



Relion® Protection and Control

# 650 series Engineering Manual





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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 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC).

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This product is designed and produced for industrial use.

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## Section 1 Introduction

### 1.1 This manual

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

### 1.2 Intended audience

This manual addresses system and project engineers involved in the engineering process of a project, and installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service.

The system engineer must have a thorough knowledge of protection and/or control systems, protection and/or control equipment, protection and/or control functions and the configured functional logics in the IEDs. The installation and commissioning personnel must have a basic knowledge of handling electronic equipment.

## 1.3 Product documentation

### 1.3.1 Product documentation set

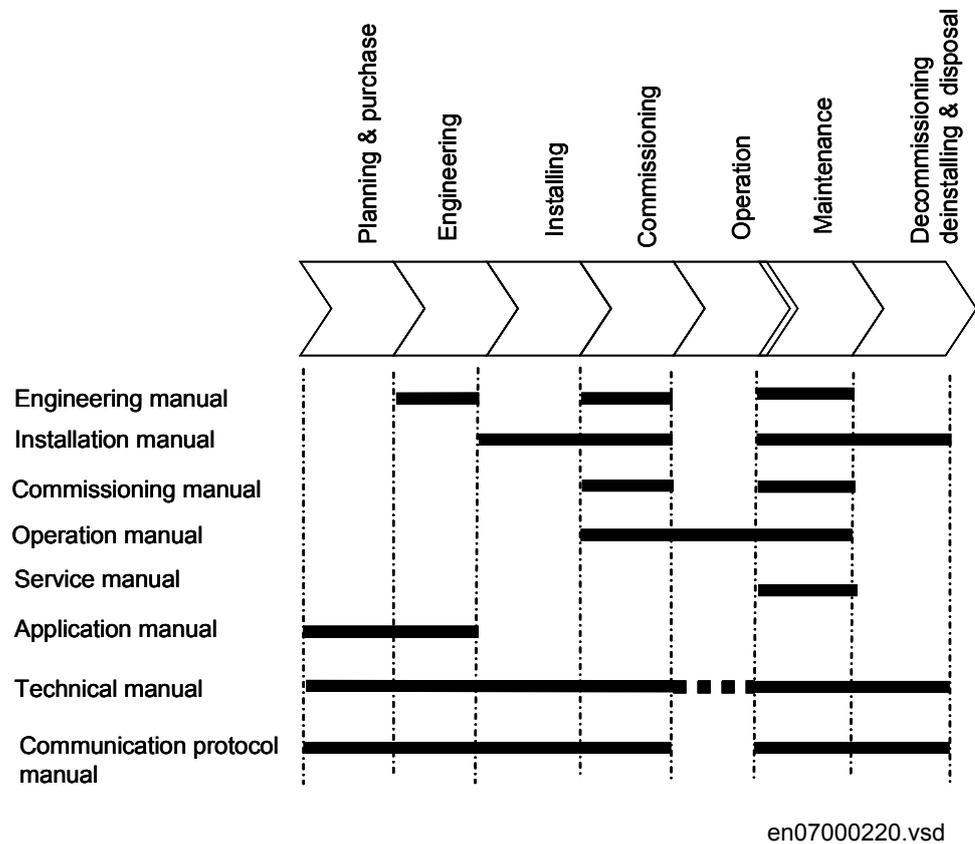


Figure 1: The intended use of manuals in different lifecycles

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

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

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for checking of external circuitry and energizing the IED, parameter setting and configuration as well as verifying settings by secondary injection. The manual describes the process

of testing an IED in a substation which is not in service. The chapters are organized in chronological order in which the IED should be commissioned.

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

The service manual contains instructions on how to service and maintain the IED. The manual also provides procedures for de-energizing, de-commissioning and disposal of the IED.

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

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

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

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



The service manual is not available yet.

### 1.3.2

## Document revision history

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

### 1.3.3

## Related documents

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

Table continues on next page

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

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

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

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

## 1.4 Symbols and conventions

### 1.4.1 Safety indication symbols



The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.



The information icon alerts the reader to important facts and conditions.



The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

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

## 1.4.2 Manual conventions

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

- Abbreviations and acronyms in this manual are spelled out in Glossary. Glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons, for example:  
To navigate between the options, use  and .
- HMI menu paths are presented in bold, for example:  
Select **Main menu/Settings**.
- LHMI messages are shown in Courier font, for example:  
To save the changes in non-volatile memory, select Yes and press .
- Parameter names are shown in italics, for example:  
The function can be enabled and disabled with the *Operation* setting.
- The ^ character in front of an input or output signal name in the function block symbol given for a function, indicates that the user can set an own signal name in PCM600.
- The \* character after an input or output signal name in the function block symbol given for a function, indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.

## 1.4.3 Functions included in 650 series IEDs

Table 1: *Main protection functions*

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

Table continues on next page

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

**Table 2:** *Back-up protection functions*

IEC 61850	ANSI	Function description
<b>Current protection</b>		
PHPIOC	50	Instantaneous phase overcurrent protection
OC4PTOC	51/67	Four step directional phase overcurrent protection
EFPIOC	50N	Instantaneous residual overcurrent protection
EF4PTOC	51N/67N	Four step directional residual overcurrent protection
SDEPSDE	67N	Sensitive directional residual overcurrent and power protection
UC2PTUC	37	Time delayed 2-step undercurrent protection
LPTTR	26	Thermal overload protection, one time constant
TRPTTR	49	Thermal overload protection, two time constants
CCRBRF	50BF	Breaker failure protection
STBPTOC	50STB	Stub protection
CCRPLD	52PD	Pole discordance protection
BRCPTOC	46	Broken conductor check
GUPPDUP	37	Directional underpower protection
GOPPDOP	32	Directional overpower protection
DNSPTOC	46	Negative sequence based overcurrent function
<b>Voltage protection</b>		
UV2PTUV	27	Two step undervoltage protection
OV2PTOV	59	Two step overvoltage protection
ROV2PTOV	59N	Two step residual overvoltage protection
OEXPVPH	24	Overexcitation protection
LOVPTUV	27	Loss of voltage check
<b>Frequency protection</b>		
SAPTUF	81	Underfrequency function
SAPTOF	81	Overfrequency function
SAPFRC	81	Rate-of-change frequency protection

**Table 3:** *Control and monitoring functions*

IEC 61850	ANSI	Function description
<b>Control</b>		
SESRSYN	25	Synchrocheck, energizing check, and synchronizing
SMBRREC	79	Autorecloser
SCILO	3	Logical node for interlocking
BB_ES	3	Interlocking for busbar earthing switch
A1A2_BS	3	Interlocking for bus-section breaker
A1A2_DC	3	Interlocking for bus-section disconnecter
ABC_BC	3	Interlocking for bus-coupler bay
BH_CONN	3	Interlocking for 1 1/2 breaker diameter
BH_LINE_A	3	Interlocking for 1 1/2 breaker diameter
BH_LINE_B	3	Interlocking for 1 1/2 breaker diameter
DB_BUS_A	3	Interlocking for double CB bay
DB_BUS_B	3	Interlocking for double CB bay
DB_LINE	3	Interlocking for double CB bay
ABC_LINE	3	Interlocking for line bay
AB_TRAFO	3	Interlocking for transformer bay
SCSWI		Switch controller
SXCBR		Circuit breaker
SXSWI		Circuit switch
POS_EVAL		Evaluation of position indication
SELGGIO		Select release
QCBAY		Bay control
LOCREM		Handling of LR-switch positions
LOCREMCTRL		LHMI control of PSTO
TR1ATCC	90	Automatic voltage control for tapchanger, single control
TR8ATCC	90	Automatic voltage control for tapchanger, parallel control
TCMYLTC	84	Tap changer control and supervision, 6 binary inputs
SLGGIO		Logic Rotating Switch for function selection and LHMI presentation
VSGGIO		Selector mini switch extension
DPGGIO		IEC61850 generic communication I/O functions double point
SPC8GGIO		Single point generic control 8 signals
AUTOBITS		AutomationBits, command function for DNP3.0
<b>Secondary system supervision</b>		
CCSRDIF	87	Current circuit supervision
SDDRFUF		Fuse failure supervision
TCSSCBR		Breaker close/trip circuit monitoring
<b>Logic</b>		
SMPPTRC	94	Tripping logic
Table continues on next page		

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

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

**Table 4:** *Designed to communicate*

IEC 61850	ANSI	Function description
<b>Station communication</b>		
		IEC61850 communication protocol
		DNP3.0 for TCP/IP communication protocol
GOOSEINTLK RCV		Horizontal communication via GOOSE for interlocking
GOOSEBINR CV		GOOSE binary receive
<b>Scheme communication</b>		
ZCPSCH	85	Scheme communication logic for distance or overcurrent protection
ZCRWPSCH	85	Current reversal and weak-end infeed logic for distance protection
ZCLCPLAL		Local acceleration logic
ECPSCH	85	Scheme communication logic for residual overcurrent protection
ECRWPSCH	85	Current reversal and weak-end infeed logic for residual overcurrent protection

**Table 5:** *Basic IED functions*

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



## Section 2 Engineering tool set

### 2.1 Introduction

The structure of a monitoring and control system for electrical substations has a principle structure as shown in [Figure 2](#). It contains a number of IEDs for the various purposes.



It is recommended to not exceed 60 IEDs in one PCM600 project. Larger projects can be divided into several PCM600 projects.

It can be subdivided in the three main parts:

- Bay level IEDs
- Station communication
- Station level IEDs

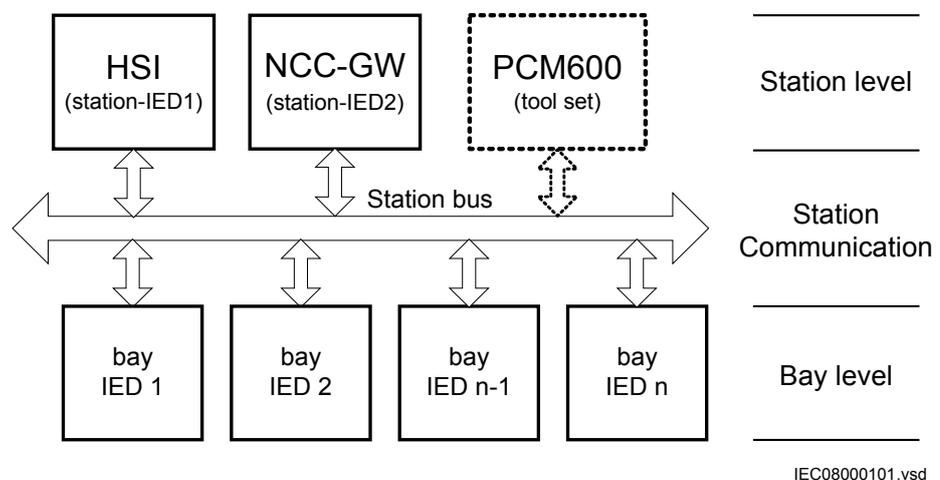


Figure 2: Principle structure of a monitoring and control system for a substation

All three parts require specific engineering and configuration. PCM600 is used to do the complete engineering and configuration activities needed for bay level IEDs.

Product type and version specific engineering data needed by PCM600 for protection, control and communication engineering of a particular bay IED is given in an IED connectivity package.

PCM600 communicates with the bay IEDs via an Ethernet connection. The connection allows to read and write all configuration data needed for proper operation from or to the IED. The IEDs have communication interfaces for protocols and media used for station communication. Bay IED IEC 61850 station communication files can be exported from PCM600 to station engineering tools for engineering of station communication between bay IEDs and station IEDs.

A PC with PCM600 can be connected to any 650 series IED within a station using the Ethernet connection

The Ethernet connection can then later also be used for service and maintenance purposes. The connection is also used to handle disturbance records from protection IEDs using the IEC 61850 file transfer.

The today IEDs are designed on the concept of the IEC 61850 standard. This is mainly given for the organization of functions represented by an equivalent logical node in the IEC 61850 standard. The mapping between the logical node data model in the IED, following the structure and rules in part 7 of the IEC 61850 standard, and the function blocks in an IED configuration is given in the IEC 61850 communication protocol manual.

The concept is also used for DNP3 protocol. The signals used or delivered by a function block are automatically generated and available for station communication. This concept allows a very efficient cost saving signal engineering.

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 in:

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

This manual is valid for PCM600 supporting the 650 series product.

## 2.2 IED engineering process

PCM600 is used for the following tasks in the IED engineering process, see [Figure 3](#):

- IED engineering management

- 
- Organizing the bay IEDs in the structure of the substation by defining voltage levels and bays below the substation. PCM600 manages the project.
  - Configuring the IED functions (for example protection and control functions and LHMI functions) by using the Application configuration tool (ACT).
  - Configuring the parameters and setting values for the IED itself and for the process functionality by using the Parameter setting tool (PST).
  - Drawing single line diagrams and do the link to dynamic process values by using the Graphical display editor tool (GDE). The single line diagrams are shown on the LHMI on the bay IED.
  - Configuring connections between the application configuration function blocks and physical hardware input and outputs by using the Signal matrix tool (SMT).
  - Communication management
    - IEC 61850 station communication engineering is done with a separate tool, for example, CCT600. PCM600 interacts with CCT600 by importing and exporting SCL files.
    - Organizing GOOSE messages received and managing the used IO signal is done by using the Signal matrix tool (SMT).
    - Communication engineering for the DNP3 protocol by using the Communication management tool (CMT).
  - Disturbance record management
    - Generating overviews about the available (disturbance) recordings in all connected protection IEDs by using the disturbance handling tool.
    - Manually reading the recording files (in Comtrade format) from the protection IEDs by using the Disturbance handling tool (DHT) or automatically by using the PCM600 scheduler.
    - Managing recording files with the assistance of the Disturbance handling tool (DHT).
    - Creating overview reports of recording file content for fast evaluation with assistance of the Disturbance handling tool (DHT).
  - Service management
    - Monitoring selected signals of an IED for commissioning or service purposes by using the Signal monitoring tool (MON).
    - Listing all actual existing IED internal events by using the Event viewer tool (EVT).
    - Listing all actual pending process events as they are stored in the IED internal disturbance report event list by using the event viewer tool (EVT).

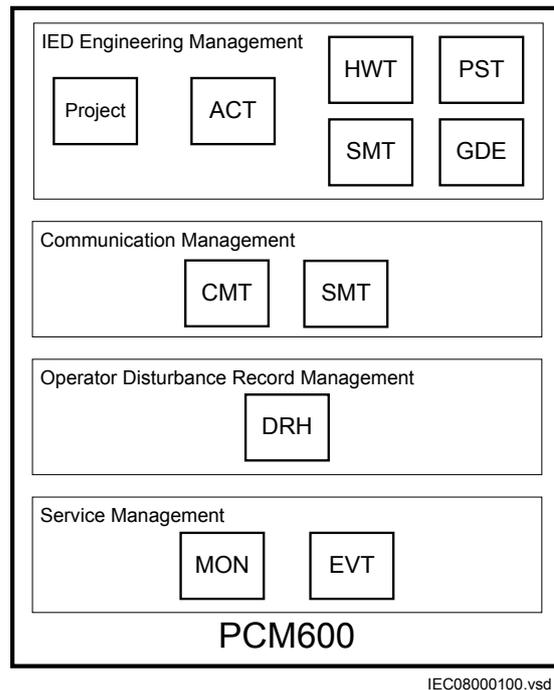


Figure 3: Organization of PCM600 in different management tasks

Additional functionality to manage the project and to organize the user rights:

- PCM600 user management
  - Organizing users with their rights, profile and password to use the different tools and activities within the tools.
  - Defining allowed activities for the user profiles to use tools in PCM600.
- IED user management
  - Organizing users with their rights, profile and password to read and write files of the IED.
  - Defining allowed activities for the user profiles to use the read and write function.

Once the engineering of the IED is done the results must be written to the IED. Conversely some parts of the engineering information can be uploaded from the IED for various purposes.

The connection between the physical IED and PCM600 is established via an Ethernet link on the front or rear port on the IED.

# Section 3 Engineering process

## 3.1 Workflow

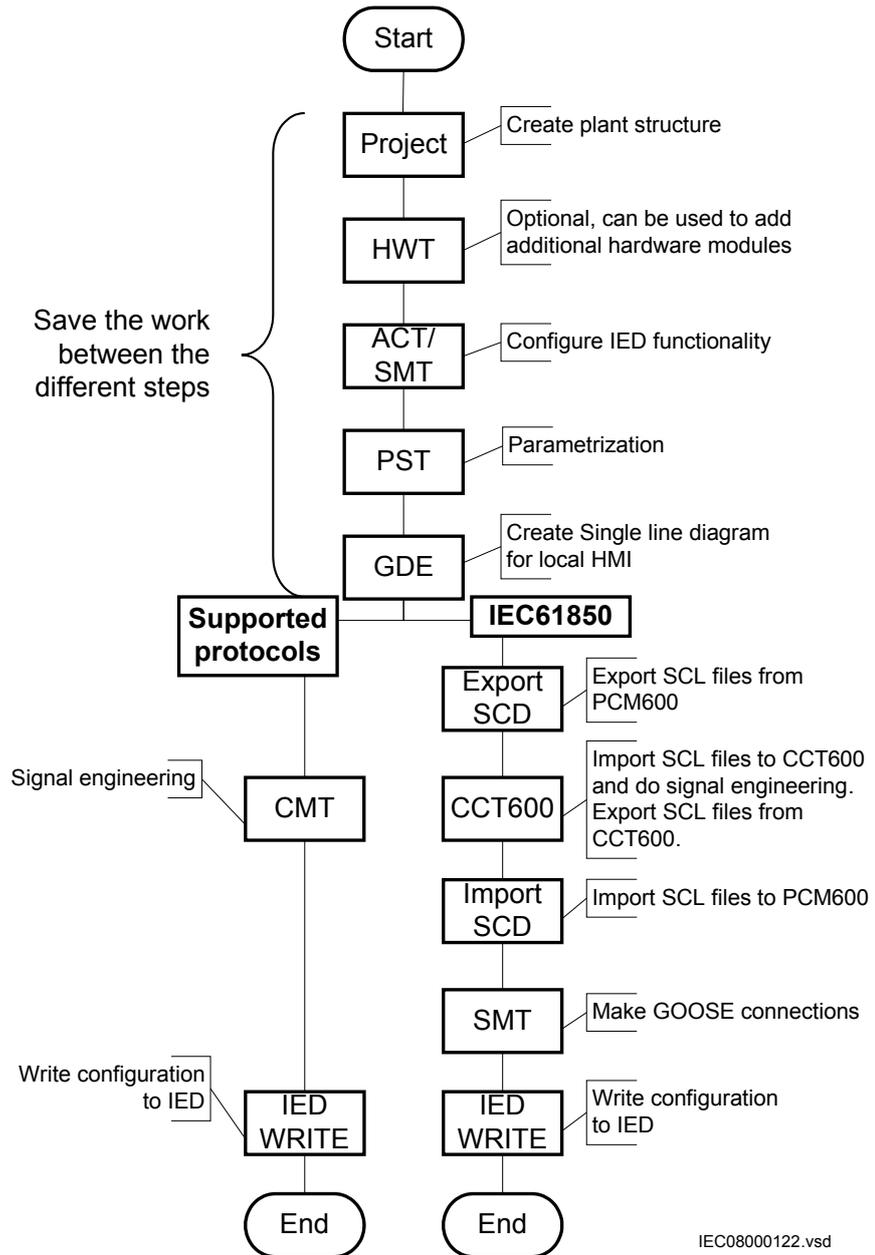


Figure 4: IED engineering workflow

The described sequence in [Figure 4](#) is a proposal based on practical experience and dependencies of the steps. It is possible to do a different sequence based on the available information at the time the project is started. This means that several iterations may be needed to finish the project.

- Setting up the PCM600 project
  - Build the plant structure according to the substation structure.



It is recommended to not exceed 60 IEDs in one PCM600 project. Larger projects can be divided into several PCM600 projects.

