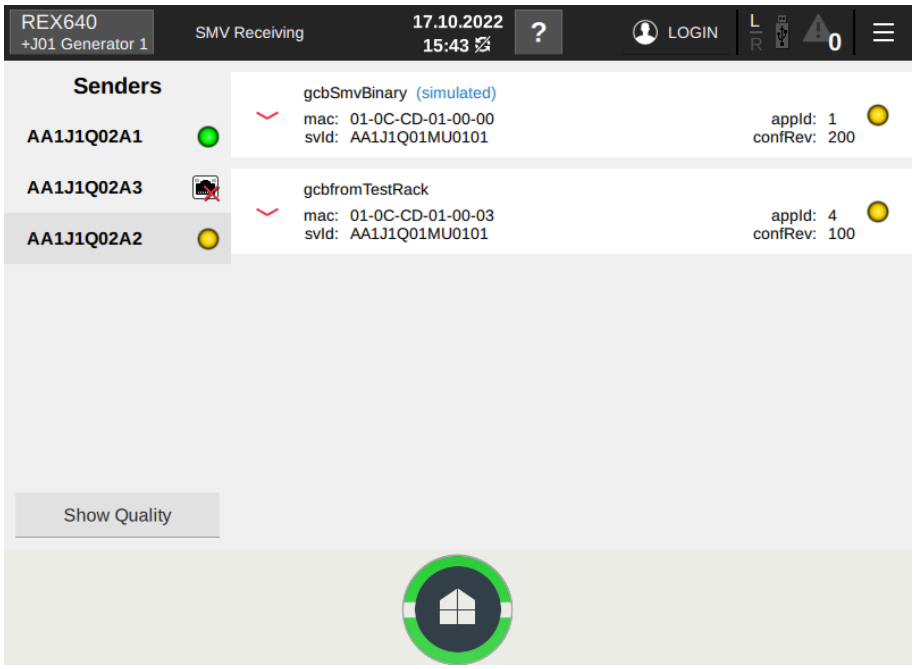

Figure 44: Subscribed SMV publishers on the LHMI during the simulation

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 17: SMV sender

Item	Description	Checked
Missing sender	Disable the SMV sender via **Configuration** > **Communication** > **Ethernet** > **SMVSENDER** and verify the expected handling in receivers. In the SMV receivers's Measurement view, the voltage values should be in brackets indicating invalid or questionable measurement. If The 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 the SMVSENDER.	
Internal fault test	Force internal fault in the sender via **Tests** > **IED test** and check that the receiving devices behave as expected.	

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 18: SMV receiver

Item	Description	Checked
WARNING	*WARNING* (**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. *WARNING* is active when the IED starts.	
ALARM	*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.	
Max delay	The maximum delay (**Monitoring** > **IED status** > **SMV traffic**) must be in all conditions smaller than the *SMV Max Delay* parameter (**Configuration** > **System**). Larger values indicate configuration problems in the network or the need to change the *SMV Max Delay*.	
Average delay	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.	
Measurement	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 6.48ms).	

Table 19: Time synchronization

Item	Description	Checked
Time quality	Observe the grandmaster accuracy (**Monitoring** > **IED status** > **Time Synchronization**). The `IED GNRLLTMS1 WARNING` signal is activated if the accuracy is not within the specified limits.	
Missing clock	Disable the clock master and check that one IED takes the clock master role.	
SMV Synch accuracy	The global clock is seen when the clock master is present.	
Local synch accuracy	According to 9-2 LE the synchronization accuracy needs to be better than 4 µs which is the defined supervision limit. [1]	

Table continues on the next page

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

Item	Description	Checked
Max Dev synch Accuracy	According to 9-2 LE the synchronization accuracy needs to be better than 4 µs which is the defined supervision limit. [1]	
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.	

Table 20: Network

Item	Description	Checked
Max HSR loop size	Maximum supported HSR loop size is 30. Consider applying different topology in case a larger system is needed.	
Redundancy	Check the maximum delays in different network setups.	

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.

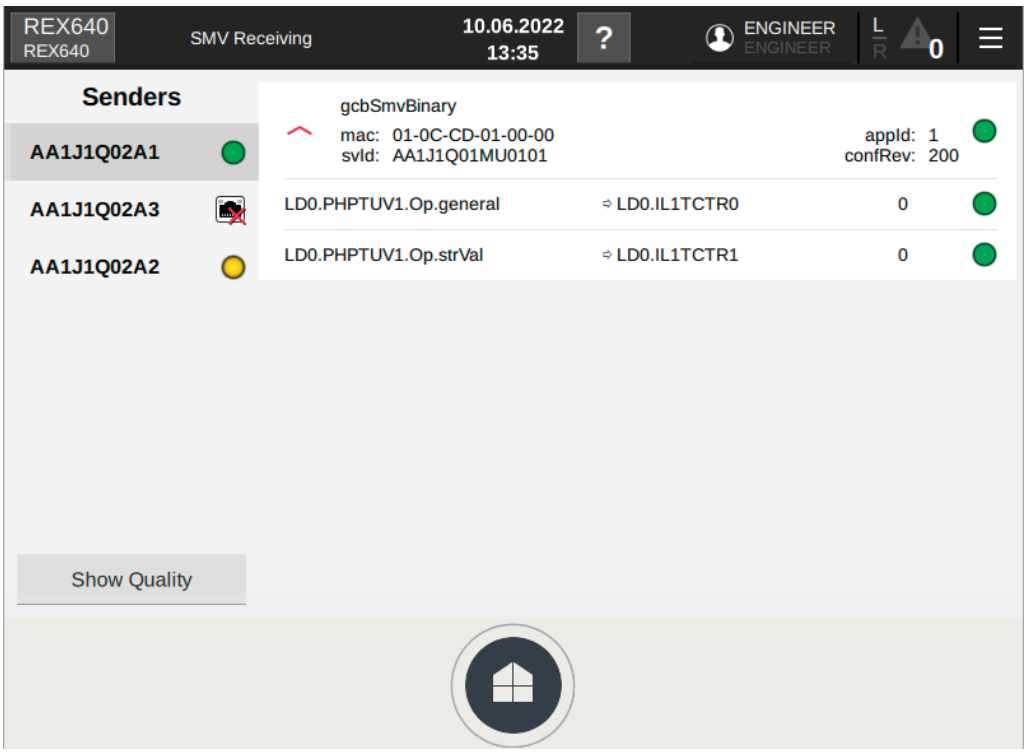

Figure 45: SMV Receiving page

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.

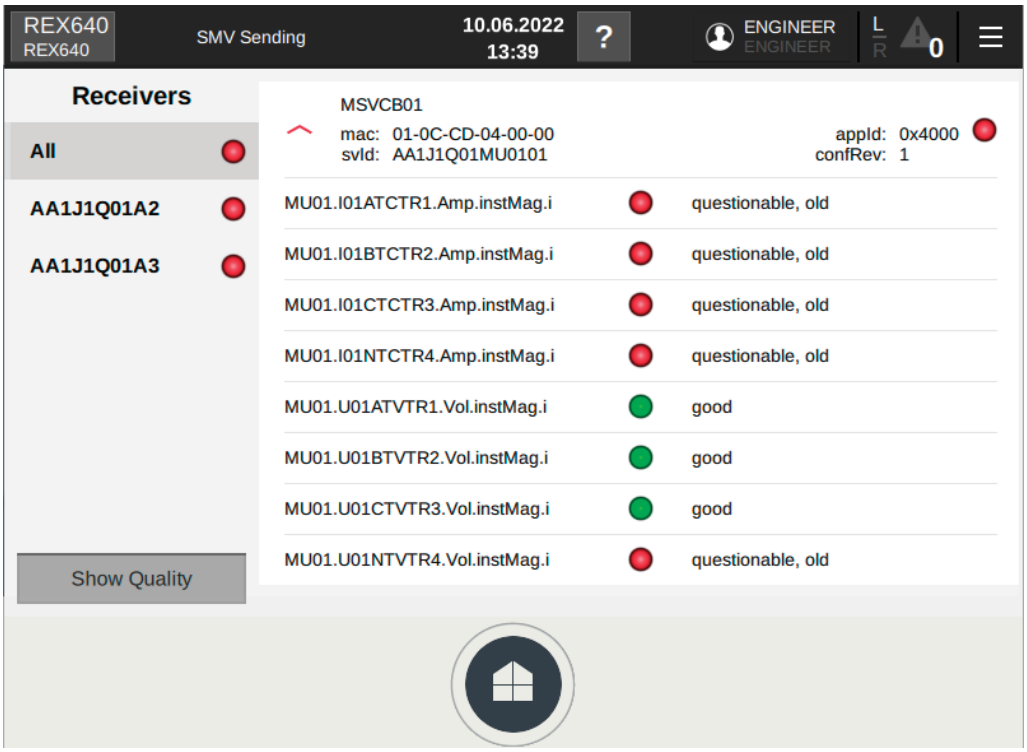

Figure 46: SMV Sending page

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.

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**.

