Relion® Protection and Control

615 series
IEC 61850 Engineering Guide

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and 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 IED 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 IED case internals may contain high voltage potential and touching these may cause personal injury.

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

Whenever changes are made in the IED, 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 615 series protection IEDs with PCM600 and IET600. This guide concentrates especially on the configuration of GOOSE communication with these tools. 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 IEDs. 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

The application manual contains application descriptions and setting guidelines sorted per function. The manual can be used to find out when and for what purpose a typical protection function can be used. The manual can also be used when calculating settings.

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

The engineering guide provides information for IEC 61850 engineering of the 615 series protection IEDs with PCM600 and IET600. This guide concentrates especially on the configuration of GOOSE communication with these tools. 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.

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

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

The operation manual contains instructions on how to operate the IED once it has been commissioned. The manual provides instructions for monitoring, controlling and setting the IED. The manual also describes how to identify disturbances and how to view calculated and measured power grid data to determine the cause of a fault.

The point list manual describes the outlook and properties of the data points specific to the IED. The manual should be used in conjunction with the corresponding communication protocol manual.

The technical manual contains application and functionality descriptions and lists function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service.

1.3.2 Document revision history

Document revision/date	Product series version	History
A/2008-05-30	1.1	First release
B/2008-07-02	1.1	Content updated
C/2009-03-04	2.0	Content updated to correspond to the product series version
D/2009-07-03	2.0	Content updated
E/2010-06-11	3.0	Content updated to correspond to the product series version
F/2011-09-19	3.0	Content updated
G/2012-05-11	4.0	Content updated to correspond to the product series version

Download the latest documents from the ABB Web site
http://www.abb.com/substationautomation.

1.3.3 Related documentation

Name of the document	Document ID
IEC 61850 Tissues Conformance Statement (TICS)	1MRS756464
IEC 61850 Protocol Implementation eXtra Information (PIXIT)	1MRS756465
IEC 61850 Protocol Implementation Conformance Statement (PICS)	1MRS756466
IEC 61850 Model Implementation Conformance Statement (MICS)	1MRS756467

Product series- and product-specific manuals can be downloaded from the ABB Web site http://www.abb.com/substationautomation.

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 in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push-button navigation in the LHMI menu structure is presented by using the push-button icons.

To navigate between the options, use ⬆ and ⬇.
- HMI menu paths are presented in bold.
  Select **Main menu/Settings**.
- LHMI messages are shown in Courier font.
  To save the changes in non-volatile 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".
- IED input/output messages and monitored data names are shown in Courier font.
  When the function starts, the `START` output is set to TRUE.

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.

One 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.
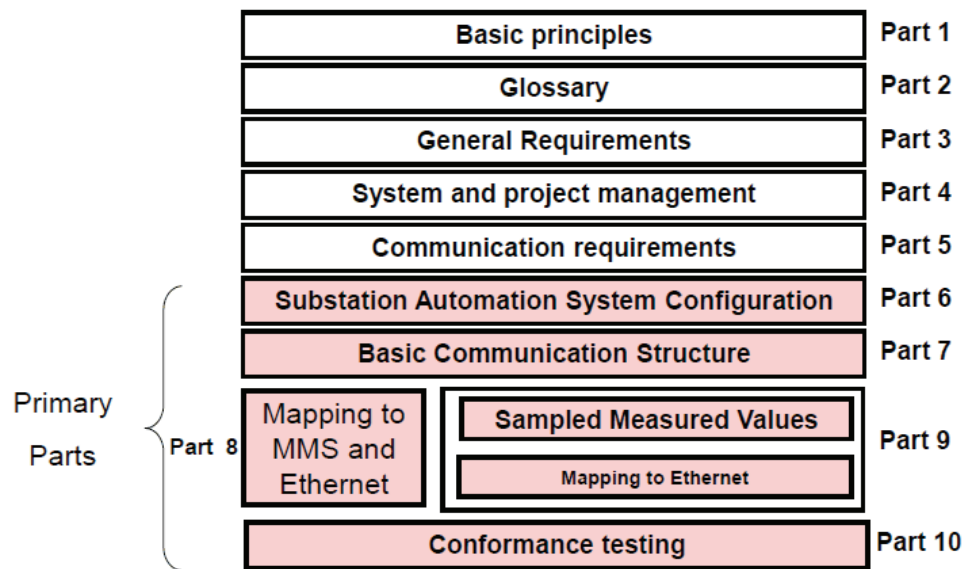
Figure 1:   *Structure and parts of the IEC 61850 standard*

The IEC 61850 standard specifies an expandable data model and 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 parts 8-1, 9-2). However, IEC 61850 is also open for possible new communication concepts in the future.
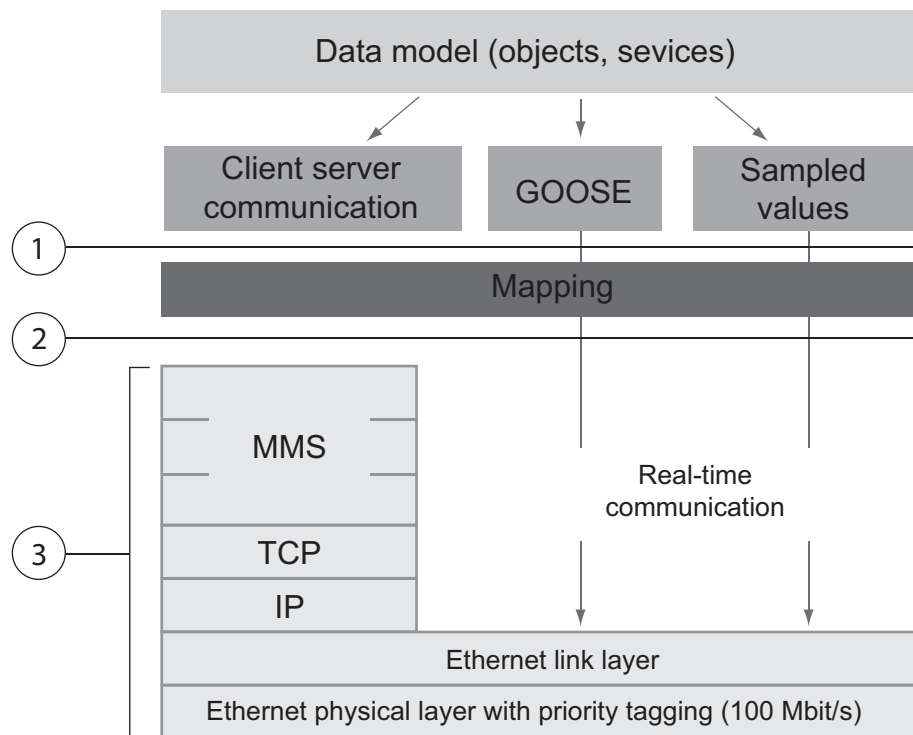
Figure 2:   *Communication stacks and mapping used in IEC 61850*

1   Abstract communication services interface (ACSI)

2   Stack interface

3   ISO/OSI stack

Section 3   PCM600 tool

Protection and Control IED Manager PCM600 offers all the necessary functionality to work throughout all stages of the IED life cycle.

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

With the individual tool components, you can perform different tasks and functions and control the whole substation. PCM600 can operate with many different topologies, depending on the customer needs.

PCM600 is used to conduct complete engineering and configuration activities needed for the bay level IEDs.

Connectivity Packages are separate software packages that provide type and version information to PCM600. Further Connectivity Packages assist the tool with communications.

PCM600 uses IEC 61850 over Ethernet to communicate with bay IEDs. This communication allows PCM600 to configure and monitor the IEDs. In addition to IEC 61850 the IEDs have optional communications protocols and hardware to connect to station engineering tools. PCM600 provides the ability to export the configuration of the IEDs or entire substation in a standard file format which allows for station engineering.

A PC with PCM600 can be connected to any 615 series IED within a station by using the Ethernet connection. The connection can also be used for service and maintenance purposes. In addition, the connection is used to handle disturbance records from the protection IEDs using the IEC 61850 file transfer.

The modern-day IEDs are designed using the concept of the IEC 61850 standard. This is primarily in regards to how functions within the IED are modelled and how the IED is represented in the substation. See the IEC 61850 parameter list for the list of logical nodes available in the IED and observe how they follow the structure and rules as defined in part 7 of the standard.

The engineering of the used communication protocols is a separate task and an addition to the engineering of protection and control functions.

PCM600 can be used for different purposes throughout the IED life cycle. A set of special tools is available for different applications.

The applications can be organized into groups.

- IED product engineering
- IED communication engineering per protocol
- IED system monitoring
- IED product diagnostic

For more information, see PCM600 documentation.

3.1 Connectivity packages

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

A connectivity package includes all of the data which is used to describe the IED. For example it contains a list of what parameters exist, which data format is used, the units, the setting range, the access rights and visibility of the parameter. In addition it contains code which allows software packages that consume the connectivity package to properly communicate with the IED. It also allows for localization of text even when its read from the IED in a standard format such as COMTRADE.

Update Manager is a tool that helps in defining the right connectivity package versions for different system products and tools. Update Manager is included with products that use connectivity packages.

3.2 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.4 SP1 or later
- RED615 Connectivity Package Ver. 4.0 or later
- REF615 Connectivity Package Ver. 4.0 or later
- REM615 Connectivity Package Ver. 4.0 or later
- RET615 Connectivity Package Ver. 4.0 or later
- REU615 Connectivity Package Ver. 4.0 or later

Download connectivity packages from the ABB Web site http://www.abb.com/substationautomation

3.3   IET600

PCM600 Engineering Pro includes the Intergrated Engineering Toolbox IET600. IET600 is used to configure the 615 series IEDs for use in IEC 61850 horizontal communication and to edit client and event reporting properties.

IET600 acts as a system tool which is used to define and share the system-wide 61850 parameters, such as communication addresses, horizontal communication data and its priorities and client/server (system level/IED) connections. The actual configuration of the IED and the downloading of configuration changes are done with PCM600.

Section 4   615 series data model

4.1   615 series implementation

If the IED is ordered with no Ethernet communication interface, the front port on the device still works according to IEC 61850. All settings and configurations are changed by using IEC 61850 via the front Ethernet port of the LHMI. Without the Ethernet option, event reporting or peer-to-peer services cannot be used.

