RELION® PROTECTION AND CONTROL

REX610

IEC 61850 Engineering Guide

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This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2014/35/EU). This conformity is the result of tests conducted by the third party testing laboratory KEMA in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

Safety information

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

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

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

National and local electrical safety regulations must always be followed.

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

When the plug-in unit has been detached from the case, do not touch the inside of the case. The relay case internals may contain high voltage potential and touching these may cause personal injury.

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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Section 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

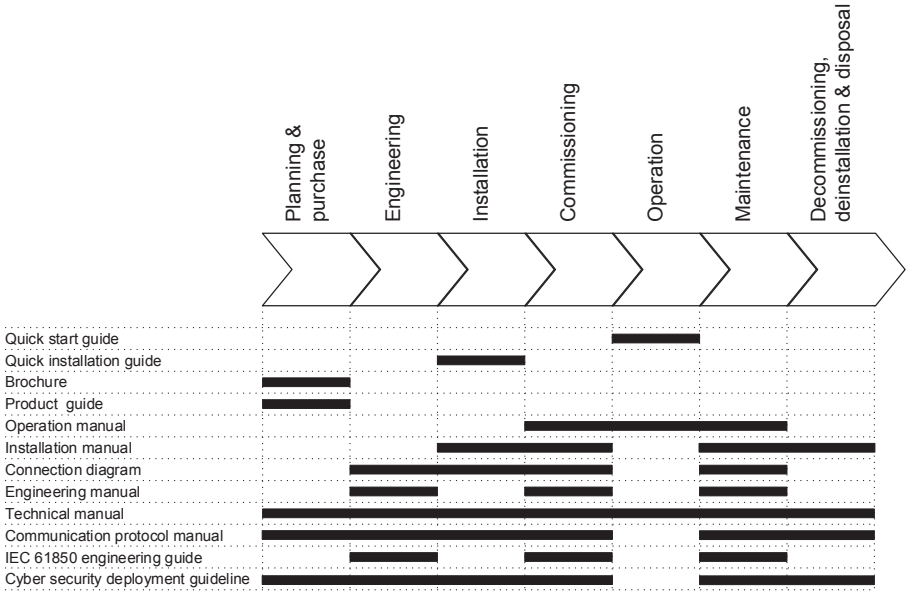

Figure 1: The intended use of documents during the product life cycle

1.3.2 Document revision history

Document revision/date	Product version	History
A/2022-04-21	1.0	First release

1.3.3 Related documentation

Name of the document	Document ID
IEC 61850 Tissues Conformance Statement (TICS)	2NGA000854
IEC 61850 Protocol Implementation eXtra Information (PIXIT)	2NGA000855
IEC 61850 Protocol Implementation Conformance Statement (PICS)	2NGA000853
IEC 61850 Model Implementation Conformance Statement (MICS), 615 series parameter list	2NGA000852

Download the latest documents from the ABB Web site 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.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  To navigate between the options, use ^ and v.
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- LHMI messages are shown in Courier font.
  To save the changes in nonvolatile memory, select `Yes` and press ↵.
- 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".
- A functional earth terminal is indicated in figures with the symbol ⏚.
- Equipment protected throughout by double insulation or reinforced insulation (equivalent to class II of IEC 61140) is indicated in figures with the symbol ⧈.

Section 2 IEC 61850 overview

The international IEC 61850 standard defines a framework for substation communications 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.

IEC 61850 standard for communication networks and systems in substations has been out since 2005 and used successfully in ABB products. IEC 61850 standard is updated with a new version, Edition 2. Edition 2 extends to new application areas in transmission and distribution power systems and also defines a new functionality to Edition 1 functionality. REX610 supports only IEC 61850 Edition 2.

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.

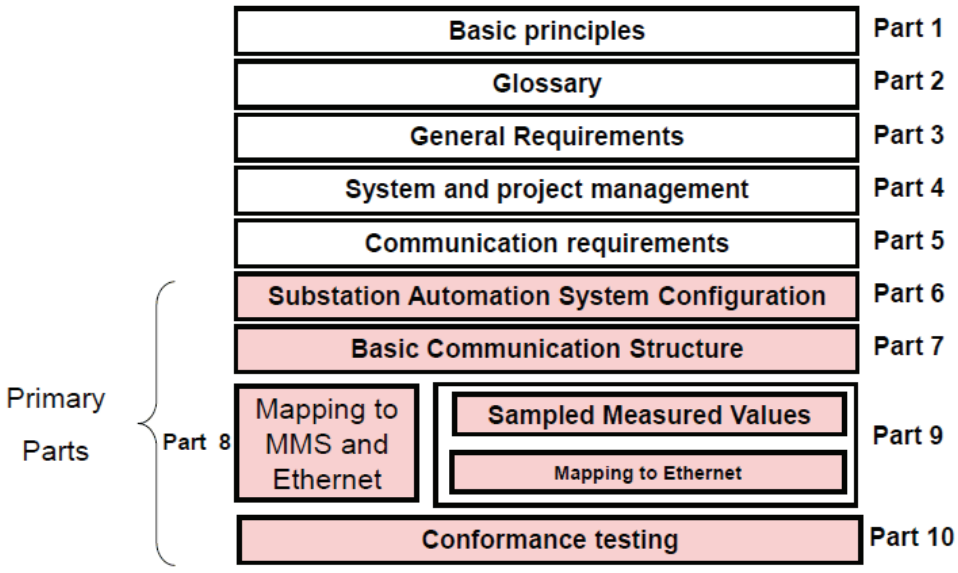

Figure 2: Structure and parts of the IEC 61850 standard

The IEC 61850 standard specifies an expandable object-oriented data model and 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 is supported.

The standard also defines an XML description language for substation automation systems. The language facilitates efficient integration of devices into systems in an automated fashion. 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 provide a broad range of features from mainstream communication (standard part 8-1). Communication profiles in IEC 61850 can be divided to 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 possible new communication concepts in the future.

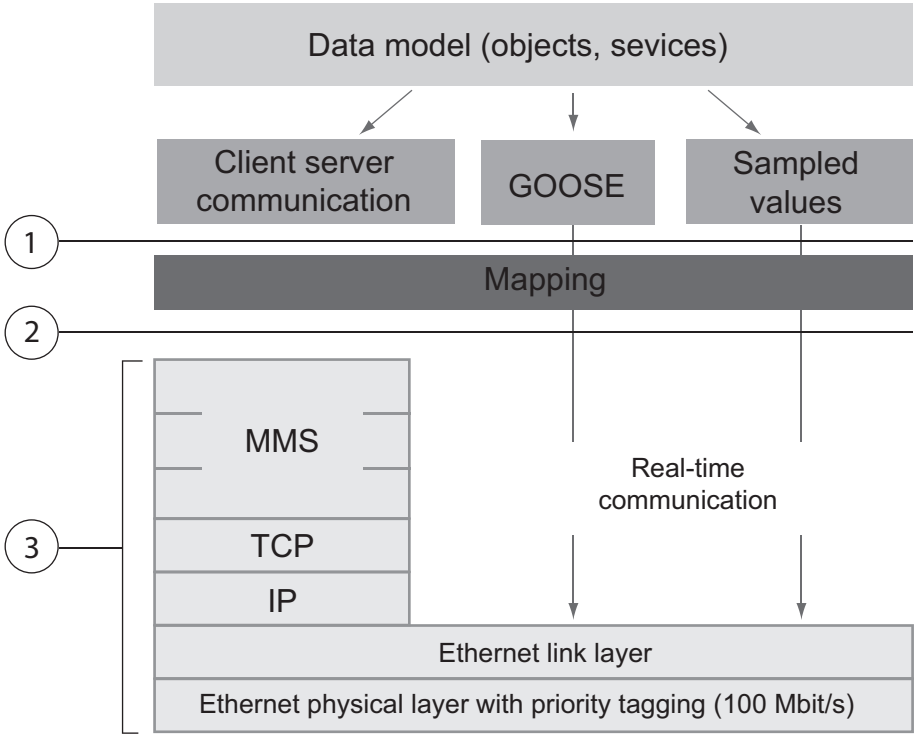

Figure 3: Communication stacks and mapping used in IEC 61850

1 Abstract communication services interface (ACSI)
2 Stack interface
3 ISO/OSI stack

Section 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.

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.2.11 or later
- REX610 Connectivity Package Ver.1.0 or later

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

Section 4 REX610 data model

4.1 Product implementation

The protection relays have been fully designed 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 relays support a wide range of the services provided by the standard.

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

4.2 Information model

The protection relay is fully modelled according to the IEC 61850 standard. The data model can include up to three 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 set of logical devices and logical nodes. Data models also include full modelling and functionality of setting, setting groups and configuration according to the IEC 61850 concept.

- Control logical device, CTRL
- Disturbance recorder logical device, DR
- Protection logical device, LD0

All generic functionality, such as modelling of physical inputs and outputs as well as the alarming LED functionality, resides under logical device LD0.

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.