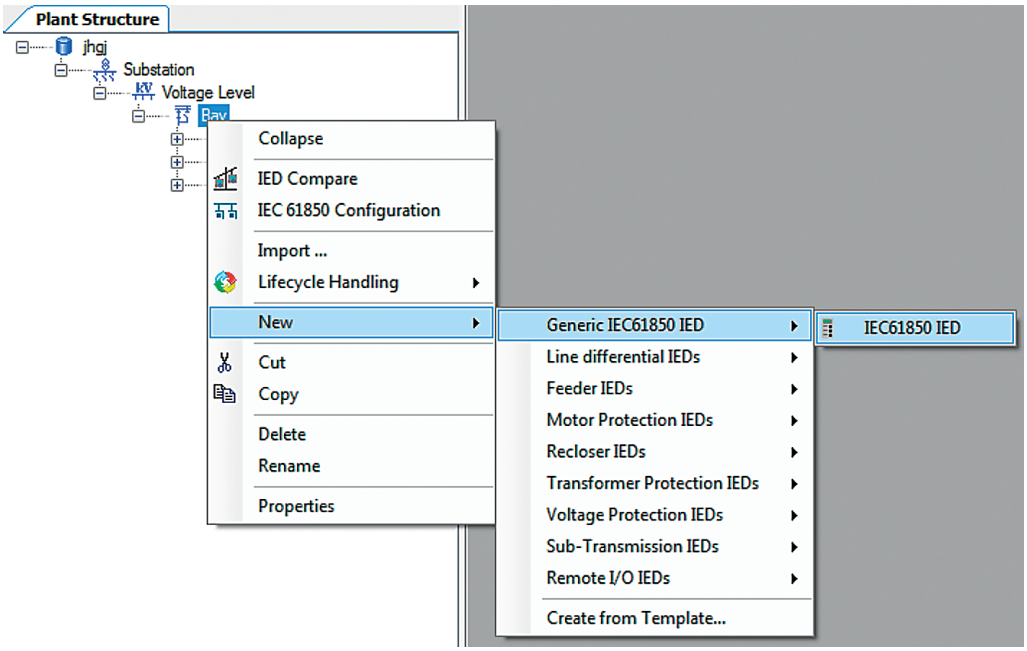

Figure 47: Creating a generic IEC 61850 IED

2. Rename the IED object as “Client_G”.

3. Right-click the **IED** and then select **Import**.

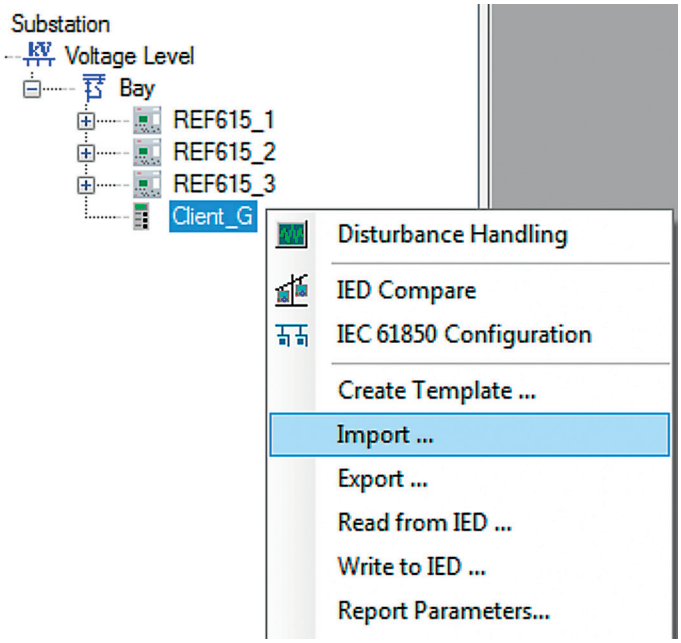

Figure 48: Selecting Import on the shortcut menu

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 then click **Import**.

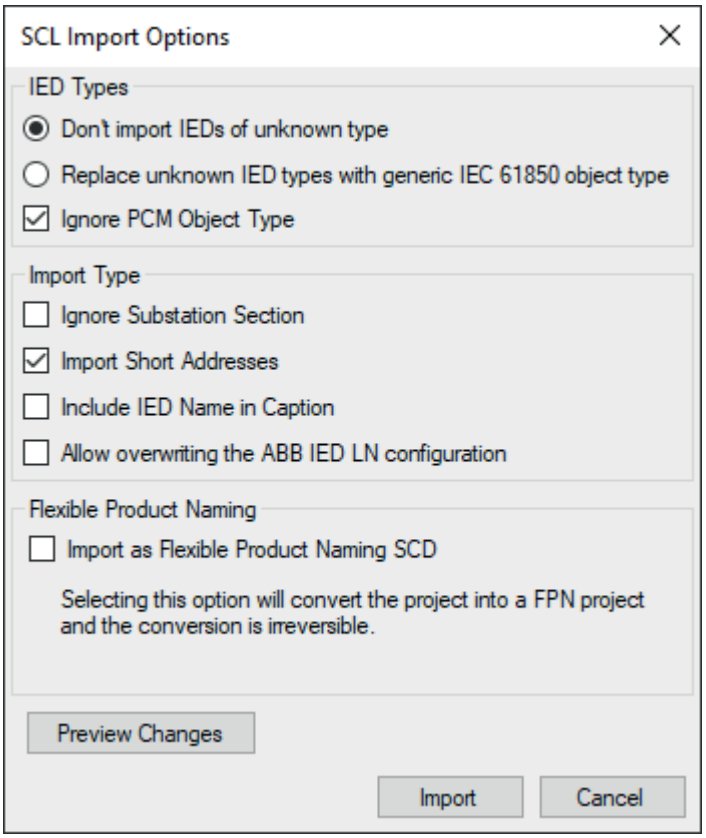

Figure 49: Defining SCL import options

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

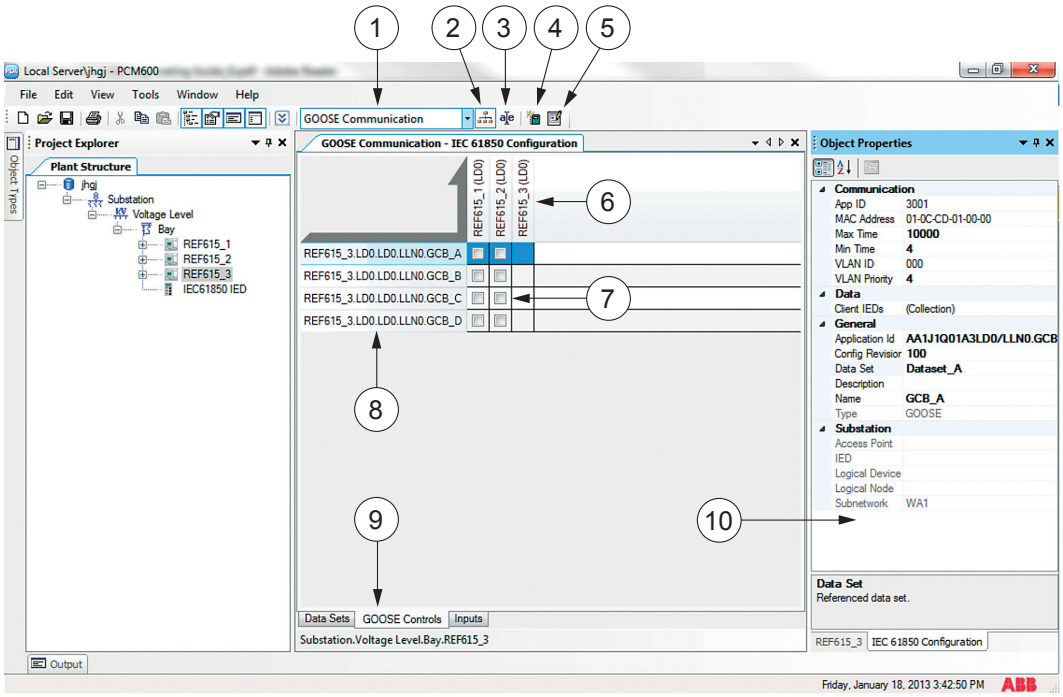

Figure 50: IEC 61850 Configuration user interface

1 Engineering mode selection

2 Switch engineering mode on and off

3 Switch IEC 61850 IED naming on and off

4 Create new object

5 Selection details

6 Receiving access points

7 Mapping grid

8 Data to send/receive

9 Engineering type selection

10 Object properties

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.

Figure 51: Engineering mode selection button

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 contextsensitive 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.

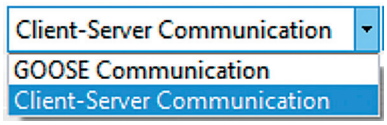

Figure 52: Selecting Client-Server Communication

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.

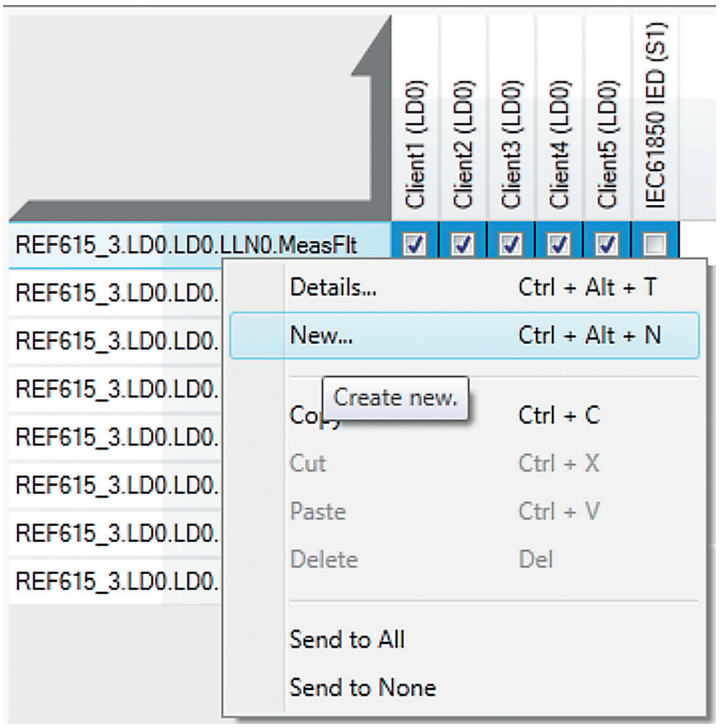

Figure 53: Creating a new data set

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.