ABB 615 series IEDs have been designed around IEC 61850. This means that the functionality of the IED is represented in a data model in accordance with the standard and the IEDs support a range of the services provided by the standard.

- Process data: monitoring of status information, measurements
- Application data: protection activations, tripping, fault recordings
- Disturbance recorder files
- Control commands
- Protection settings
- Setting groups
- Configuration data
- Self-supervision messages
- Fast horizontal communication between devices
- Time synchronization

4.2   Information model

ABB 615 series relays are modelled in IEC 61850 using three logical devices.

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

Generic functionality, such as physical inputs and outputs as well as the alarming LED functionality, resides under LD0.

> Different configurations have different data models.

During system engineering in the system configuration tool, do not delete or rename logical devices, logical nodes, data objects or data attributes in IEC 61850 data model.
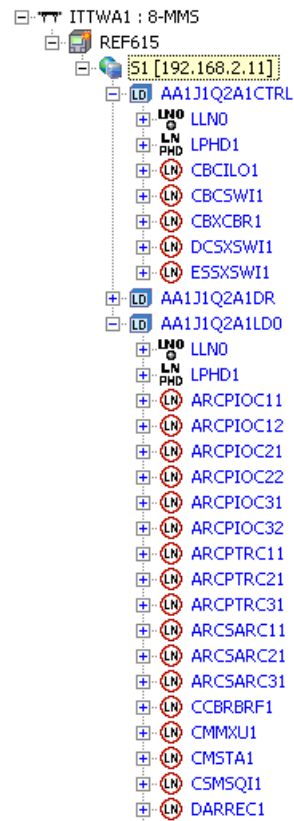
Figure 3:   *Example of an IEC 61850 data model of a 615 series IED*

In the IEC 61850 standard, communications 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 modelled under LLN0 which is a special logical node that describes common functionality of the logical device.

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 615 series IEDs are capable of vertical communications which is between the IED and monitoring and control systems such as PCM600 or MicroSCADA. Each IED has five separate clients with which a client can read or write data (an active

PCM600 connection is considered to be a client). The IED can report data in either buffered or unbuffered mode and execute control sequences.

The 615 series IEDs are also capable of horizontal or peer-to-peer communications. They can be programmed to publish (send) information to and subscribe (receive) information from other devices according to the IEC 61850-8-1.

4.3.1 Predefined vertical communication data sets

In vertical communications, the IED can generate events that are automatically reported to any listening clients. These communications are configured via a series of nine 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 data sets and report control blocks can be modified using IET600, however, this should only be done by individuals that are extremely familiar with both the 615 series IEDs and IEC 61850. Inappropriate modifications can result in misoperation of the IED.

- StatIed– generic status information of IEDs
- StatIo – inputs, outputs, LEDs
- StatUrg – measurement limit supervision, control feedback
- StatNrmlA and StatNrmlB – protection start and trip signals, auto-reclose status
- StatDR – digital fault recorder status
- MeasReg – registered measurement values at faults
- MeasFltA and MeasFltB – measurements

The 615 series supports both buffered and unbuffered reporting. In the predefined configuration all report control blocks are configured to use buffered reporting. Further, a single data set can only be used by one report control block, and the same data set entry cannot be used in different data sets.

The default values for the data sets and control blocks are suitable for most applications. Only users who have an in-depth understanding of the IED and IEC 61850 should modify the default configuration.

Vertical communications protocols, such as Modbus, rely on the data sets for event generation. Modification of the default configuration will have an impact on vertical communications.

615 series allows free renaming and editing of report control blocks and datasets. However, it is mandatory to keep certain signals in datasets for 615 series IEDs as removing signals from datasets affect also the available events in the local HMI. Data objects PhyHealth, PhyHealth1and PhyHealth2 from logical node LD0.LPHD1 give indications of the IED internal or system configuration faults and these must be available in some of the IEC 61850 datasets.

Datasets define also the status events which are available in the local HMI event list.

It is not recommended to mix status (FC=ST) and measurement (FC=MX) data to the same dataset due to the IED internal event handling.

A 615 series IED can have at maximum 14 configured data sets and 10 report control blocks for event handling. The maximum length for a data set is 256 data attributes. Report data sets define the data in the data object level. The amount of data attributes within a data object varies, however, a 615 series IED can have 1500 data attributes in data sets in total.

615 series IEDs do not support defining data on data attribute level for data sets used for vertical reporting. Only data object level is allowed.

4.3.2 Vertical communication diagnostic counters

The IEC 61850 data model of the 615 series IEDs includes a logical node LD0.MMSGGIO1 for IEC 61850 vertical communication diagnostic. The counters are available via the HMI or PCM600 path **Monitoring/Communication**.

Table 1:   Diagnostic data objects

Data object	Description	Diagnostic information
IntIn1	Successful connections	Number of succeeded client connection attempts
IntIn2	Failed connections	Number of failed client connection attempts
IntIn3	Concludes	Number of session concludes
IntIn4	Sent aborts	Number of association aborts sent by server
IntIn5	Received aborts	Number of received association aborts by server
IntIn6	Sent rejects	Number of sent rejects by server
IntIn7	Received request	Number of received client requests
IntIn8	Failed requests	Number of failed client requests
IntIn9	Reads	Number of variable reads
IntIn10	Failed reads	Number of failed variable reads
IntIn11	Writes	Number of succeeded variable writes
Table continues on next page		

Data object	Description	Diagnostic information
IntIn12	Failed writes	Number of failed variable writes
IntIn13	Reports	Number of sent reports
IntIn14	Active connections	Number of active client connections

To reset the vertical communication diagnostic counters, write `true` to RstCnt.Oper.ctlVal attribute under MMSGGIO1.

GOOSE communication has its own diagnostic counters.

4.4 Parameter setting and disturbance recorder

The protection function parameters can be set and the active setting groups changed by using the standard IEC 61850 services. Disturbance recorder files in COMTRADE format are retrieved by using PCM600.

When setting the parameter **Configuration/Communication/MMSGGIO1/Unit mode** to *Primary*, the values sent over IEC 61850 are scaled according to the CT and VT settings. Reset the SW after changing the parameter. This feature is needed if the SCADA system or substation gateway does not handle scaling from nominal values.

Disturbance recorder files in COMTRADE format are also retrieved by using the IEC 61850 compatible services from the **/COMTRADE/** directory.

Section 5   GOOSE

5.1   Horizontal communication

GOOSE is used in substation automation for fast horizontal communication between the IEDs. GOOSE can be used for direct data exchange, for example, of interlocking and blocking information between IEDs. According to the IEC 61850-8-1 standard, GOOSE uses a publisher/subscriber profile in which information is shared from one IED to one or several IEDs 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 615 series IEDs.

A 615 series IED can send any type of status or measurand data in the GOOSE messages from its IEC 61850 data model. The status data response time, that is, the time it takes for the application to handle a received GOOSE message and to send the concerned data back to the network, is with the 615 series IEDs below 3 ms. The response time fulfils the tightest Type 1A, Class P2/3 requirements of the standard.

When a 615 series IED is configured to send measurements, the analog, integer or counter type of data should be placed on its own dataset. The triggering of analog type of data sending is controlled by deadband handling, zero-point clamping and limit supervision.

The horizontal communication configuration consists of the IEDs' GOOSE control block, data set and GOOSE input configuration. The result of the configuration work is a system configuration file which can be downloaded to the IEDs. The used files in the workflow are IEC 61850 standard format SCL files.

5.1.1   Configuring horizontal communication

See detailed descriptions of the steps in corresponding chapters.

1. Add devices to a PCM600 project.
2. Export the SCD file.
3. Import the SCD file to IET600.
4. Engineer the GOOSE connections between the devices.

4.1. Define the published GOOSE data and control blocks.
4.2. Define the subscribing IEDs for the GOOSE data.
5. Export the SCD file back to PCM600.
6. In PCM600, engineer the IED applications with GOOSE inputs.

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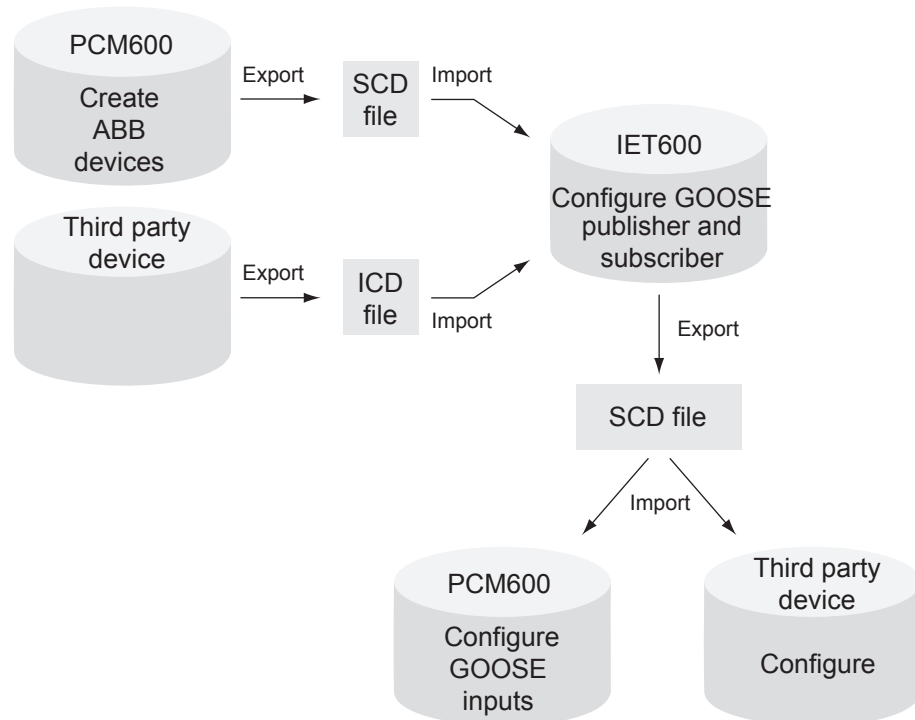

Figure 4:   Horizontal communication configuration process

5.2   GOOSE publishing properties

GOOSE data is transmitted at regular intervals in 802.1Q multicast frames over the LAN. Peer devices can determine the state of the communications by listening for the transmissions. When the data changes state the data is transmitted at a greatly increased frequency to ensure the timeliness of its reception and then gradually tappers off to the original transmission frequency with the new data.