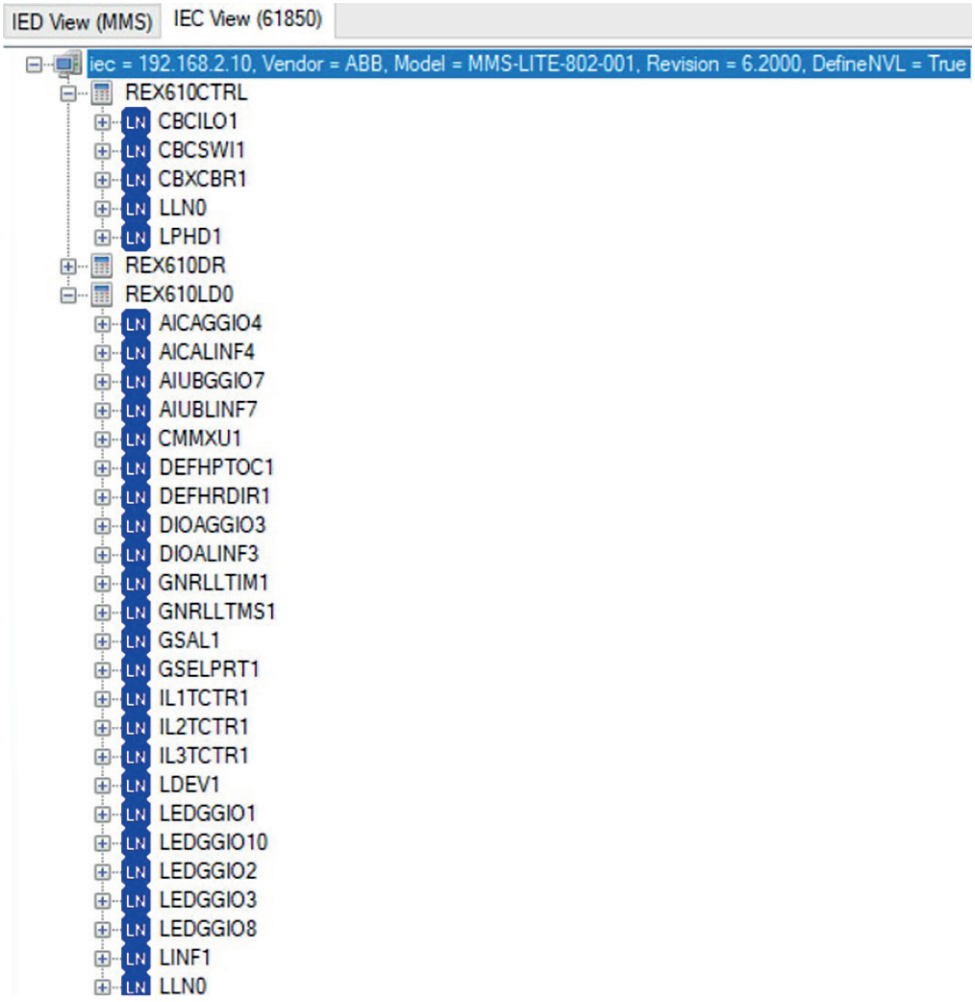

Figure 4: Example of an IEC 61850 data model of a protection relay

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. Setting Group control block is located in logical device LD0 logical node LLN0. GOOSE control block can be configured under LLN0 of any logical device, and data set available under LLN0 of the corresponding logical device will be visible for mapping. Report control block can be configured under any logical node of any logical device, and data set will be visible for mapping only if it is present under the corresponding logical node.

The full data model can be exported from PCM600 in the form of a SCL file, which is defined in part 6 of the standard.

4.3 Vertical and horizontal communication

The protection relays are capable of vertical communication between the protection relay and monitoring and control systems (clients) such as PCM600 or MicroSCADA. Each protection relay can communicate to five separate clients to receive events, read or write data (an active PCM600 connection is considered to be a client). It is recommended to use three separate clients including PCM600. 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.

IEC 61850 standard Edition 2 increased several identification string lengths which affect communication engineering and interoperability. The table lists 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 Edition 2

Object	Edition 2 length	Description
IED name	60 (64-4)	Excluding the longest LD name length of 4 characters
Report control block name	30	Without a two digit RCB instance number
Data set name	32	
RptID	129	Report Identifier
GoID	129	GOOSE Identifier

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

Control Block	Maximum data sets	Maximum length	Description
GoCB	4	40 data attributes	The protection relays allow a maximum of four GOOSE control blocks, which effectively limits the protection relay to four data sets for GOOSE. The sending GOOSE data sets can have a maximum total of 40 data attributes. To minimize the message-handling load in the receiving and sending protection relays, it is recommended to limit data attribute amount to 20 per data set.
RCB	10	40 data attributes	PCM600 allows a maximum of 10 data sets for the report control blocks.

4.3.1 Vertical communication diagnostic counters

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

Table 3: Diagnostic data objects

Data object	Description	Diagnostic information
SucConnCnt	Successful connections	Number of succeeded client connection attempts
FailConnCnt	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
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** via LHMI and via the IEC 61850 communication by writing `TRUE` to the *RsCnt.Oper.ctlVal* attribute under MMSLPRT1.

GOOSE communication has its own diagnostic counters. See the Diagnostic counters section in this manual for information on the diagnostic counters used in GOOSE communication.

4.4 Parameter setting and disturbance recorder

The relay's protection function settings and parameters can be set and the active setting groups changed by a IEC 61850 client using the standard IEC 61850 services. The disturbance recorder files in COMTRADE format are retrieved from the **\COMTRADE** directory by using PCM600 or FTP.

Section 5 GOOSE

5.1 Horizontal communication

GOOSE is used in substation automation for fast horizontal communication between the 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.

IET600 is used to configure the vertical and horizontal communication properties of the protection relays.

The protection relay can send any type of status or measurement data in the GOOSE messages from its IEC 61850 data model.

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.

5.1.1 Configuring horizontal communication

Configure GOOSE by using the IEC 61850 Configuration tool in PCM600.

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 01-0C-CD-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 non-configured VLAN; in this case, switches do not filter these messages on a port basis. This is recommended if there is no need to split the logical network. The VLAN identifier is a three-character hexadecimal value with range 000...FFF.
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 Configuring GOOSE with the IEC 61850 Configuration tool

See detailed descriptions of the steps in corresponding chapters.

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

5.3.1 Defining IEDs and starting the IEC 61850 Configuration tool

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 tool.

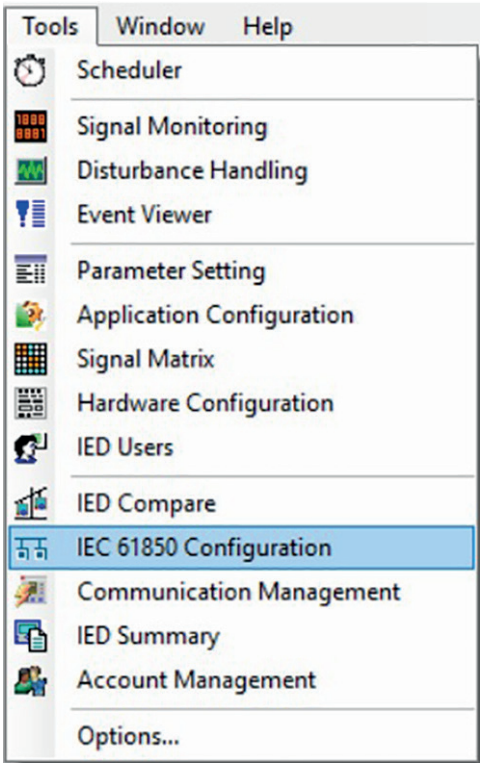

Figure 5: Starting IEC 61850 Configuration

5.3.2 Configuring a GOOSE publisher with the IEC 61850 Configuration tool

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.

5.3.2.1 Creating a GOOSE data set with the IEC 61850 Configuration tool

The sending data set is defined with the GOOSE control block. The sending GOOSE data set can have a maximum of 20 data attributes to minimize the message-handling load in the receiving and sending IEDs.

All data sets must be configured under the logical node LLN0 and must be provided with names unique within the IED. The IEDs allow a maximum of four GOOSE control blocks, which effectively limits the IED to four data sets for GOOSE, as there is a one-to-one correspondence between the GOOSE control blocks and GOOSE data sets. Typically, it is 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.

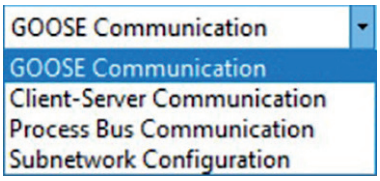

Figure 6: Selecting GOOSE communication

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**.