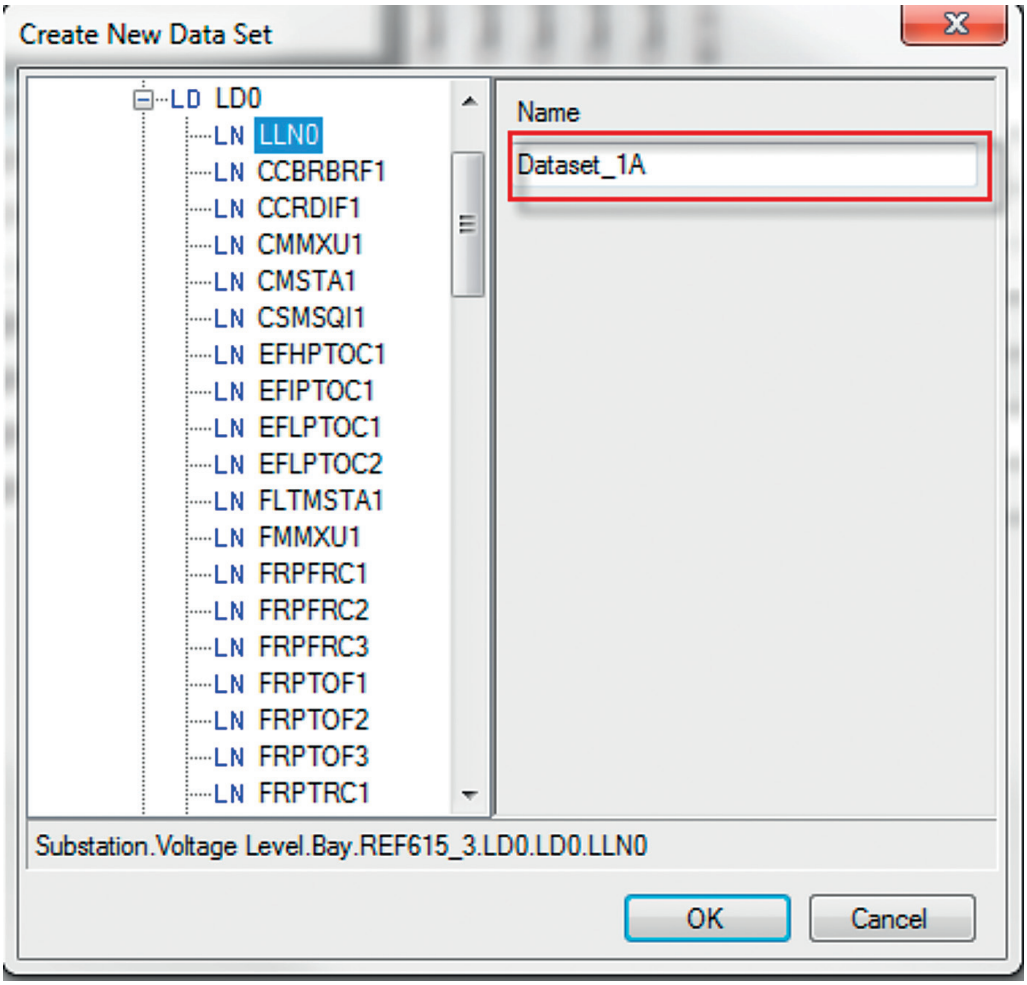

Figure 54: Naming the data set

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.

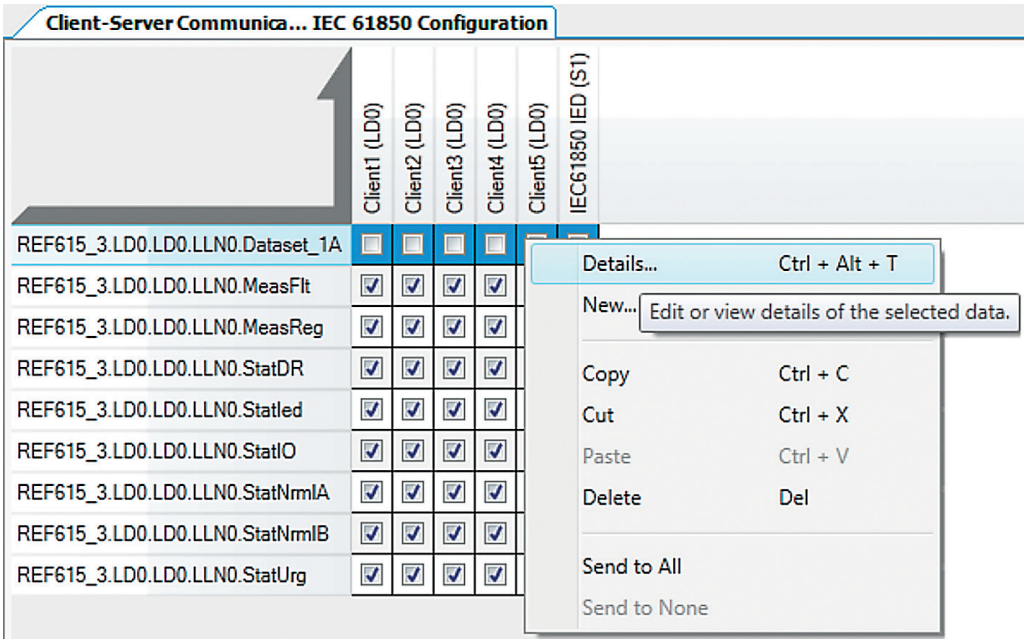

Figure 55: Adding data attributes

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 type of data. Also configuration and setting values can be added to data sets in case required.

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.

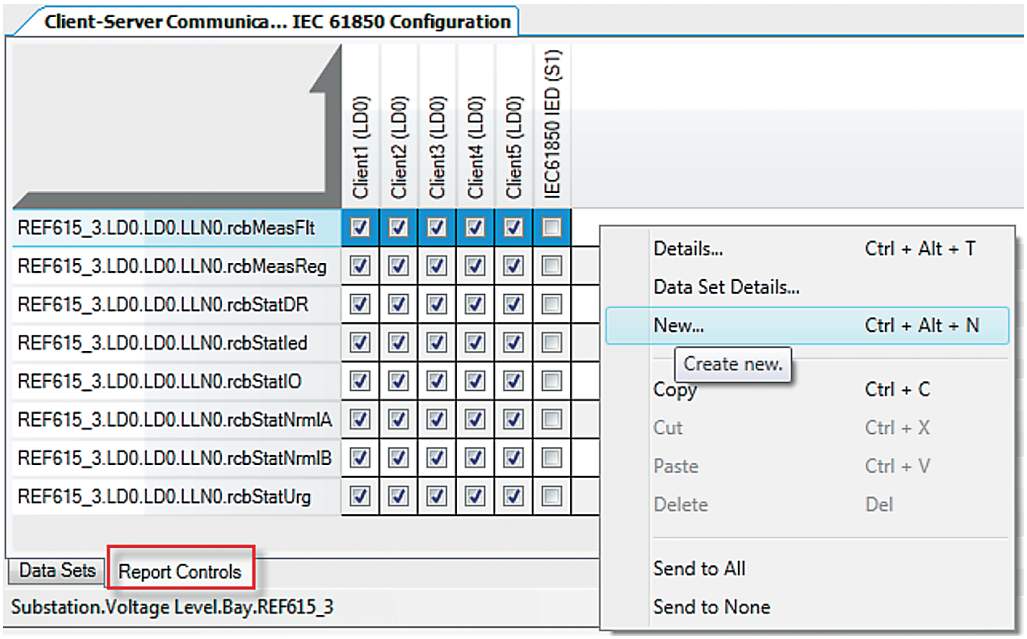

Figure 56: Adding a new report control block

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.