In GOOSE, data sending is based on data sets and GOOSE control blocks. The data set defines what IED data is used in GOOSE service and sent to local Ethernet

subnetwork in a GOOSE message. The GOOSE control block links the data set and its attributes to actual data.

Table 2:   *GOOSE control block attributes*

GoCB attribute	Description
Multicast address	A multicast addressing scheme is used when sending GOOSE 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.
Ethernet frame-specific information (802.1 Q tagging info: APPID, priority and VLAN id)	APPID is a GoCB-specific integer value identifying the sender GoCB and its data. The APPID must be unique for the GoCB in the system. The priority can be used according to the local network priority scheme, but normally the default value is sufficient. The VLAN group can be used when configuring the Ethernet network topology Virtual LANs for routing and filtering multicast messages. Configuration is done in managed Ethernet switches.
GoCB name	The name of the GoCB structure seen from the IEC 61850/MMS client. Some IEDs use this as a unique data reference.
GoID	A GOOSE control block specific string. The default value is the GoCB path in the 61850 namespace if nothing is set. It is recommended to set the value in IET600. Check the GOOSE Control block GoID name according to the system requirements of the receiving device. Although the 615 series IEDs use MAC address and APPID for receiving packet detection, some devices require that the GOOSE control block GoID is named explicitly.
Data set definition	Data sent in GOOSE messages to the network.
ConfRev	ConfRev increases when the referenced data set is modified. Both the GOOSE sender and the receiver must have the same ConfRev value. This ensures that the both IEDs have the same configuration level in the substation configuration. ConfRev usage is done automatically by tools. If the latest system configuration is not downloaded to all required IEDs, the configuration revision may differ between the receiver and sender.

5.3   Configuring GOOSE

5.3.1   Defining IEDs and exporting the SCD file

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

> For more information, see PCM600 documentation.

1. Create a PCM600 project with all the needed IEDs.
2. To export the SCD file, click the **Plant Structure** tab, right-click the substation node in the submenu and select **Export**.

The file includes the whole substation configuration in SCL format for other tools.
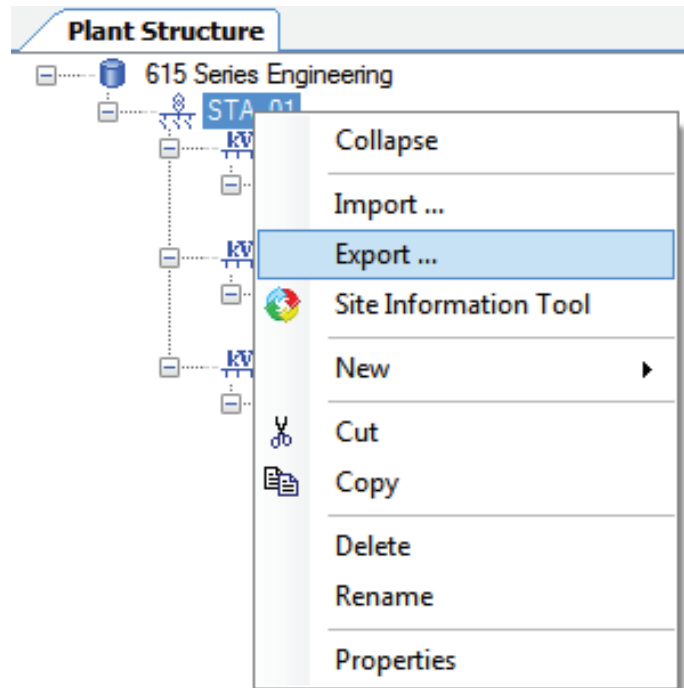

Figure 5:   *Exporting an SCD file from PCM600*

3. Define the export options.

   A dialog box with several options opens. As IET600 does not use the private sections, this section is not important (other ABB tools such as COM600 and MicroSCADA do use the private sections). It is important to not export as a template and make sure that all of the other options to include sections are selected.
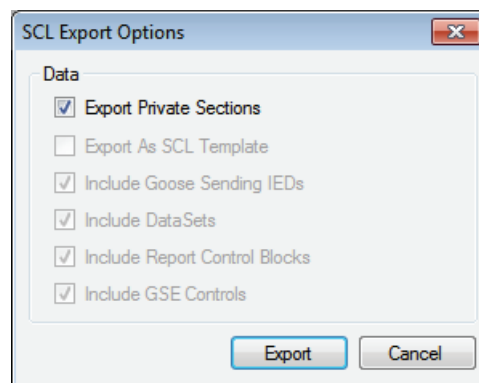

Figure 6:   *Export options for an SCL file*

4. Click **Export**.

5.3.2   Creating an empty project

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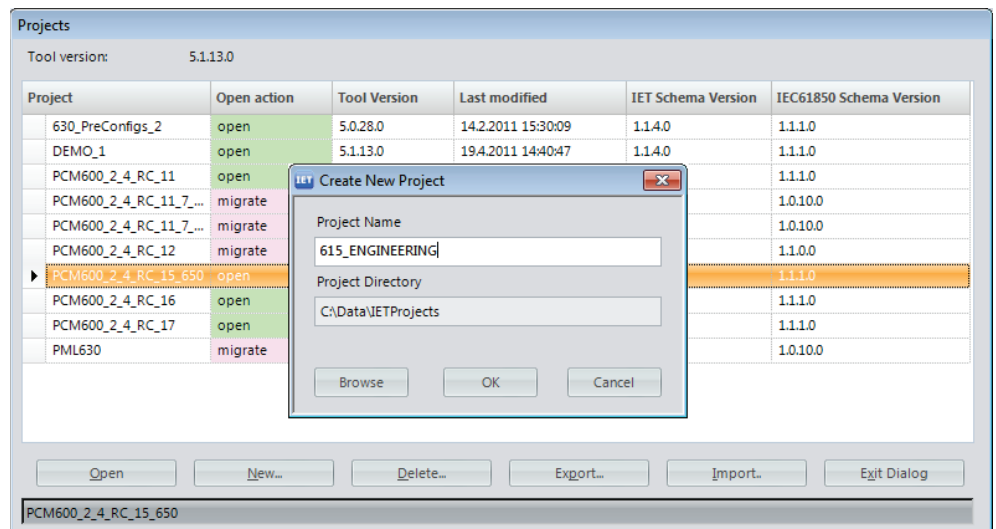4. In the **Projects** dialog, click **New**.
5. Name the project.

Figure 7:   Naming a project

6. To select the destination folder for the project, click **Browse**.
7. Click **OK**.

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

5.3.3   Importing the SCD file

1. Import the SCD file from PCM600 to the empty project.

    •   Click **Import SCL File** on the shortcut menu of the project object
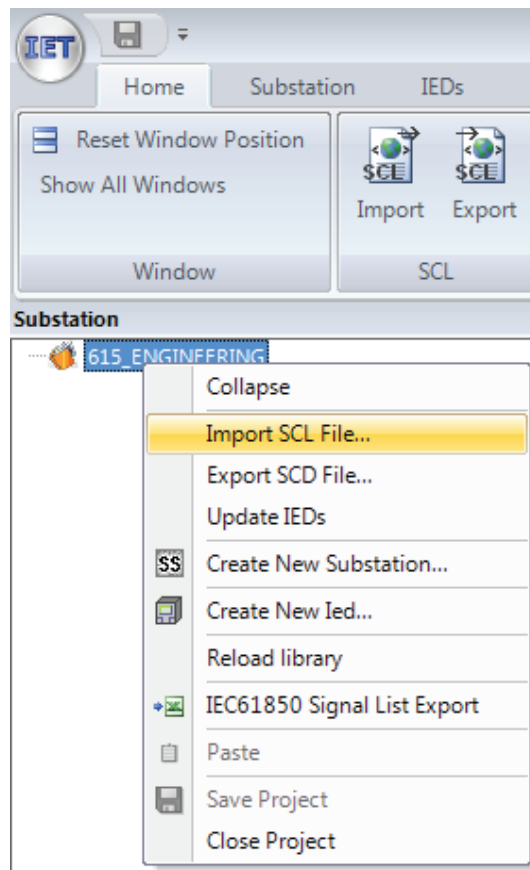   •   Click the **Import** button

Figure 8:   Importing an SCL file

2.   Locate the SCL file and click **Open**.

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

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

5.3.4 Configuring a GOOSE publisher

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.

> A 615 series 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.

5.3.4.1 Creating a GOOSE data set

Define the sending data set used by the GOOSE control block. With the 615 series IEDs, the sending GOOSE data set can have at maximum 20 data attributes to minimize the message handling load in receiver and sending IEDs.
All data sets must be configured under the logical node LLN0 and must be provided with names unique within the IED. In 615 series IEDs there are a maximum of four GOOSE control blocks allowed, which effectively limits the relay 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 **IEDs** tab in the navigation pane.
2. Click the IED node.
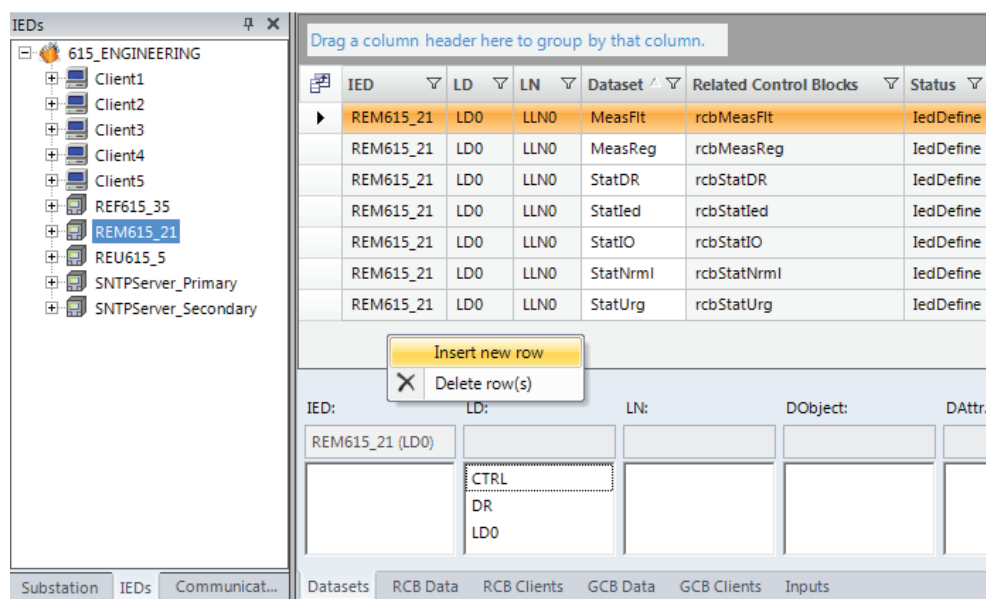3. Click the **Datasets** tab in the editor pane.