- Insert an IED online or offline, by importing a \*.pcmi file or by selecting an IED template from the template library (\*.pcmt).
- Rename the IED objects in PCM600 to the projects definitions.
- ACT Application configuration
  - Configure the protection or control function for example for a transformer application as requested.
  - Save the configuration made with ACT to make the interfaces and signals available for other engineering tools within PCM600, for example for PST.
- PST Parameter setting and configuration
  - Check the configuration parameters of the physical IED for communication channels, CT and VT conversion values of the transformer module, for example.
  - Check and adjust if needed the setting values for example for:
    - Presentation parameters for local HMI.
    - Settings for protection or control functions.
    - Number of setting groups.
- GDE Single line diagram configuration
  - Create a single line diagram of the switch yard.
  - Include measurements when needed.
  - Link the dynamic elements to functions created in ACT, for example a breaker object to the switch function.
- Local HMI engineering
  - Include and engineer the function blocks for LHMI element groups with ACT.
  - Define the function key and LED behavior with PST.
  - Configure the function keys and LEDs with ACT.
- Communication protocol engineering

- 
- The engineering steps are protocol dependent.
  - Use the communication management tool (CMT) for DNP3 engineering.
  - Use a station configuration tool, for example CCT600, for IEC 61850 engineering. See the application manual for other protocols (LON, SPA, IEC103).



The IED restarts automatically when writing an IED configuration where changes have been made to, for example configuration parameters. It is not possible to communicate with the IED during the restart.



## Section 4      Setting up a project

### 4.1                  PCM600 operates on projects

A typical project in PCM600 contains a plant structure including one or several IED objects, where each IED object contains the engineering data created or modified using the different PCM600 tools.

Several projects can be created and managed by PCM600, but only one project can be active at a time.

### 4.2                  Installing Connectivity packages

A Connectivity package contains the complete description of the IED data signals, parameters and protocol addresses for a certain IED type and version. Several types of IEDs can be managed in one PCM600 project, thus the corresponding Connectivity package has to be installed on the PC. A Connectivity package is managed in a separate tool called *Connectivity Package Manager*.



PCM600 must be installed before the connectivity packages can be installed.

A Connectivity package for a specific IED type and version is divided in two parts. The IED connectivity package base module is common for all and 650 series IEDs. The IED specific module is separate for each type of IED.

#### Installing IED Connectivity package

The Connectivity package is available on the CD that was distributed along with the IED.

##### Procedure

1. Close PCM600 before running the *IED Connectivity Package RE\_650.exe* installation wizard.
2. Select the IED type(s) to install in the installation wizard window, for example *REL650 module 1.0.0 Module v.n.* (*n* = version number). The installation software guides the user through steps required to install the *IED Connectivity package base module* and the specific IED type modules. The IED specific module is installed to same location as for IED Connectivity package base module. The default directory is *C:/Program Files/ABB/Connectivity Packages/IEDConnPackRE\_650*.



Be sure to install the connectivity package from a \*.exe and not from a \*.msi file when working in Windows Vista or problems may occur if the connectivity package needs to be un-installed.

## Activating installed connectivity packages

### Procedure

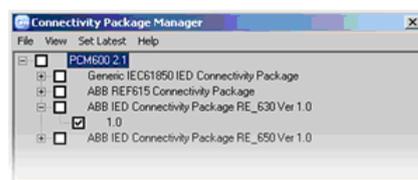
1. Activate the appropriate connectivity package in the *Connectivity package manager* after the installation. Launch the *Connectivity package manager* from the *Start* menu.
2. When a *Connectivity package* has not been activated before starting PCM600 the message box in [Figure 5](#) is shown.
3. Click *Yes*, or run the *Connectivity package manager* from the *Start* menu.



IEC09000392-1-en.vsd

Figure 5: Connectivity package message box

4. The *Connectivity package manager* shows the IEDs that are compatible with the installed PCM600 version.
5. Activate the *ABB IED Connectivity Package RE\_650 Ver. n* to use 650 series products. (*n* = version number)
6. Always use the latest version of a connectivity package, see [Figure 6](#). Click *Set Latest* in the menu bar.



IEC09000393-1-en.vsd

Figure 6: Connectivity package manager window

PCM600 recognizes the installed *Connectivity Package(s)* during startup and corresponding IED types are available in PCM600 when starting a new project.

## 4.3 Setting up communication between PCM600 and the IED

The communication between the IED and PCM600 is independent of the used communication protocol within the substation or to the NCC.

The communication media is always Ethernet and the used protocol is TCP/IP.

Each IED has an Ethernet interface connector on the front and on the rear side. The Ethernet connector can be used for communication with PCM600.

When an Ethernet based station protocol is used, PCM600 communication can use the same Ethernet port and IP address.

For the connection of PCM600 to the IED two basic variants have to be considered.

- Direct point to point link between PCM600 and the IED front port.
- Indirect link via a station LAN or from remote via a network.

The physical connection and the IP address must be configured in both cases to enable communication.

The communication procedures are in both cases the same.

1. If needed, set the IP address for the IEDs.
2. Set up the PC or workstation for a direct link (point to point), or
3. Connect the PC or workstation to the LAN/WAN network.
4. Configure the IED IP addresses in the PCM600 project for each IED to match the IP addresses of the physical IEDs.

### Setting up IP addresses

The IP address and the corresponding mask can be set via the LHMI for each available Ethernet interface in the IED. Each Ethernet interface has a default factory IP address when the complete IED is delivered. This is not given when an additional Ethernet interface is installed or an interface is replaced.

- The default IP address for the IED front port is 10.1.150.3 and the corresponding subnetwork mask is 255.255.255.0, which can be set via the LHMI path **Main menu/Configuration/Communication/TCP-IP configuration/1:ETHFRNT**
- The default IP address for the IED rear port is 192.168.1.10 and the corresponding subnetwork mask is 255.255.0.0, which can be set via the LHMI path **Main menu/Configuration/Communication/TCP-IP configuration/1:ETHLAN1**



The front and rear port IP addresses cannot belong to the same subnet or communication will fail. It is recommended to change the IP address of the front port, if the front and rear port are set to the same subnet.

### Setting up the PC or workstation for point to point access to IEDs front port

A special cable is requested to connect two physical Ethernet interfaces together without a hub, router, bridge or switch in between. The Tx and Rx signal wires must be crossed in the cable to connect Tx with Rx on the other side and vice versa. These cables are known as null-modem cable or cross-wired cable. The minimum length should be about 2 m. The connector type is RJ-45, see [Figure 7](#).

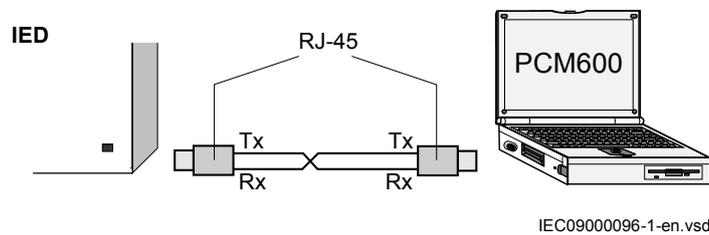


Figure 7: Point to point link between IED and PCM600 using a null-modem cable

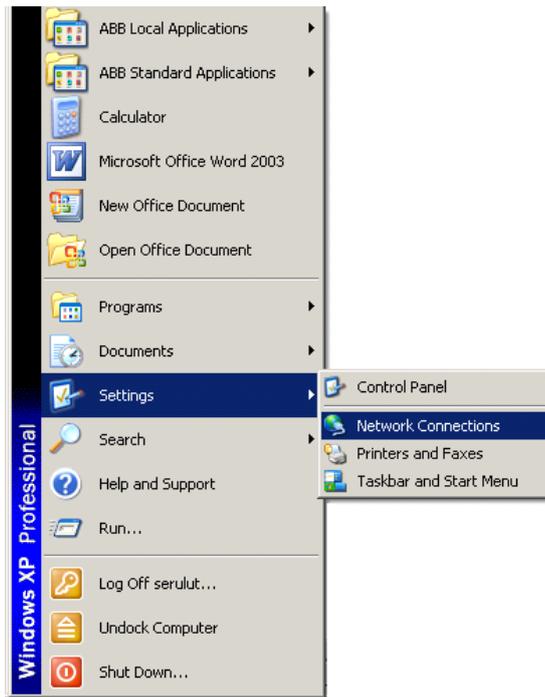
The following description is an example valid for standard PCs using Microsoft Windows operating system. The example is taken from a Laptop with one Ethernet interface.



Administrator rights are requested to change the PC communication setup. Some PCs have the feature to automatically detect that Tx signals from the IED are received on the Tx pin on the PC. Thus straight (standard) Ethernet cable can be used.

When a computer is connected to the IED and the setting *DHCP*Server is set to *On* via the LHMI path **Main menu/Configuration/Communication/TCP-IP configuration/1:ETHFRNT/DHCP**Server, the IEDs DHCP server for the front port assigns an IP address for the computer. The computer must be configured to obtain its IP address automatically as described in the following procedure.

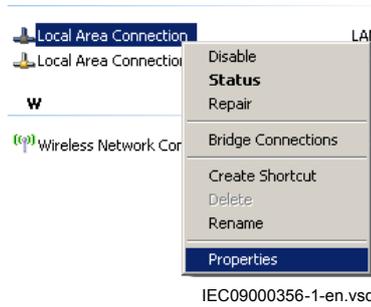
1. Select *Network Connections* in the PC, see [Figure 8](#).



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Figure 8: Select: Network connections

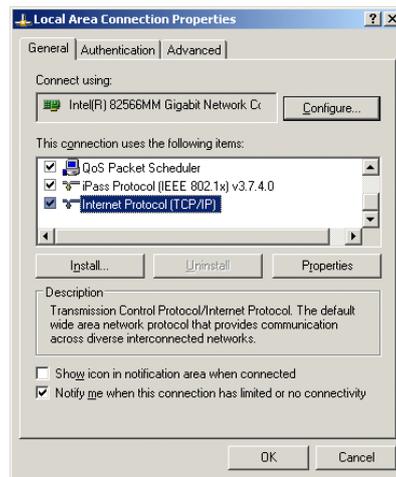
2. Select *Properties* in the status window, see [Figure 9](#).



IEC09000356-1-en.vsd

Figure 9: Right-click Local Area Connection and select Properties

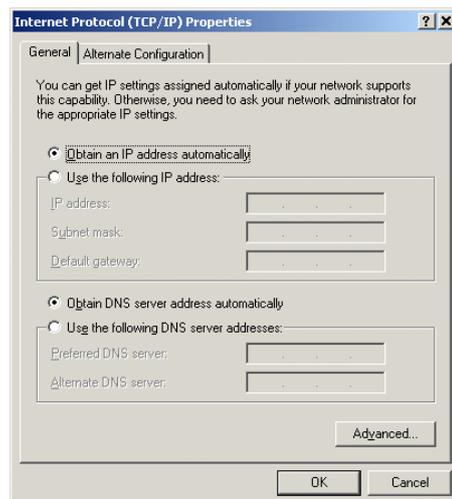
3. Select the TCP/IP protocol from the list of configured components using this connection and click *Properties*, see [Figure 10](#).



IEC09000357-1-en.vsd

Figure 10: Select the TCP/IP protocol and open Properties

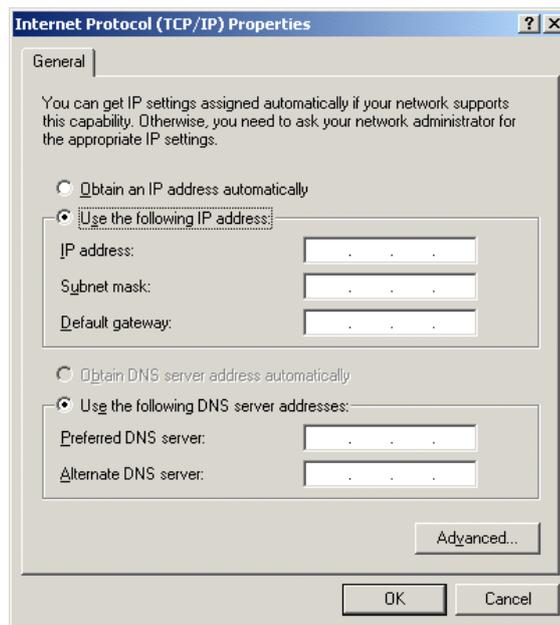
4. Select *Obtain an IP address automatically* if the parameter *DHCP*Server is set to *On*, see [Figure 11](#).



IEC09000358-1-en.vsd

Figure 11: Select: Obtain an IP address automatically

5. Select *Use the following IP address* and define *IP address* and *Subnet mask* if the parameter *DHCP*Server is set to *Off*, see [Figure 12](#). The IP address must be different from the IP address chosen for the IED.



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Figure 12: Select: Use the following IP address

6. Close all open windows and start PCM600.

### Setting up the PC to access the IED via a network

This task depends on the used LAN/WAN network. PC and IED must belong to the same subnetwork.

## 4.4 Managing projects in PCM600

It is possible to:

- open existing projects
- import projects
- create new projects
- export projects
- delete projects
- rename projects
- copy and paste projects

Extensions of the exported project file is \*.pcmp and those files are only used for exporting and importing the projects between PCM600s. PCM600 uses the SQL server and the projects are stored as SQL databases (.mdf files).

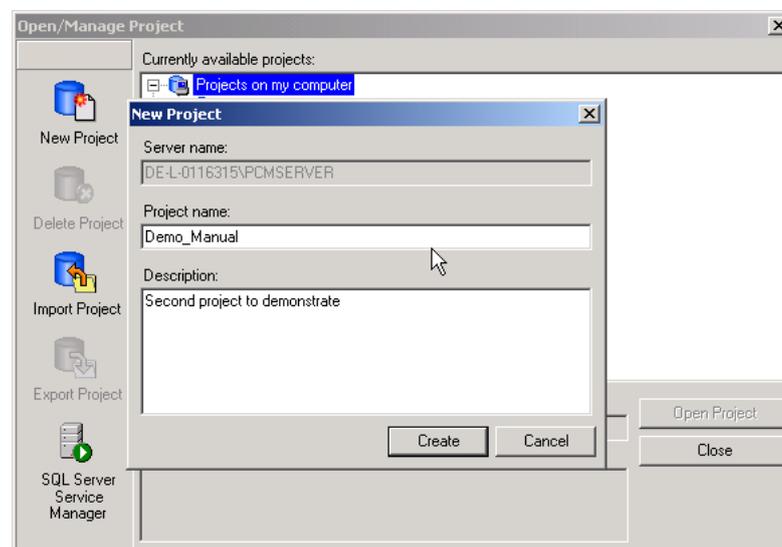


It is possible to create new projects from the *File* menu. Currently open projects and project tools shall be closed before.

## Creating a new project

### Procedure

1. Select *File* and *Open/Manage Project ...* to see the projects that are currently available in the PCMDatabases.
2. Open *Projects on my computer*.
3. Click the icon *New Project*. To create new project currently open projects and object tools shall be closed.
4. The *New Project* window opens, see [Figure 13](#).



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Figure 13: PCM600: Create a new project window

5. Name the project and include a description (optional) and click *Create*.
6. PCM600 sets up a new project that will be listed under *Projects on my computer*.

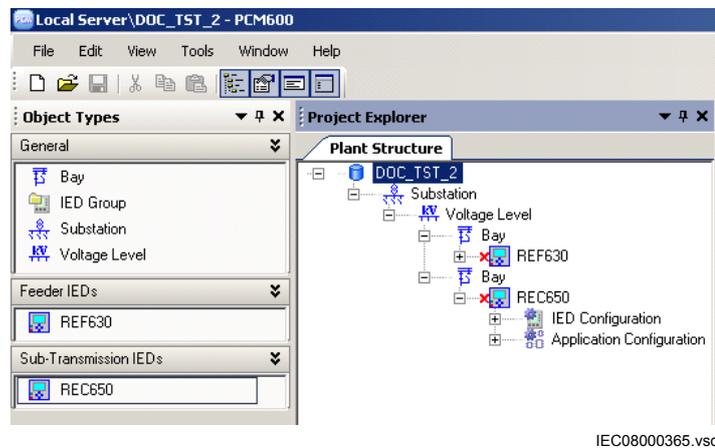
## 4.5 Building a plant structure

The plant structure is used to identify each IED in its location within the substation organization. It is a geographical image of the substation and the bays within the substation. The organization structure for the IEDs may differ from the structure of the primary equipment in the substation. PCM600 has the possibility to set up a hierarchical structure of five levels for the IED identification.

Build up the plant structure according to the project requirements. PCM600 offers several levels to build the hierarchical order from Center down to the IEDs in a bay.

The following levels are available:

1. Project = Center
2. Substation = Name of the substation
3. Voltage Level = identifies to which grid type or part in the substation the IED belongs to
4. Bay = Bay within the voltage level
5. IED = selection of the IED, which is used in the bay. Several IEDs are possible within a bay, for example one control IED and two protection IEDs.



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Figure 14: PCM600: Set up a plant structure

Once a plant structure is built the name of each level in the structure should be renamed by the names/identifications used in the grid. Use the right mouse button to build the plant structure by selecting the elements from the context menu. Rename the level after insertion, using the *Rename* possibility or the *Object Properties*. [Figure 14](#) shows the start of a project with two IEDs placed but still not renamed.



To build a plant structure is useful when a complete grid with an essential number of IEDs has to be built.

Procedure to build a plant structure:

- Right-click in the plant structure and select *New* and *Create from Template ...*, or
- Right-click in the plant structure and select *New, General* and select one of the elements *IED Group* or *Substation*.
- Click *View* in the menu bar and select *Object Types*. Select the needed elements and drag and drop them into the plant structure. Close the window if it does not close automatically.

### 4.5.1

## IEC 61850 naming conventions to identify an IED

This section is only valid when the IEC 61850 standard is used for station bus communication. According to the IEC 61850–6 clause 8.4, the SCL model allows two kinds of project designation in the object properties.

- A technical key is used on engineering drawings and for signal identifications. This is contained in the attribute name as identification of each object. If this value is used as reference to an object, it is contained in an attribute name starting with a string denoting the reference target object type, and ending with the string *Name*. The technical key is used within SCL for referencing other objects. Observe that name is a relative identification within a hierarchy of objects.
- A user oriented textual designation is contained in attribute desc. Attributes are not allowed to contain carriage return, line feed or tab characters. The semantics of desc shall also be relative within an object hierarchy.

PCM600 takes care for these two possibilities. The two possible signal designations are available per object in the object properties for all hierarchical levels beginning with the station as highest level.

The technical key is automatically generated based on the rules and type specifications of IEC 61346 and the extended definitions done for substations by a technical committee. The technical key is shown in the *Object Properties* under *SCL Technical Key* or *Technical Key*.

- The station is predefined by “AA1” where 1 is the index. To get the real station name that is used it is possible to rename the 'SCL Technical Key' for the station to the name used by the project. To minimize the word length take a short form, because this will be used also in the messages transmitted to identify the events etc. In the example = DMSTAT.
- The voltage level. In the example = 400kV and C1 selected from the drop down list below the SCL Technical Key.
- The bay and the IED are appended with the coding defined in the IEC 61346 standard and the substation definition lists. Bay = F409 and Q1. IED = TR\_421 and SB1.

The user oriented textual designation is visible in the plant structure for each object. It is the name given by default or changed via the *Rename* possibility. See [Figure 15](#), *Object Properties*, the row *Caption*.

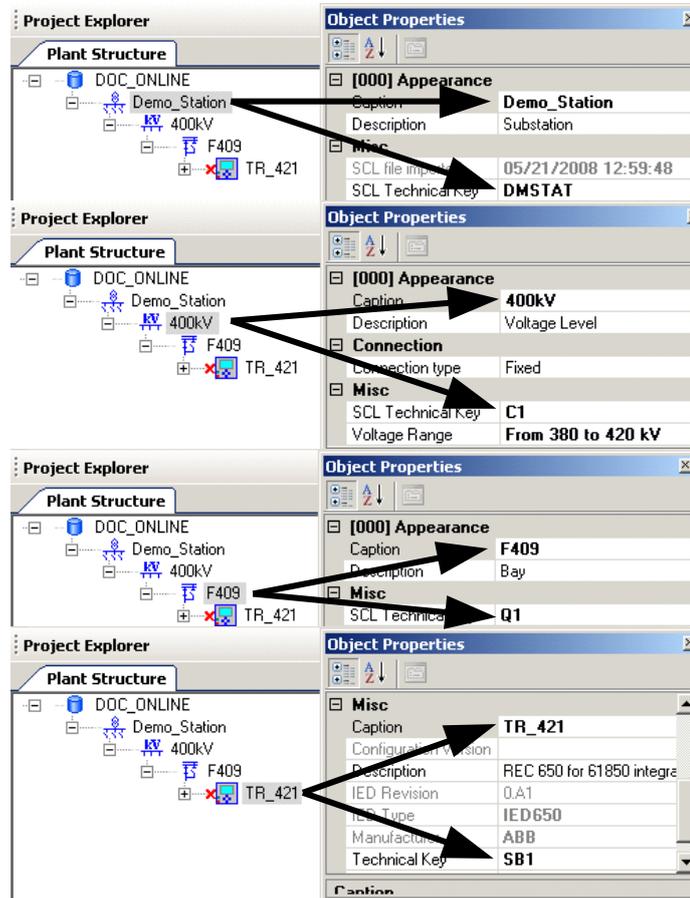


Figure 15: PCM600: IEC 61850 signal designation concept

[Figure 15](#) shows the IED named in the example TR\_421 in the object properties with the two designations TR\_421 and SB1.