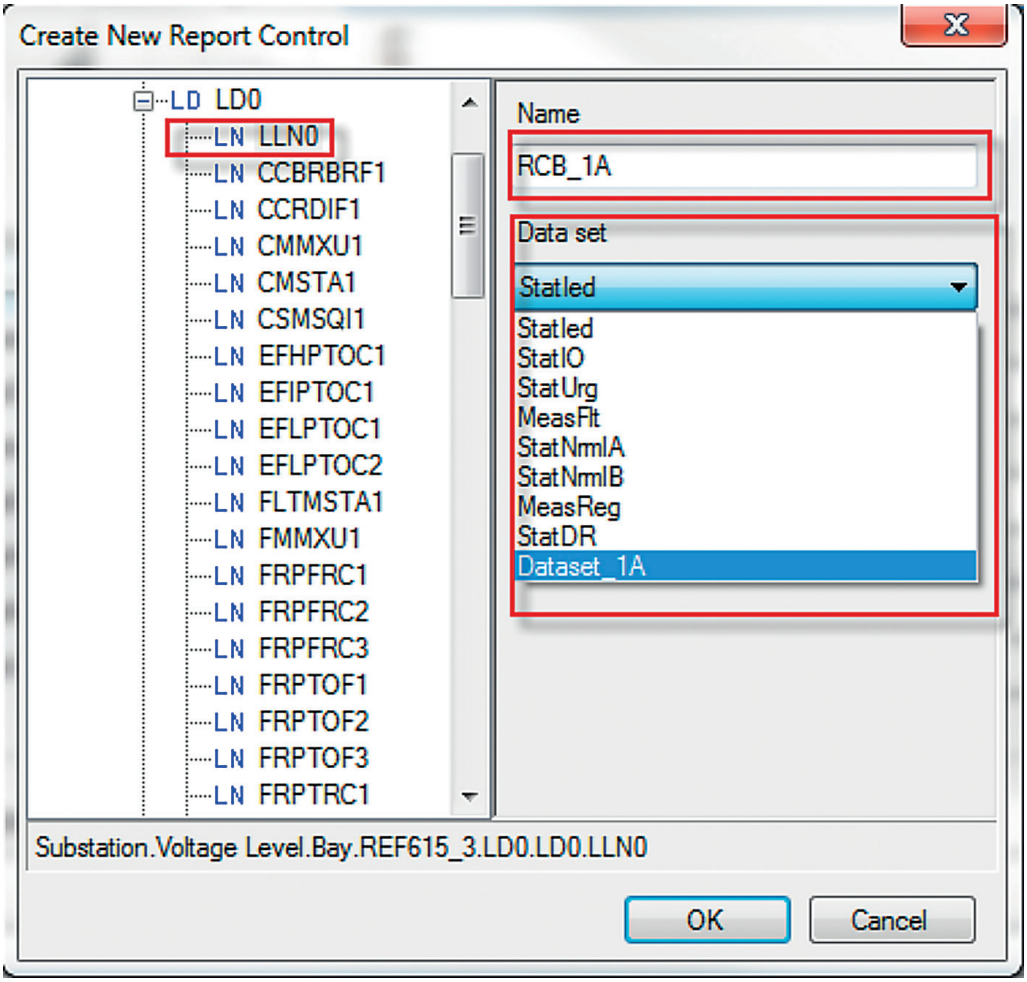

Figure 57: Selecting a data set to be linked with the RCB

7. Edit the properties and options of the created RCB.

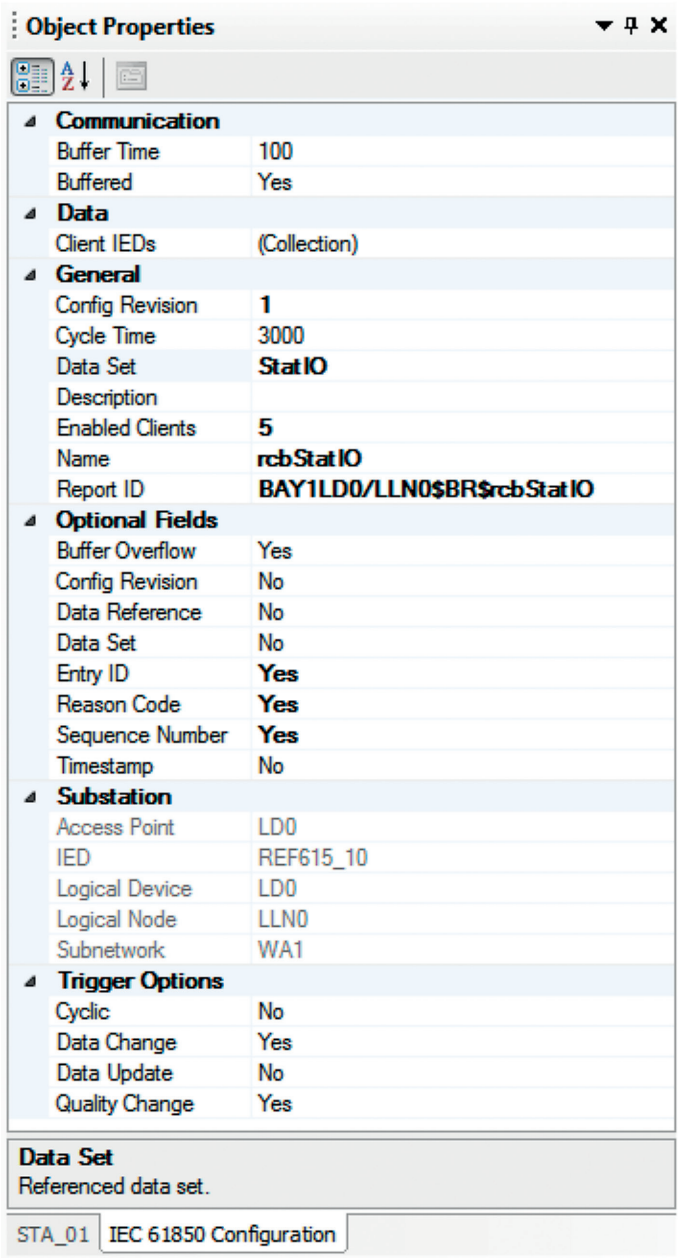

Figure 58: Editing the RCB properties

Data set entries in a data set linked to the GCB can be modified from the **RCB Control Block** tab by selecting the **Data Set Details** in the shortcut menu.

7.4.1 Report control block trigger options

The report control block properties can be configured in the Object Properties window. The properties contain standard options such as buffering and trigger options. The parameters have effect on the reporting behavior and the content of

the MMS reports sent to the clients. Detailed description of the report control block options can be found in the IEC 61850 standard part 7-2.

Trigger options

The triggering method for the MMS report can be configured under Trigger Options in the report control block's Object Properties window. By default all data sets are configured to be triggered by *data change*, *data update* and *quality change*. The *General Interrogation* option is also enabled to allow the client to make interrogation for the data set content.

For fast event based reporting it is recommended to keep these default trigger options enabled for most datasets. Some datasets, such as ones including measurement and counter data, can report data with 'data update' flag only.

Cyclic trigger option is recommended for measurement data only. It can be used for periodic update of instantanoues measurement values. More information in chapter 'Cyclic reporting'.

Cyclic reporting

The *Cyclic* trigger option can be enabled to allow periodical reporting of the data set values. Enabling the cyclic trigger option also changes the internal behavior of the relay to periodically update and report the instantaneous values of the data set content, such as instCVal. This can be beneficial, for example, in reporting slowly changing measurement values periodically to the client. By enabling the cyclic trigger option, instantaneous measurement values can be reported in a periodical manner instead of data change based reporting. As the data based reporting relies on the internal deadband values of the measurement Application Function, it can be slow to detect small changes in the measurement data. The cycle period for updating and reporting the data can be set by the *Cycle Time* property.

To configure cyclic reporting only, enable the Cyclic trigger option, and disable the *Data Change* and *Data Update* trigger option. If all options are enabled, the report control block reports cyclical and event based reports to the client.

It is recommended to use the default *Data Change* and *Data Update* trigger options for status data for fast change detection. This includes most of the default data sets with Stat (ST) data objects. The *Cyclic* trigger option is recommended only for the periodical sending of measurand (MX) values.

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.

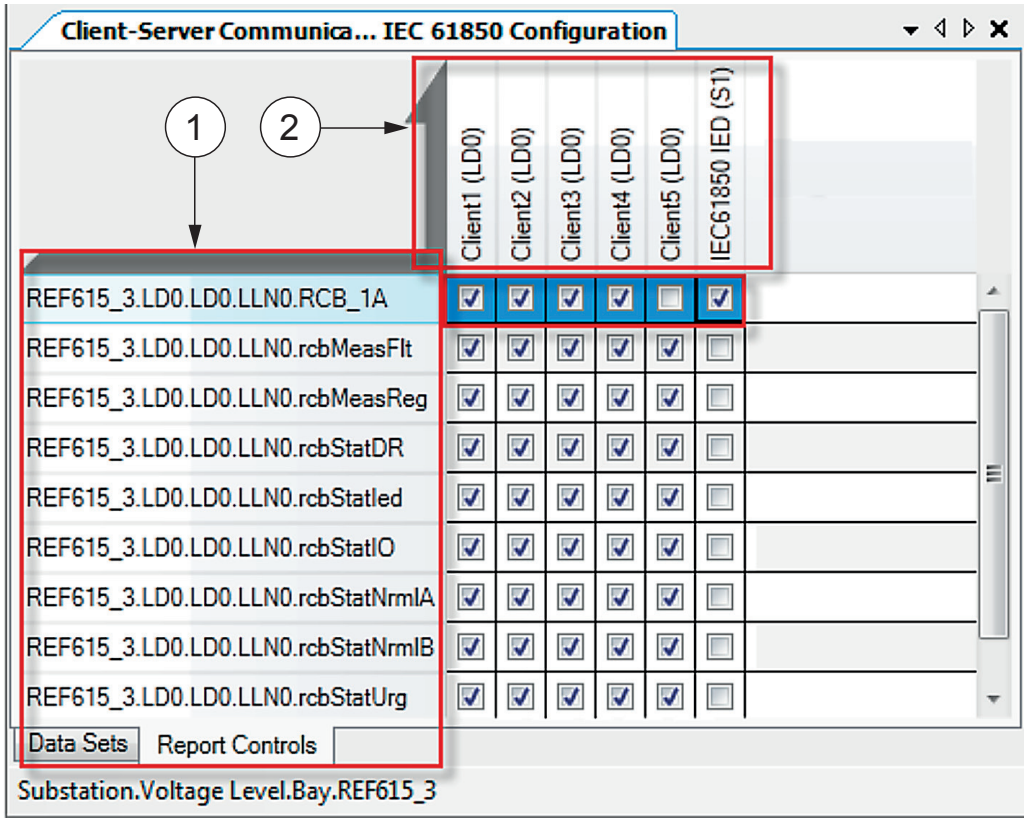

Figure 59: RCB clients

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 include also 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. Export SCD file from PCM600 to configure substation section in external tool.

8 Flexible product naming

8.1 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 customerspecific communication model.
- Error tracing of communication can be the same between different installations.

8.2 Mapping examples

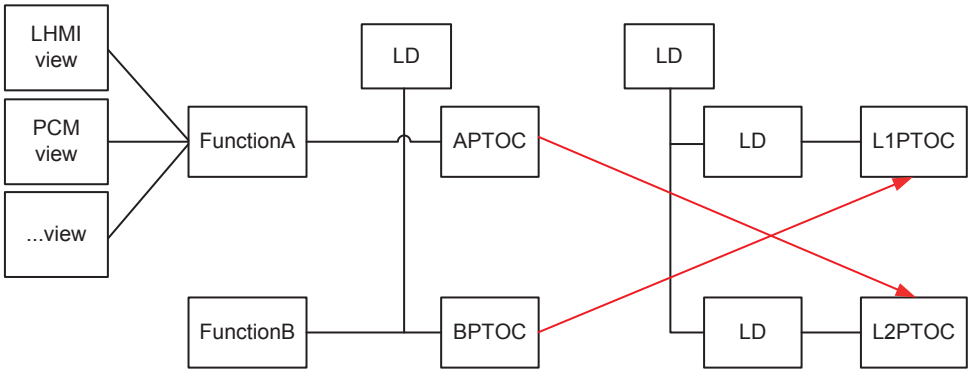

Figure 60: L1PTOC in the customer model mapped to BPTOC in the IED model and L2PTOC mapped to APTOC

The mapping shown in *Figure 60* results in the mapping shown in *Figure 61*.