Figure 9:   Creating a data set in IET600

4.   To add a new data set, right-click on the area containing the data set names and select **Insert new row** on the shortcut menu.
5.   Define the LN where the data set is to be placed (accept preselected "LD0/ LLN0") and give the data set a unique name.
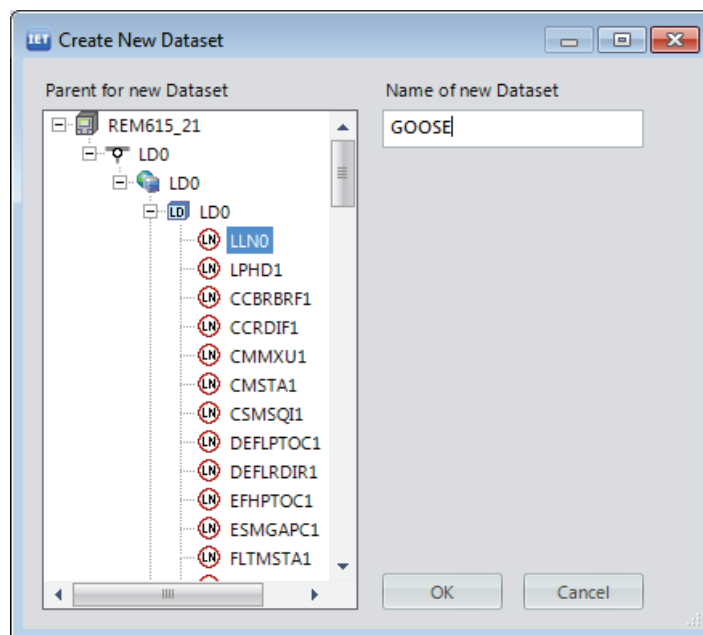

Figure 10:   Naming a data set in IET600

After creating the GOOSE data sets, define the data attributes for the data sets.

Defining data attributes

1. Select the **Datasets** tab on the editor pane.
2. Select a GOOSE data set.
3. Using the selection lists below the data set grid, select a data attribute to be used.

   - Click **Append >>** to add the data attribute to the end of the data set.
   - Click **Insert >** to add the data attribute above the selected row in the data set entries list.

A maximum of 20 data attributes can be added to a single GOOSE data set. If the configured published data set is larger, it is not accepted by the IED.

Figure 11:   Adding data set entries

The possible amount of attributes that can be added to a data set and the amount of already added attributes is shown above the data set entries list. However, since IET600 cannot make a difference between the maximum data attribute count of a data set for vertical reporting and a GOOSE data set, too high a maximum value is shown for a GOOSE data set.

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

The data set entries must be single data attributes, such as stVal and q.

A full list of the available signals with descriptions and IEC 61850 names is available in a file in the connectivity package installation directory, such as `C:\Program Files\ABB\Connectivity Packages\REF615\4.0\Documents\EN\IEC\RE_615 IEC Parameters_1MRS756606x.htm`

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

5.3.4.2 Configuring a GOOSE control block

1. Select the IED node on the **IEDs** tab in the navigation pane.
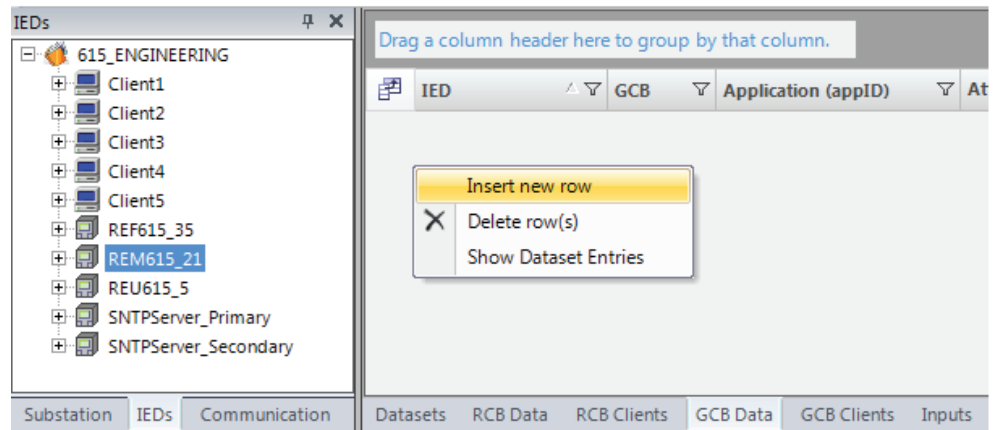2. Select the **GCB Data** tab in the editor pane.

Figure 12:   Creating a GOOSE control block

3. To add a new GOOSE control block, right-click the area containing the existing GOOSE control blocks and select **Insert new row** from the shortcut menu.
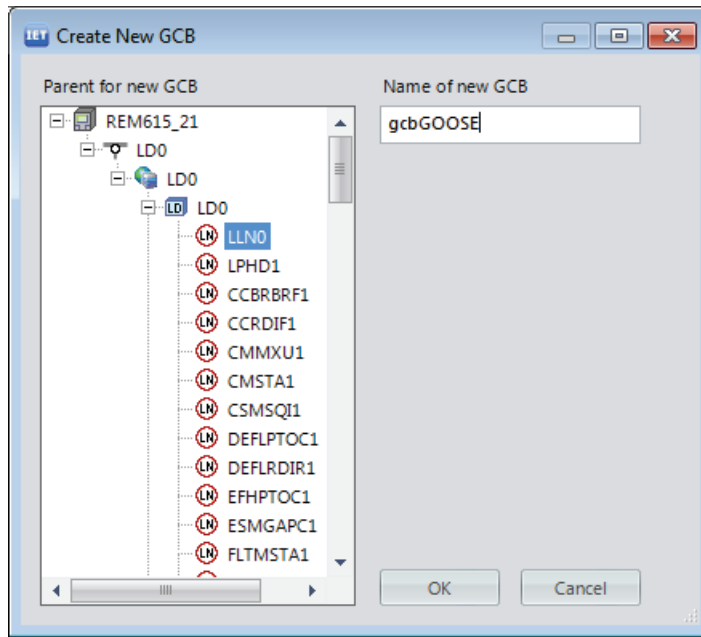
Figure 13:   Naming a GOOSE control block

4. Browse to LLN0 under LD0 to define where the GOOSE control block is to be placed.
5. Give a unique name to the GOOSE control block.
6. In the **Attached Dataset** drop-down list, select the previously created data set. After creating the GOOSE control block, edit its properties and addresses. Edit at least **MAC Address** and **APP-ID**.

IED	GCB	Application (appID)	Attached Dat	t(min)	t(max)	Conf.Rev	MAC Address	APP-ID
REM615_21	gcbGOOSE	REM615_21	GOOSE	10	10000	10000	01-0C-CD-01-00-15	0015

Figure 14:   GOOSE control block properties

> To set the visibility of the GoCB columns, click the top left icon of the table and enable/disable the columns in the **Field Chooser** dialog.
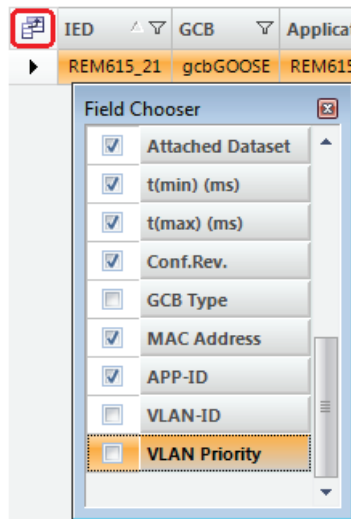
Figure 15:   Field Chooser dialog

Table 3:   Selected GOOSE control block properties

GoCB property	Description
GCB	GOOSE control block name
Application (appID)	A unique GoID for each GoCB in the system. Recommendation is to define a device-specific value and not to use the default empty value.
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 615 series 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.
Conf.Rev.	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. "Configuration Revision" cannot be manually edited in IET600.
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.
Table continues on next page	

GoCB property	Description
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 the recommended, if there is no need to split the logical network. The VLAN identifier is a 3-character HEX 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.

With the 615 series IEDs, only *t(max)* is configurable, not *t(min)*.

Conf.Rev. cannot be manually edited. IET600 updates it automatically to the next multiple of 100 when the configuration changes.

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

5.3.5 Configuring a GOOSE subscriber

A 615 series 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.

5.3.5.1 Configuring GOOSE inputs

1. Select the root node on the **IEDs** tab in the navigation pane.
2. Click the **GCB Clients** tab in the editor pane.
   The rows of the GCB client editor show GoCBs, that is "senders", and the columns show the IEDs available as GOOSE clients, that is "receivers". If the client IED is not on the same subnetwork as the GoCB sender, it cannot be configured as a client.
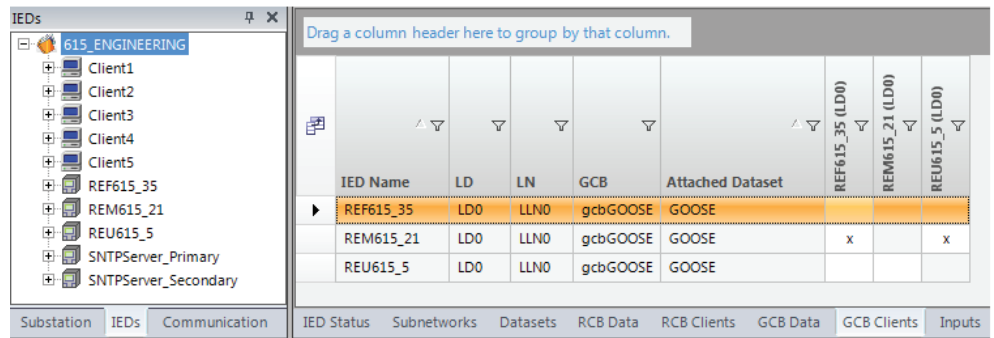
Figure 16:   GCB client editor

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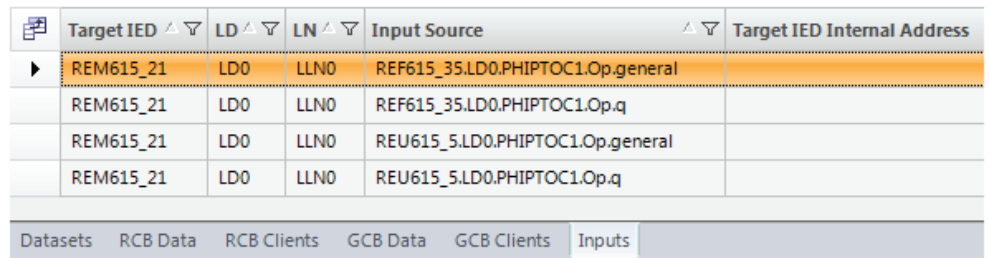Upon adding or removing clients, the corresponding input sections are
updated automatically.