The created technical key for the full path name of the IED would be:

- DMSTATC1Q1SB1
  - DMSTAT = Demo\_Station in the project
  - C1 = voltage level from 380 to 420 kV
  - Q1 = the first bay in the voltage level
  - SB1 = IED for the bay Q1. With SB it is identified as a Control IED.

## 4.6 Inserting an IED

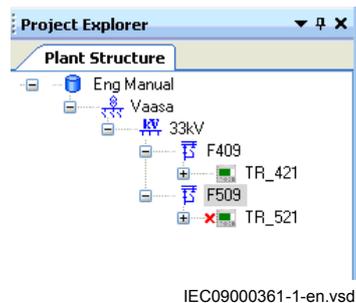
The context menu or the *Object Types* view shows the available 650 series IEDs possible to insert, on the bay level in the plant structure, according to the installed connectivity package.

In the plant structure it is possible to:

- Insert an IED in *Offline mode* or in *Online mode*:
  - Online mode: When the IED is already connected to PCM600 and the communication is established, PCM600 can read the configuration directly from the physical IED. This is useful when an order specific IED is used. The order configuration are written to the IED at the factory and can be accessed by PCM600. The housing type, the used overlay version for local HMI and the IO boards included in the IED will be read from the IED directly.
  - Offline mode: When the physical IED is not available or not connected to PCM600 the engineering steps are done without any synchronization with the IED. The offline configuration in PCM600 can be synchronized with the physical IED at a later state by connecting the IED to PCM600.



It is possible to judge whether the inserted IED is in offline mode or online mode from the plant structure. A red color cross before the IED symbol indicates the offline mode as shown in [Figure 16](#).



*Figure 16: Plant structure showing IED TR\_421 in online mode and IED TR\_521 in offline mode*

- Import a template IED available in the template library as a \*.pcmt file.
- Import a pre-configured IED available as a \*.pcmi file.

### Inserting an IED in online mode

For setting up an IED online the IED must be connected to PCM600.

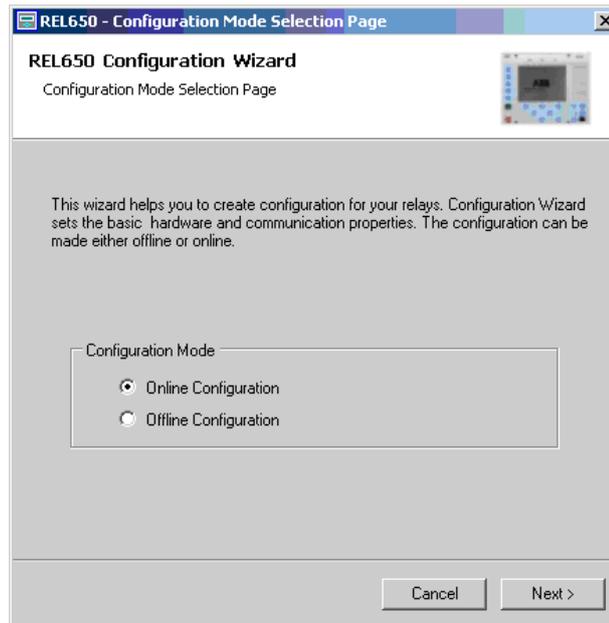
Procedure:

1. Right-click the Bay and select *New* and *Sub-Transmission IEDs*.
2. Select the IED type to insert.



It is also possible to drag-and-drop an IED from the Object Types window to the Bay level.

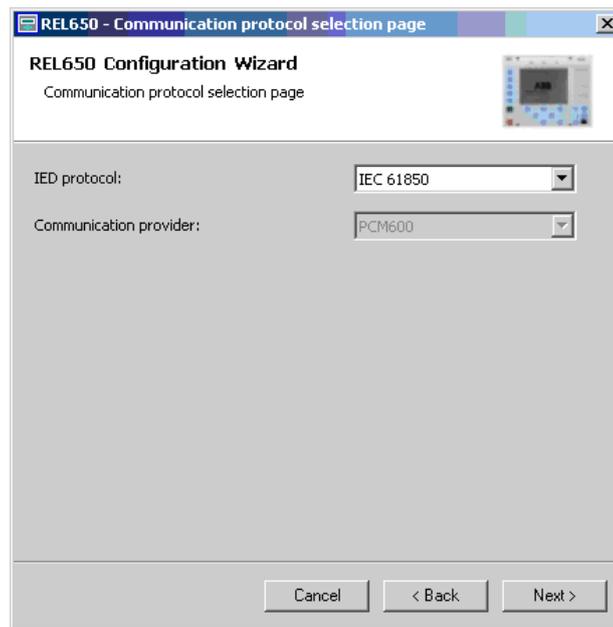
3. Select the *Online Configuration* mode, see [Figure 17](#).



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*Figure 17: PCM600: Communication mode selection wizard*

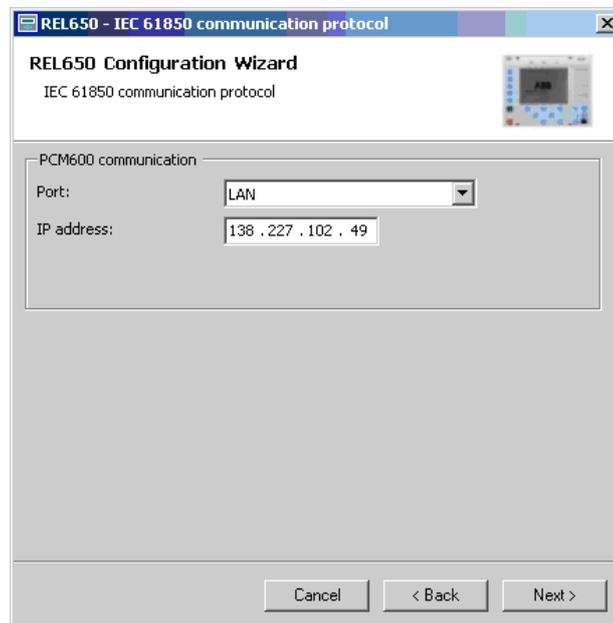
4. Select the IED Communication protocol, see [Figure 18](#).



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Figure 18: PCM600: Communication protocol selection wizard

5. Select the port and insert the correct IP address of the physical IED to configure, see [Figure 19](#).



IEC09000662-1-en.vsd

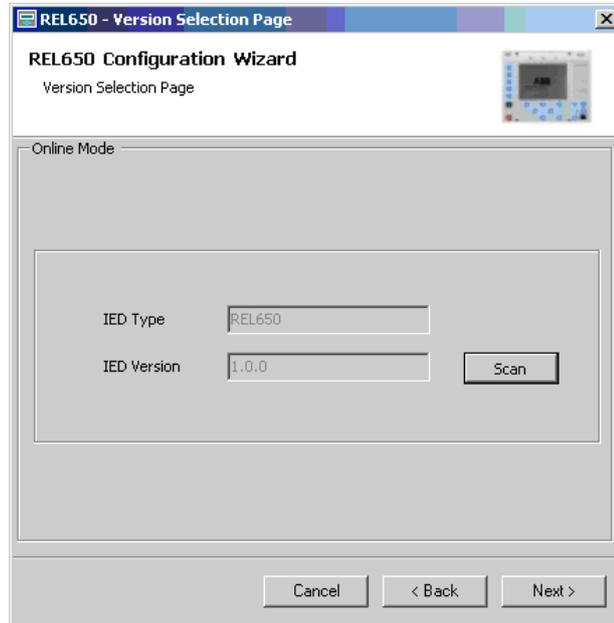
Figure 19: PCM600: Communication port and IP address

6. Cross check that the IED, whose IP address has been inserted, has been detected online by PCM600, see [Figure 16](#).



The user can not scan data from the IED or proceed further if the IED is not online or if the IP address is not correct.

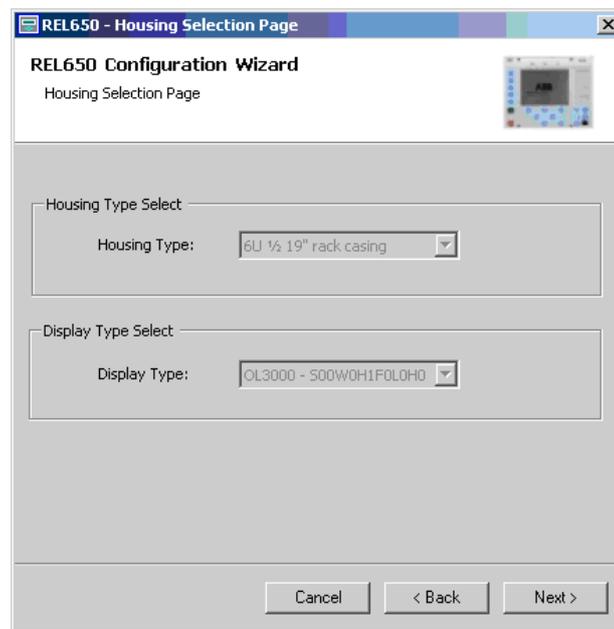
- Click the *Scan* option to scan/read the *IED Type* and *IED Version* for the IED that is online, see [Figure 20](#).



IEC09000663-1-en.vsd

*Figure 20: PCM600: IED Version detection*

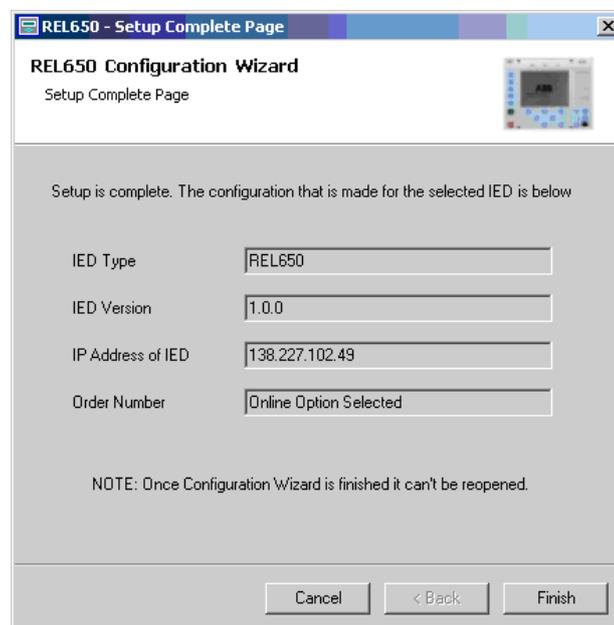
- Click next to open the *Housing Selection Page* and select the housing and display type of the IED, see [Figure 21](#)



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Figure 21: PCM600: IED housing and display type detection

9. The *Setup Complete Page* dialog shows the summary of the *IED Type*, *IED Version*, *IP Address of IED* and *Order Number*, see [Figure 22](#). It is possible to *Cancel* the insertion or confirm the configuration and do the insertion with *Finish*



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Figure 22: PCM600: IED Setup completion wizard



Note that it is not possible to go back and do any modification if an error is found in the setup complete page. If an error is detected, the user has to cancel the insertion and insert the IED again.

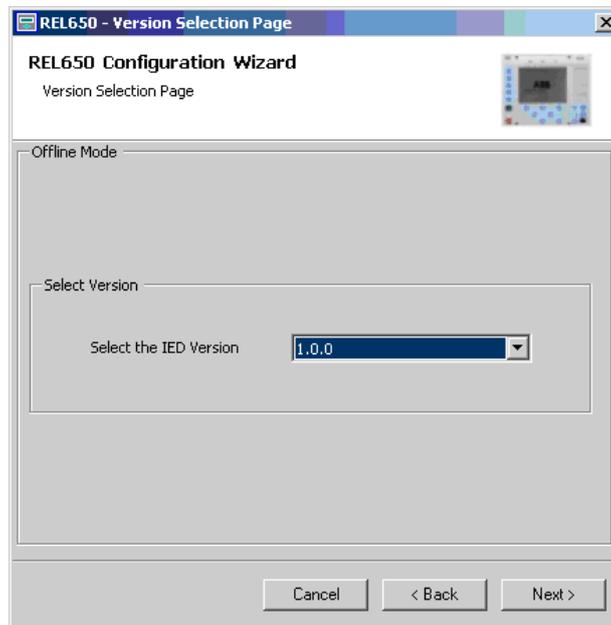


When the online configuration is completed it is advised to read the configuration from the IED to ensure that the IED object in PCM600 has the same configuration data as the physical IED.

### Inserting an IED in offline mode

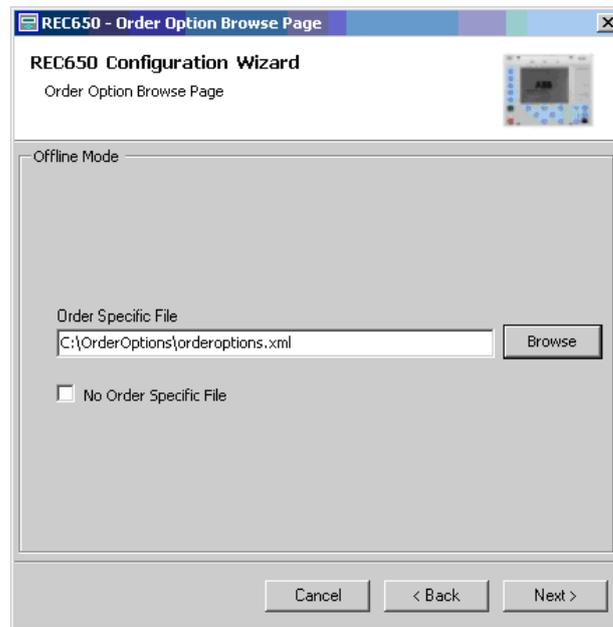
Working in offline mode has an advantage compared to online mode that one can start preparing configuration even though IED is not available. Setting up an IED in offline mode is almost similar to that of an online mode; however with offline mode it is not necessary to type the correct IP address in the Communication port and IP address dialog.

The version information and order specific file needs to be selected, see [Figure 23](#). The order specific file is delivered in a order confirmation E-mail. If no order specific file is available then select the *No Order Specific File* option, see [Figure 24](#).



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Figure 23: PCM600: IED Version selection



IEC09000681-1-en.vsd

Figure 24: PCM600: IED Order code selection

### Inserting an IED from the template library

An IED in the plant structure can be exported as a template (\*.pcmt). The user can build up a template library with all the exported IED templates. It is possible to insert an IED from the template library to create a new IED in the plant structure. Change the IP address, the name and the technical key that corresponds to the physical IED after a template IED has been imported.



A template IED can only be inserted when the bay is selected in the plant structure.

Procedure to insert a template IED:

1. Right-click the *Bay* in the plant structure.
2. Select *New* and *Create from Template ...* to open the *Create New Object from Template* window, see [Figure 25](#).

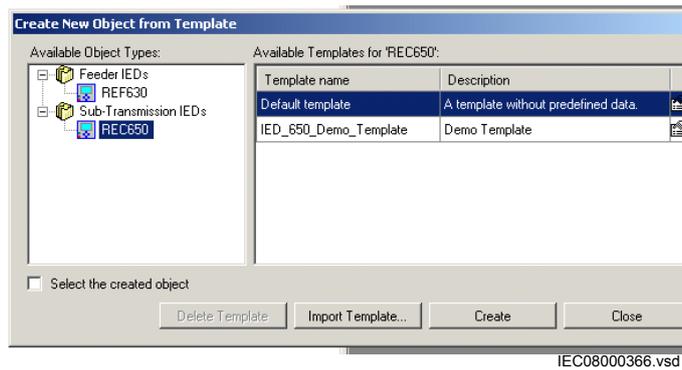


Figure 25: PCM600: Selecting IED from template library

3. Select the IED from the list of available IEDs.
4. Click the icon in the right column of the list of available templates to open the *Template Properties*. Verify the template information, see [Figure 26](#) and click *Close* to close the window.

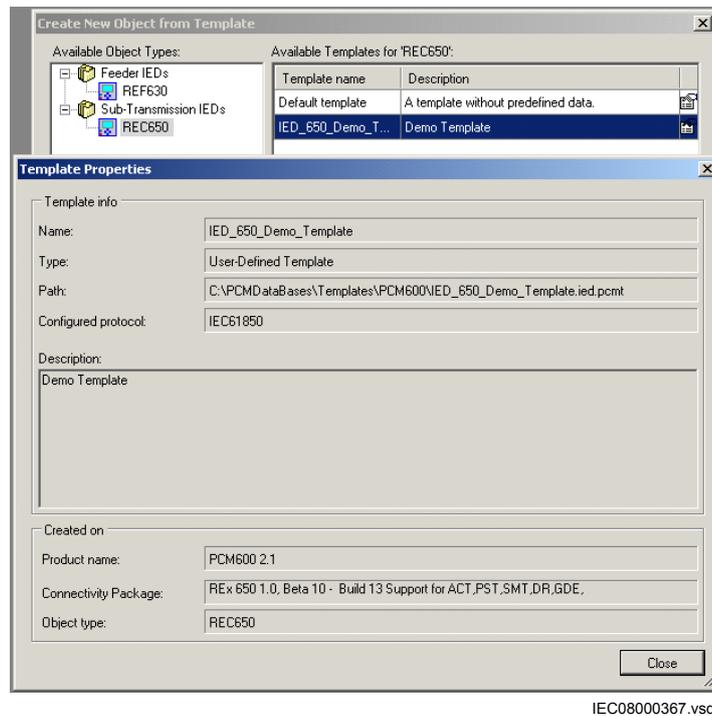


Figure 26: PCM600: IED Template Properties

5. Click *Delete Template* to delete the template, click *Import Template* to import a template from the selection window or click *Create* to insert the selected IED to the bay, see [Figure 25](#).



It is possible to insert more than one IED from the *Create New Object from Template* window and the selection window remains open until the user clicks *Close*.

### Inserting a pre-configuration

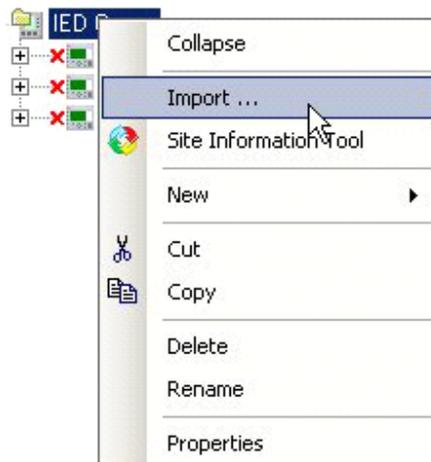
Pre-configurations in PCM600 are available as \*.pcmi files and include all information that is related to the IED object in PCM600. The pre-configuration is bound to a specific hardware configuration.

Two alternatives to insert a pre-configuration:

- Use the pre-configuration that has been ordered together with the IED.
- Create an own configuration, export the configuration as \*.pcmi file and use it to configure other IEDs.

Procedure to insert a pre-configuration

1. Right-click the bay and select *Import ...* to select the IED template file (\*.pcmi) , see [Figure 27](#).



IEC09000644-1-en.vsd

Figure 27: Import an IED from the context menu

2. Import the \*.pcmi file from the bay level in the plant structure.
3. Click *OK* to insert the new IED object in the plant structure.
4. Modify the configuration in ACT in case of changes.
5. Write the configuration to the IED.



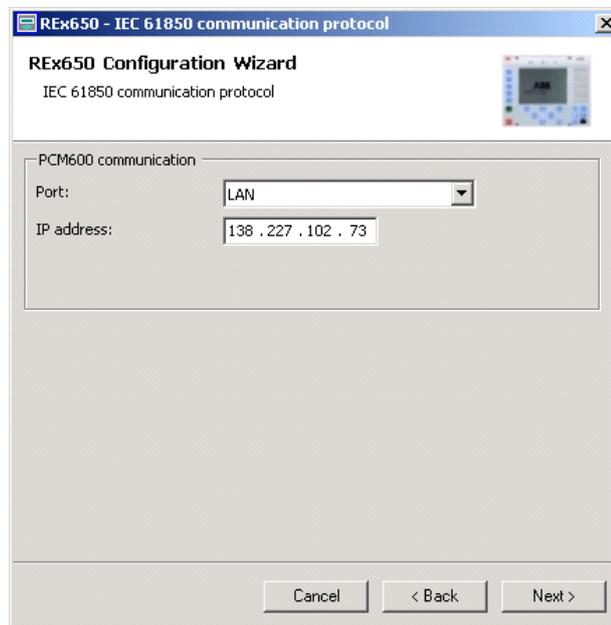
Ordered default configurations are not locked. The user can use any of the available default configurations in the IED or as a base for

the own configuration. The only requirement is that all needed hardware and software options are available.