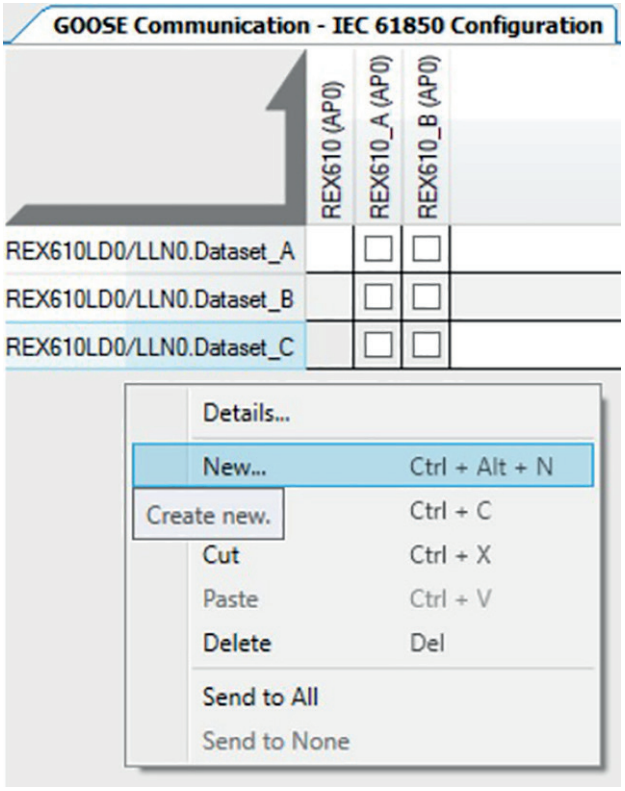

Figure 7: Creating a new data set

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

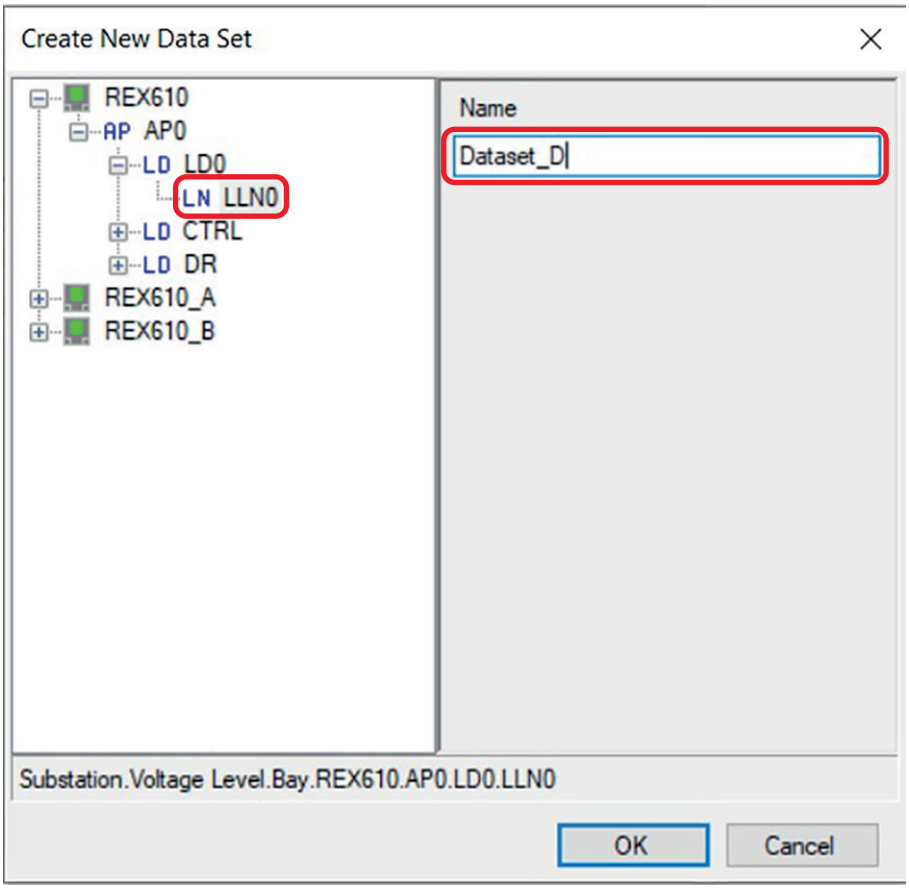

Figure 8: Naming the data set

A maximum of 80 data attributes can be added to IED's GOOSE data sets. Recommendation is to divide attribute amount to 20 per GOOSE data set, for maximum performance in sender/receiver. After creating the GOOSE data sets, define the data set entries (data attributes or data objects) for the data sets.

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 must be located after the status value of the corresponding data object.

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

Defining GOOSE data set entries with the IEC 61850 Configuration tool

1. Select the **Data Sets** tab.
2. Right-click a data set and select **Details** to add data attributes.

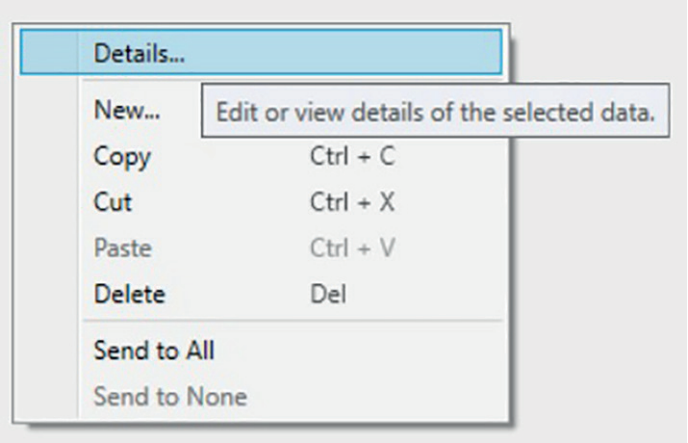

Figure 9: Opening Details

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**.

A maximum of 40 data attributes can be added in total to a IED's GOOSE data sets. Recommendation is to divide the attribute amount to 20 per GOOSE data set, for maximum performance in sender/receiver.

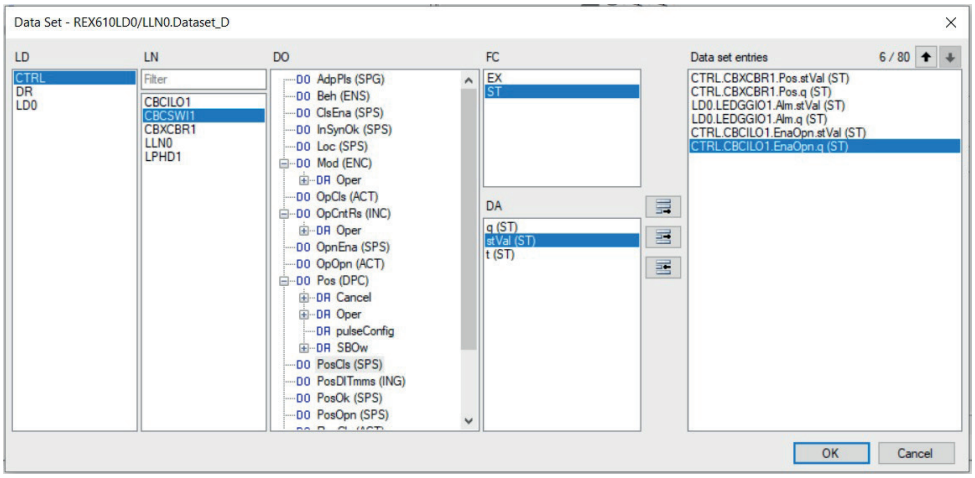

Figure 10: Adding data set entries

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

The data attribute entries are single data, such as stVal and q. Data set entries can be also defined on the data object level. Data object level GOOSE entries can only be received of the following CDC types: SPS, SPC, ACD, ACT, DPS and DPC.

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

5.3.2.2 Configuring a GOOSE control block with the IEC 61850 Configuration tool

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**.

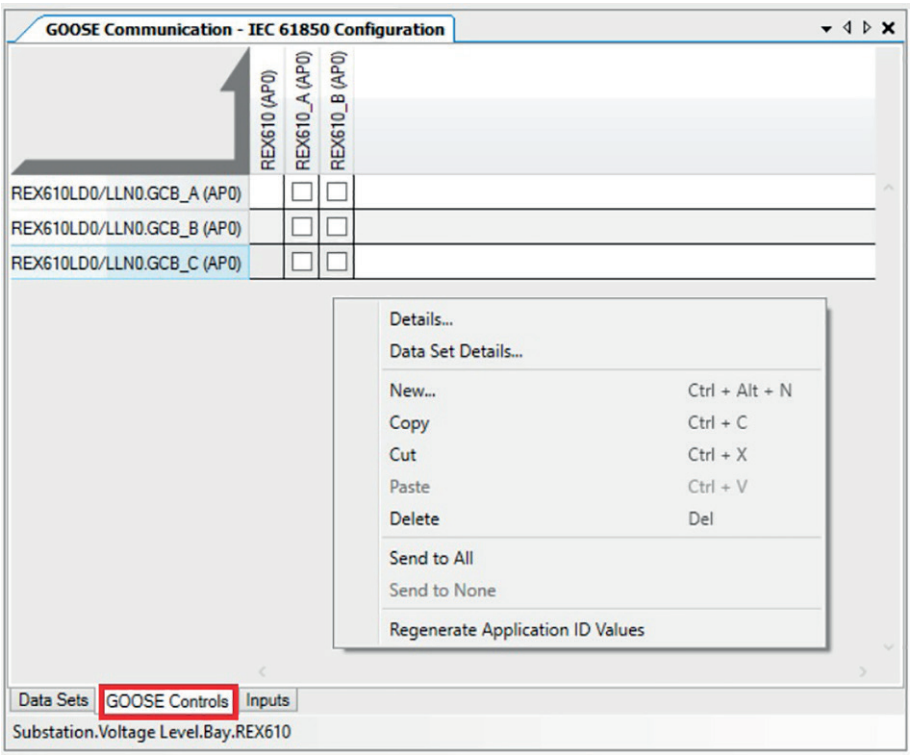

Figure 11: Creating a new GOOSE control block

4. Browse to LLN0 under LD0 or any logical device to define where the GOOSE control block is to be placed.
5. Give a unique name to the GOOSE control block.