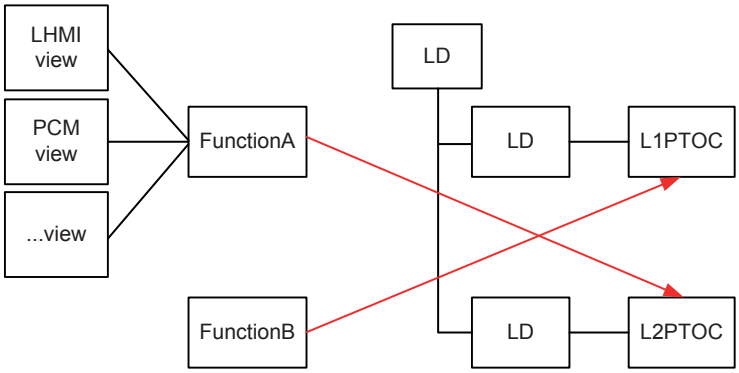

Figure 61: L1PTOC mapped to FunctionB and L2PTOC mapped to FunctionA

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.

8.3 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.

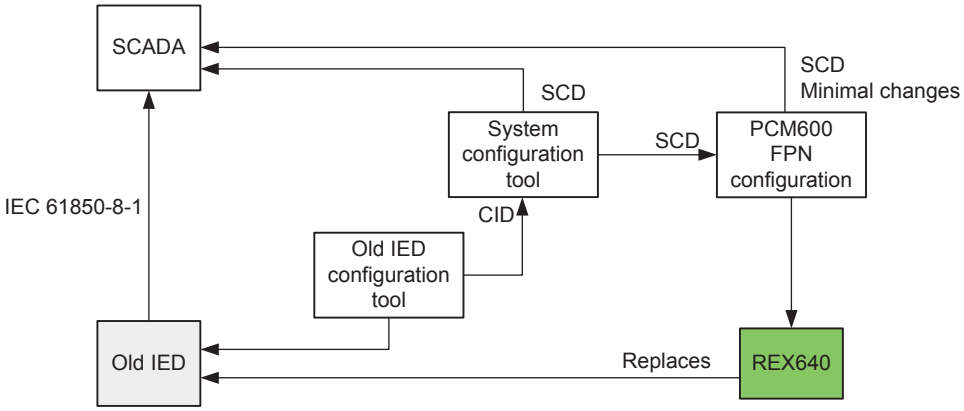

Figure 62: Retrofit workflow for an existing IED

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.

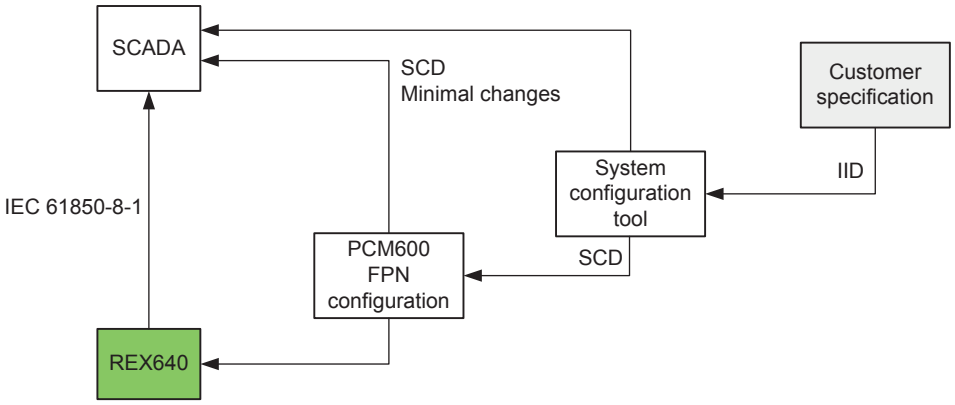

Figure 63: Customer-specification based workflow

8.4 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/Communicaton/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.

8.4.1 Network configuration

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.

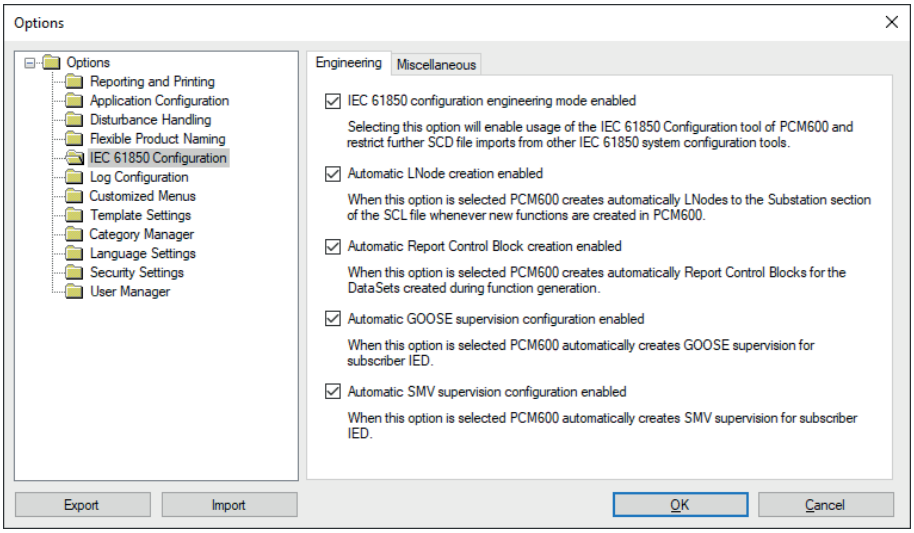

Figure 64: Enabling IEC 61850 configuration engineering mode

3. On the toolbar, select **Subnetwork configuration** from the drop-down list.

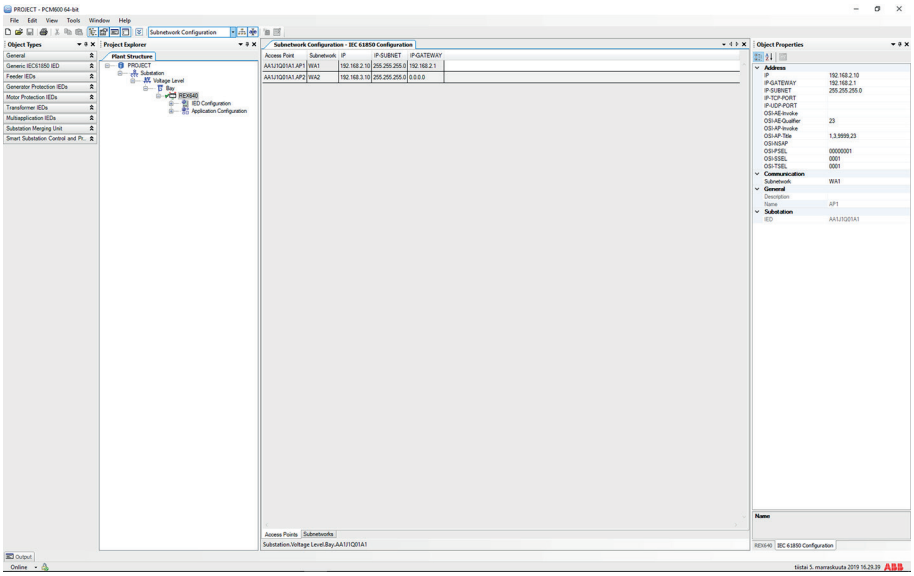

Figure 65: Subnetwork configuration for REX640

4. Configure Ethernet ports in Ethernet Configuration.

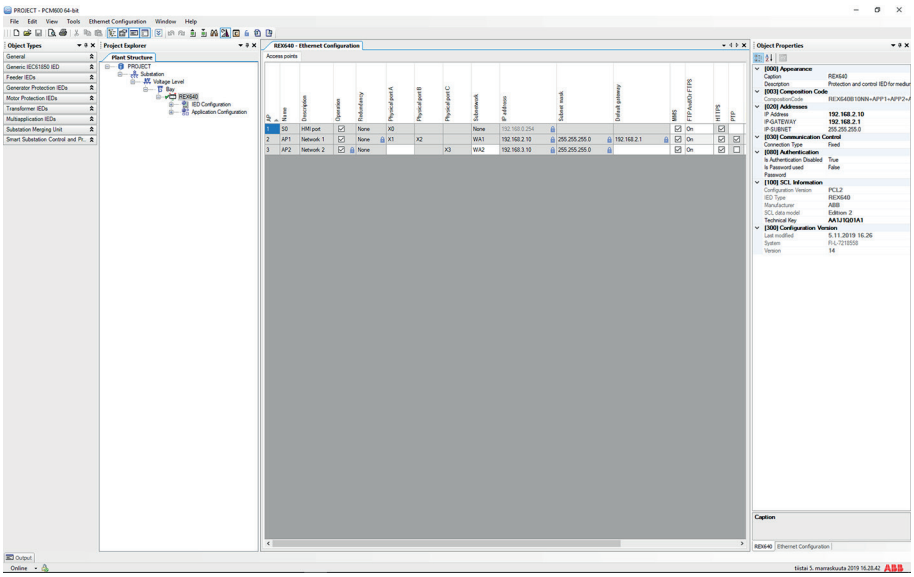

Figure 66: Configuring Ethernet ports

8.4.2 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.