#### 4.6.1 Setting IED IP address in the project

There are two alternatives to set IP address of the IED object in PCM600. The IED object in PCM600 must have the same IP address and subnetwork mask as the front or rear port on the physical IED to which the PC is connected. The IP address of the physical IEDs front and rear port can not be set from PCM600 but only from LHMI.

- Via the first window of the wizard when including a new IED in a project, see [Figure 28](#).



IEC09000617-1-en.vsd

*Figure 28: Alternative 1: IP address via first Wizard window*

- Via the IP address of the IED in the *Object Properties* window, see [Figure 29](#).

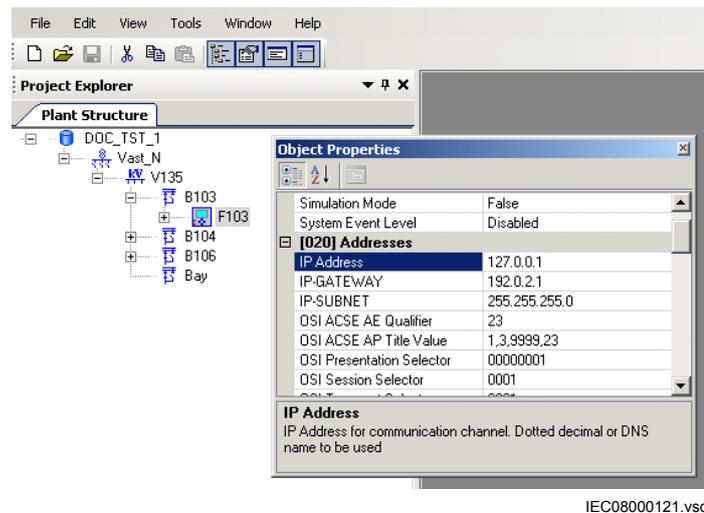


Figure 29: Alternative 2: IP address via IED Object Properties window

#### Procedure

1. Select the IED to enter the IP address.
2. Open the *Object Properties* window.
3. Place the cursor in the *IP address* row and enter the IP address.

The used alternative depends on the time at which the IP address is available. To enter the IP address via the IED object properties window allows to change the IP address at any time.

## 4.7 Setting technical key

Both a physical IED and an IED object in PCM600 have a technical key. The purpose of the technical key is to prevent download of a configuration to wrong IED. The technical key in the IED and PCM600 must be the same, otherwise it is not possible to download a configuration. Each IED in a PCM600 project must have a unique technical key. It is therefore not possible to set the same technical key for several IEDs in the same PCM600 project.



The IED is delivered with a factory default technical key. The validation of the technical keys between PCM600 and the IED will not occur if the IED contains the factory default technical key.



The technical key property in PCM600 corresponds to the IED name attribute in SCL files. Avoid changing the IED name attribute

outside PCM600, because data in PCM600 might be lost when importing SCL files.

When writing a configuration to the IED, PCM600 checks the mismatch between the IED object and the physical IED technical key, if any. For communication between the IED and PCM600 the technical key must be the same. Users have the option to read the technical key from the IED and update it to PCM600 or write the PCM600 technical key to the IED. The user can also define an own technical key. The error message displayed due to mismatch between PCM600 and IED technical key is shown in [Figure 30](#).



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*Figure 30: Error message due to mismatch between PCM600 and IED technical key*

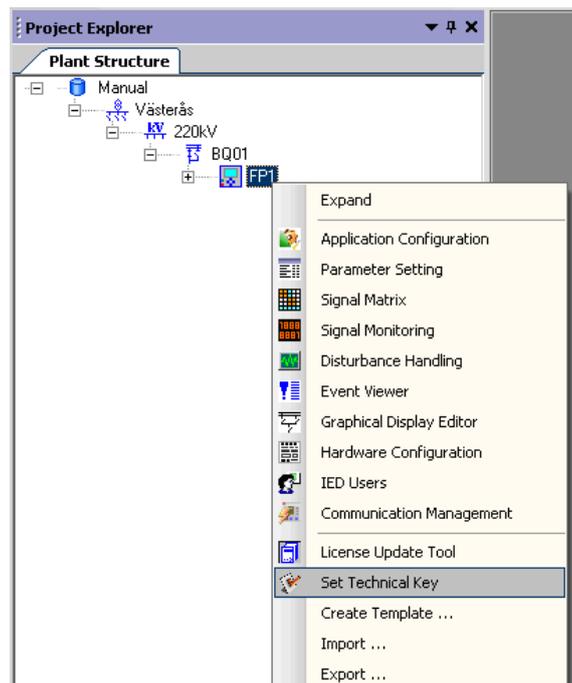


Be sure that the IED object in PCM600 has the same IP address as the physical IED, which is intended to be connected through the technical key concept.



The technical key for an IED object in PCM600 can also be changed in the *Object properties* window.

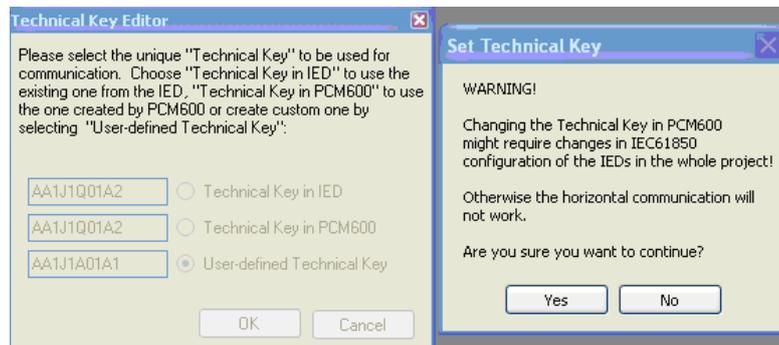
1. Select the IED in the plant structure.
2. Right-click and select *Set Technical Key*, see [Figure 31](#).



IEC09000667-1-en.vsd

Figure 31: PCM600: Set technical key menu at IED level

- A dialog window opens to inform about the technical key concept.
3. Click *OK* in the dialog window.  
The technical key is read from the IED and the technical key editor window opens, see [Figure 32](#).



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Figure 32: PCM600: Technical key editor

It is possible to

- use the existing technical key in the IED,
- use the existing technical key defined for the IED object in PCM600 or
- set a user defined technical key, which changes the technical key for both the physical IED and IED object in PCM600.



Be sure to not use a technical key with more than 10 characters.

4. Click *OK* to confirm the selection.  
It is not possible to set a user defined name or select the *Technical key in IED* if the value is the same as already given to another IED object in the PCM600 project. A dialog window opens if this is the case.



---

## Section 5 Protection and control engineering

### 5.1 Creating an application configuration with ACT

#### 5.1.1 Overview

ACT is used to create the application configuration for an IED. The application configuration is built up with function blocks.

Function blocks are dedicated for different functionality, for example:

- Preprocessing blocks
- Control related functions
- Protection related functions
- Monitoring functions
- Communication



For detailed information about function blocks see the technical manual and the application manual.

Some function blocks are mapped as logical nodes according to the IEC 61850 standard. See the IEC 61850 communication protocol manual for detailed information. Other function blocks are not mapped as logical nodes, for example:

- Logical gates
- Timers

The basic general features of the Application configuration tool ACT:

- Organization of an application configuration
  - Organize an application configuration into a number of logical parts (MainApplication).
  - Organize a MainApplication over a number of pages.
- Features to program an application configuration:
  - Insert function blocks, make connections and create variables.
  - Include the hardware IO channels directly in the application configuration.
  - Set function blocks and signal visibility to SMT.



SMT is not supporting signals of integer type or group signals. So, even if these types of signals are set as visible for SMT, they will not be shown in SMT.

- Document the application configuration, for example to make printouts.
- Test the application configuration online.
- Save application configurations as templates in an application library to reuse them in other IEDs.
- Validate the application configuration during the configuration process on demand and while writing the application configuration to the IED.



For instructions on how to perform the different tasks in PCM600, see PCM600 online help.

## 5.1.2

### Function blocks

- Function blocks are the main elements of an application configuration. They are designed for a various number of functions and organized in type groups. The different function block types are shown in the Object Types View. [Figure 33](#) presents an overview of the main parts that are relevant for function blocks.
- Set user defined names for function blocks and signals marked with blue text.



Signals that have a user defined name created in ACT, will only be visible in PST if the IED configuration is written to the IED and read back to PCM600. Otherwise the default signal name is shown in PST. If possible, set the user defined name to a signal before connecting the signal to other function blocks. Setting a user defined name to a connected signal may consume processing time.

- Set IEC 61850, ANSI or IEC 60617 symbol standard.
- Set IEC or/and ANSI naming style.
- Lock function blocks.
- Set visibility for execution order, cycle time and instance number.
- Manage signals, for example hide, show and rearrange.
- Invert Boolean inputs and Boolean outputs.



Mandatory signals must be connected.

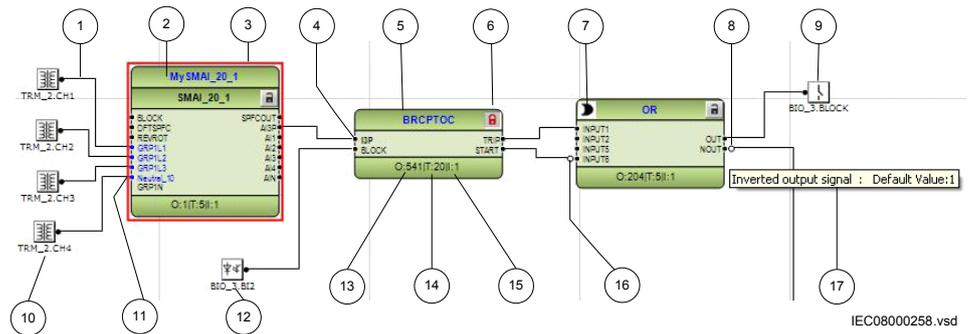


Figure 33: ACT: Function block overview

- 1 Connection(s)
- 2 User defined function block name
- 3 Function block, selected (red)
- 4 Mandatory signal (indicated by a red triangle if not connected)
- 5 Function block name
- 6 Function block, locked (red)
- 7 ANSI symbol
- 8 Inverted output
- 9 Hardware, binary output channel
- 10 Hardware, analog input channel
- 11 User defined signal name
- 12 Hardware, binary input channel
- 13 Execution order
- 14 Cycle time
- 15 Instance number
- 16 Inverted input
- 17 Signal description note

### 5.1.3 Signals and signal management

A function block has set of input and output signals. The placement of the signals for a function block is from left to right. Input signals are placed on the left side and output signals are placed on the right side.

A function block can contain more signals than needed in that application part. Hide unused signals to get a clear picture.

Signals are located on both sides of the middle position up and down. When there is space left, move some signals up or down for a better visibility and connection routing.

Boolean input and output signals may need to be inverted to fulfill the logic. ACT supports to add the inversion logic to a binary signal.



The input signal on glue logic function blocks can only be inverted if a glue logic function block with lower execution order in the same cycle time is available. Similar, the output signal can only be inverted if a glue logic function block with higher execution order in the same cycle time is available. Up to two input signals and two output signals can be inverted for glue logic blocks in the same cycle time.



Even though current is injected to the IED and the IED is connected to PCM600 in online mode, the signal value in ACT is shown as zero.

All not mandatory input signals have a default value that will be used when not connected.

## 5.1.4

### Function block execution parameters

Three function block execution parameters have influence on the runtime execution of the function block within the application configuration.

- Execution order
- Cycle time
- Instance number

Each time a new function block is selected these parameters have to be selected from the drop down lists in ACT. Depending on the function block type not all three parameters are selectable. The cycle time may be predefined to one value. The instance number is a counter for the total possible number of function blocks of that type used within an application configuration.

The *Execution Order* and *Instance Number* are a combination that is predefined within a product. It is possible to select a pair out of the list. [Figure 34](#) shows an example how the drop down list could look like.

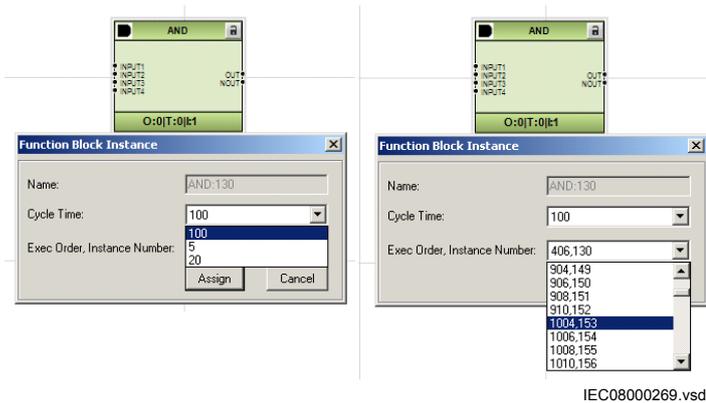


Figure 34: ACT: function block organization parameters



A minus sign in front of the cycle time, for example -200ms, indicates that the application is time driven, otherwise the application is analogue data driven. Analogue data driven applications require sample values from Analogue input modules - in case the physical module is broken, applications are not executed. Time driven applications are executed periodically regardless of the status of the analogue signal processing.

The *Cycle Time* can be selected to 5, 20 or 100 ms. Depending on function block type and the 650 series product only one, two or all three possibilities may be available.

The combination *Execution Order, Instance Number* is predefined by ABB. Mainly for basic logic function blocks like for example *AND, OR*, a set of combinations spread over the full range of execution orders is available. This gives the possibility to select a combination which fits to the execution order range needed in that application part.

### Application configuration cycle time and execution order organization

The application execution within the 650 series products is organized in three time classes, see [Figure 35](#).

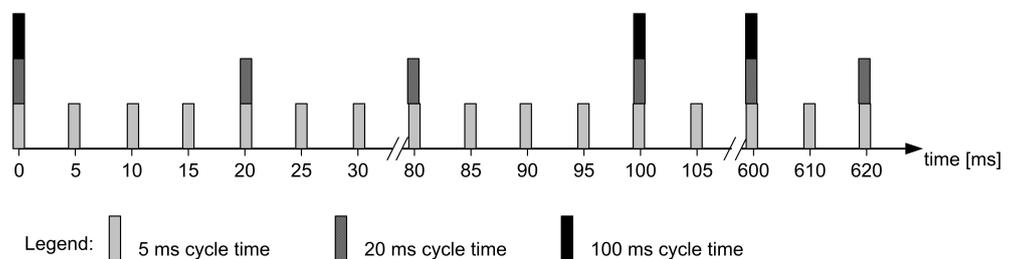


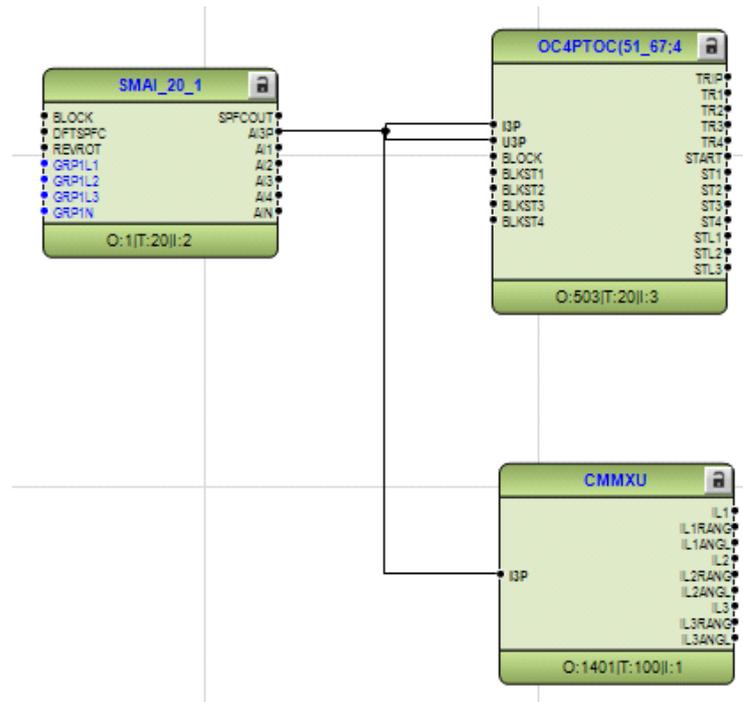
Figure 35: ACT: Possible MainApplication cycle times



For the same time point, faster cycle times are executed first.



A function block that is placed after a function block in the execution flow must have the same or a higher cycle time and/or execution order. See [Figure 36](#).



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Figure 36: Cycle time and execution order

A function block type can be defined to be a member of one or several cycle times. A function block instance can be set only to one cycle time.

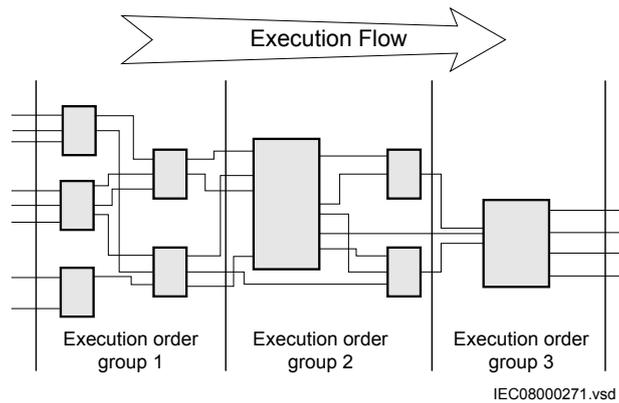


Figure 37: ACT: Concept of Execution order sequence

In the conceptual MainApplication example in [Figure 37](#), the execution order of the main function block in the execution order group 2 defines the execution orders needed in group 1 and 3. The preceding logic done with function blocks in group 1 must have a lower execution order than the ones in group 2. The following function blocks in group 3 must have a higher execution order than the main function block in group 2.

### 5.1.5 Configuration parameters

Configuration parameters are found in the parameter setting tool. For example, the SMAI function block has to be configured to support AC-current values or AC-voltage values.

### 5.1.6 Connections and variables

A connection is the link or "wire" between function block outputs and inputs.

Rules and methods to do connections:

- Drag a line between two signals.
- Link two signal by using variables.

#### Connection validation

A connection is only useful and possible between two signals of the same base attribute type, see [Figure 38](#).

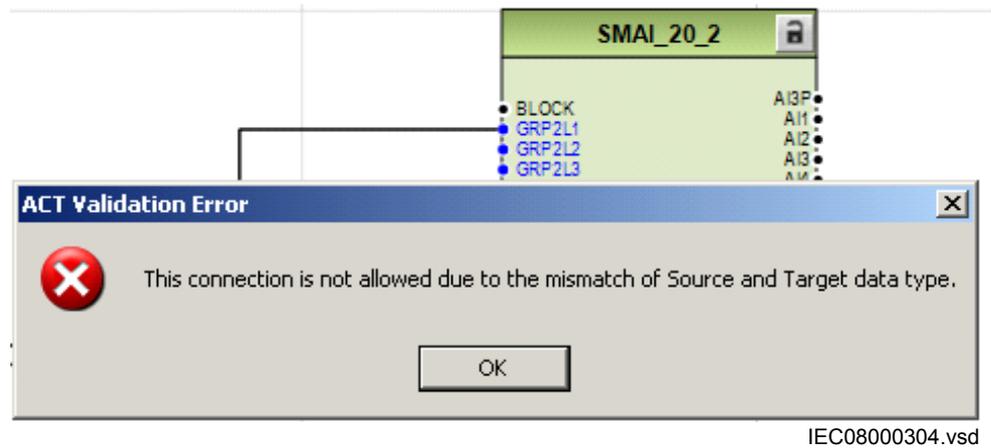


Figure 38: ACT: Warning message by signal mismatch for a connection

## 5.1.7

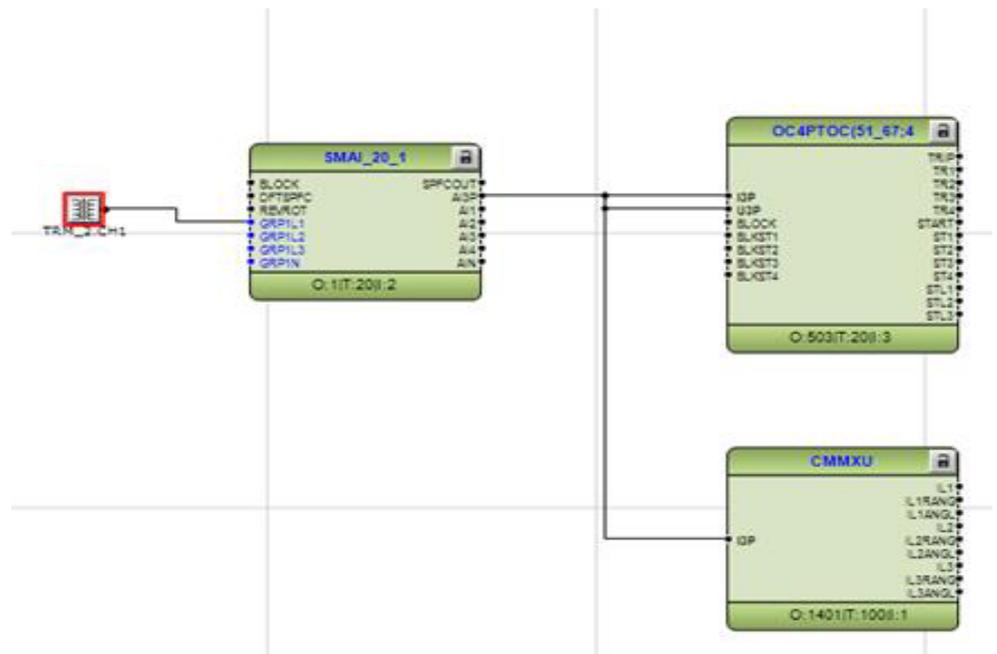
### Hardware channels

Hardware channels can only be connected to a function block input or output. A hardware connection can be established in ACT or SMT. When a hardware channel is connected a graphical symbol appears in ACT, see [Figure 39](#). The connection is also represented in SMT with a cross mark. Hardware channels are always visible in SMT.