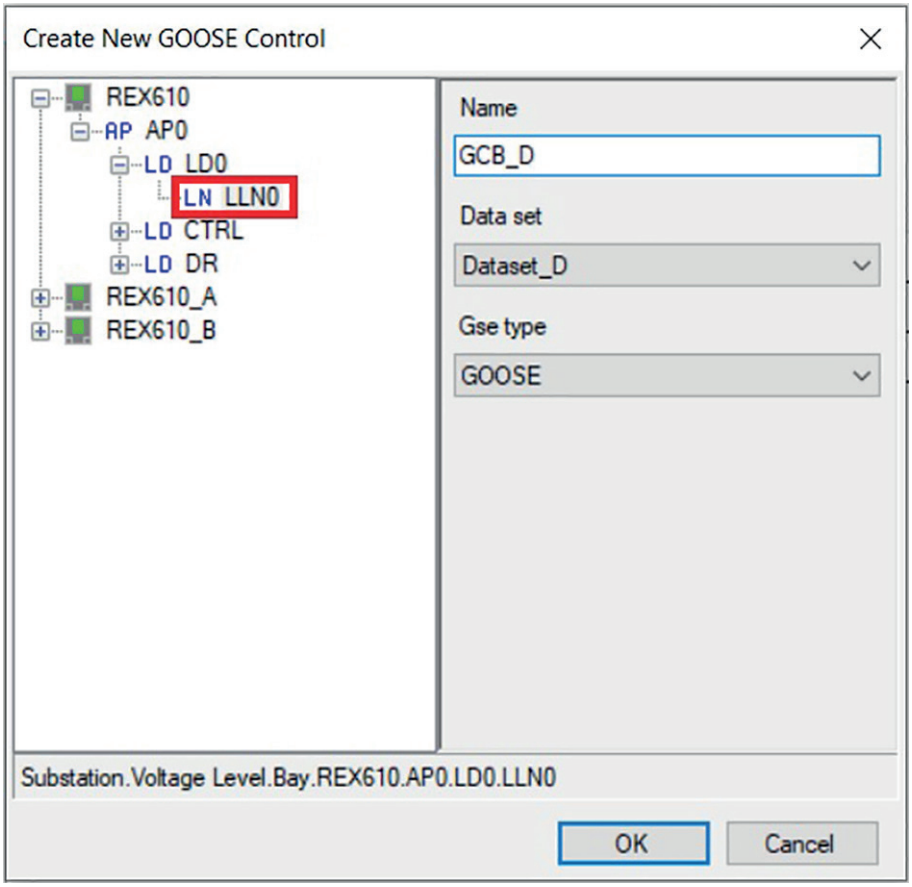

Figure 12: Naming a GOOSE control block

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

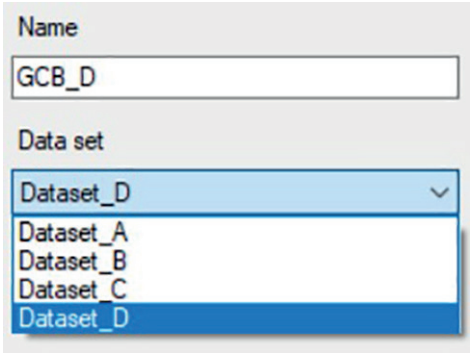

Figure 13: Data set drop-down list

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.

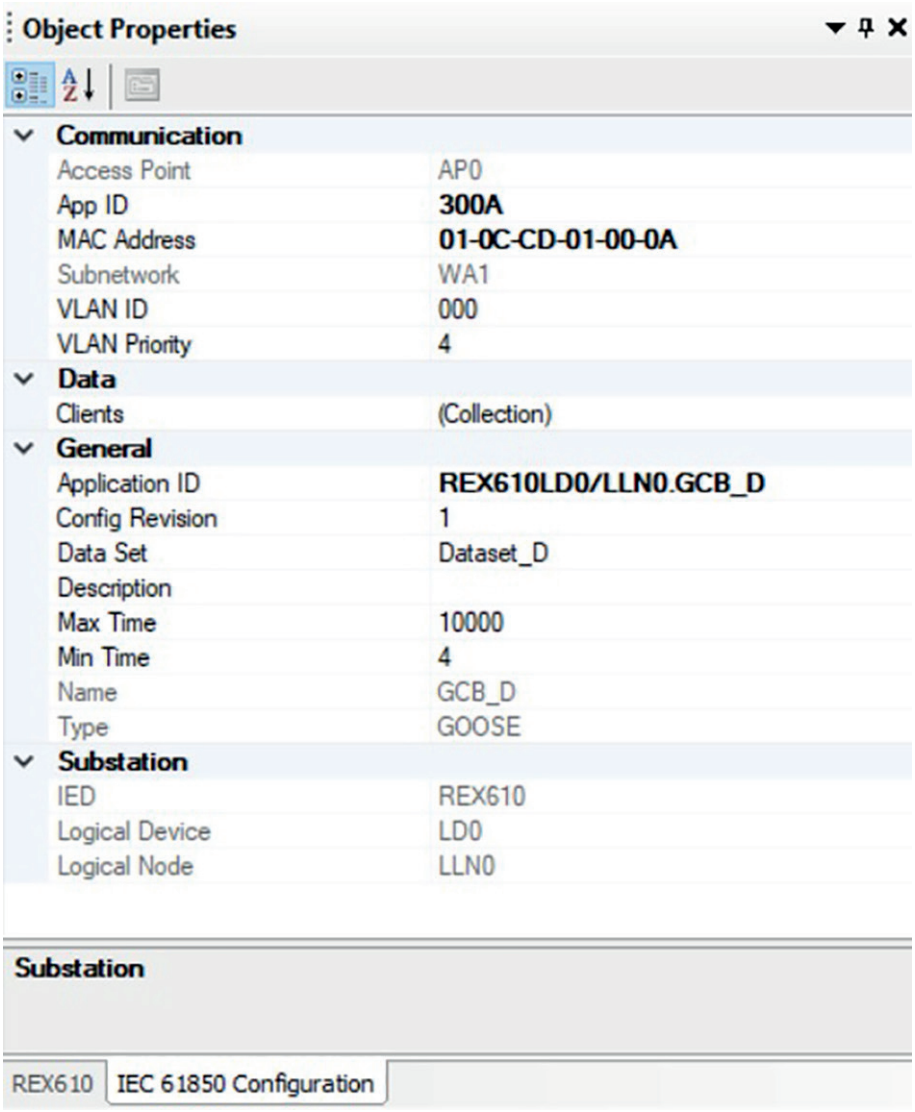

Figure 14: GOOSE control block properties

Table 5: GOOSE control block properties

GoCB property	Description
GoCB name	GOOSE control block name. The maximum length is 28 characters.
Application (AppID)	A unique GOOSE Identification string for each GoCB in the system. Recommendation is to define a device-specific value and not to use the default empty value. The maximum length is 64 characters.
t(min) (ms)	Indicates the maximum response time in milliseconds to data change. This time can be used by the receiver to discard messages that are too old. In principle, t(min) can vary depending on the data type, but for the IEDs, the value is always “10 ms” for sent data .
t(max) (ms)	Indicates the background "heartbeat" cycle time in milliseconds; the default value is “10 000 ms”. If there are no data changes, the IED still resends the message with the heartbeat cycle to enable the receiver to detect communication losses, that is, the communication is supervised.
Configuration Revision	Contains an integer value that is sent in every GOOSE message. The integer indicates the amount of changes in the data set. The receiver checks the message for configuration mismatches.
MAC Address	Multicast MAC address to which the specific GOOSE data is sent. The receiving IED filters the frames and starts to process them if a specific multicast address is defined in the configuration. It is recommended to have one unique multicast address per GoCB. The address range for GOOSE Multicast addresses is 01-0C-CD-01-00-00...01-0C-CD-01-01-FF
App ID	Unique HEX value application identifier for sending the GoCB within the system. It identifies the purpose of this particular data set. The value range is 0000...3FFF.
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 3-character HEX value with range 000...FFF. Recommended values are 2...1001.
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.

Both *t(max)* and *t(min)* are configurable. The default minimum setting for *t(min)* is "4 ms".

The multicast *MAC address* is usually unique, and *APP-ID* must be unique.

5.3.3 Configuring a GOOSE subscriber with the IEC 61850 Configuration tool

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

5.3.3.1 Configuring GOOSE inputs with the IEC 61850 Configuration tool

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.

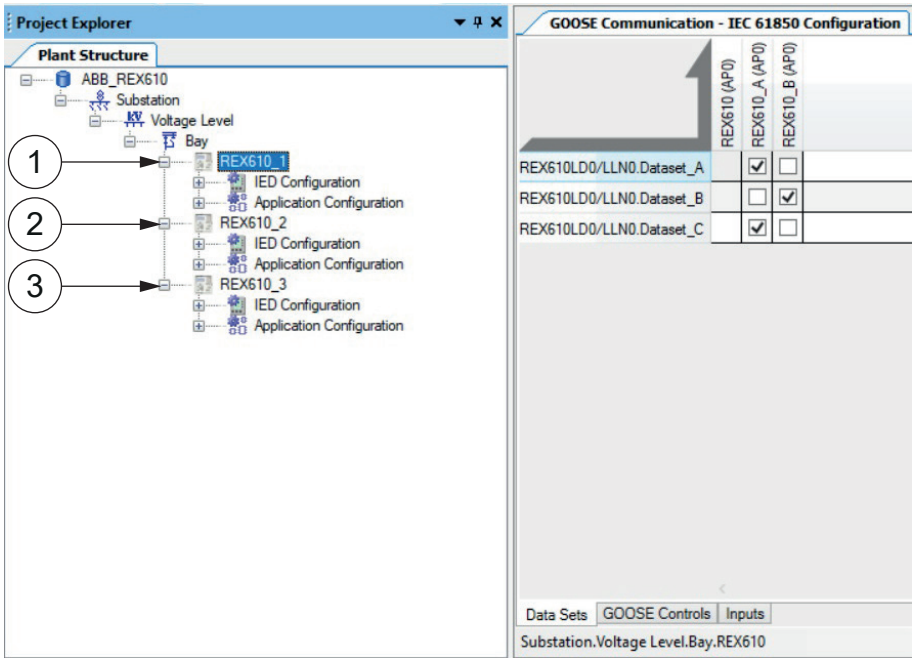

Figure 15: GCB client editor showing the senders and receivers

1 Subscriber 1
2 Subscriber 2
3 Publisher

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

5.4 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 the Application Configuration tool.