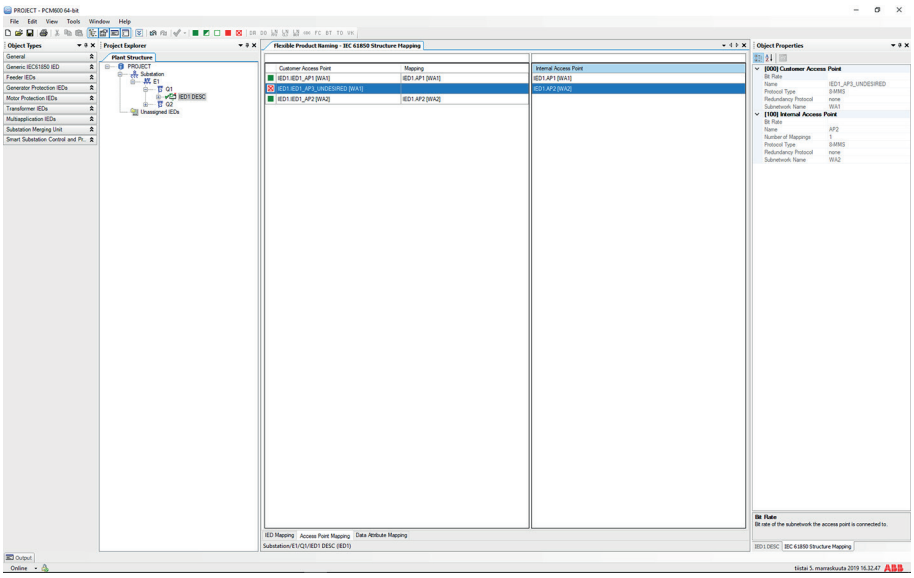

Figure 67: Mapping access points

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.

8.5 Engineering

8.5.1 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.

8.5.2 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.

8.5.3 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 projectspecific 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.

8.5.4 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.

8.5.5 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.

8.5.6 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.

8.6 Data model

8.6.1 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.

8.6.2 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.

8.6.3 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.

Table 21: Examples of functional constraint rules

FPN model	ABB model	Description
SP	SG	See *Chapter 8.7.3 Setting group parameters*.
SG	SP	See *Chapter 8.7.3 Setting group parameters*.
SV	ST, MX ,DC	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.
BL	ST	Not supported by REX640 directly, but it is possible to map to generic data.
OR	ST	Not supported by REX640 directly, but it is possible to map to generic data.
SR	ST, DC	Not supported by REX640 directly, but it is possible to map to generic data.

8.6.4 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.

8.6.5 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: Example of the SCL data order

DA fc	DA name	DA bType	type
MX	instCVal	Struct	MyVector
MX	cVal	Struct	MyVector
MX	range	Enum	MyRangeConfig
MX	rangeAng	Enum	MyRangeConfig
MX	q	Quality	

Table continues on the next page

DA fc	DA name	DA bType	type
MX	t	Timestamp	
SV	subEna	BOOLEAN	
SV	subCVal	Struct	MyVector
SV	subQ	Struct	MyVector
SV	subID	VisString64	
BL	blkEna	BOOLEAN	
CF	units	Struct	MyUnit
CF	db	INT32U	
CF	dbAng	INT32U	
CF	zeroDb	INT32U	
CF	rangeC	Struct	MyRangeConfig
CF	rangeAngC	Struct	MyRangeConfig
CF	magSVC	Struct	MyScaledValueConfig
CF	angSVC	Struct	MyScaledValueConfig
CF	angRef	Enum	
CF	smpRate	INT32U	
DC	d	VisString255	
DC	dU	Unicode255	
EX	cdcNs	VisString255	
EX	cdcName	VisString255	
EX	dataNs	VisString255	

8.6.6 Primary values

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

Table 23: Parameter Unit mode

Parameter	Values	Menu path
Unit mode	1=Primary; 0=Nominal	**Configuration** > **Communication** > **Protocols** > **MMS**

8.6.7 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.

8.7 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.

8.7.1 Device menu

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

8.7.2 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 statusonly 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-normalsecurity by status-only in control model (ctlModel).

There are some recommendations for the menu parameters.

- *Test mode* = "LD0.LLN0.Mod" via **Tests** > **IED test**
- *Device state* = "LD0.LLN0.Beh" via **Monitoring** > **IED status** > **Self-supervision**
- *Control mode* = "CTRL.LLN0.Mod" via **Configuration** > **Control** > **General**
- *Operation* = "Function block master Mod" via **Settings** > **Settings** > **<Category>** > **<Function name>**
- *<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.

Table 24: Mapping example 1

FPN model					ABB model			
LD	**LN**	**DO**	**DA**	**Default**	**LD**	**LN**	**DO**	**DA**
Prot					LD0			
	LLN0					LLN0		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
	HIPTOC1					PHIPTOC1		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal

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 25: Mapping example 2

FPN model					ABB model			
LD	**LN**	**DO**	**DA**	**Default**	**LD**	**LN**	**DO**	**DA**
Prot					LD0			
	LLN0					(NONE)		
		Mod					(NONE)	
			stVal	on				(NONE)
			Oper.ctlVal					(NONE)
			ctlModel	status-only				(NONE)
		Beh					(NONE)	
			stVal					(NONE)
	HIPTOC1					PHIPTOC1		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal

Mapping example 3

DARREC1 is moved logically under control functions and existing ABB data LD0.DARREC1.Mod.stVal is explicitly mapped to new Control.Q1RREC1.Mod.stVal.

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 26: Mapping example 3

FPN model					ABB model			
LD	**LN**	**DO**	**DA**	**Default**	**LD**	**LN**	**DO**	**DA**
Control					CTRL			
	LLN0					LLN0		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
	Q1CSWI					CBCSWI1		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
					LD0			
	Q1RREC1					DARREC1		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal

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 27: Mapping example 4

FPN model					ABB model			
LD	**LN**	**DO**	**DA**	**Default**	**LD**	**LN**	**DO**	**DA**
Control					CTRL			
	LLN0					LLN0		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
	Q1CSWI					CBCSWI1		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
					LD0			
	Q1RREC1					DARREC		
		Mod					(NONE)	
			stVal	on				(NONE)
			Oper.ctlVal					(NONE)
			ctlModel					(NONE)

Table continues on the next page

FPN model					ABB model			
LD	LN	DO	DA	Default	LD	LN	DO	DA
		Beh					Beh	
			stVal					stVal

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.TPRPPTR1/2.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 28: Mapping example 5

FPN model					ABB model			
LD	LN	DO	DA	Default	LD	LN	DO	DA
Prot1					LD0			
	LLN0					TRPPTRC1		
		Mod					Mod	
			stVal					stVal
			Oper.ctlVal					Oper.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
	OCPTRC1							
		Op					Op	
			general					general
	OCP-TOC1					PHIP-TOC1		

Table continues on the next page

FPN model					ABB model			
LD	**LN**	**DO**	**DA**	**Default**	**LD**	**LN**	**DO**	**DA**
		Mod					Mod	
			stVal					stVal
			Op-er.ctlVal					Op-er.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
Prot2								
	LLN0					TRPPTRC2		
		Mod					Mod	
			stVal					stVal
			Op-er.ctlVal					Op-er.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal
	DEFPTRC1							
		Op					Op	
			general					general
	DEFP-TOC1					DEFHP-TOC1		
		Mod					Mod	
			stVal					stVal
			Op-er.ctlVal					Op-er.ctlVal
			ctlModel					ctlModel
		Beh					Beh	
			stVal					stVal

8.7.3 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 29: Mapping of setting group parameters

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

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

8.7.4 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.

8.8 Control

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

8.8.1 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.

8.8.2 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.

8.9 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 30: Possible errors if the imported FPN SCD file contains invalid data sets

Condition	Cause	Remedy
The customer IED contains [xx] data sets. The internal IED allows 27 data sets at maximum.	There are too many data sets in the configuration.	Combine or remove some data sets.
The customer IED contains one or more data sets having [xx] entries. The internal IED allows 80 entries at maximum.	One or more data sets in the imported configuration are too big.	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.

8.9.1 Supported data types in data sets

Table 31: Supported data types in data sets

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

8.9.2 Editing data sets in IEC 61850 Configuration

To edit data sets, IEC 61850 configuration engineering mode must be enabled from options.