Supported hardware channels are:

- Binary input channels
- Binary output channels
- Analog input channels

A hardware input channel can be used as often as it is needed. A hardware binary output channel is taken from the list of available channels when a new channel is requested. That prevents for using a hardware binary output channel twice. As an example, see [Figure 39](#).



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Figure 39: ACT: HW signal channels

## 5.1.8

### Validation

Validation checks the application configuration on errors about the rules and restrictions defined for doing a MainApplication on three levels.

- During creating the logic while doing a connection or placing a function block.
- On demand by starting the validation.
- When writing the application configuration into the IED.

#### Validation when creating the application configuration

Validation is made when creating the application configuration, for example:

- A connection between two input or two output signals is not possible.
- A connection between two different data types is not possible, for example a binary output to an analog input.

#### Validation on demand

To check the validity of an application configuration, click the 'Validate Configuration' icon in the toolbar. ACT will check the application configuration for formal correctness. Found problems are qualified in:

- Warnings, marked by a yellow warning icon

- Example: A variable connected to an output signal that is not connected.
- Example: If the user connects output from higher execution order function to inputs of lower execution order function.
- Errors, marked by a red circle with a cross
- Example: A mandatory input signal that is not connected.

Warnings will not prevent writing to the IED. Errors have to be corrected before writing the application configuration to the IED. An application configuration can be saved and ACT can be closed with open errors, but not written to the IED, see [Figure 40](#).

These problems are listed in the *Output View* under the Tab *Application Configuration*. A double-click in the error or warning row will navigate to the *MainApplication>Page>Area* where the problems are identified.

The screenshot displays a ladder logic diagram with several function blocks: MySMAI\_20\_1, MySMAI\_20\_4, MyOC4PTOC, and OC4PTOC(S1\_67:4). The diagram shows connections between terminals like TRM\_2.CH1, myCH2, myCH3, and various input/output points (A1, A2, A3, A4, AIN, AIP, AIP, U3P, I3P, START, ST1, ST2, ST3, ST4, STL1, STL2, STL3). Below the diagram is a navigation bar with tabs for MainApp, Mon, DREP, and MainApp2. The 'Output' view is active, showing a table of errors and warnings.

MainApplication Name	Page No	Description
Mon	1	In OC4PTOC function block , mandatory input signal: I3P is not connected
Mon	1	Variable Var_1 has no partner in configuration!

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Figure 40: ACT: Validation on demand

### Validation when writing to the IED

When writing the application configuration to the IED an automatic validation is performed. The validation is the same as the manually demanded validation. Errors will abort the writing.

## 5.2 Setting configuration and setting parameters in PST

Configuration parameters and settings parameters are changeable either from LHMI or from PST in PCM600.



Note that the some parameters are only visible in PST and some are only visible on LHMI.



A common write from PCM600 to the IED, where parameters are changed in PST, will overwrite any parameter changes made locally from LHMI.

All variables listed and shown in the parameter list can be sorted into two groups:

- Configuration parameter or
- Setting parameter

### Configuration parameter

A configuration parameter specifies an operation mode of an application function or of the IED. These are basic configurations, which are normally configured only once and then settled. The IED configures itself at start-up according to the given configuration parameter values.

### Setting parameter

A setting parameter (short form only “setting”) is a parameter that can be changed in the IED at runtime.

### Setting group

Nearly all settings used by the IED for the protection application functions are organized in a group of settings. Up to four setting groups can be configured with different values. The IED supports the selection of a setting group at runtime.

### IED parameters organization

The organization of the parameters in a tree structure is visible in the plant structure by expanding the setting tree.

## 5.3 Connecting signals in SMT

SMT is used to do cross references, see [Figure 41](#):

- between physical IO signals and function blocks.
- for the GOOSE engineering.

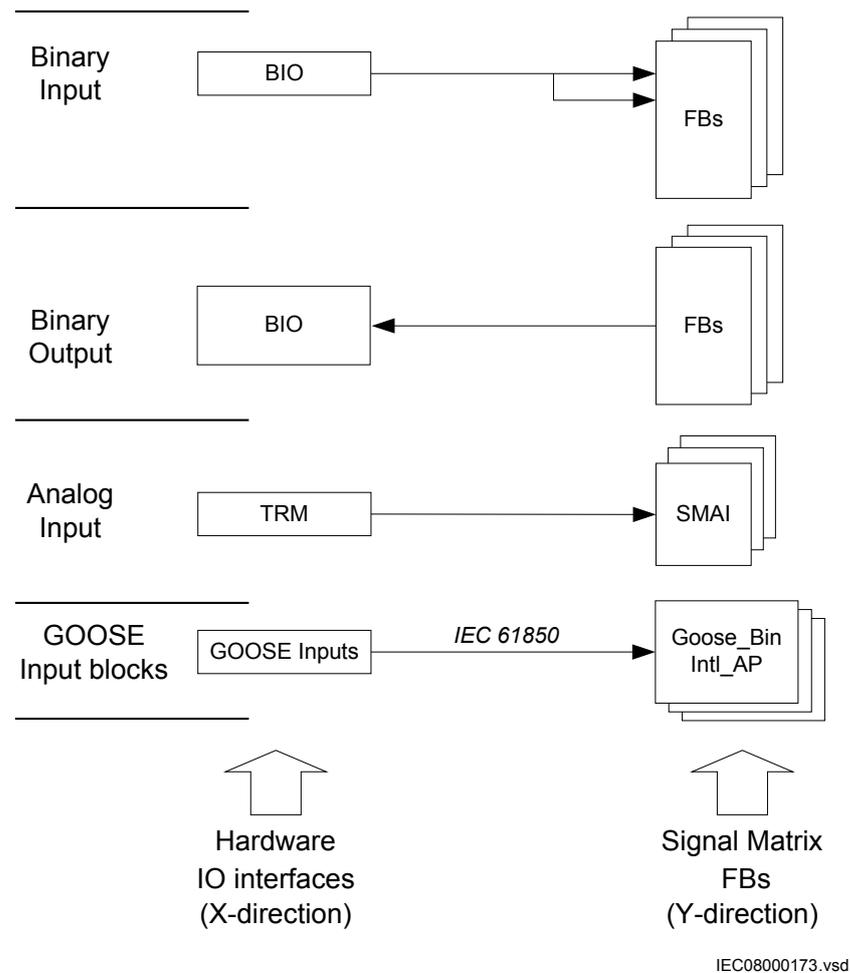


Figure 41: SMT: Operation principles

A binary input channel can be connected to one or several function block inputs, see [Figure 42](#). If a binary input channel is connected to several different function blocks in ACT, the connection will appear as glue logic in SMT.

A binary output channel can only be activated from one function block output. If it should be activated from more than one function block output, glue logic has to be used. Glue logic means inserting a logical gate (OR and AND blocks) between the function blocks and the binary output channel. This can be engineered in SMT.



Connections made in SMT will automatically also be shown in ACT.

		BIO_4							
BLOCK		B01	B02	B03	B04	B05	B06	B07	B08
SXSWI:1 (1)	EXE_OP				X				
	EXE_CL					X			
SXSWI:2 (2)	EXE_OP						X		
	EXE_CL							X	

IED - Signal Matrix			BIO_3			
			B12	B13	B14	B15
SXSWI:1	BLOCK	OR	X		X	
SXCBR:1	POSOPEN			X		
	POSCLOSE					

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Figure 42: SMT Connection between binary input channels to binary input signals

Depending on the IED capability, SMT has a separate sheet for each possible combination.

The possible sheets are:

- Binary Inputs
- Binary Outputs
- Analog Inputs
- GOOSE Receive



## Section 6 Local HMI engineering

### 6.1 LED and function key engineering

#### 6.1.1 Local HMI engineering process

The engineering process of the LEDLHMI involves several steps. [Figure 43](#) presents the pre-engineering step, the main steps in the engineering process and the required sequences.

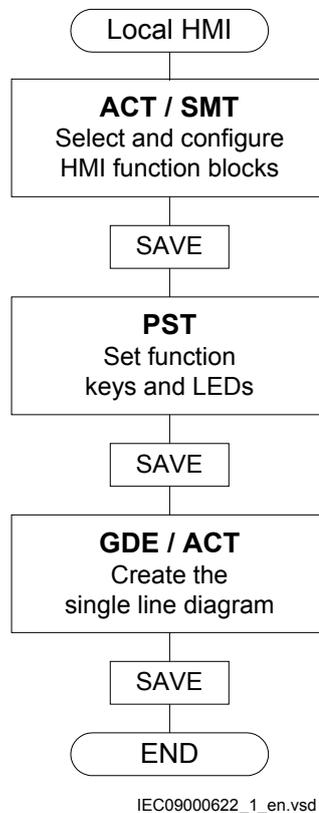


Figure 43: LHMI: Engineering process flowchart

- ACT with possible assistance of SMT

- To use the function keys and LEDs on LHMI it is needed to insert the corresponding special function blocks for these operation element groups.
- The function blocks for the LEDs are organized as single function block per LED but indexed to the group identification, for example GRP1\_LED3 (indication LED 3 in virtual LED group 1).
- The function blocks for LHMI are visible by default for PST.
- Use ACT to connect start and trip signals from application functions to LED function blocks.
- PST
  - The operation mode of the function keys and the LEDs is defined in PST.
  - The presented text labels on the LCD for LHMI keys and LEDs.
- GDE with assistance of ACT, for example
  - to make the single line diagram of the primary process part.
  - to make the dynamic links for the apparatus.
  - to make the dynamic links for measurements.

### ACT and local HMI function blocks

A set of special function blocks is available for all the operation element groups on LHMI.



See the technical manual for more information about function blocks.

List of LHMI function blocks that are available in ACT:

- LHMICTRL
- FNKEYMD1 to FNKEYMD5
- LEDGEN
- GRP1\_LED1 to GRP1\_LED15
- GRP2\_LED1 to GRP2\_LED15
- GRP3\_LED1 to GRP3\_LED15

The function blocks for the LEDs are organized in function blocks per LED. They can be placed close to the logic where the information per LED is built in ACT.

[Figure 44](#) describes the basic LHMI and the operation element groups. These are the 15 LEDs and their belonging text elements on the LCD [A]. They are operated by the keys [a] and [b].

The other group is the five function keys with their IEDs and the corresponding text elements on the LCD [B].

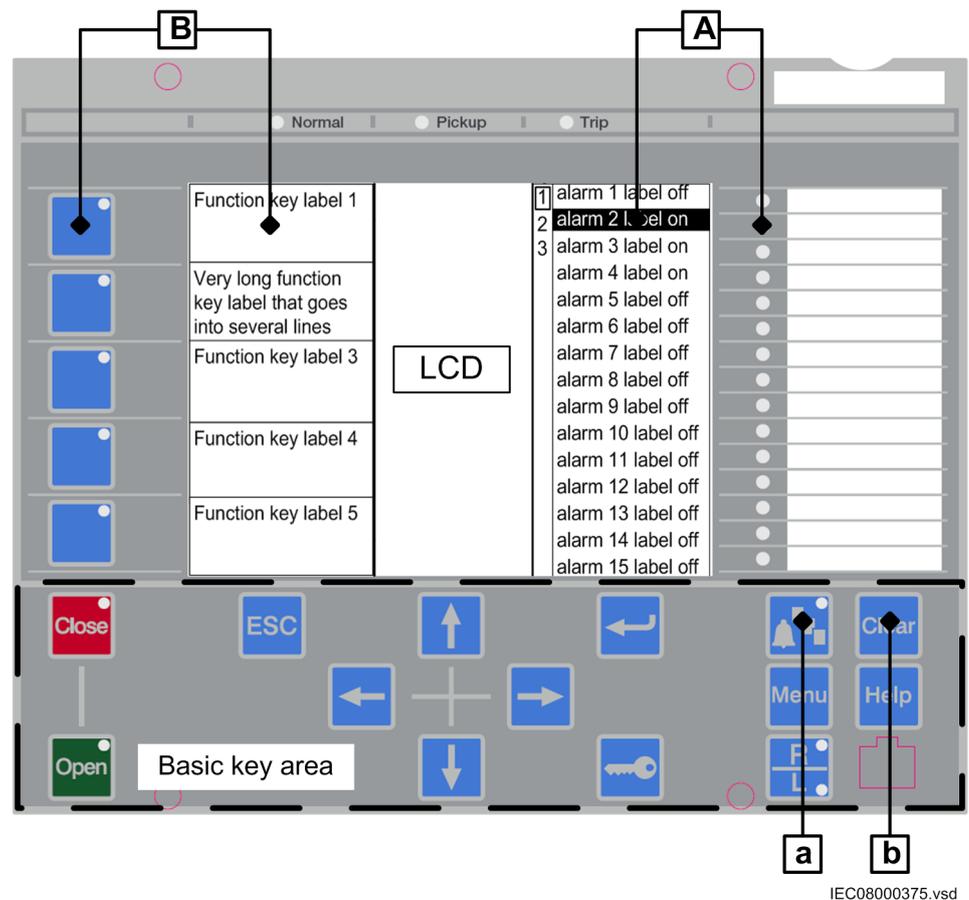


Figure 44: Local HMI: Placement of local HMI operation elements

### Function block LEDGEN

- Handles an external acknowledge signal as source to acknowledge the LEDs.
- Generates an additional pulse for general purposes whenever the LEDs are acknowledged by the operator.
- Generates a pulse whenever a new LED signal occurs. It may be used to trigger an acoustical alarm.
- Handles the timer *tReset* and *tMax* for the LED operation mode 'LatchedReset-S'.

### Function block GRP1\_LED1 to GRP3\_LED15

- The 15 LEDs on the right side of the LCD can indicate in total 45 alarms, warnings or other signals to the operator. They are organized in three groups 1 to 3.
- Each signal group belongs to one function block.
- Each LED illuminates in one of the three colors: RED, YELLOW or GREEN.
- The organization of flashing, acknowledgment and group selection is done directly between the function blocks and the basic LHMI keys, the

'Multifunction' key [a] to toggle between the three groups or the 'Clear' key [b] to acknowledge or reset the LEDs.

- Only the programming of the signals is needed for the LEDs.
- The operation mode of the LEDs is defined in PST.

### **Function block FNKEYMD1 to 5**

- Every function key has an own FNKEYMD function block.
- The 5 function keys on the left side of the LCD [B] can be used to process demands.
- The function block handles the signal for the LED included in the key as input signals.
- The LED signal of the key is independent of the key function and must be programmed to process demands.
- The function block handles the operators command when the key is pressed as output signal.
- The functions are activated whenever a key is pressed the first time. The corresponding text elements for the five keys appear on the left side of the LCD. No execution of the function is done. So the first push is used to activate the presentation only.
- The next key push is handled as activate function and the output signal of the function block is set.
- The operation mode of the function key is defined in PST (pulse, toggle).

### **PST and function block configuration**

The operation mode of the function keys and the LEDs must be defined per key and LED in PST.

The function key can operate as:

- Pulsed signal
  - Each push forces a pulse of a configured time.
  - The pulse time can be set in PST.
  - The default pulse time is 200 ms.
- Toggle signal
  - Each push changes the state of the signal: OFF-ON-OFF-ON-OFF...
  - The default position after power up or reset is OFF.
- Menu shortcut
  - When pressing a key configured for that purpose, the function key panel is hidden and LHMI opens directly in the configured menu.

FnKeyCtrl LclHMI					
Function key 1					
FNKEYMD1: 1					
✓	Mode				
	PulseTime		0,001	60,000	
	LabelOn				18 character(s)
	LabelOff	LCD_FN1_OFF			18 character(s)

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Figure 45: LHMI: Function key operation mode

The LEDs have a number of different operation modes, see [Figure 46](#):

- General definitions
  - Each LED can illuminate in one of three colors: RED, YELLOW, GREEN.
  - Only one color is illuminated at a time.
  - The priority for illumination and the color is linked.
    - Prio 1 = RED
    - Prio 2 = YELLOW
    - Prio 3 = GREEN
    - When RED and YELLOW are ON at the same time, the LED will illuminate in RED.
  - The operator's acknowledge for the LED signals is done for all three signals (RED, YELLOW, GREEN) of the LED.
  - A reset of the LLEDs operates also on all three signals of the LEDs.
- Follow-S
  - The LED illumination follows the status of the signal. The LED illuminates steady (S).
- Follow-F
  - The LED illumination follows the status of the signal. The LED illuminates flashing (F).
- LatchedAck-F-S
  - The LED latches the signal change OFF-ON and flashes (F) until it is acknowledged.
  - When the signal is still ON at the time the signal is acknowledged the LED changes to steady (S) mode.
  - When the signal has already changed to OFF before the time it is acknowledged, the LED turns to OFF.
- LatchedAck-S-F

- The same as LatchedAck-F-S but the LED starts with steady state and flashes after acknowledgment.
- LatchedColl-S
  - The LED illuminates in all cases in steady mode only
  - The LED latches a signal change from OFF-ON until it is acknowledged by the operator.
  - The LED stays in steady mode when it is reset and the signal is still in ON state.
  - The LED is OFF only after the signal has changed to OFF state AND it is reset by the operator via 'Clear' operation.
- LatchedReset-S
  - This mode is used for all LEDs that are used to indicate a disturbance. The LEDs will stay in the last state after the disturbance run time until they are reset after a defined time.
  - The timers are set in PST in the function block LEDGEN.



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Figure 46: LHM I: LED operation mode

## 6.1.2 LED operation modes

Description of different operation modes for LEDs to be configured in ACT and PST.

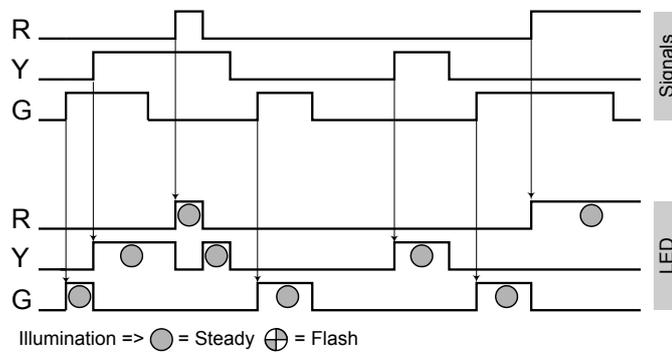
Six operation modes are listed in the drop down menu in PST.