Figure 17:   GOOSE inputs

5.3.6   Finalizing GOOSE configuration

5.3.6.1   Exporting the SCL file

1. Export the SCL file.
   - Click **Export SCD File** on the shortcut menu of the project object
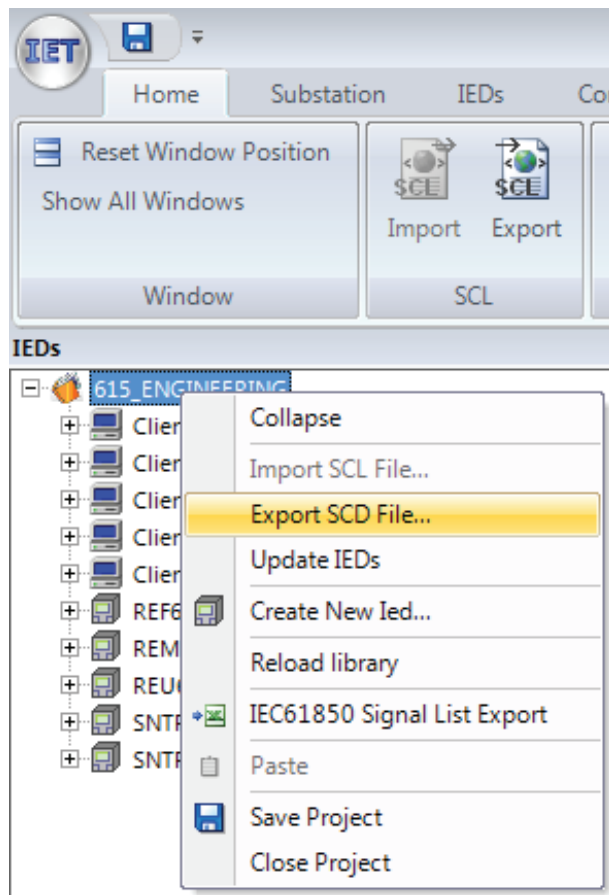   - Click the **Export** button.

Figure 18:   Exporting an SCD file

2.   Select the file destination and click **Save**.
     It is recommended to leave the SCD file exported from PCM600 as a backup.

5.3.6.2   Importing the SCL file

1.   Open PCM600 and make sure the original project is open.
2.   Go to the **Project Explorer** view and select the **Plant Structure** tab.
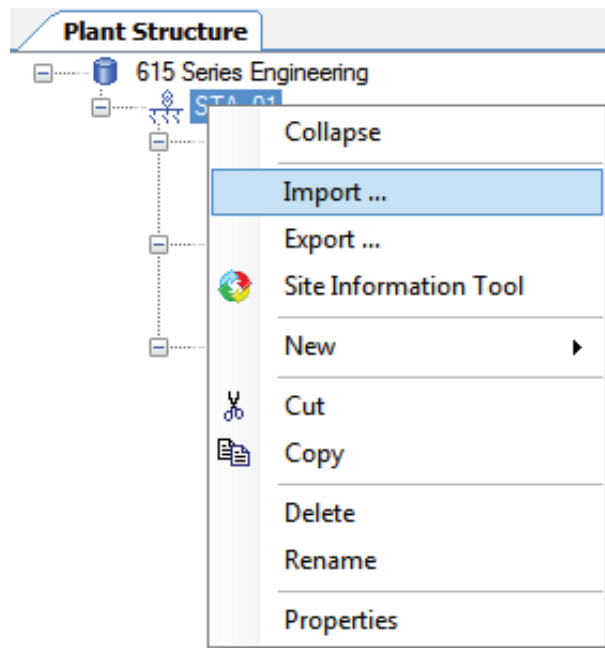3.   Right-click the project and select **Import**.

Figure 19:   Importing an SCD file to PCM600

4.   Open the SCL file exported from IET600.
5.   In the **SCL Import Options** dialog box under IED Types, select **Don't import IEDs of unknown type** if the GOOSE configuration does not include third party devices.
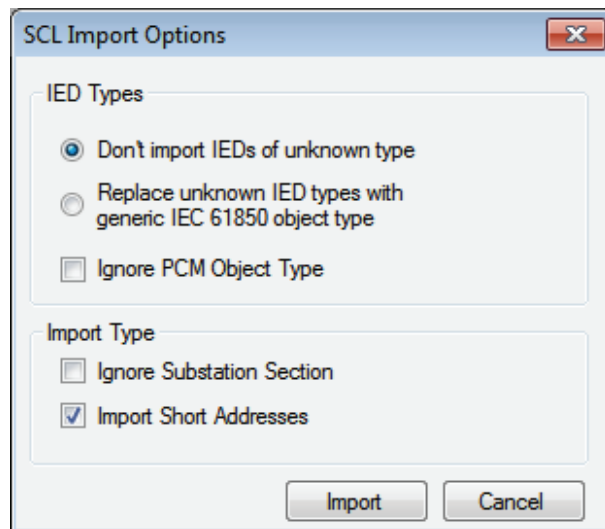

Figure 20:   SCL import options in PCM600

6.   Click **Import**.

For more information, see PCM600 documentation.

5.3.6.3   Connecting GOOSE inputs to an IED application

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

The GOOSERCV function block can only be added by using 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.
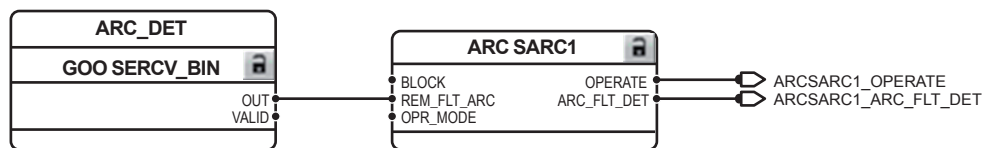

Figure 21:   Adding the GOOSERCV function block

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 IED, and select **Signal Matrix**.
5. To map the input points to the receiving input data, click the cell.
   To expand the source field, click the edge of the field and expand it until the whole GOOSE source address is visible.
6. In Signal Matrix tool in the GOOSE sheet, the GOOSE publisher data is mapped 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 22: GOOSE sheet in Signal Matrix tool

The GOOSE receive 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 IED startup phase, the IED 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.

In Signal Matrix tool, the received GOOSE data can be directly connected to the IED application. The GOOSE inputs are shown on the Binary or Analogue 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 IED 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 tool.

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

5.4　　　　Received GOOSE message handling

A GOOSE frame is not accepted if the Needs Commission bit is set. A frame with the Test bit set is only accepted if the receiving IED is also in the test mode. The Test bit is active in the sender if the IED is set to test mode.

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

The GOOSE frame is also not accepted if the ConfRev deviates from the one in the configuration. These error situations can be observed in the GSEGGIO1 diagnostic counters.

The default GOOSE input value is 0 for the all data types. This value is used when the subscribed GOOSE data is corrupted, or it is not received from the network and the peer IED is considered to be in a time-out state.

If a peer device sends the data including the quality attribute, the receiver IED 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.

5.5　　　　GOOSE supervision

5.5.1　　　　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 IED is not available or there are communication time-outs.

If there are no GOOSE-related data changes, the 615 series IED resends the 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 IED should use an enabled signal for interlocking and a blocking-type signal for protection.

5.5.2   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 input, FALSE (0), is taken into use when there is a communication error on the receiver side. If one IED application function block input receives several signals from several IEDs, the input value is calculated in OR or AND operation 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 copper cables connected between IEDs having no detection of single data loss. In all cases, however, a separate alarm event is always generated by the GSEGGIO1.Alm data object for IEC 61850 event clients.

GSEGGIO1.Alm can also be used on the application side as an input in the Signal Matrix Tool's Binary Outputs sheet (signal GSEGGIO ALARM). For example, it is possible to change the setting group in case one or several IEDs are disconnected from the network.

5.5.3   Alarm supervision in application

In a communication time-out situation, all the peer IEDs 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.

5.5.4   Diagnostic counters

The IEC 61850 data model of the 615 series IEDs includes a logical node LD0.GSEGGIO1 for the GOOSE communication diagnostic. The counters are also available via the HMI or PCM600 path **Monitoring/I/O Status/Communication/ GSEGGIO1/Monitoring**.

It is possible to reset the counters via **Monitoring/I/O Status/Communication/ GSEGGIO1/Monitoring/Reset counters** and via the IEC 61850 communication by writing `True` to the GSEGGIO1.RstCnt.Oper.ctlVal data attribute.

Table 4: *Diagnostics data objects*

Data object	Description	Diagnostics information
IntIn1	Received messages	When increasing, the IED is receiving GOOSE messages.
IntIn2	Transmitted messages	When increasing, the IED is sending GOOSE messages.
IntIn3	Received state changes	Received GOOSE messages with a new stNum value
IntIn4	Received sequence number	Received GOOSE retransmissions or heartbeat cycle messages with a new sequence number
IntIn5	Received frames with test bit	Received GOOSE frames with the test flag on
IntIn6	State errors	Number of notified state number jumps
IntIn7	Sequence errors	Number of notified sequence number jumps
IntIn8	Receiver time-outs	Number of notified peer IED time-outs
IntIn9	Received ConfRev mismatches	When increasing, there is a mismatch between the received GOOSE frame information and the used GOOSE configuration.
IntIn10	Received frames with Needs Commissioning	One peer IED Indicates that its configuration is not valid or up-to-date.
IntIn11	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 IED is in time-out.