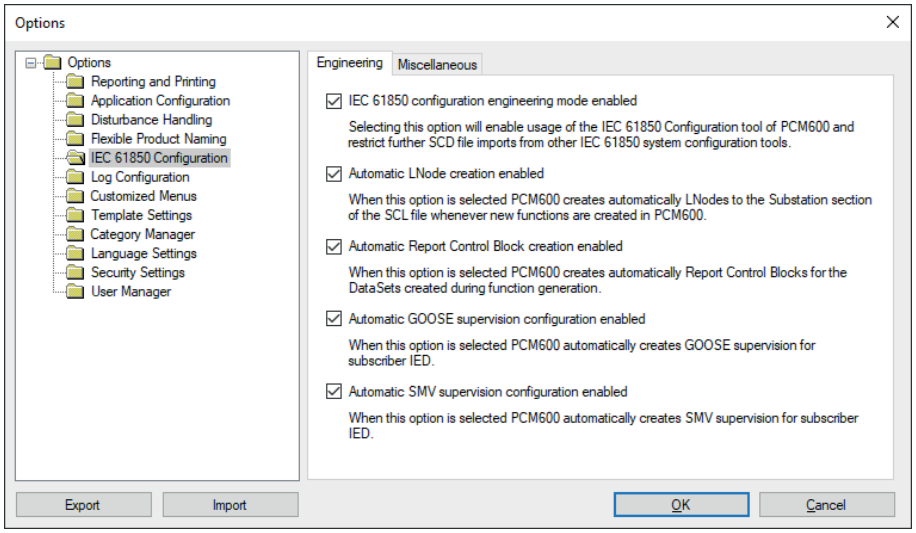

Figure 68: Enabling IEC 61850 configuration engineering mode

1. To open IEC 61850 Configuration, right-click an IED and select **IEC 61850 Configuration**.

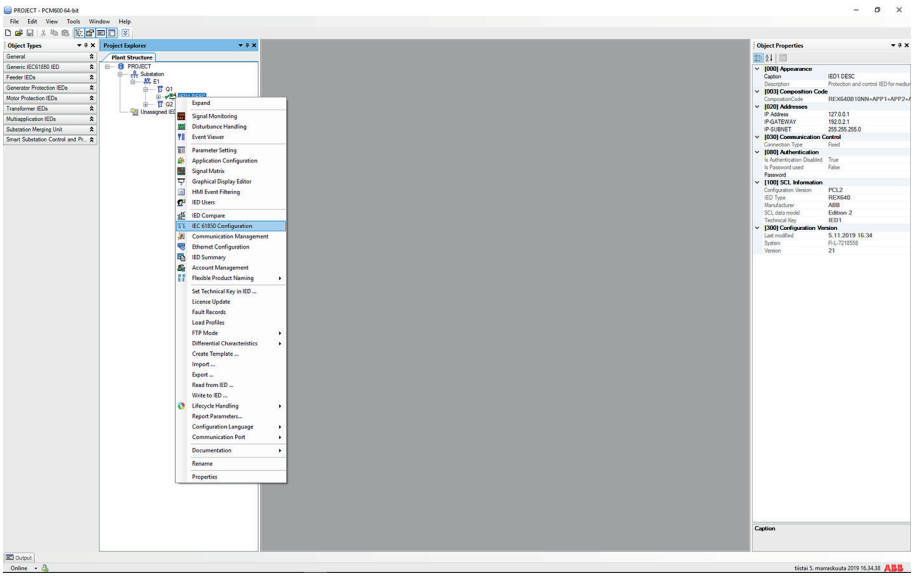

Figure 69: Opening IEC 61850 Configuration

2. On the toolbar, select the communication mode for which data sets are managed.

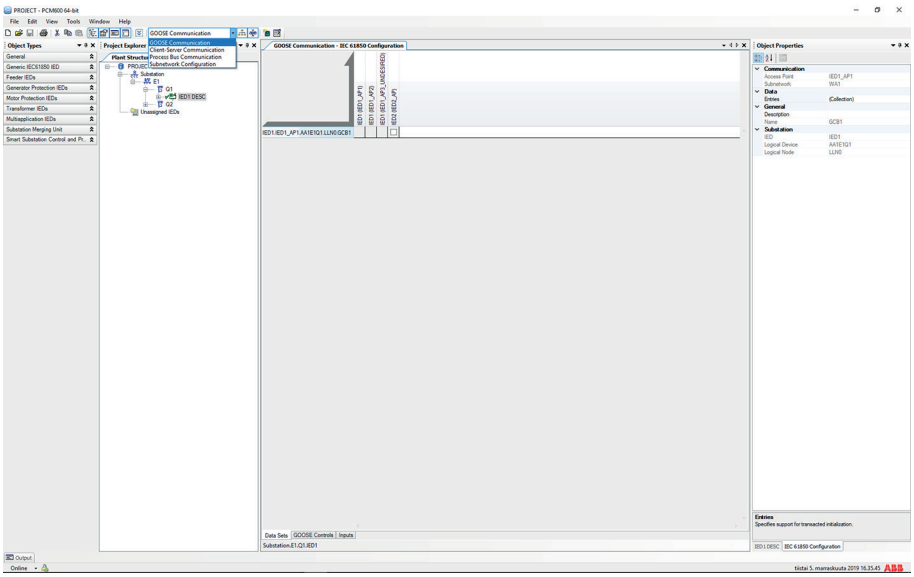

Figure 70: Selecting the type of the data sets to be edited

3. Manage data sets on the **Data Sets** tab.
   a) To add new data sets, right-click and select **New**.
   b) To delete data sets, select the data sets to be deleted, right-click and select **Delete**.
   c) To edit entries in a data set, select the data set and open **Entries** from **Object Properties**.

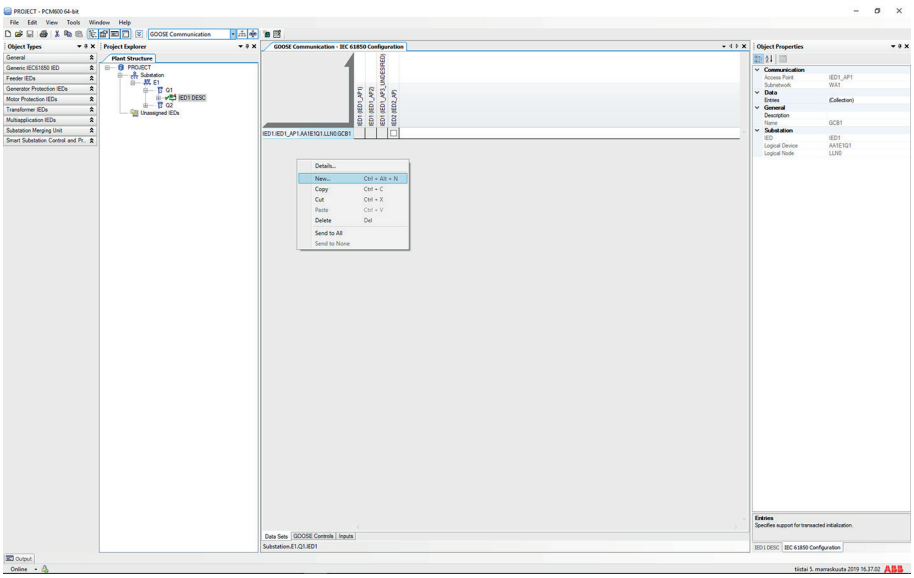

Figure 71: Adding, deleting or editing a data set

This opens a dialog box where entries can be added or removed.

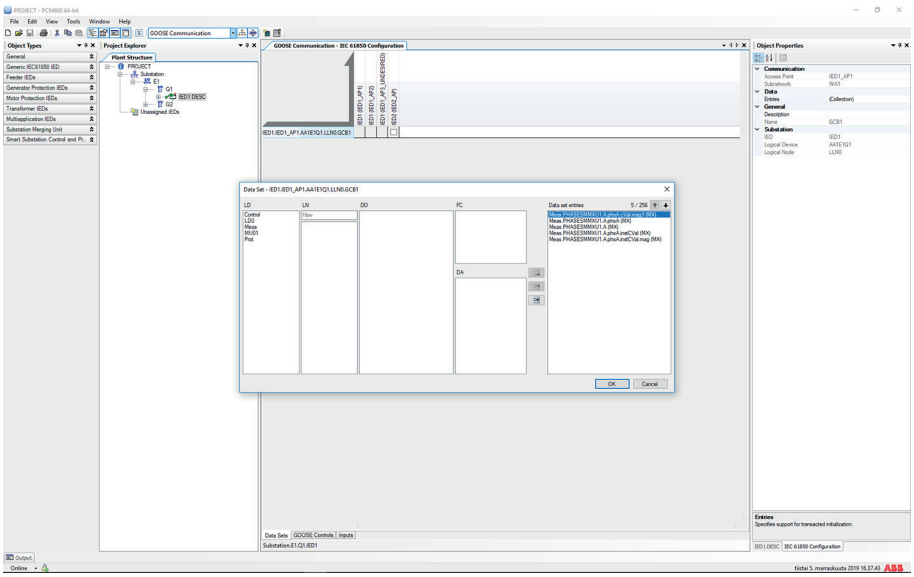

Figure 72: Editing data sets

8.10 Sampled measured values

The relay supports sending of one and receiving of four IEC 61850-9-2 LE streams. Each stream contains four currents and four voltages. 16 received measurements in total can be connected into the protection relay application.

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.
- The content of the default SV dataset PhsMeas1 must not be modified.

8.11 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 *Chapter 8.6.5 Standard compatibility*.

8.11.1 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 32: Possible errors if imported FPN SCD file contains invalid GOOSE control blocks

Condition	Cause	Remedy
The customer IED contains [xx] GOOSE control blocks. The internal IED allows 6 GOOSE control blocks at maximum	There are too many GOOSE control blocks in the imported configuration.	Check the GOOSE control blocks using IEC 61850 Configuration.