- Follow-S
- Follow-F
- LatchedAck-F-S
- LatchedAck-S-F
- LatchedColl-S
- LatchedReset-S

General operation definitions for the LEDs:

- Each LED can illuminate in one of three colors: RED, YELLOW, GREEN
- Only one color is illuminated at a time
- The priority for illumination and the color is linked
  - Prio 1 = RED
  - Prio 2 = YELLOW
  - Prio 3 = GREEN
  - When RED and YELLOW are ON at the same time, the LED will illuminate in RED
- The operator's acknowledge for the LED-signals is done for all three signals (RED, YELLOW, GREEN) of the LED.
- A reset of the LED operates also on all three signals of the LED

**LED operation mode Follow-S**

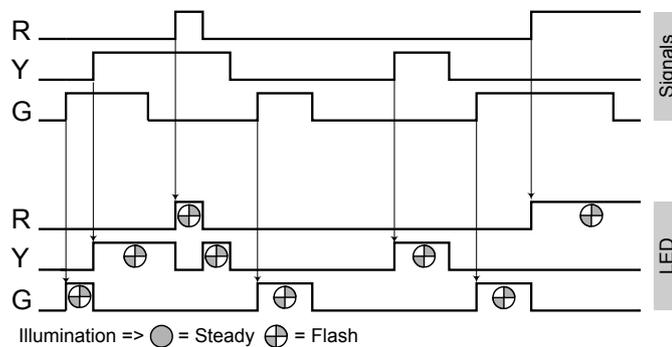


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Figure 47: LHMI: LED operation mode Follow-S

Monitoring a signal with a LED is a simple mode, where the LED follows the signal state. More than one signal per LED can be used when applicable. See [Figure 47](#) for the valid priority rules. The LED illuminates always in steady state.

**LED operation mode Follow-F**



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Figure 48: LHMI: LED operation mode Follow-F

This is the same mode as Follow-S but the LED illuminates flashing, see [Figure 48](#). This mode may be used to indicate that a tap changer or Petersen coil is moving.

**LED operation mode LatchedAck-F-S**

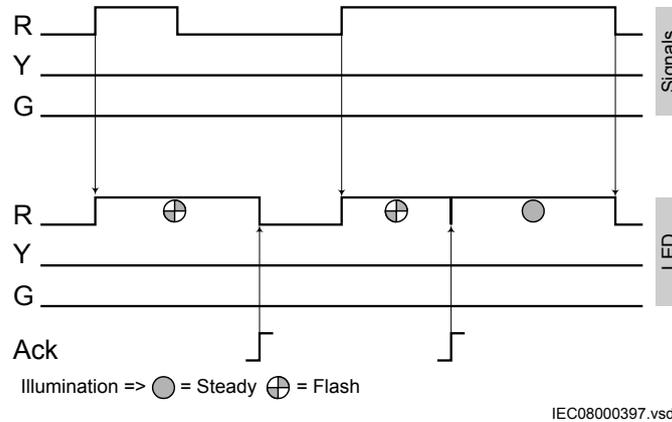


Figure 49: LHMI: LED operation mode LatchedAck-F-S / Base

The classical mode to indicate incoming alarms or warnings, which the operator has not seen since the last acknowledgement, is presented in [Figure 49](#) as a basic operation mode. Two possibilities for the operator to acknowledge:

- The signal is already gone when acknowledged, the LED turns OFF (at least for this color).
- The signal is still ON, the LED stays illuminated and changes to steady state.

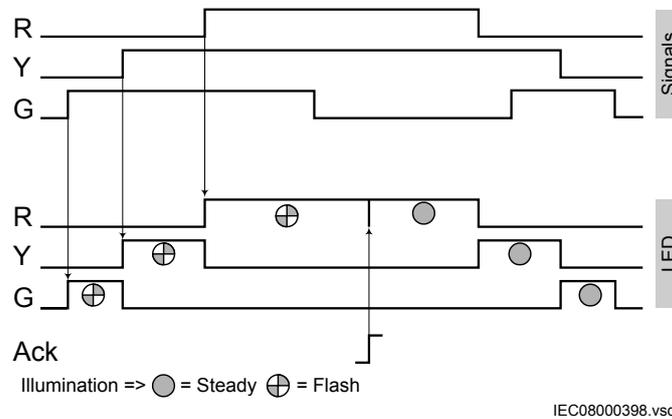


Figure 50: LHMI LED operation mode LatchedAck-F-S Ack Prio / 1

When more than one color is used the rules for priority are valid. Two basic principles are:

- Two or more signals are still ON when the LED is acknowledged.

- All colors (signals) are acknowledged and they will illuminate in steady state.
- Incoming additional signals with lower priority will illuminate when they become the highest priority in steady mode.
- One or more signals with higher priority are changing to *ON* after an acknowledgement.
  - The higher prior color (signal) will illuminate in flash mode.

See [Figure 50](#) and [Figure 51](#) for these two principles.

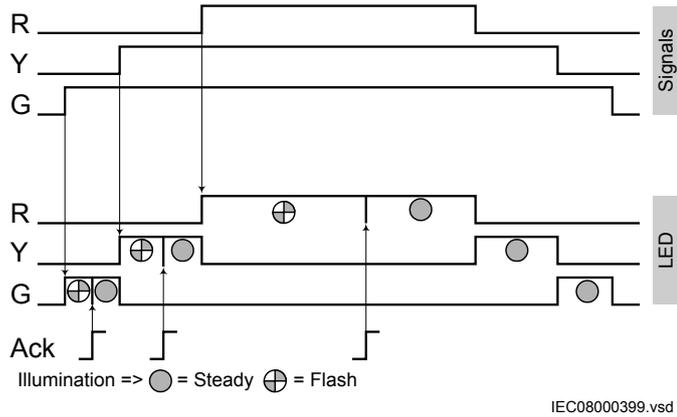


Figure 51: LHMIL LED operation mode LatchedAck-F-S Prio / 2

### LED operation mode LatchedAck-S-F

This operation mode operates exactly as the one described above (LatchedAck-F-S). The only difference is that the illumination mode is changed. Flash mode instead of steady mode and steady mode instead of flash mode.

### LED operation mode LatchedColl-S

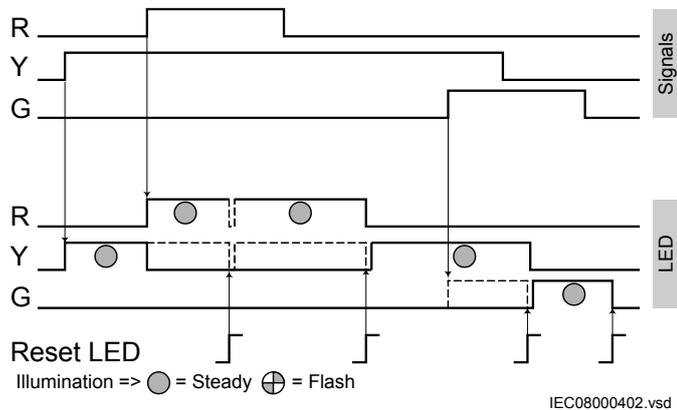


Figure 52: LHMIL LED operation mode LatchedColl-S

This mode catches a signal change to *ON* and the LED stays *ON* until the operator resets the LEDs for this group.

If the signal is still *ON* when a reset LED is done, the LED will illuminated again. This occurs when the application configuration accesses the signal again in the next cycle after reset. The thin dashed lines in [Figure 52](#) shows the internal state of the LED following the signal and reset, when no higher prior signal is given.

The LED illuminates always in steady mode.

### LED operation mode LatchedReset-S

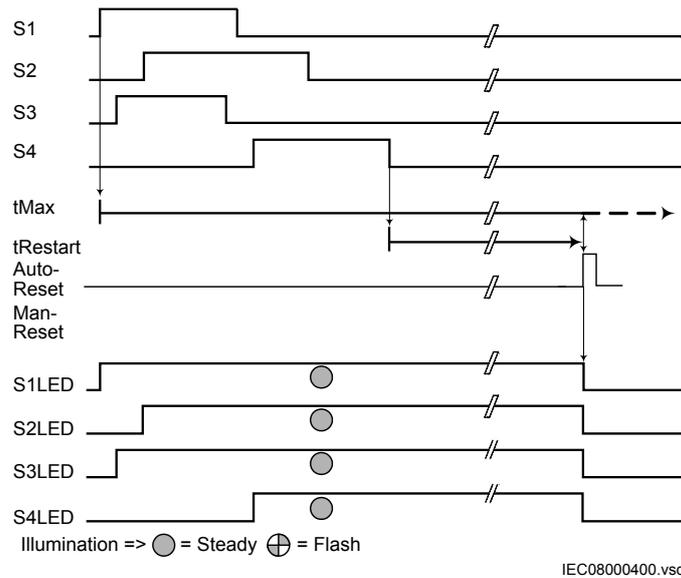


Figure 53: LHMI: LED operation mode LatchedReset-S

This mode is useful to monitor signals that are involved in case of a disturbance, see [Figure 53](#). The signal state after the disturbance allows a fast overview about the disturbance. To get always the situation of the last occurred disturbance, the LEDs are reset after a predefined time (*tReset*). So this is the longest time a disturbance can be monitored by the LED situation.

In case a second disturbance occurs before the *tReset* time has elapsed, see [Figure 54](#), the signals that are still ON at the end of *tReset* will return to ON with the next application configuration cycle after *tReset*. To clear these LEDs, a second timer *tMax* is used. *tMax* is started when the first signal of the disturbance changes to ON. *tMax* is stopped, when *tReset* could clear all LEDs.

A disturbance runs for a maximum of some seconds, while *tReset* can be in the range of 60 to 90 seconds.

The timer *tReset* and *tMax* are configured in PST as part of the function block LEDGEN

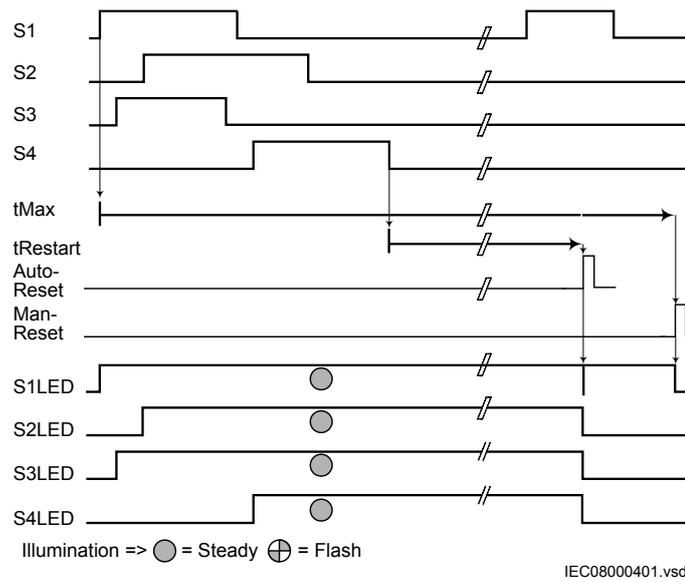


Figure 54: LHMIL LED operation mode LatchedReset-S / 2

## 6.2 Single line diagram engineering



Phase angles are shown as radians in single line diagram (GDE measurand) symbols but in degrees in other views on the LHMI.

### 6.2.1 Concept description to present and generate diagrams in graphical display editor

Additional concept information to use GDE, see [Figure 55](#):

- Different GDE windows
- HMI display raster layouts
- Drawing lines (doing a Link)

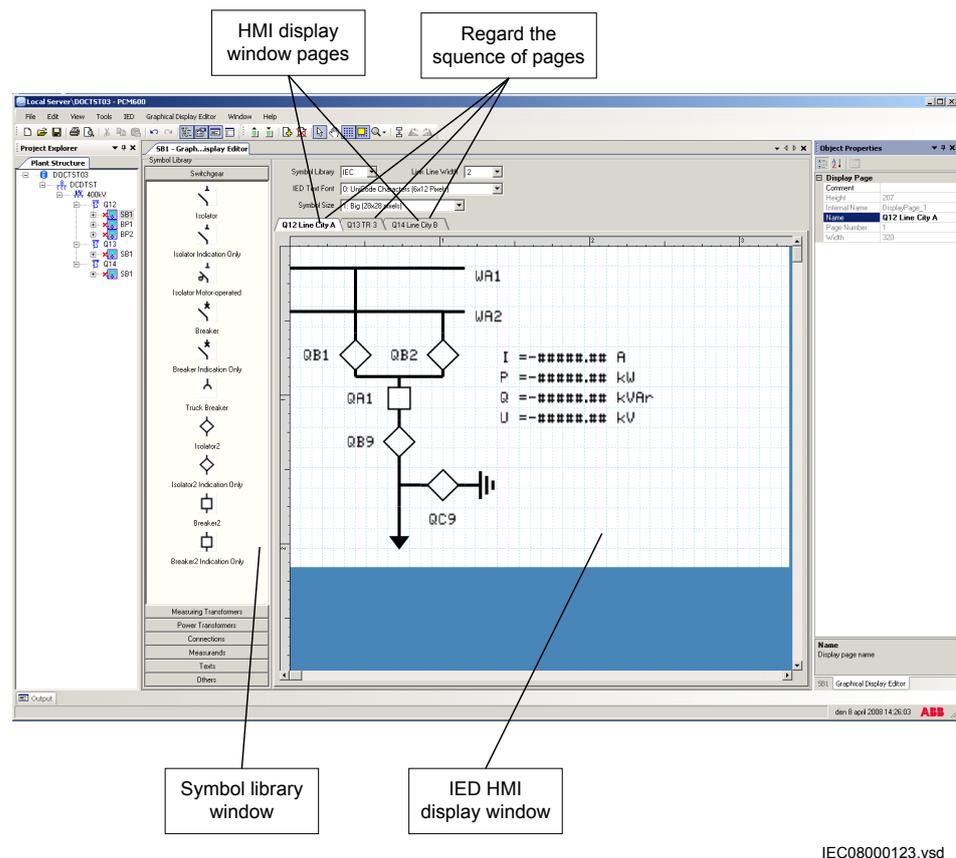


Figure 55: GDE: Screen image with active GDE

### Procedure

1. Start GDE to open a presentation of the tool.
2. GDE has a fixed symbol library window on the left side of the display.
3. The presentation is empty when no page exists for the IED.

### Display window and sequence order



It is important to link correctly between the HMI display page and the corresponding bay that is presented as a single line diagram on this HMI page.

Rules to handle HMI pages:

- Several single line diagrams can be created for one bay.
- The IED supports one bay.
- The sequence order of the HMI pages in the graphical display editor starts from left to right.
- Measurements and the single line diagram can be shown on the page in any possible order and placement.
- All symbol objects, for example apparatus, text and measurement, on the HMI page must be linked to the correct function block in the application configuration in order to present the correct process values.

### Symbol library

The symbol library window contains some panes that include drawing symbols or elements to create a single line diagram, measurements and texts on a page. Click on the name bar of the selected element to open the pane.

The library shows the symbols either in ANSI standard or in IEC standard. The standard is selected by the drop down list box located on top of the display window.

When changing to the other library standard, GDE closes the library windows, changes the symbols according to the selected new standard and redraws the single line diagram in the display window.

Select the different panes and their symbols to become familiar with the available symbols.

Measurements (Measurands) are presented in one format that explains itself when selected. Select the format and drop it in the drawing area. Use the object properties to make adaptations.

### Special symbols for dynamic text

In the text pane the symbol library contains a set of special symbols to present text that depends on the status of variables. A set of three symbols is either valid for a single bit information or for a list of up to 32 different inputs. The corresponding function blocks in ACT are of type xxxGGIO.

- Select *Dynamic Text* and *Indication* to present the text for the actual value of the function block, see [Figure 56](#).
- Click *Select Button* to select the value.

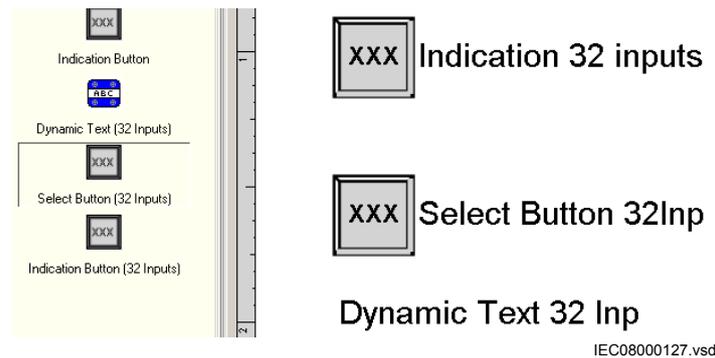


Figure 56: GDE: Dynamic Text symbols

The standard (IEC or ANSI) for the symbols and the selection of the font size for the text elements can be changed using the two selector boxes on top of the page window.

### HMI display raster layout and text font selection

The raster in the page changes from symbol presentation to text presentation when a text object is selected and vice versa.

The text can be presented in two different font sizes:

- UniCode characters (6 x 12 pixel), or
- UniCode characters (13 x 14 pixel)

The total size of the presented white area (page) represents the visible part of the LHMI display without header and foot-line.

The visible display for a single line diagram is organized in a raster of 13 x 8 (columns x rows). Each symbol -presented by 24 x 24 pixels- included by the drag and drop method must be dropped in a raster box. The icon “snap to grid” must be enabled to place a symbol. The description text for an apparatus object can be placed in all four directions around the symbol. The description is part of the apparatus object. It is possible to place the symbols not under assistance of *Snap to Grid*.

### Handling text

The raster switches when text is selected in a raster of 45 x 15 (columns x rows). One raster box is the placeholder for one character. A text element must be placed in the position of the raster. The name and the unit of a measurement or text symbol can be changed either by double click the symbol or via the object property window.

Select and toggle *Show Texts using the IED Fonts* to get a view how it will look like later on the real HMI display.

### Doing Link to draw lines

The line width has to fit to the line width used for the symbols. The standard size is 2. Choose the line width in a selection box placed in the upper area above the page. A line that is not connected to a symbol may be done in any line width in the range 1 - 5. But it needs to be simple connection points to be drawn.

Procedure to draw lines when the apparatus symbols are placed, see [Figure 57](#):

1. Place the apparatus or transformer symbols by drag and drop in a raster box.
2. Place the connections symbols by drag and drop in a raster box.
3. Click the *Link* icon to enable direct line drawing.
4. Center the mouse pointer on the center of a connection point; visible in two circles at the endpoints of a line, to draw a line.
5. Click to start and move the mouse pointer to the destination connection point. Center once again the mouse pointer and click to drop the line.
6. Draw all line elements that are necessary.
7. Click *Select* in the menu bar to finish the line drawing.

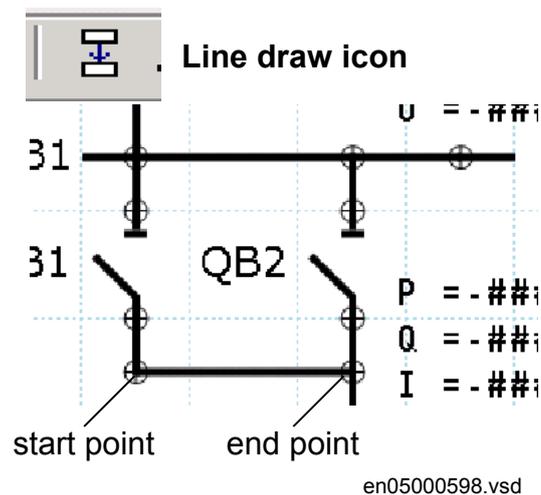


Figure 57: GDE: Drawing a line

## 6.2.2

### Bay configuration engineering

A page with a single line diagram and measurements contains active living objects. The object values are updated by the IED periodically (measurement) or in case of an event. Once the symbols are placed on the HMI page they must be linked to the corresponding function block in the application configuration, which protects or controls the object that the symbol on the HMI page represents.

#### Creating a complete HMI display page

Procedure:

1. Make a sketch how to present the single line diagram.
2. Place the apparatus, transformer and other symbols that are needed for the single line diagram into the raster boxes.
3. Add connection points where needed.
4. Link the apparatus symbols with line elements.
5. Adjust the text symbols while writing to north, east, south or west. Use the object property window to do it.
6. Place measurements when needed.
7. Edit the name, unit and number of decimals of the measurements.
8. Select each object that has a dynamic link and do the link to the corresponding process object, see [Figure 58](#).
9. Check to select the correct function block. Function blocks of the same type can have different instance numbers.
10. Validate that all links are done.
11. Save the complete picture.
12. Repeat the steps for all pages when more than one is needed.
13. Write to IED.