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

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

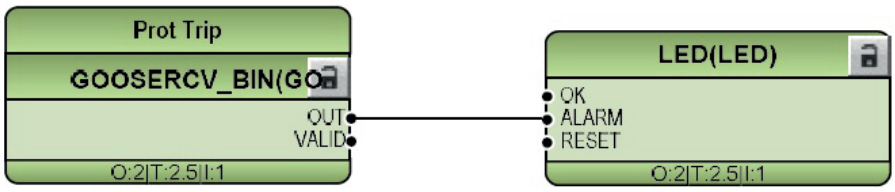

Figure 16: Adding the GOOSERCV function block

3. Create the connection into the application.
   3.1. Create the connection.
   3.2. Click **Calculate execution order**.
   3.3. Click **Validate configuration**.
   3.4. Save the connection to the application.
4. To open the Signal Matrix tool, 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 in the GOOSE sheet, map the GOOSE publisher data into the corresponding GOOSERCV function block.
   The columns in the GOOSE sheet represent publisher data and the rows represent the possible subscriber input point.

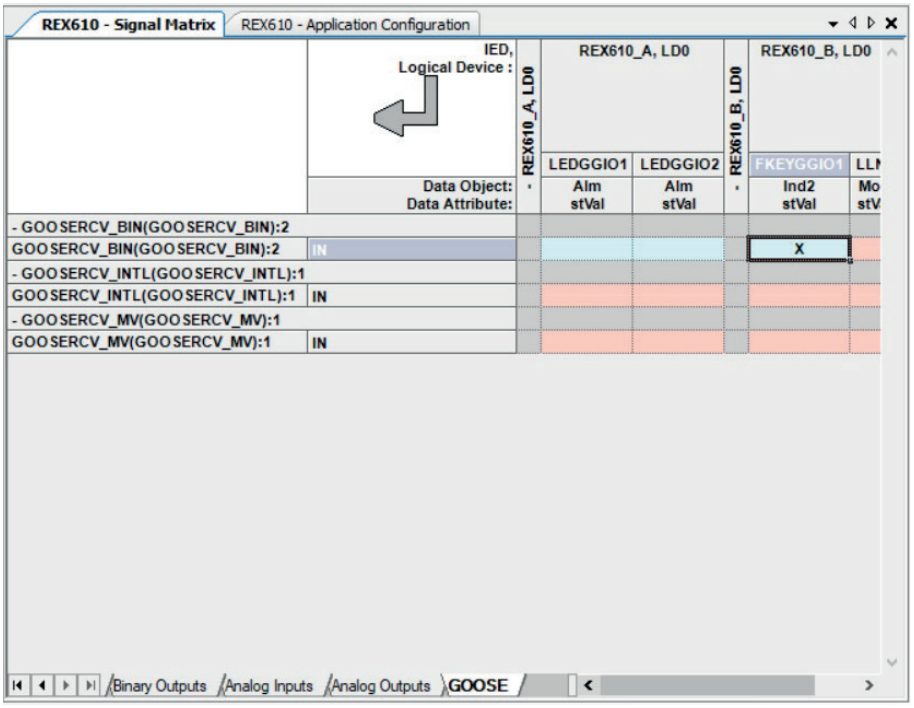

Figure 17: GOOSE sheet in Signal Matrix

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 supervision information.

During the protection relay start-up phase, the protection relay keeps the value of the output VALID as “1” until the communication is activated. After the communication is activated, the value of the output VALID is updated by the value received via the communication.

If the data type does not match with the GOOSERCV function block, the attribute cell is red.

It is recommended to restrict the total number of GOOSERCV blocks to 20.

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.

5.5 Received GOOSE message handling

A GOOSE frame is not accepted if the Needs Commission bit is set. Data with the Test quality bit set is accepted only if the receiving device is also in the test mode. For more information about GOOSE quality handling, see the corresponding flowcharts.

GOOSE frame quality is not processed if the GOOSE packet is received at Data Attribute level. GOOSE frame quality bits are processed only at Data Object level.

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

When the GOOSE sender is in test mode and the GOOSE receiver is not, the data value is defaulted and the quality is set to invalid.

See the technical manual for more information on the test mode.

The GOOSE frame is also not accepted 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 at Data Object level, the receiver device input object is not updated according to the received status value if the data quality is bad or questionable. The default value is also used in this case.

5.6 GOOSE supervision

5.6.1 Background sending

To ensure reliability and availability of the application, the GOOSE communication must be supervised. Design the application so that it can 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 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 2xTAL, 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.

5.6.2 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) in case there is a communication error. This handling is applicable for all signal types (binary, double binary and floating point). In addition to the default value handling, 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 type of data. Exact fail-safe functionality must be checked from the function block description in the technical manual.

If one relay application function block input receives several signals from several protection relays, the input value is calculated in OR or AND operation (configured in the Application Configuration tool) 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 as the traditional galvanic signal wires connected between protection relays. The advantage in the GOOSE-based signalling is that the application always detects faulty connections, which is not the case with the Normally Open (NO) type of physically wired galvanic contacts.

In all cases, however, a separate alarm event is always 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 Tool's Binary Outputs sheet (signal GSELPRT ALARM). For example, it is possible to change the setting group in case one or several protection relays are disconnected from the network.

5.6.3 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. Take this into account 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.

5.6.4 Diagnostic counters

The IEC 61850 data model of the protection relays includes a logical node LD0.GSELPRT1 for the GOOSE communication diagnostic. The counters are also available via the HMI path **Monitoring/I/O Status/Communication/GSELPRT1/Monitoring** or PCM600 path **Application configuration/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	Diagnostics 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

Table continues on next page

Data object	Description	Diagnostics information
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
StWrnCnt	State errors	Number of notified state number jumps
SeqWrnCnt	Sequence errors	Number of notified sequence number jumps
RxTmOutCnt	Receiver time-outs	Number of notified peer device time-outs
ConfErrCnt	Received ConfRev mismatches	When increasing, there is a mismatch between the received GOOSE frame information and the used GOOSE configuration.
NdsComCnt	Received frames with Needs Commissioning	One peer device Indicates that its configuration is not valid or up-to-date.
DSErrCnt	Errors in received data set	Received data are syntactically wrong, or there are less data in received data set than expected.
Alm	Receiver alarm	Alarm signal value connected to the event and application logic. It is active when one peer device is in time-out.