GOOSE Alarm is activated in the receiver IED in certain situations.

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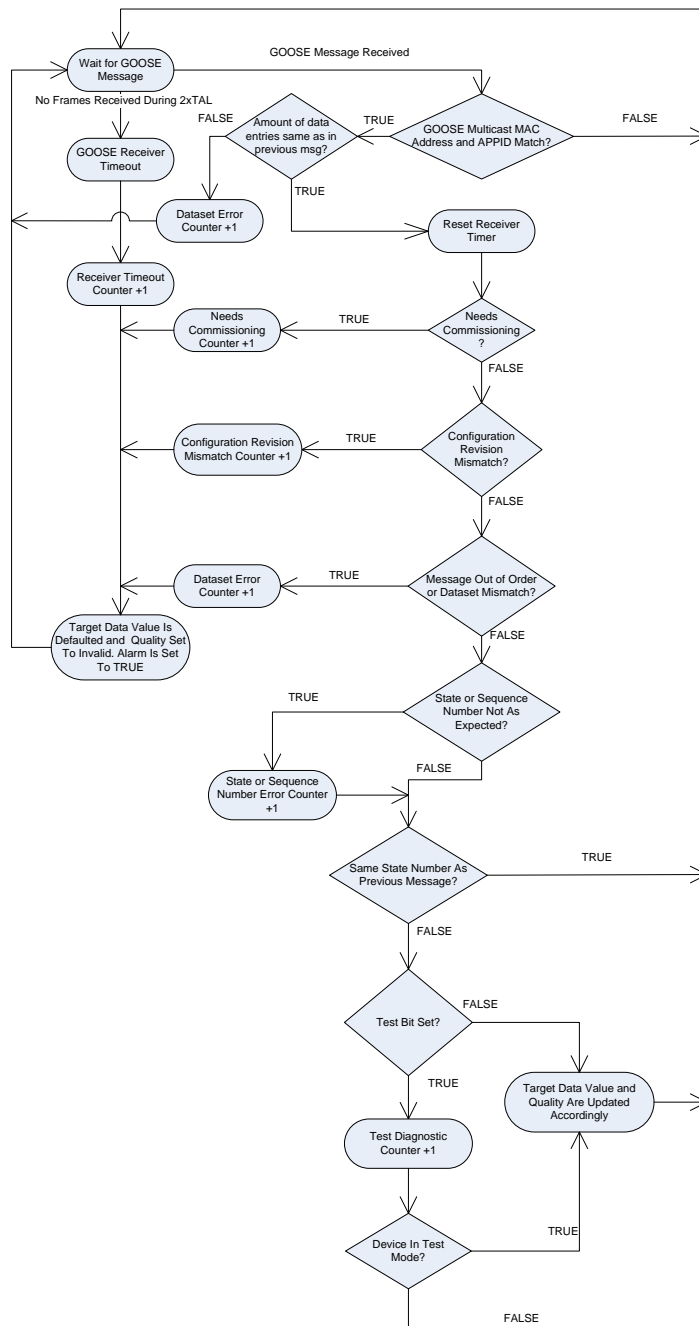• The Needs Commissioning bit is active in the received message

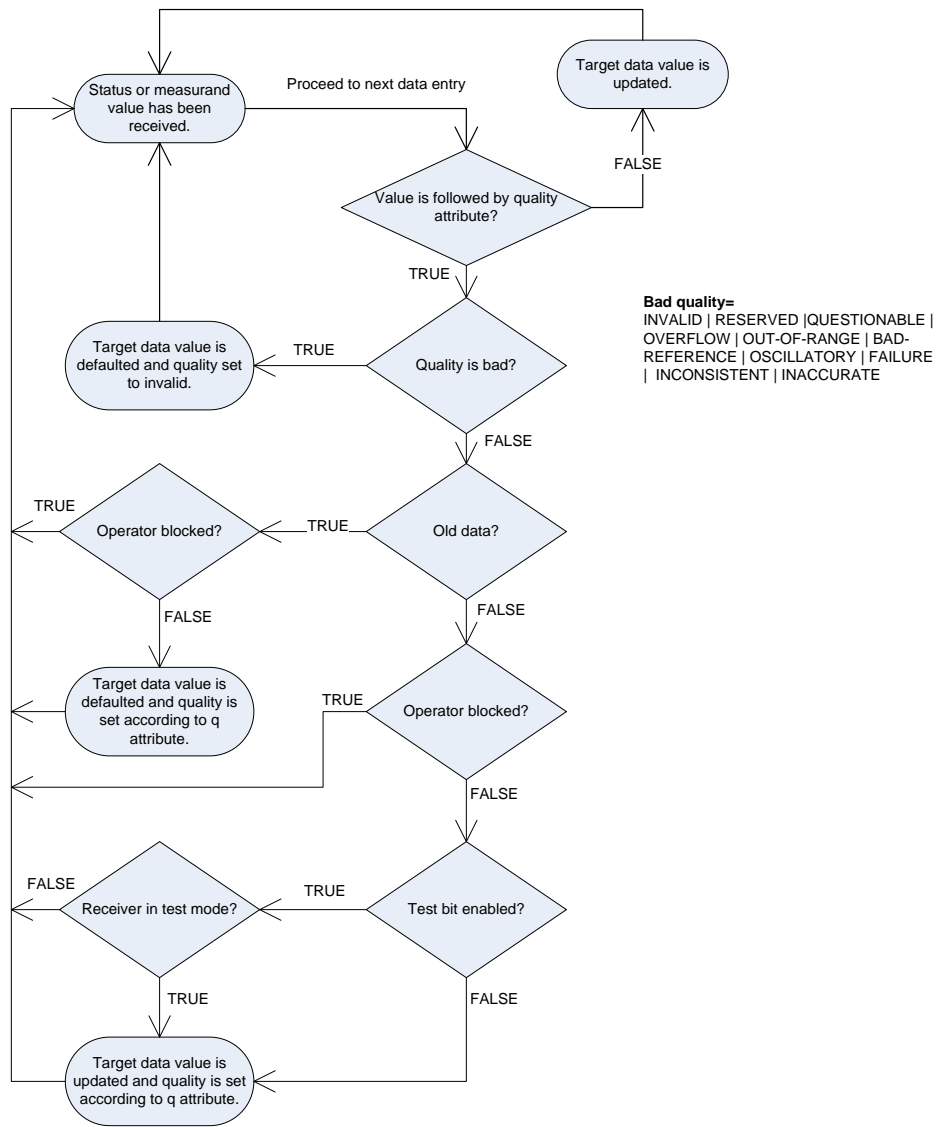*Figure 23:   Receiving GOOSE data in 615 series IEDs*

Figure 24:   *Receiving GOOSE data with quality in 615 series IEDs*

Section 6   IET600 engineering

6.1   Managing IEC 61850 clients

When IED configurations are changed using IET600, some preparations are required when a project is started and the 615 series IED data model is imported to the tool for the first time.

- The default 615 series IED SCL export from PCM600 contains five default client definitions, "Client1"..."Client5", which are used by all the RCBs. MicroSCADA and COM600 clients can use the client definitions directly. If other clients need to be added to the IET600 project, import the ICD file describing the client data model to the project and attach the file to the same IEC 61850 subnetwork in the **Communication** tab.
- Create the bus connections for the IEC 61850 clients.

6.1.1   Importing a new IEC 61850 client

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

1. To create an IED, click the **IEDs** tab in the navigation pane.
2. Click the root node in the IED tree.
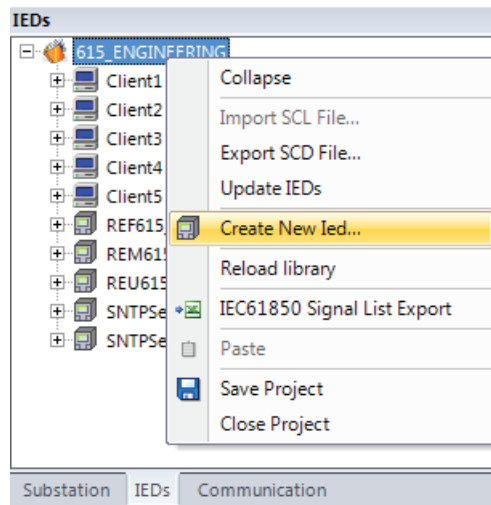3. Right-click the node and click **Create New IED** on the shortcut menu.

Figure 25:   Creating a new IED

4.   Type the name of the client IED as it is in the file to be imported. Click **OK**.
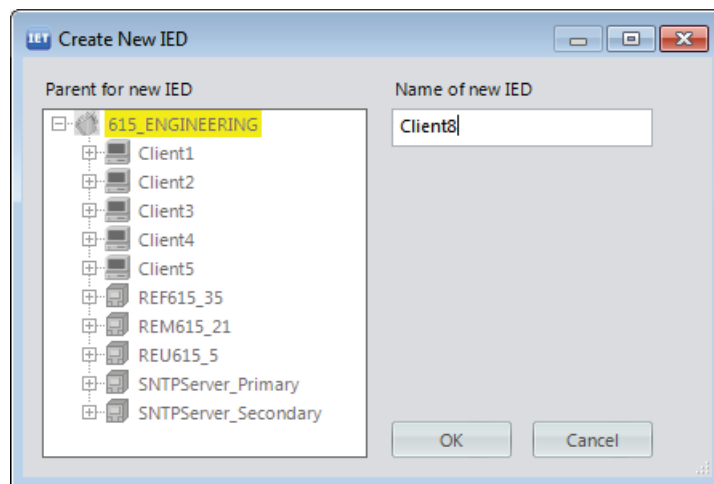

Figure 26:   Naming the new IED

5.   Right-click on the created IED and click **Update IED** on the shortcut menu.
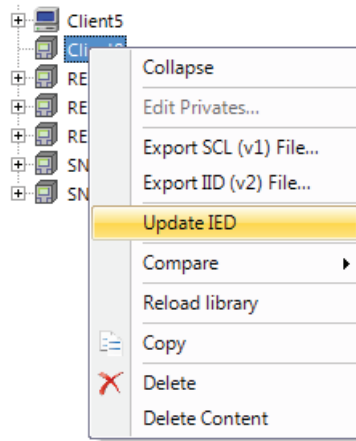
Figure 27:   Choosing a SCD file for updating the IED