8.11.2 Editing GOOSE control blocks in IEC 61850 Configuration

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

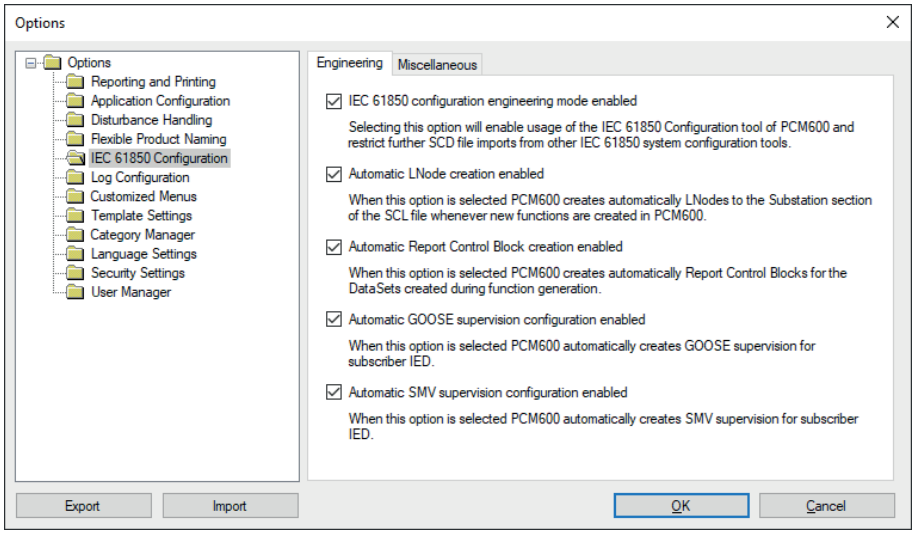

Figure 73: Enabling IEC 61850 configuration engineering mode

1. To open IEC 61850 Configuration, right-click an IED and select **IEC 61850 Configuration**.

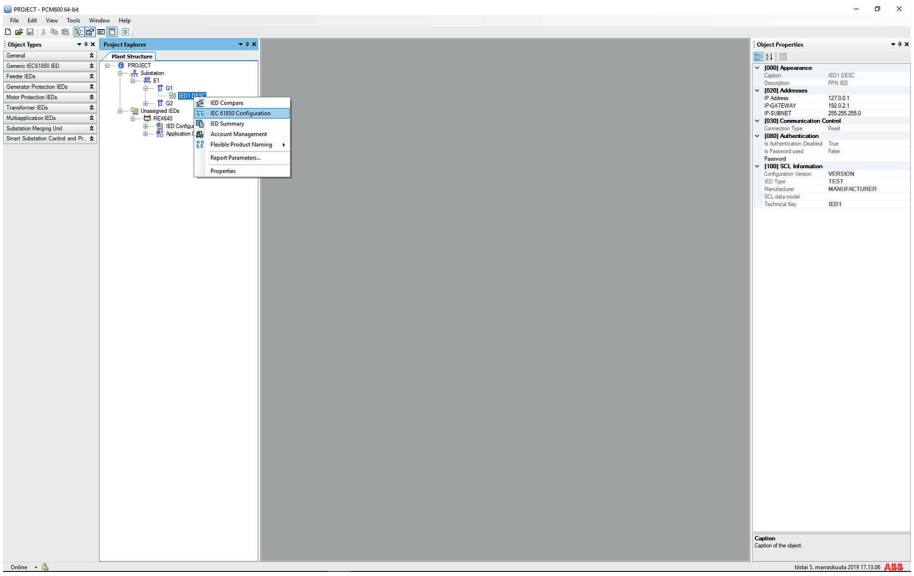

Figure 74: Opening IEC 61850 Configuration

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

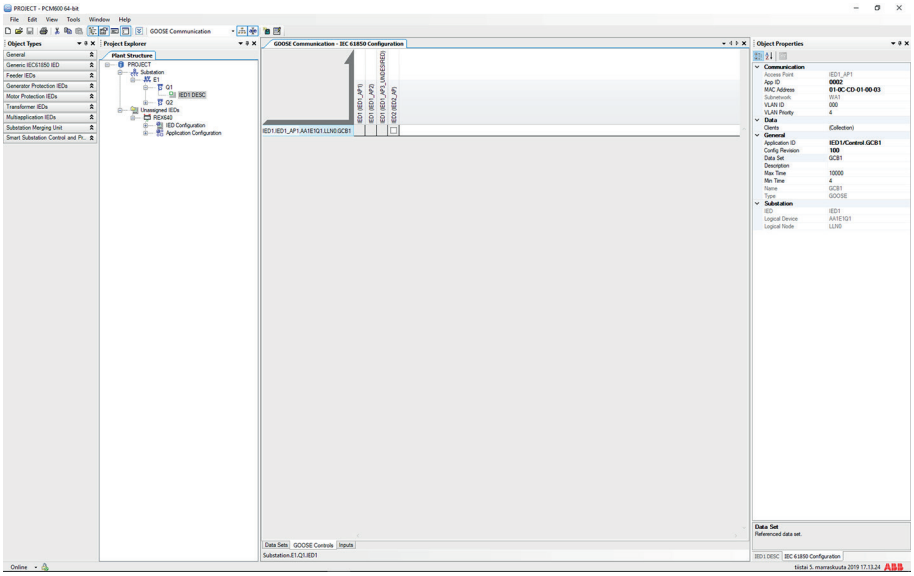

Figure 75: Editing GOOSE control blocks

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

8.12 Reporting

8.12.1 SCL configuration checklist for ReportControl

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

Table 33: Possible errors if imported FPN SCD file contains invalid ReportControl blocks

Condition	Cause	Remedy
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.	Some of the report controls have too many clients.	Check the report control blocks using IEC 61850 Configuration.
Too many reporting clients	Enabled clients are out of valid range for some of the report control blocks.	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.

8.12.2 Editing ReportControl blocks in IEC 61850 Configuration

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

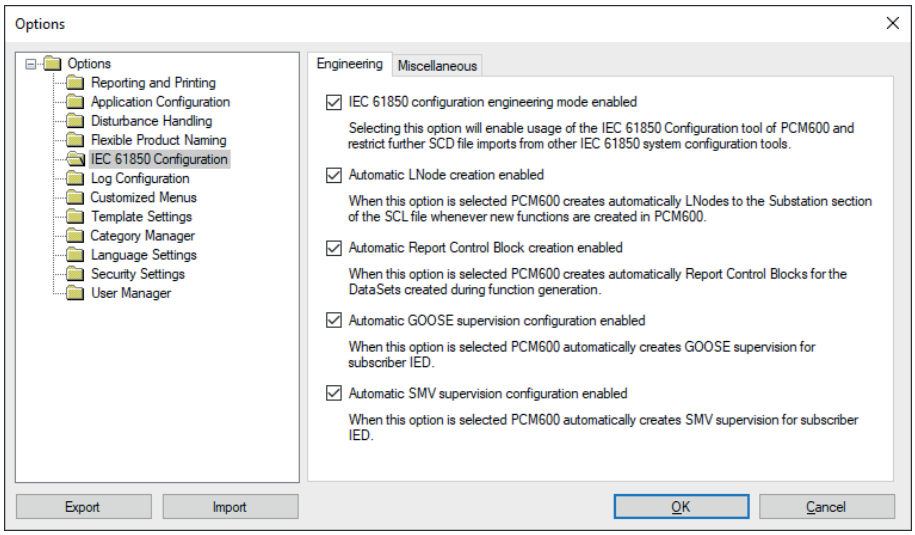

Figure 76: Enabling IEC 61850 Configuration engineering mode

1. To open IEC 61850 Configuration, right-click an IED and select **IEC 61850 Configuration**.

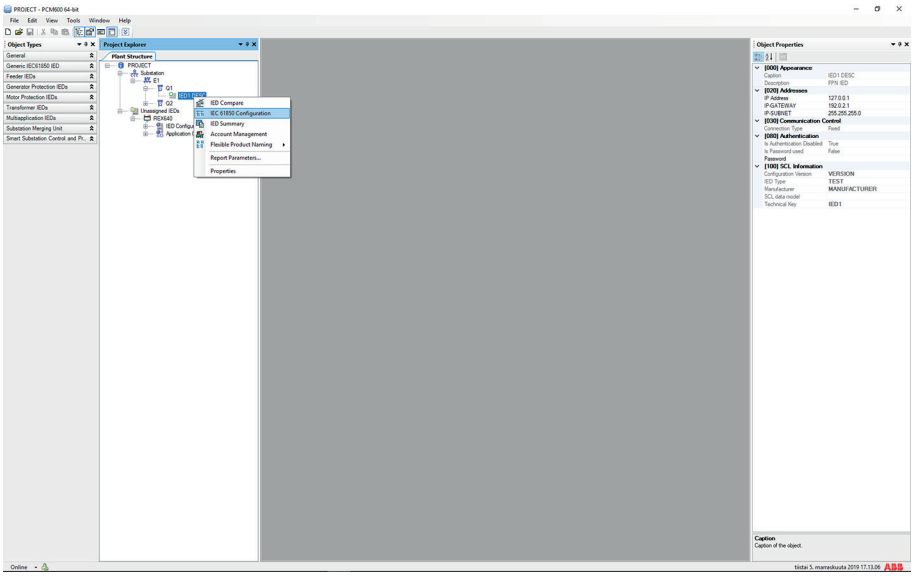

Figure 77: Opening IEC 61850 Configuration

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

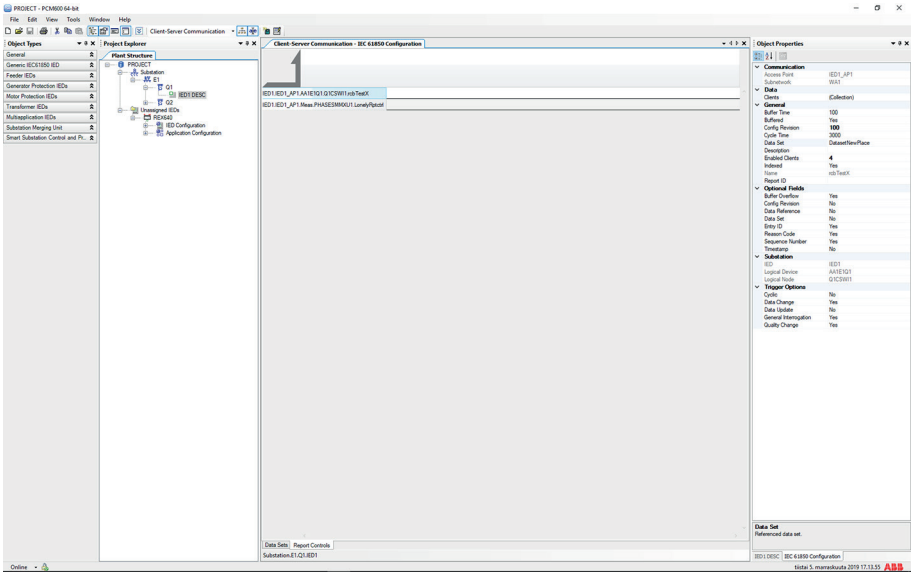

Figure 78: Selecting client-server communication

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.

8.13 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.

8.14 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.

9 Glossary

Access point	The connection that ties wireless communication devices into a network
ACSI	Abstract communication service interface
ACT	1. Application configuration tool in PCM600 2. Trip status in IEC 61850
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
DR	Disturbance recorder
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN.
FC	Functional constraint
FPN	Flexible product naming
FTP	File transfer protocol
FTPS	FTP Secure

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
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
Modbus	A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices.
NTP	Network time protocol
P2P	peer-to-peer
PCL	Product connectivity level
PCM600	Protection and control IED manager
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 substation description configuration language defined by IEC 61850
SHMI	Switchgear HMI
SI	Sensor input
SMV	Sampled measured values
ST	Connector type for glass fiber cable
SVCB	Sampled value control block
TAL	Time allowed to live
TCP/IP	Transmission control protocol/Internet protocol
VLAN	Virtual LAN
VT	Voltage transformer

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