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

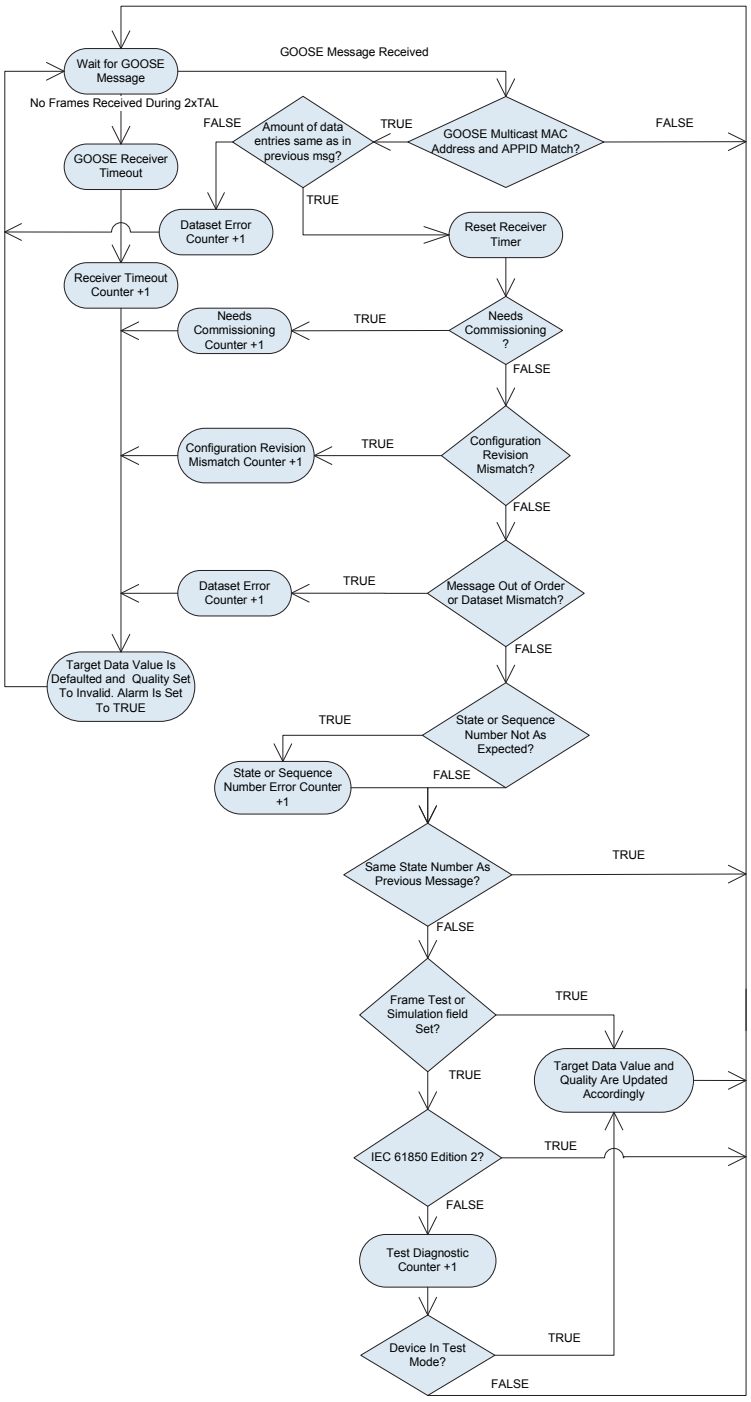

Figure 18: Receiving GOOSE data in the protection relays

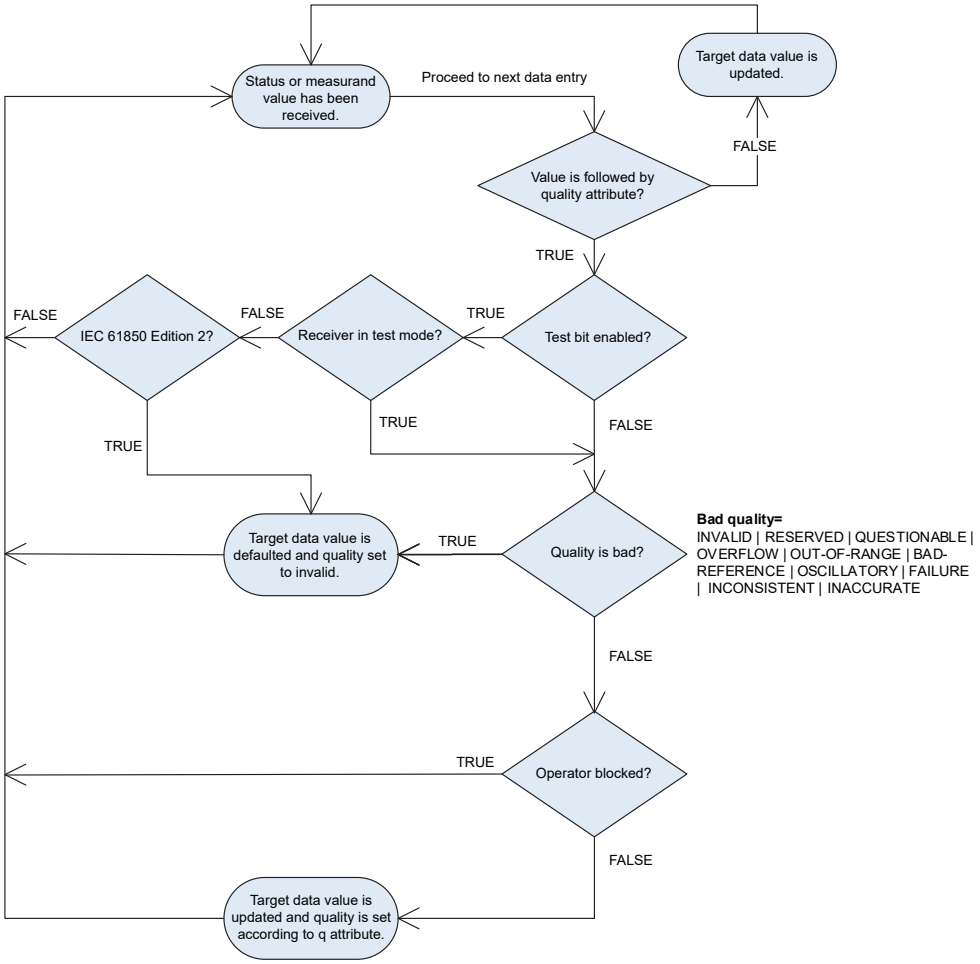

Figure 19: Receiving GOOSE data with quality in the protection relays

Section 6 Engineering of event reporting with PCM600

6.1 Managing IEC 61850 clients with the IEC 61850 Configuration tool

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 the IEC 61850 Configuration tool shows the clients in the client-server communication.

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

6.1.1 Adding new IEC 61850 clients for the IEC 61850 Configuration tool

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 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 IED** and select **IEC61850 IED**.

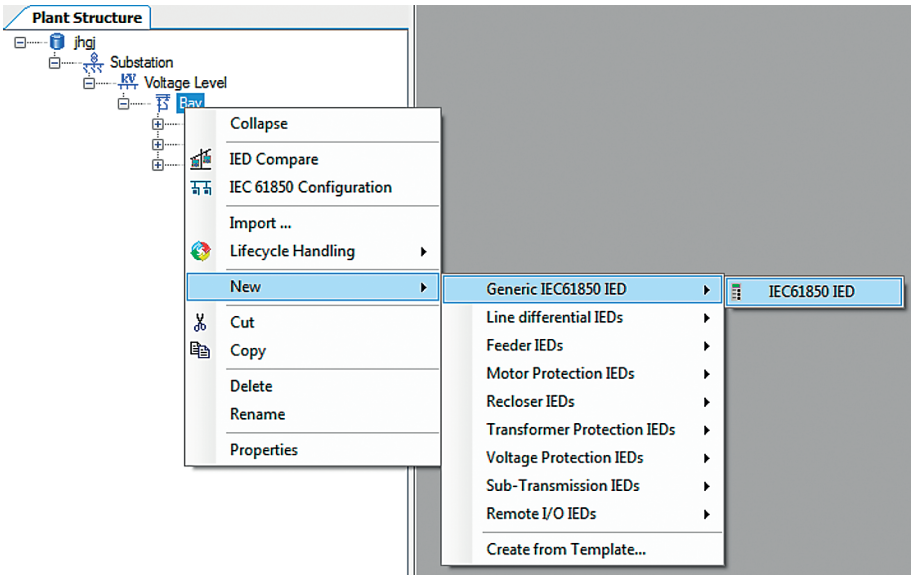

Figure 20: Creating a generic IEC 61850 IED

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

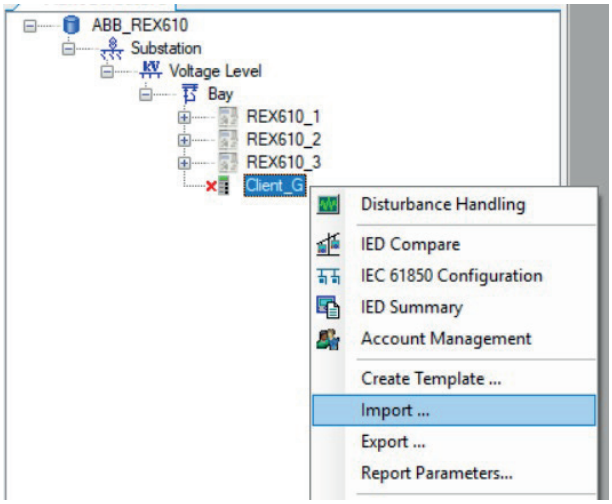

Figure 21: Selecting Import on the shortcut menu

4. Select a valid Client SCL file (ICD or CID) and click **Open** in the file selection dialog box.
5. Select **Ignore PCM Object Type** and then click **Import** in the **SCL Import Options** dialog box.

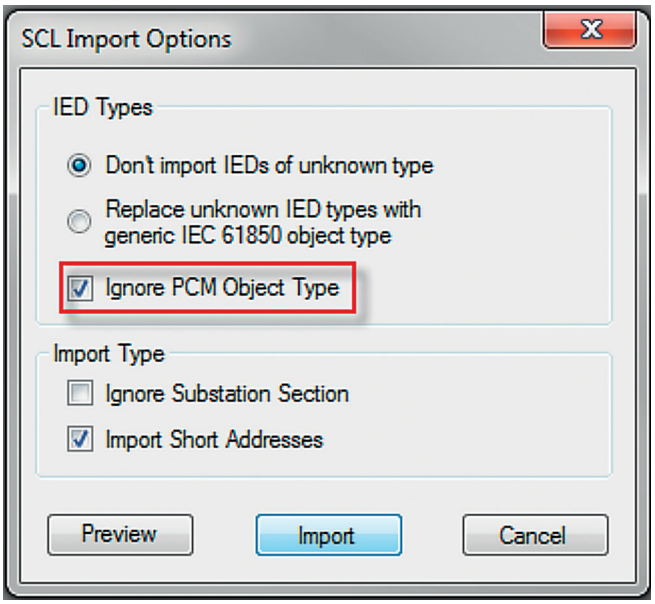

Figure 22: Defining SCL import options

6. Start the IEC61850 Configuration tool and select **Client-Server communication** as engineering mode.

The newly added client should be present in the **Clients** column along with other clients in both the **Data Set** tab and the **Report Controls** tab.