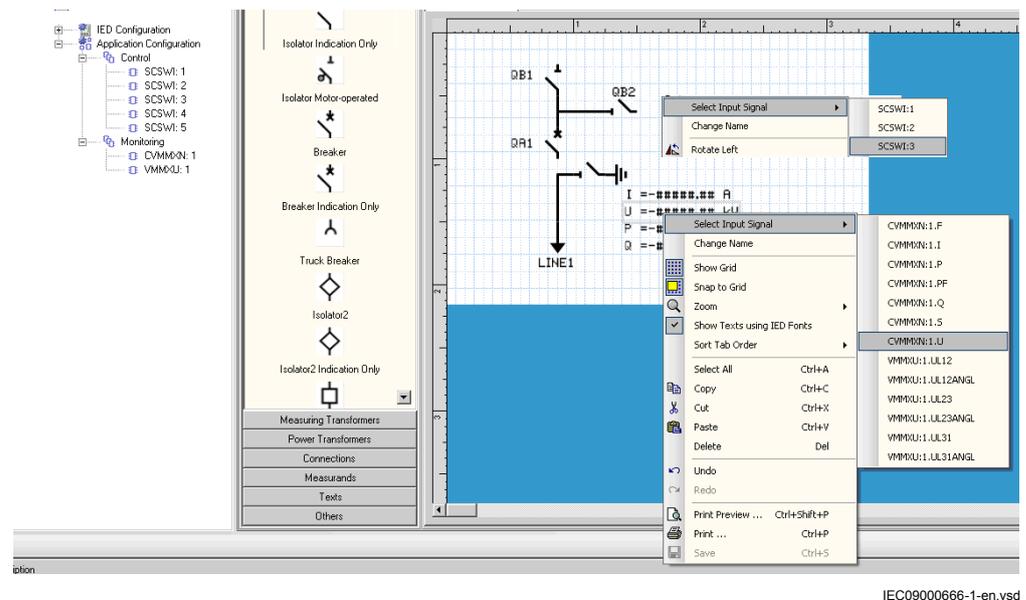


Figure 58: GDE: Establish a dynamic object link

### Linking process objects

To describe a process object within an IED it needs to be established in the application configuration, configured when given with its parameters by PST and linked to be displayed in the HMI.

Three tools are involved for the described steps:

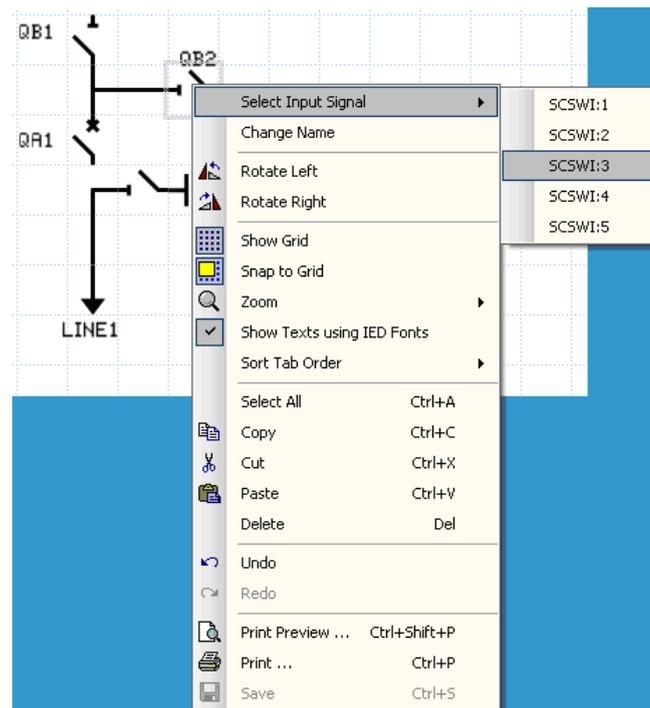
- ACT to program the application function block for apparatus and/or measurements.
- PST to adapt the settings and/or configuration parameter of the application function block.
- GDE to establish the link for updating the selected data attribute in the HMI of the application function block.

The following application function blocks are used to deliver the needed information:

- Switch controller (of type CSWI) for an apparatus.
- All configured function blocks with measurements (of type MMXU) for the measurements.
- VSGGIO for one bit indications for the dynamic text symbols.
- SLGGGIO for 32 bit indications for the dynamic text symbols.

#### Procedure

1. Right-click the apparatus symbol and select *Select Input Signal*. A list of engineered switch control application function blocks opens, see [Figure 59](#).
2. Select the switch control application function block that corresponds to the selected apparatus.
3. Right-click the measurement symbol and select *Select Input Signal*. A list of the engineered measurement application function blocks opens.
4. Select the measurement application function block that corresponds to the selected symbol.

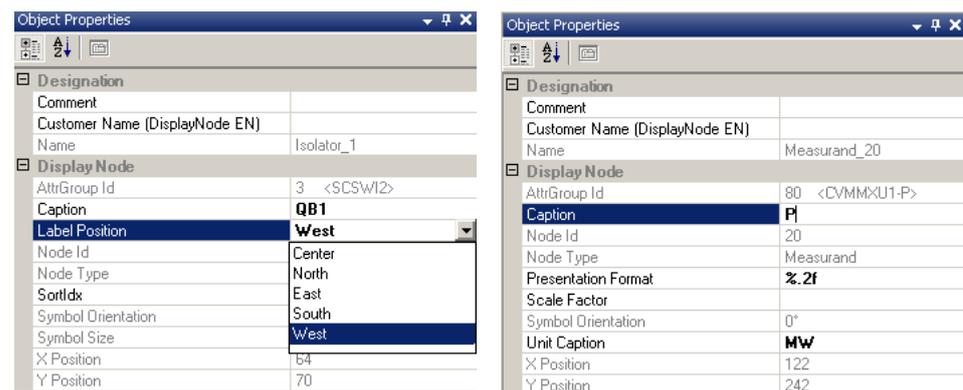


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Figure 59: GDE: Input signal selection

The ordering number in the selection window of the process objects corresponds to the number given in the PST tree and to the application function block in ACT.

Only those apparatus and measurements are shown that are configured in the application configuration program.



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Figure 60: GDE: Object properties windows for text insertion

---

## 6.3 Events and indications

To get IED events to the LHMI event list and indications for *Ready*, *Start* and *Trip* indication LEDs, disturbance report needs to be engineered.



Detailed information about disturbance report subfunctions is found in the technical manual.



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## Section 7 IEC 61850 communication engineering

### 7.1 IEC 61850 interface in the IED and tools



More information about the implementation of IEC 61850 in IEDs is available in the IEC 61850 communication protocol manual.

#### 7.1.1 Function view for IEC 61850 in PCM600

The IED function blocks have a design based on the demands and advantages of the IEC 61850 standard. This means that there is a strict relation between the function blocks and the logical node types. This relation is automatically handled by the PCM600 tools.

The concept in IED is such that the 61850 data for each function instantiated in ACT will be automatically created. This means that the user do not need to handle any instance information for the functions regarding IEC 61850.

#### 7.1.2 IEC 61850 interface in IED

See [Figure 61](#) for a principle view of the IEC 61850 logical node concept in the IED.

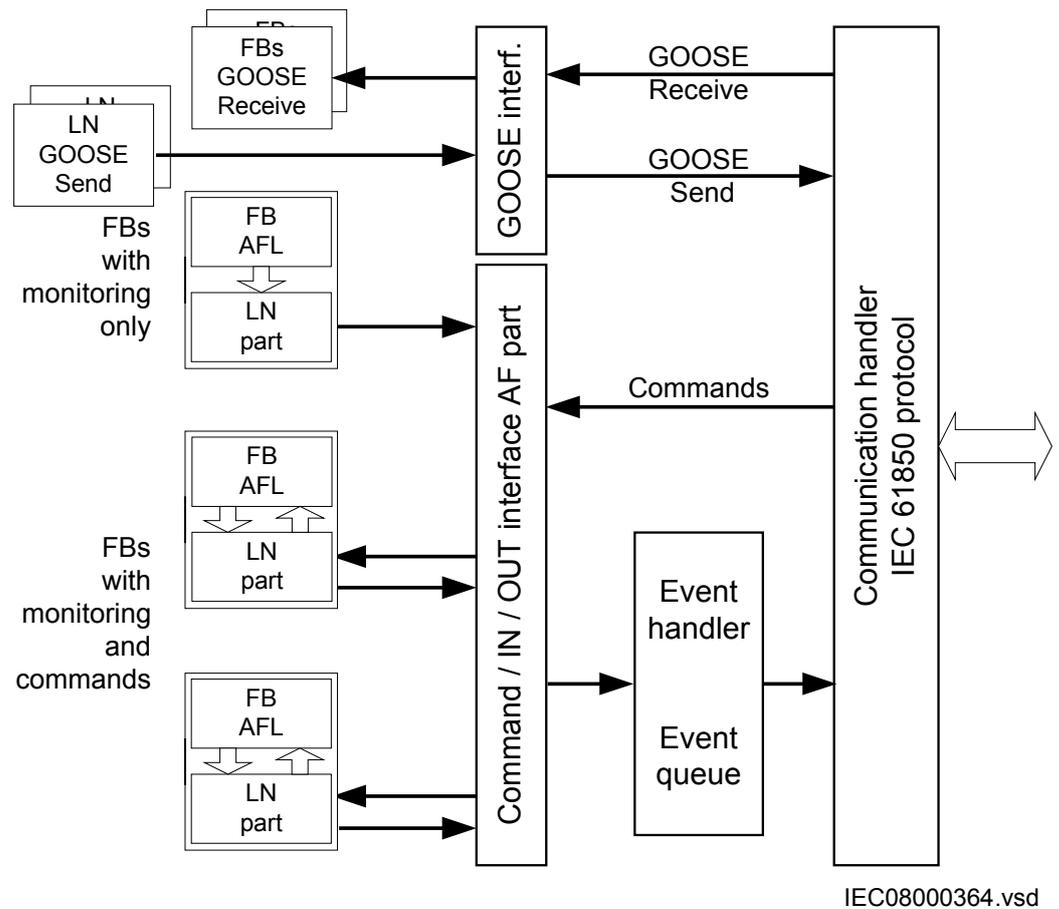


Figure 61: IEC 61850: Communication interface principle

IEC 61850 has as a concept for the identification of all signals for communication that belong to a function by a logical node as a placeholder. All signal information in command and monitoring direction, which belongs to a function, is available within the logical node.

Whenever a function block is instantiated in ACT, PCM600 automatically generates the corresponding logical node data. In Figure 61 this is shown by two parts per function block. The upper part is the visible function block in ACT and the lower part is the logical node data for the function block.

### 7.1.2.1

#### GOOSE data exchange

The IEC 61850 protocol supports a method to directly exchange data between two or more IEDs. This method is described in the IEC 61850–7–2 clause 15. The concept is based on sending a multicast over the Ethernet. Whoever needs the information detects the telegram by its source address and will read the telegram and deals with it. The telegrams are multicast sent and not acknowledged by the receiver.

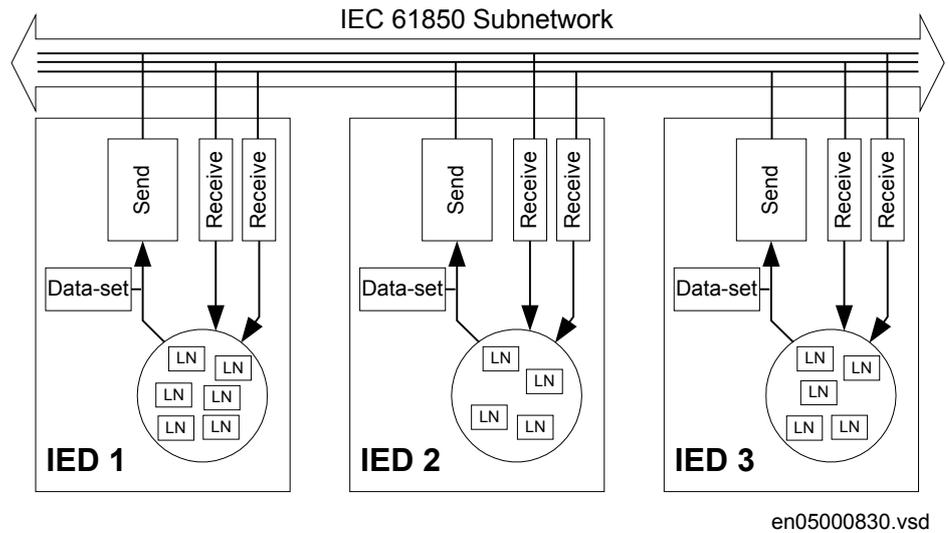


Figure 62: IEC 61850: Horizontal communication principle

Figure 62 shows an example with three IEDs where each IED communicates with all the others.

When a GOOSE message shall be sent it is defined by configuring the data set with the defined trigger option and the GOOSE control block (GoCB). This engineering process is done in a station configuration tool, for example CCT600. The task involves configuring lists with the signal, value and quality (data attributes) that belong to the GOOSE message dataset.

In the opposite direction the standard only defines the IED as a receiver of the GOOSE message. How the GOOSE input signals are handled must be defined in the IED application configuration. The SCD file generated by CCT600 (or any other station configuration tool) contains these GOOSE data sets as input data. The input data must be connected to a GOOSE receive function block (GOOSEBINRCV and GOOSEINTLKRCV) in SMT.

### 7.1.3

## Station configuration description file types

The IEC 61850 standard defines SCL-file types in the sequence of engineering. These files have a different definition, which is explained in IEC 61850-6. Three of these file types are used in the engineering process for an IED.

- ICD = IED Capability Description
  - Capability description of the IED in logical nodes and their data. No information about communication configuration, for example, is included.
  - An IED is already extended by default data sets. They are predefined by ABB. Changes or additional data sets, for example, have to be done with CCT600.
- SCD = Station Configuration Description

- Complete configuration description of all IEDs in a station and the full engineering of process signals and communication structure is included. This includes all needed data sets and all control blocks.
- CID = Configured IED Description
  - The CID file contains the information needed to configure just one specific IED.



The uploading of IEC 61850 communication configuration is not supported when reading a configuration from an online IED.

## 7.2 IEC 61850 engineering procedure

### 7.2.1 IEC 61850 protocol references and pre-conditions

To engineer the IEC 61850 protocol interface for the IED, the following additional manuals or knowledge of their contents is required.

- Knowledge of the IEC 61850 engineering process as described in the IEC 61850 standard.
- The Technical Manual describes function blocks defined as logical nodes.
- The IEC 61850 Communication Protocol Manual.
- The IEC 61850 conformance documents for the IED to be engineered.

### 7.2.2 Sequence for engineering of IEC 61850 protocol

The IEC 61850 standard defines the complete part needed for information communication in a substation. This can be split into the following parts:

- Description of the substation part including the used logical nodes
- Description of the IEDs with their logical nodes
- Description of the communication network
- Description of the engineering process

For more details please refer to the IEC 61850 standards. In the following description it is assumed that PCM600 together with CCT600 is used as system configuration tool.

A short form of a typical sequence is shown in [Figure 63](#) when a complete station is exported as a SCD file.

1. Export SCL files from PCM600. In the scenario in [Figure 63](#) it is a SCD file. Other SCL file types are possible to export.
2. Configure horizontal and vertical communication in the station configuration tool, for example CCT600.
3. Import SCL files to PCM600 project. In the scenario in [Figure 63](#) it is the updated SCD file.

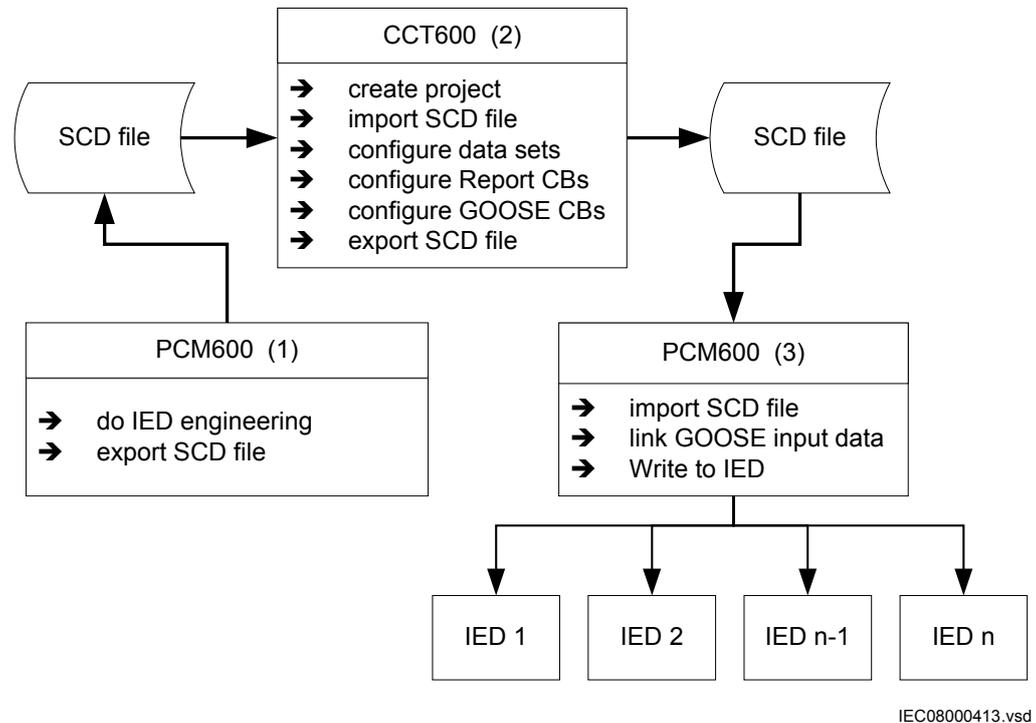


Figure 63: IEC 61850: Signal engineering procedure flow

## 7.3 Exporting SCL files from PCM600

A pre-condition is that all IEDs in the project must be engineered in PCM600. The hardware interface, for example the communication port, has to be selected and configured. The used interface addresses have to be set according to protocol and project definitions. The station communication port has to be activated in the IED, that is to set the IEC61850-8-1 *Operation* setting to *On*.

### 7.3.1 Exporting SCD files

Procedure to export the SCD file from PCM600:

1. Select the station in the plant structure, see [Figure 64](#).

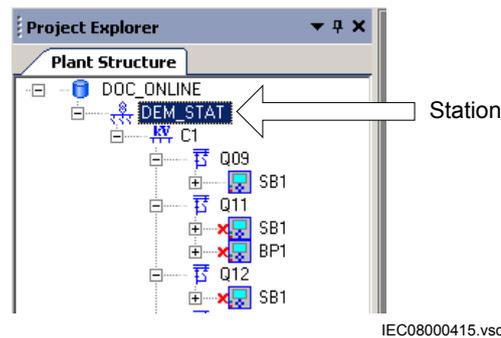


Figure 64: IEC 61850: Export SCD step 1

2. Right-click the station and select *Export* ....
3. Select a location from the open standard Windows menu to store the file and name it.
4. The *SCL Export Options* window opens, see [Figure 65](#).

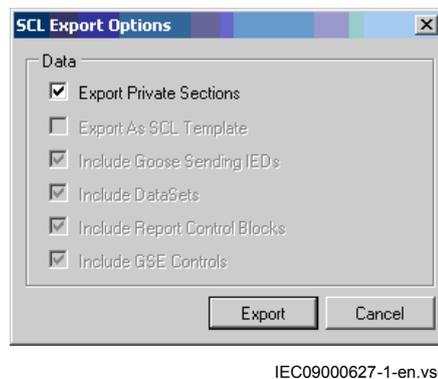


Figure 65: IEC 61850: SCL Export Options

5. Select *Export Private Sections* and click *Export* to export the private sections to the SCD file. A progress window shows the ongoing export of the station.

## 7.3.2 Exporting ICD or CID files

Procedure to select the export type, when the IED is selected in the plant structure:

1. Right-click the IED in the plant structure and select *Export* to open the *Export* window.
2. Select the type of file to export from the *Save as type* drop down list.
  - Configured IED Description (\*.cid) for the IEC 61850 structure as needed for the IED at runtime.
  - IED Capability Description (\*.icd) for the IEC 61850 structure, see [Figure 66](#).

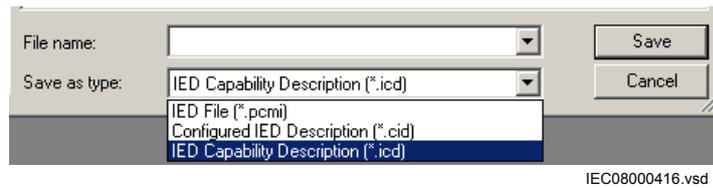


Figure 66: IEC 61850: Export IED file type selection

3. The *SCL Export Options* window opens.
4. Select *Export Private Sections*, *Export As SCL Template* or *Include Goose Sending IEDs* and click *Export*, see [Figure 67](#).