6.   Select any valid SCL file (SCD, ICD, CID or IID) and click **Open** from the file selection dialog box.
7.   IET600 automatically matches IEDs with the same name in IET600 and in the file. To import the IED from the file, click **OK**.
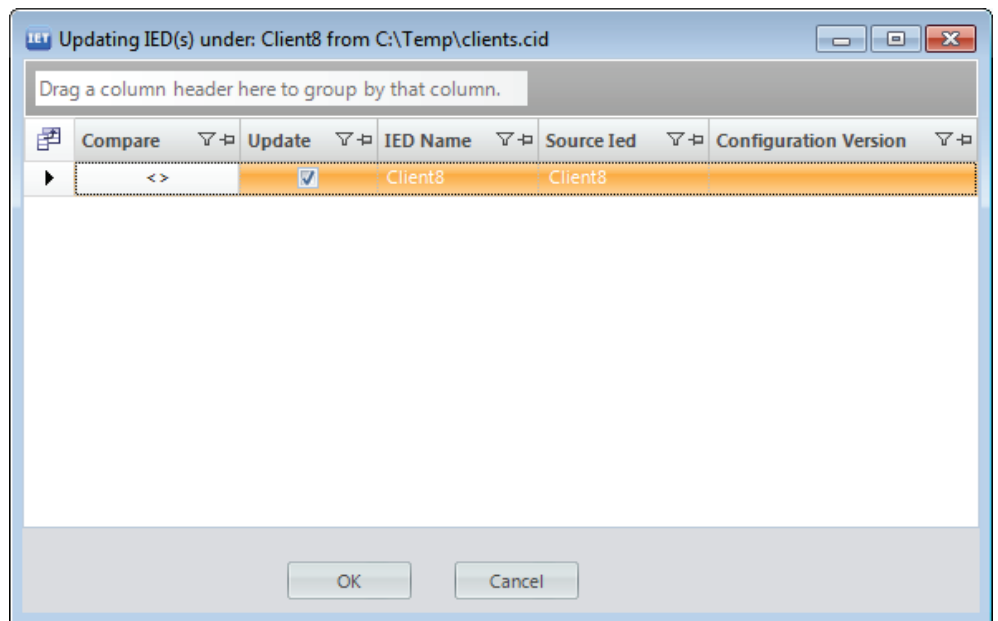

Figure 28:   Updating the IED

 The procedure used in configuring IEC 61850 clients can be used to create and/or update any IED, also several IEDs at the same time.

6.1.2　Attaching IEC 61850 clients to a bus

1. Click the **Communication** tab in the navigation pane.
2. Click the **Subnetworks** tab in the editor pane.
3. In the Subnetworks grid, select the bus from the Subnetwork list to attach the IEC 61850 client to the bus.
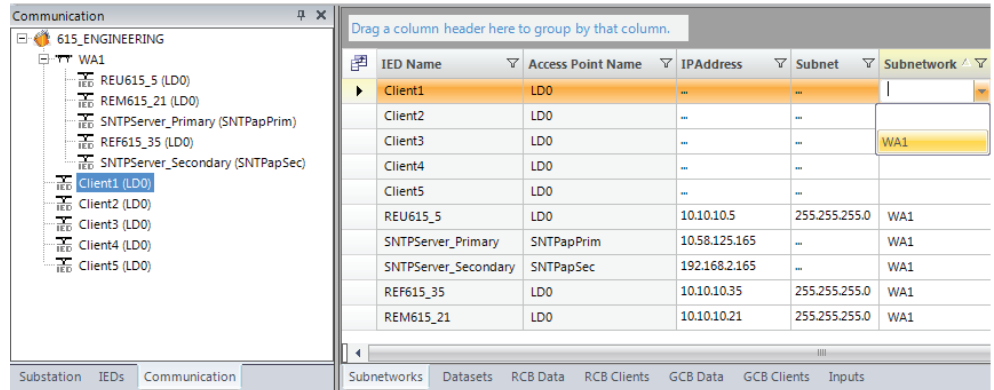   An alternative way is to drag and drop the client in the **Communication** tab to the correct subnetwork.

Figure 29:　Defining bus connection properties for IEC 61850 clients

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

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

6.2　IET600 user interface

IET600 user interface is divided into sections, that is, panes for navigating and displaying the project data.
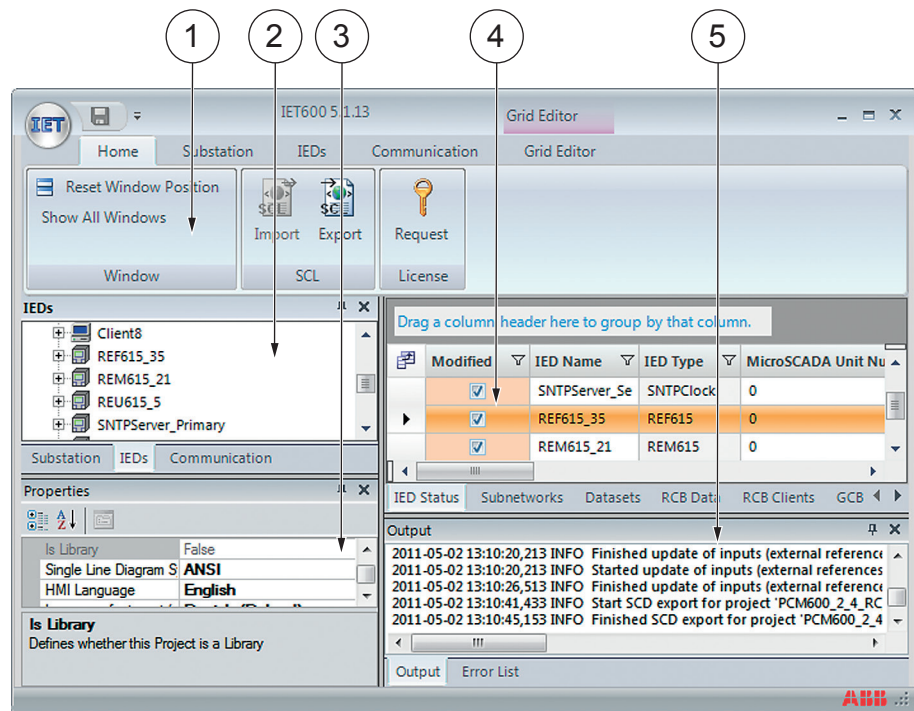
Figure 30: *IET600 user interface*

1   Menu on the top of the user interface

2   Navigation pane for context-oriented navigation and filtering the various editors

3   Properties pane for detailed properties of the selected element in the navigation pane

4   Editors for detailed design and engineering of the substation, IEDs and IEC 61850 communication

5   Logging and messaging (output) pane

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

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

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

Available editor tabs depend on the selected node type, not on the selected navigation tab. Choose any available context view to do the needed engineering tasks.

> Choose upper or lower level in the structure to see the data of single, many or all IEDs at the same time in the editor pane.

6.2.1   Setting visibility of columns in grid editors

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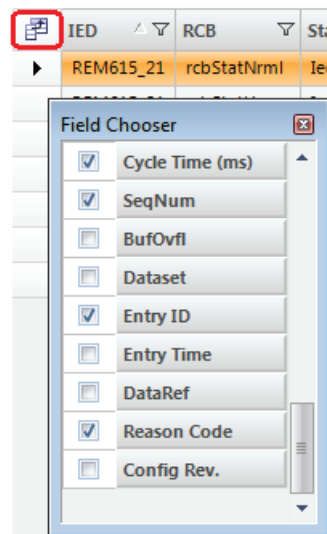
Most tables include columns which are hidden by default.

Figure 31:   Setting column visibility in a grid editor

1.   To set the visibility of the columns, click the top left icon of the table.
2.   Enable/disable the columns from the **Field Chooser** dialog box.

6.3   Substation section configuration

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

The SLD editor is a graphical editor for the configuration of the substation section in IET600. It provides tools to draw the primary equipment and the interconnection between the equipment in the bay.
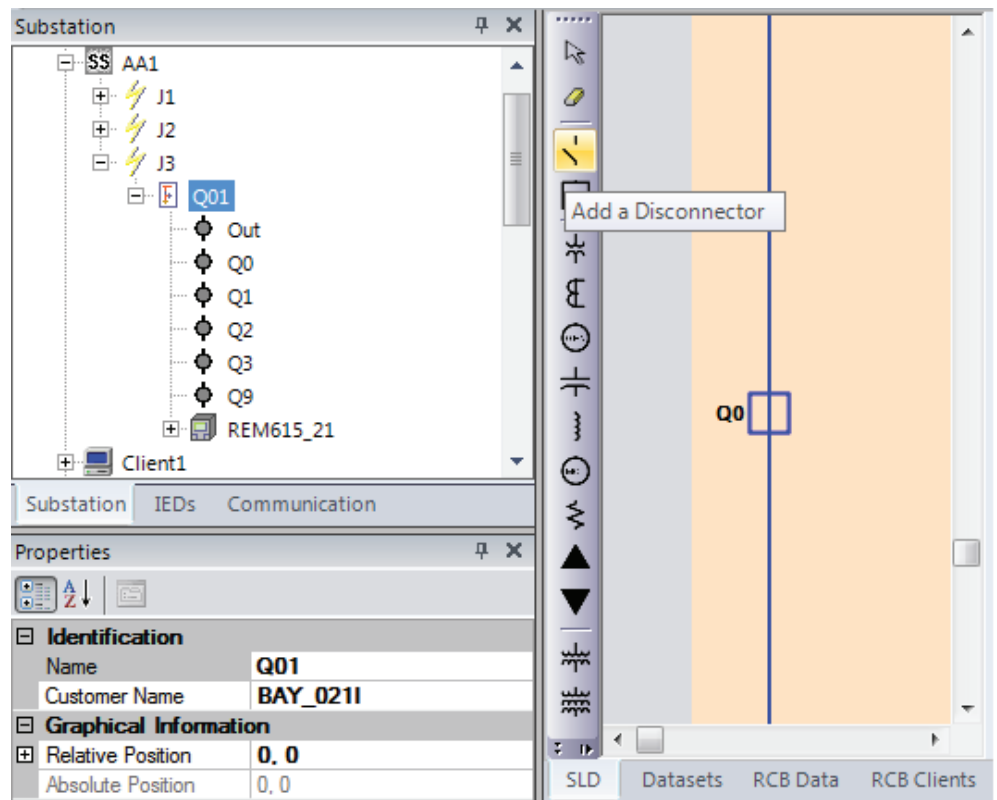
Figure 32:   SLD Editor