6.2 IEC 61850 Configuration tool user interface

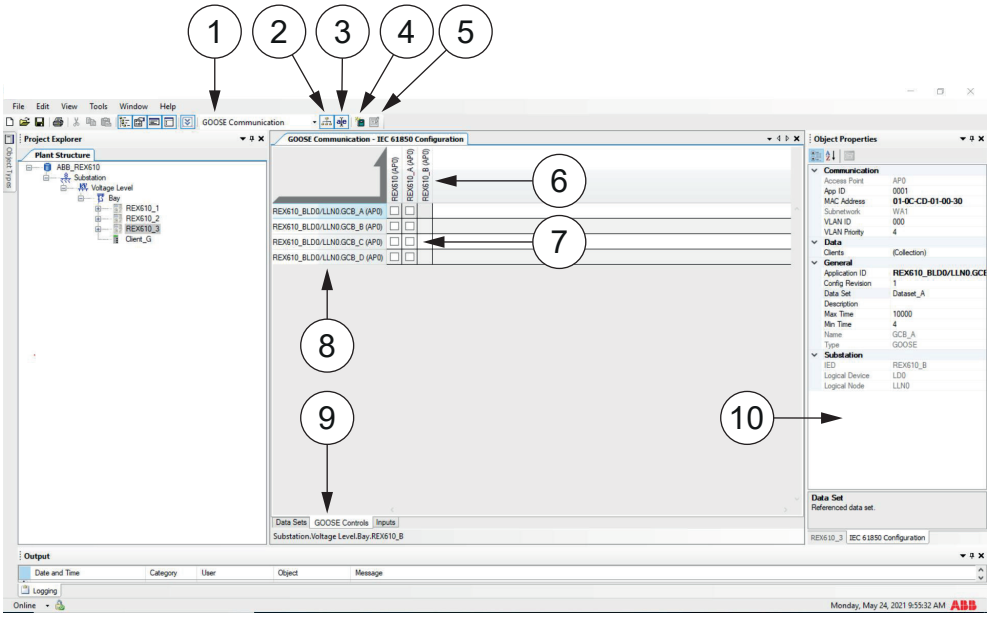

Figure 23: IEC 61850 Configuration tool user interface

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. Three modes are available: “GOOSE Communication”, “Client-Server Communication” and “Process Bus Communication” along with sub-network 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 24: 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
   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/receiving in the selected engineering mode and type is displayed as rows in the mapping grid. The data is context-sensitive, with the current selection in the PCM600 plant structure. A check mark in the row means that the data is sent to or received by an access point. Double-click a data to open the data editor.
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
   - 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.

6.3 Creating data sets with the IEC 61850 Configuration tool

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.

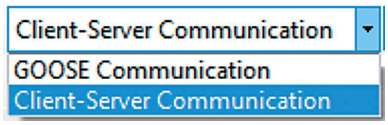

Figure 25: Selecting Client-Server Communication

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.

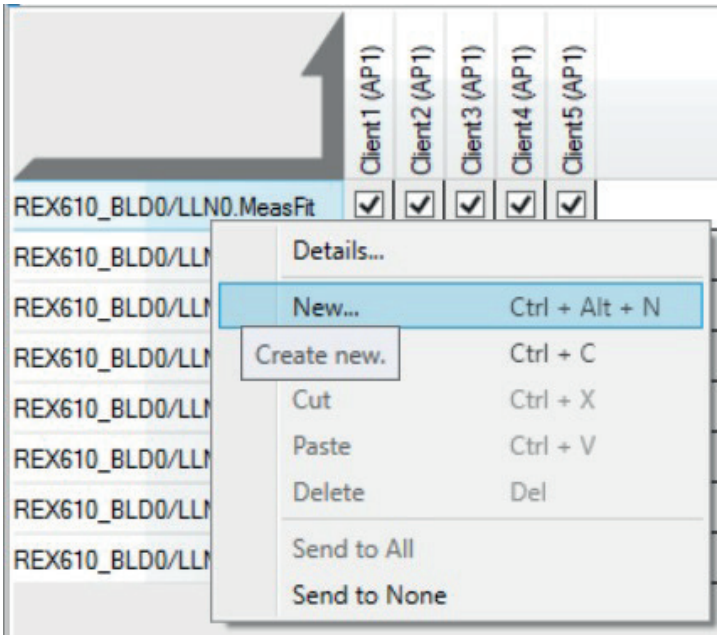

Figure 26: Creating a new data set

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.

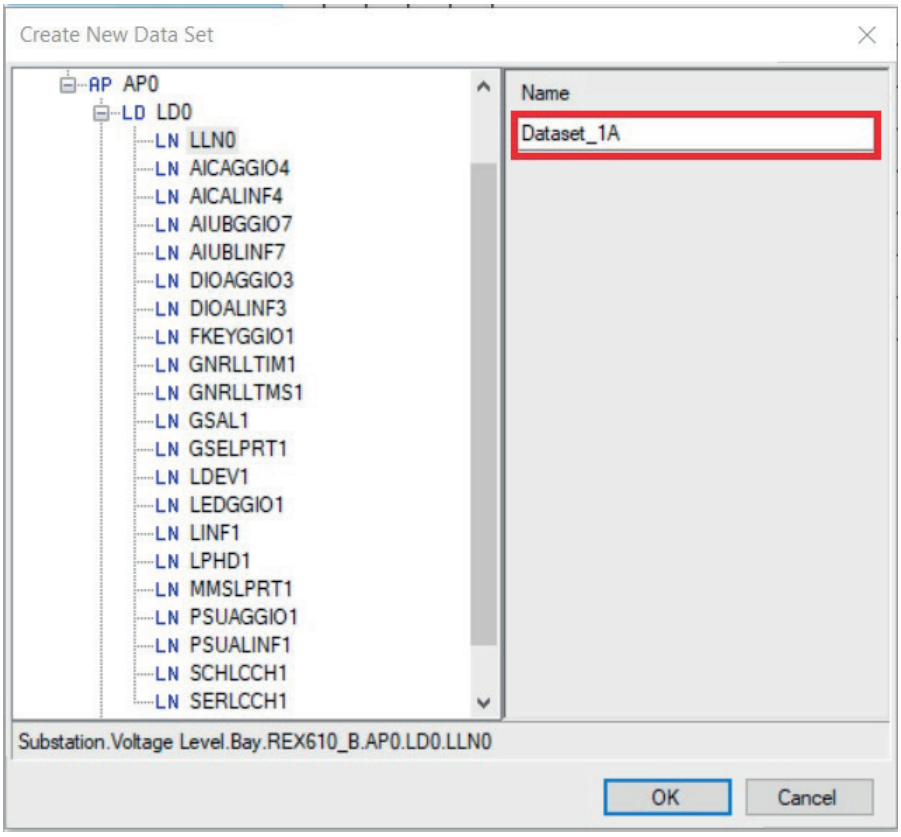

Figure 27: Naming the data set

After creating data sets, define the data set entries (data attributes or data objects) for the data sets.

6.3.1 Defining data set entries with the IEC 61850 Configuration tool

1. Select the **Data Sets** tab.
2. Right-click a data set and select **Details** to add data attributes.

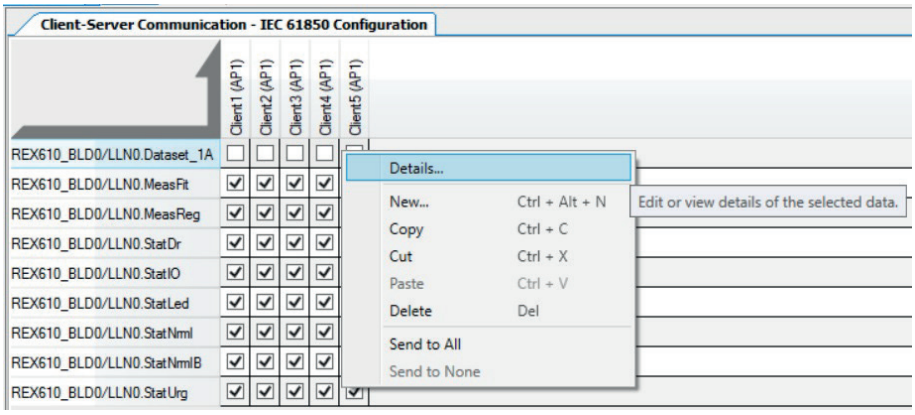

Figure 28: Adding data attributes

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 **Removed 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.

It is not recommended to configure input signals of the function blocks in IEC 61850 reports or GOOSE data sets. Report Control Block or GOOSE Control Block should use the function block output signals instead.

6.4 Creating report control blocks with the IEC 61850 Configuration tool

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 report control blocks and select **New** to add a new report control block.

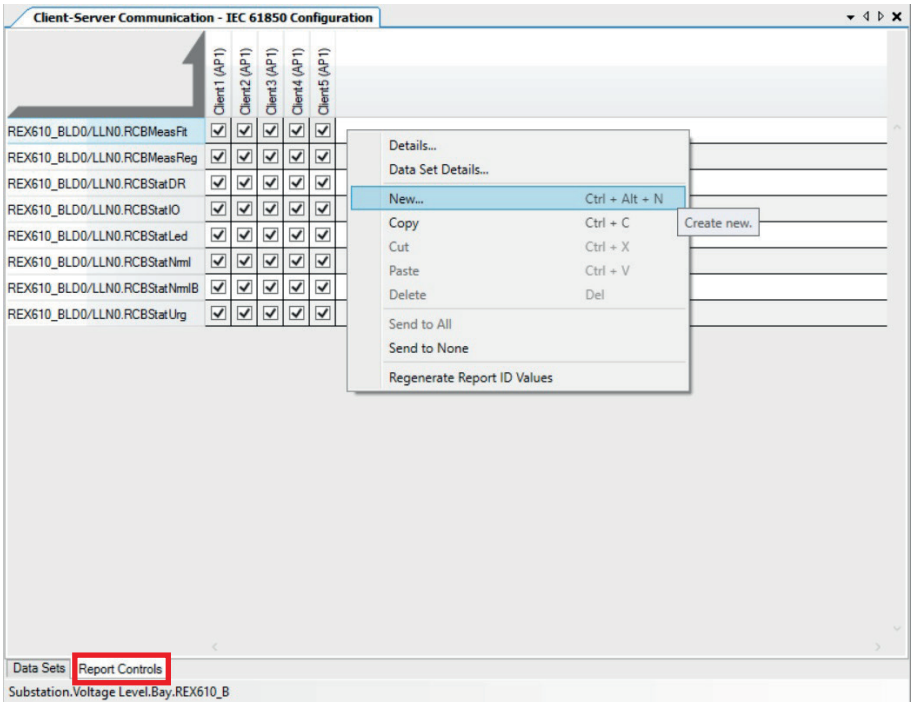

Figure 29: Adding a new report control block

4. Browse to any logical node where the data set is created to define where to place the report control block.
5. Give a unique name to the report control block.
6. In the drop-down list, select the previously created data set to link with the RCB.

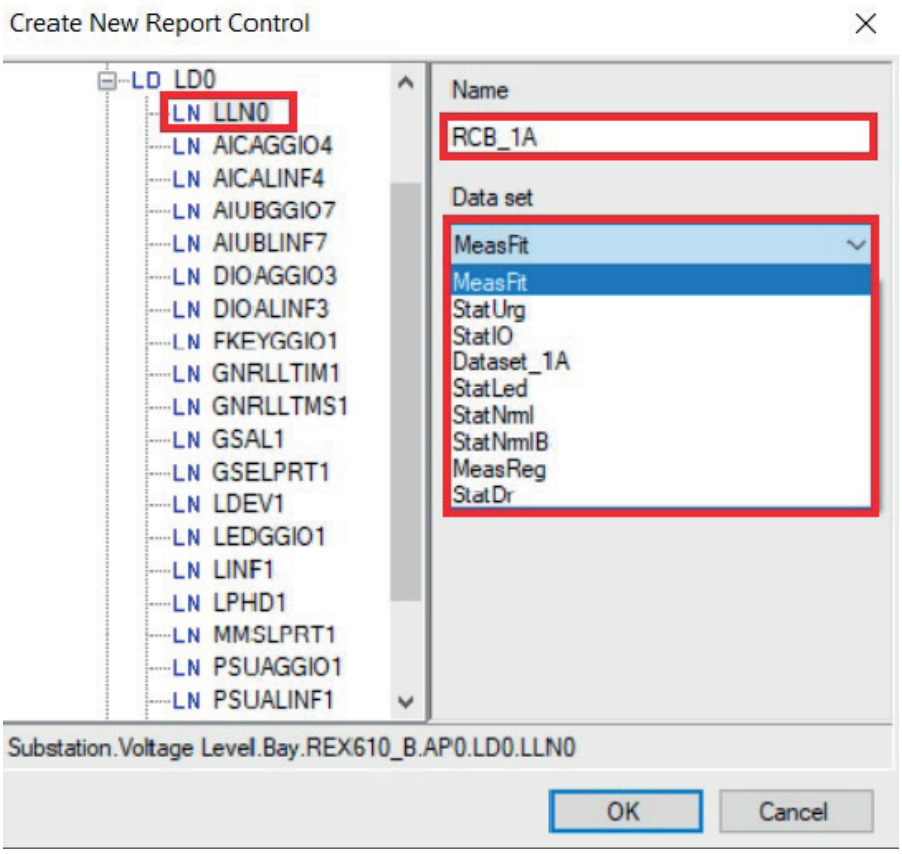

Figure 30: Data set drop-down list

7. Edit the properties and options of the created report control block.

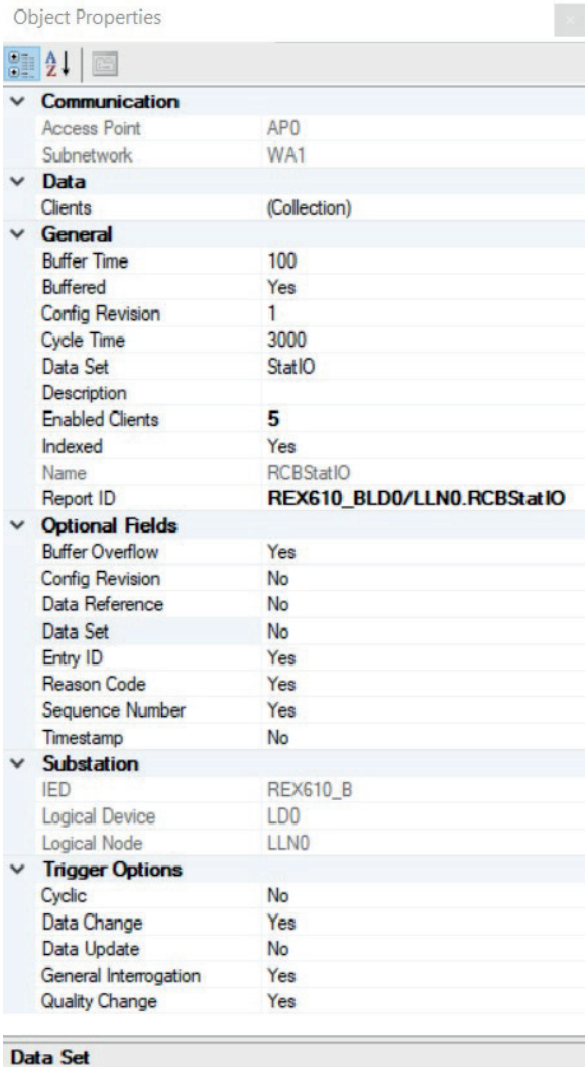

Figure 31: Report control block properties

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

6.5 Configuring RCB clients with the IEC 61850 Configuration tool

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.

The RCB name is limited to 30 characters (without two-digit index number) for IEC 61850 Edition 2.

1. In the **Plant Structure**, click the IED node which is RCB server.
2. Click **Report Controls** tab.
   The rows of the **Report Controls** window show 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 a report control block, click the check-box in the grid, corresponding to the client and RCB.
   Five clients at the maximum can be connected to a RCB.

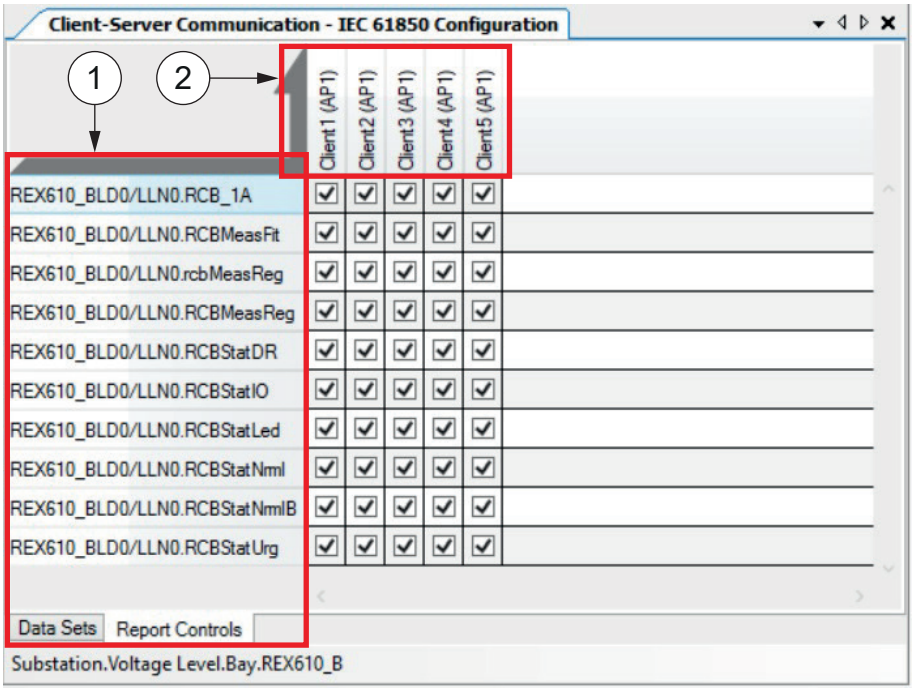

Figure 32: RCB clients

1 RCBs configured for the IED

2 RCB clients

The clients are added or removed automatically to the corresponding data sets in the **Data Sets** tab. Date sets are based on the configuration done in the **Reports Controls** tab and vice-versa.

6.6 Substation section configuration in the IEC 61850 Configuration tool

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. REX610 1.0 does not support automatic mapping of conducting equipment in the substation topology. Thus, IET600 or an equivalent tool should be used for engineering.

At the moment, the IEC 61850 Configuration tool does not support engineering of the substation section. Instead, IET600 or an equivalent tool can be used for engineering, if needed.

Section 7 Glossary

ACSI	Abstract communication service interface
APPID	Application identifier
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.
CTRL	Control logical device
Data set	The content basis for reporting and logging containing references to the data and data attribute values
DR	Disturbance recorder
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FTP	File transfer protocol
GCB	1. GOOSE control block 2. Generator circuit breaker
GoCB	GOOSE control block
GOOSE	Generic Object-Oriented Substation Event
HMI	Human-machine interface
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
IED	Intelligent electronic device
IET600	Integrated Engineering Toolbox
LD0	Logical device zero (0)
LED	Light-emitting diode

LHMI	Local human-machine interface
LLN0	Logical node zero (0)
LN	Logical node
MAC	Media access control
MicroSCADA	Substation automation system
Multicast address	An identifier for a group of hosts that have joined a multicast group
PCM600	Protection and Control IED Manager
RCB	Report control block
SCADA	Supervision, control and data acquisition
SCD	Substation configuration description
SCL	XML-based system configuration description language defined by IEC 61850
SI	Sensor input
TAL	Time allowed to live
TCP/IP	Transmission Control Protocol/Internet Protocol
VLAN	Virtual LAN
XML	Extensible markup language

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