SLD in the IED is configured using the Graphical Display Editor of PCM600, not in IET600

In addition to the substation topology configuration, logical nodes of IEDs need to be mapped to proper objects, for example, to support the automatic bay configuration via SCL files in SCADA system. Logical nodes are mapped with the LN Mapping Editor.
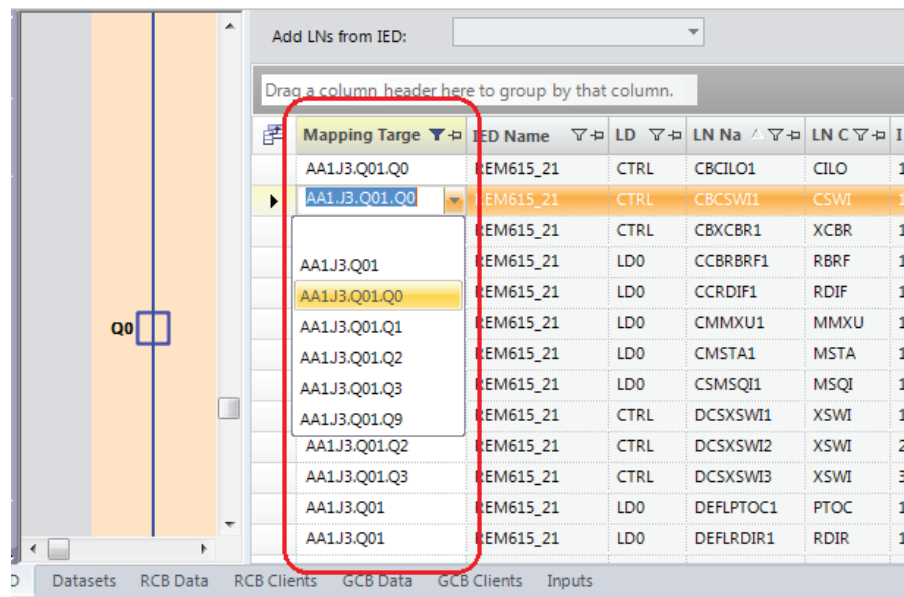
Figure 33:   *LN Mapping Editor*

6.4   Creating data sets

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

- Grid for existing data sets (data set creating, deleting and renaming)
- List of data set entries for selected data set (viewing, deleting)
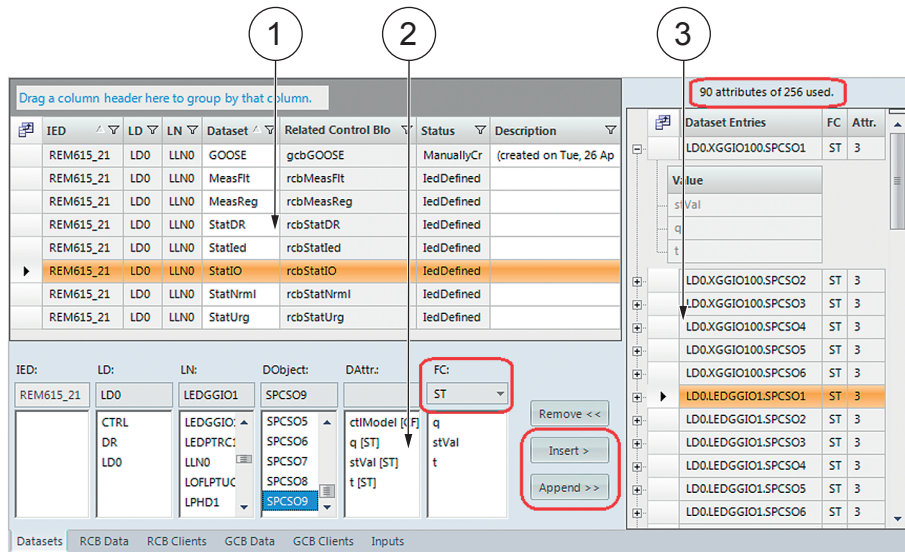- Selection lists for adding new entries to a selected data set

Figure 34:   Dataset editor

1   Grid

2   Selection lists

3   List of data entries

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

> Above the data set entries list is shown how many attributes it is possible to add to the data set and how many are already added.

> Select a proper FC (functional constraint) value for the data attributes to be added to a data set. If none is selected ("(all)" is shown on the list), it is not possible to add attributes to the data set.

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

6.5 Creating report control blocks

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

1. Click an IED node in the IEDs navigation pane.
2. Click **RCB Data** tab in the editor pane.
3. Right-click on the area containing RCB names and select **Insert new row** on the shortcut menu.
4. Define the LN where the RCB is to be placed (preselected **LD0/LLN0** is recommended) and the name for the new RCB.
   Use the field chooser to show or hide the wanted properties. For example, **SeqNum**, **Entry ID** and **Reason Code** options (set by default in the 615 series) are hidden by default.
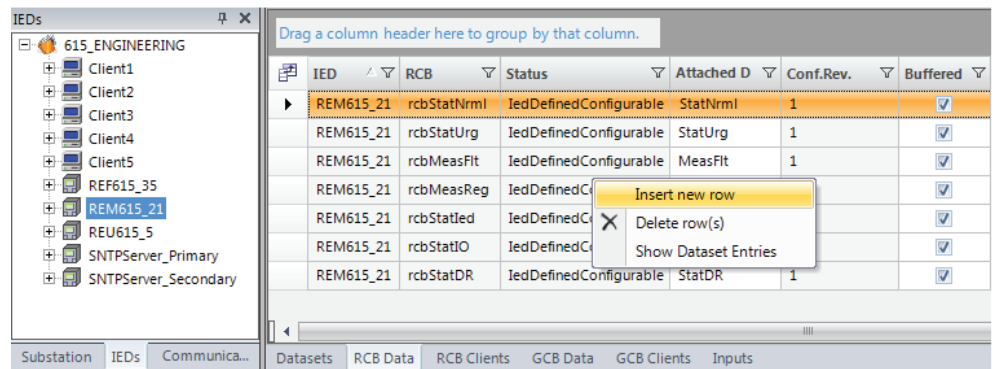

Figure 35:   *RCB editor*

> *Conf.Rev* cannot be manually edited. IET600 updates it automatically to the next multiple of 100 when the configuration changes.

> Deleting an RCB does not totally remove it from IET600. Instead, its status is set to "Deleted", and it is not exported to SCL files. Removing a data set automatically puts the related RCB in to a "Deleted" state.

> An RCB cannot be renamed. To rename an RCB, delete it and create a new RCB with a new name.

6.6   RCB client configuration

To succeed with an RCB client configuration, the potential clients and their communication configuration should be known. Therefore, add the IEDs and configure them to the subnetworks before configuring the RCB client.

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

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

	IED Name	LD	LN	RCB	Attached Dataset	Client1 (LD0)	Client2 (LD0)	Client3 (LD0)	Client4 (LD0)	Client5 (LD0)
▶	REM615_21									
	REM615_21	LD0	LLN0	rcbMeasFlt	MeasFlt	1	2	3	4	5
	REM615_21	LD0	LLN0	rcbMeasReg	MeasReg	1	2	3	4	5
	REM615_21	LD0	LLN0	rcbStatDR	StatDR	1	2	3	4	5
	REM615_21	LD0	LLN0	rcbStatIed	StatIed	1	2	3	4	5
	REM615_21	LD0	LLN0	rcbStatIO	StatIO	1	2	3	4	5
	REM615_21	LD0	LLN0	rcbStatNrmI	StatNrmI	1	2	3	4	5
	REM615_21	LD0	LLN0	rcbStatUrg	StatUrg	1	2	3	4	5

Datasets   RCB Data   RCB Clients   GCB Data   GCB Clients   Inputs

Figure 36:   RCB client editor

Different keys can be used when editing the cells.

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

RCB client editor supports both manual and semi-automatic client configuration.

6.6.1   Configuring RCB clients semi-automatically

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

There are also buttons to allow semi-automatic configuration of default clients and RCB clients.
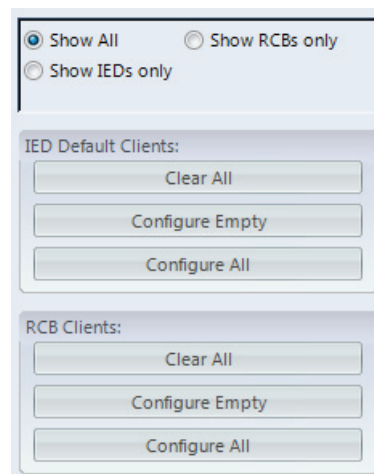
Figure 37:   Semi-automatic configuring of RCB clients

1.   Configure the default clients which are used by the rule-based RCB
     generation to automatically configure RCB clients.
     Use buttons on the RCB client editor.

     •   **Clear All** removes all default clients
     •   **Configure Empty** fills out only default clients for those IEDs that have
           no clients configured yet
     •   **Configure All** deletes all existing default clients and fills them out
           afterwards

2.   Configure the RCBs clients.
     The default clients must be configured before configuring RCB clients
     otherwise the automatic RCB client configuration does not work. Use buttons
     on the RCB client editor.

     •   **Clear All** removes all RCB clients
     •   **Configure Empty** copies the default client configuration of this IED to
           its RCBs (only for those RCBs that have no clients configured yet)
     •   **Configure All** deletes the existing RCB clients and copies the default
           client configuration of this IED to its RCBs

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

Section 7   Glossary

615 series	Series of numerical IEDs for low-end protection and supervision applications of utility substations, and industrial switchgear and equipment
ACSI	Abstract communication service interface
APPID	Application identifier
CID	Configured IED description
COM600	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.
CT	Current transformer
CTRL	Control logical device
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
GCB	GOOSE control block
GoCB	GOOSE control block
GoID	GOOSE control block-specific identifier
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 in PCM600
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
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.
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 substation description configuration language defined by IEC 61850
stVal	Status value
SW	Software
TAL	Time allowed to live
TCP/IP	Transmission Control Protocol/Internet Protocol
VLAN	Virtual LAN
VT	Voltage transformer
XML	Extensible markup language

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