Figure 67: IEC 61850: Export IED file Options

## 7.4 Engineering of vertical and horizontal communication in CCT600

Procedure for signal engineering for the station by using CCT600:

1. Create a project in CCT600.
2. Import the SCD file created by PCM600, see [Figure 68](#).

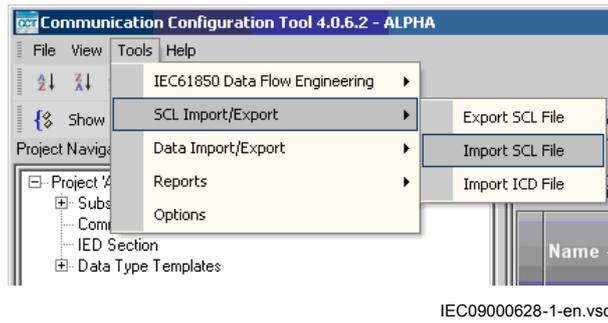


Figure 68: CCT600 Import SCL file

3. Do vertical communication engineering (monitoring direction).
  - 3.1. Check the default data sets, see [Figure 69](#).

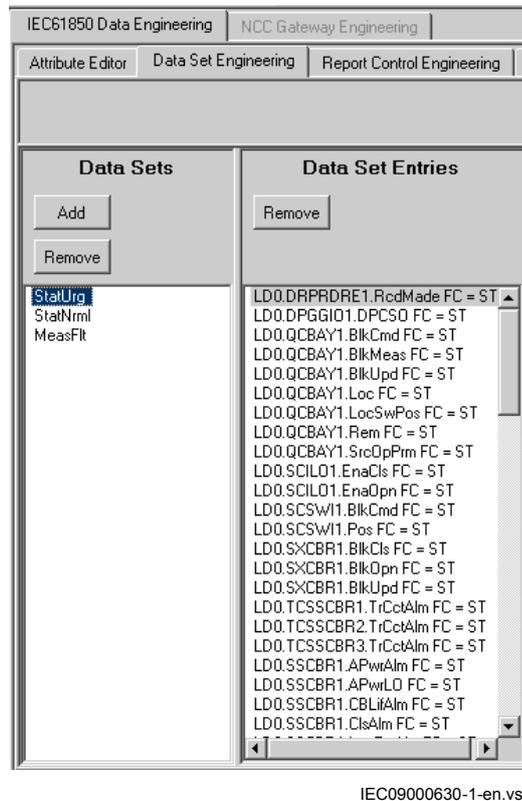


Figure 69: CCT600 data sets default content

- 3.2. Configure and/or re-configure the default data sets.



Note that reporting data sets shall only contain data intended to be used by clients, for example for event handling.



The data set for GOOSE may contain signals on data attribute level or on FCDA level. The latter is also called *structured GOOSE*.

- 3.3. Configure additional Report Control Blocks when needed for each data set used for vertical communication.



Up to 8 report clients can be configured.

- 3.4. Link the IED clients to the Report Control Blocks.
4. Do horizontal communication engineering.

- 4.1. Configure GOOSE control blocks for each data set configured for GOOSE messages.



GOOSE messages can contain the data types positions and booleans. GOOSE messages must not contain analog data or GOOSE transmission fails. Be sure to configure the data sets to not include any analog data.



Be sure to set the same GoID for sending and receiving GOOSE messages.



Note that one data must only be included in a GOOSE data set once.

- 4.2. Define client IEDs for each GOOSE control block.
- 4.3. Link the IEDs to the GOOSE control block that shall receive the GOOSE control block.
5. Update the data flow.
6. Export the updated SCD file.



All data sets, all Report Control Blocks and GOOSE control block must be located at LLN0.

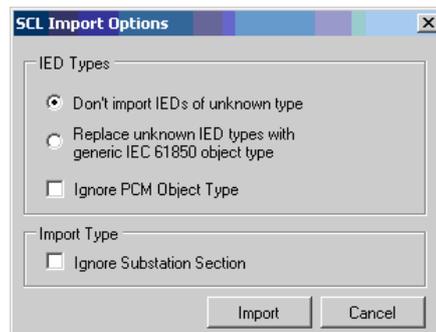
## 7.5 Importing SCL files to PCM600

The IED engineering tool must be able to receive a SCD file or an ICD file as import to receive the engineered communication extensions, for example for the different IEDs.

### 7.5.1 Importing SCD files

Procedure to import a SCD file to PCM600:

1. Select the station in the plant structure.
2. Right-click the station and select *Import ...*
3. Select the file to be imported from the open standard Windows menu and start the reading.
4. A *SCL Import Options* window opens, which queries how the file should be handled during import, see [Figure 70](#).



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Figure 70: IEC 61850: Import SCD file

- 4.1. Click *Ignore Substation Section* to not import the "SSD-file" part of the SCD-file.
  - 4.2. Click *Don't import IEDs of unknown type* to protect the existing IEDs in case the SCD file does not match the original configuration in PCM600.
  - 4.3. Click *Replace unknown ...* can be used when it is known, that the file includes additional IEDs that are needed. The IED of type "Generic IEC 61850 IED" is used to integrate these kinds of IEDs in the plant structure etc.
  - 4.4. Click *Ignore PCM Object Type* to update the IED object(s) in PCM600 from the IED type(s) in the SCD file, disregarding if the IED type(s) in the SCD file matches the IED object(s) in PM600 or not.
  - 4.5. Start *Import* when the file definition has been completed. A progress window presents the import procedure.
5. Make connections from sending IEDs to receiving function blocks in SMT.

- 
- 5.1. Make connections between the signals that the server is sending and the GOOSE receive interface function blocks (GOOSEBINRCV and GOOSEINTLKRCV) on the client's side.



If a client is defined for GOOSE receive then at least one cross in SMT is required to be able to write the configuration to the IED.



Be sure to set the setting *Operation* for GOOSEBINRCV and GOOSEINTLKRCV to *On* in PST to enable GOOSE communication.

6. Write the configuration to the IED, see [Figure 71](#).



Note that the engineered data is written to the IED when executing a common *Write to IED* operation.

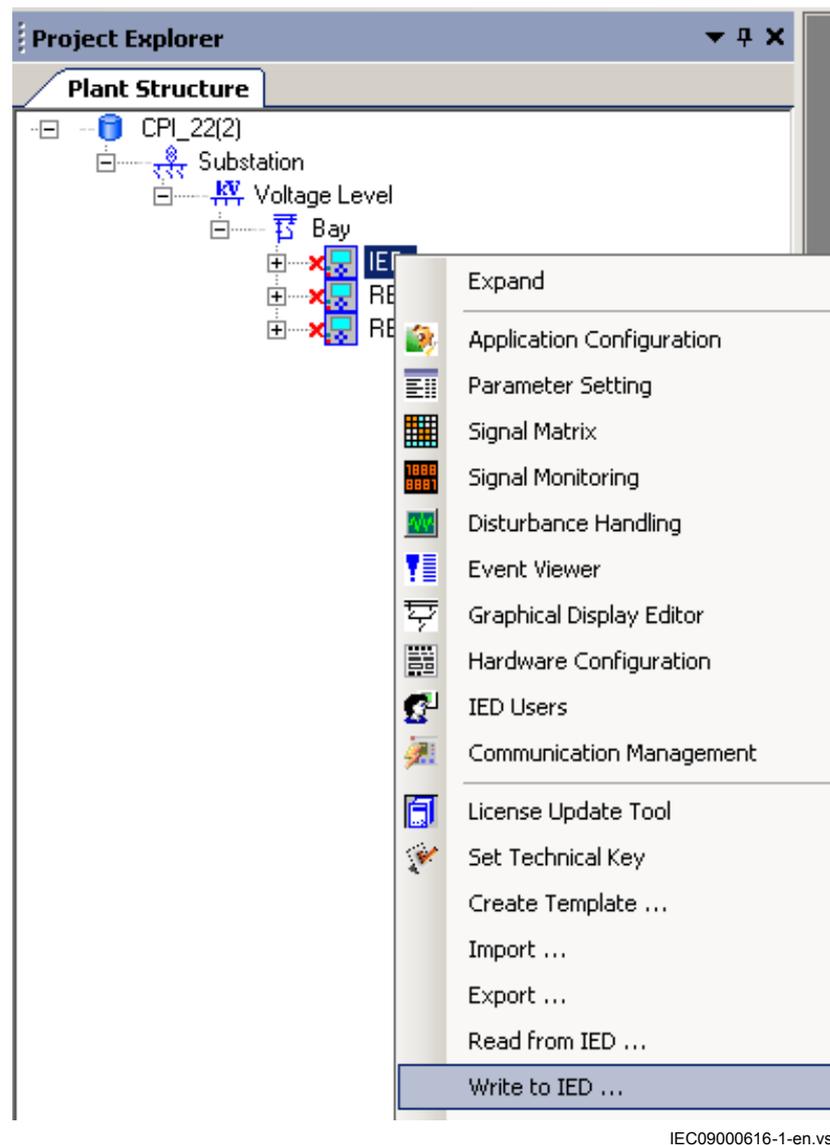


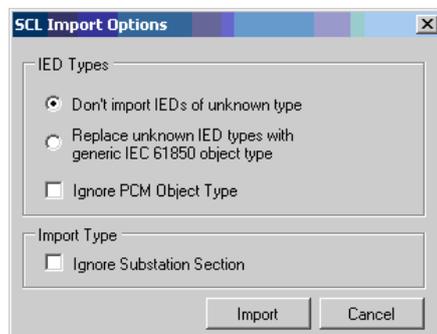
Figure 71: Common write menu

## 7.5.2 Importing ICD or CID files

Procedure to import a complete ICD file or CID file:

1. Select an existing IED to import IEC 61850 files.
2. Select the file type of IEC 61850 to import from the *Files of type* drop down list (ICD or CID)
3. The *SCL Import Option* menu opens, which queries how the file should be handled during import, see [Figure 72](#).

- 3.1. Ignore *Substation Section* will not import the "SSD-file" part of the SCD-file.
  - 3.2. *Don't import ...* protects the existing IEDs in case the SCD file does not match the original configuration in PCM600.
  - 3.3. *Replace unknown ...* can be used when it is known that the file includes additional IEDs which are needed. The IED of type *Generic IEC 61850 IED* is used to integrate these kinds of IEDs in for example the plant structure.
  - 3.4. Click *Ignore PCM Object Type* to update the IED object(s) in PCM600 from the IED type(s) in the SCD file, disregarding if the IED type(s) in the SCD file matches the IED object(s) in PM600 or not.
  - 3.5. Start *Import* when the definition has been completed. A progress window presents the import procedure.
- 4.



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Figure 72: IEC 61850: SCL Import option

## 7.6 Writing communication configuration to IED

IEC communication depends on proper communication configuration in all IEDs that communicate via IEC 61850. It is not possible to read the communication configuration from the IED to PCM600.

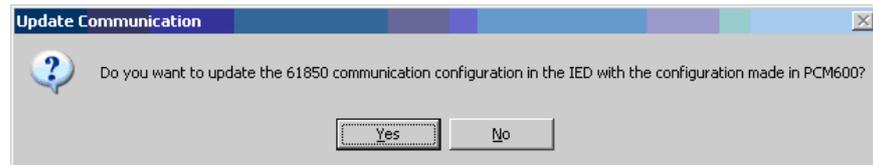
However, it is possible to make a configuration change in one IED, without affecting the communication engineering. For example, when the ACT configuration is changed, but no changes are done for the instantiation or deletion of functions that represent a logical node.

When a changed configuration is written to the IED, the user is asked to update the communication configuration.

1. Click *Yes* in the *Update Communication* window to update the communication configuration part in the IED.
2. Click *No* in the *Update Communication* window to keep the communication configuration part in the IED. Other parts of the configuration will be updated.



If no change has been done to the communication configuration part, select *No* in the *Update Communication* window.



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*Figure 73:* Update the communication configuration in the IED with the configuration made in PCM600

## Section 8 DNP3 communication engineering

### 8.1 Signal configuration user information



Basic knowledge about DNP3 and the used definitions are required to use CMT. See the DNP3 communication protocol manual for information on the DNP3 implementation in the IED.

CMT allows to configure the signals that are used to communicate with clients or master units for DNP3 protocols.

On the left window CMT organizes all available signals from the application configuration in containers that are preselected as signal types.

On the right window CMT provides containers that are selected by tabs. Each container represents one communication channel. The number of possible communication channels is IED type dependent. The IED uses TCP/IP as communication channel. DNP3 can be tunneled over TCP/IP, and serial communication RS-485 is not supported.

Use direction icons that are located between the windows to move all signals or a set of individual signals between the windows.

DNP3 signal types, index and default setting for classes are predefined in CMT. Adapt the signal configuration to project definitions. The signal type can not be modified due to the fact that the internal signal set up is fixed.

When the default configuration values are sufficient, the task is finished when all signal are moved according to the project requirements.

With the *Save* option, the signals are stored for the communication part of the IED according to the default selections.

Only for analog measurements additional configuration parameters are shown to do signal scaling to DNP3 protocol presentation. This can be done when the *Configuration Table View* is selected.

Finally, the signal configuration to the different DNP3 channels can be listed in a report on demand and per signal type.

### 8.2 Configuring DNP3 protocol signals

Procedure

1. Save the actual project configuration in PCM600 to make all signals visible for CMT.
2. Right-click the IED in the plant structure and select *Communication Management* to start the Communication management tool.
3. Select the DNP3 protocol from the new window and click *OK*. [Figure 74](#) presents the design of the two container windows, which open after the selection of DNP3.
  - The right window shows tabs for possible communication channels.
  - The left window has a drop down menu for signal selection and buttons for signal movement, see [Figure 74](#).

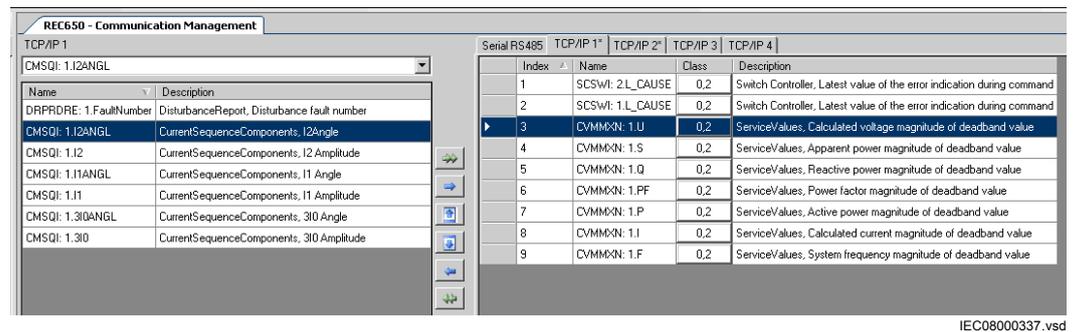


Figure 74: CMT: Container window design when selecting DNP3 protocol

Procedure to move signals:

1. Select one or several signals.
  - Click in the list of signals to select one signal.
  - Press *Shift* or *Ctrl* and several signals to select a set of signals.
  - Right-click in the list of signals, select *Select All* from the context menu or press *Ctrl+A* to select all signals.
2. Press the blue arrow button to insert the selected signals into the configuration.
3. Press the green double arrow button to insert all signals into the configuration, see [Figure 75](#).

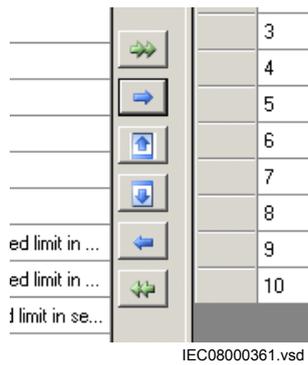


Figure 75: CMT: Move buttons

- Click the drop down list *Signal Type*: to select the other signal types for this channel.
- Repeat to move signals for all signal types and save the selection.



Content changes in the DNP3 container are marked with a star at the end of the name, see [Figure 76](#). The star indicates that changes in the container have to be saved before leaving CMT.

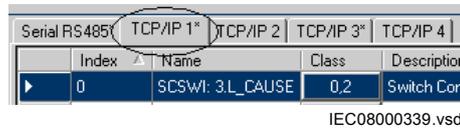


Figure 76: CMT: Marker to indicate changes in the container

### 8.3 Setting DNP3 signal parameters

Two parameters per signal can be set for all signal types:

- The index of the signal
- The class configuration

Procedure to set the index of the signal:

- Click the two inner arrows to sort signals to another index sequence, or select *Set Index ...* from the context menu to move one or a set of signals to another array, see [Figure 77](#).

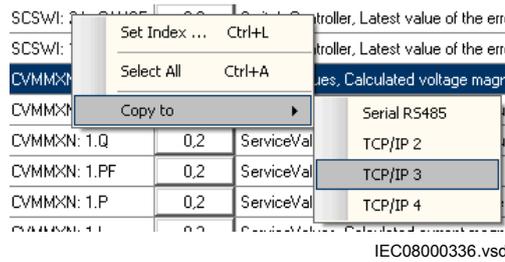


Figure 77: CMT: Context menu in DNP3 window

- The selection window shows the number of signals selected, see [Figure 78](#).

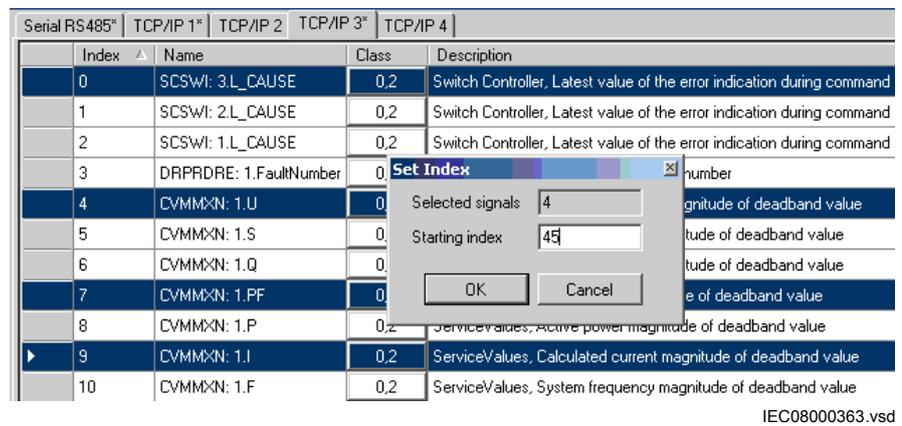


Figure 78: CMT: Set Index menu

- Define the *Starting index* for this group and click *OK*.

Procedure to set class configuration:

- Click in the class field of the signal to change the class configuration.
- The *Select Class* window opens.
- Make the selection according to the definitions in the project and click *OK* to close the window and get the new configuration, see [Figure 79](#).

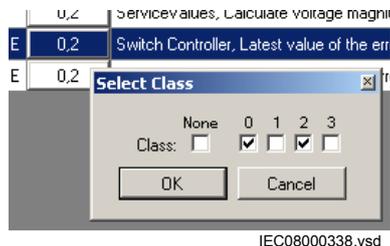


Figure 79: CMT: Select Class window

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### 8.3.1 Configuring DNP3 class

In DNP3 the user classifies the signals and defines those signals that are not member of any class. CMT has a default predefined organization of classes per signal type. In the master station the classes can be polled in sequences according to the demands in the project. Unsolicited reporting is possible as well.

Modify the organization of the classes for each signal individually.

#### Procedure

1. Click in the *Class* field of the signal. A new window *Select Class* opens where the user classifies the signal.
2. Select the signal classes and choose between *None* and *0* to *3* according to the project demands.
3. Click *OK* to set the signal classification.
4. Write to IED.



## Section 9      Glossary

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

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<b>CT</b>	Current transformer
<b>CVT</b>	Capacitive voltage transformer
<b>DAR</b>	Delayed auto-reclosing
<b>DARPA</b>	Defense Advanced Research Projects Agency (The US developer of the TCP/IP protocol etc.)
<b>DBDL</b>	Dead bus dead line
<b>DBLL</b>	Dead bus live line
<b>DC</b>	Direct current
<b>DFT</b>	Discrete Fourier transform
<b>DIP-switch</b>	Small switch mounted on a printed circuit board
<b>DLLB</b>	Dead line live bus
<b>DNP</b>	Distributed Network Protocol as per IEEE/ANSI Std. 1379-2000
<b>DR</b>	Disturbance recorder
<b>DRAM</b>	Dynamic random access memory
<b>DRH</b>	Disturbance report handler
<b>DSP</b>	Digital signal processor
<b>DTT</b>	Direct transfer trip scheme
<b>EHV network</b>	Extra high voltage network
<b>EIA</b>	Electronic Industries Association
<b>EMC</b>	Electro magnetic compatibility
<b>EMF</b>	Electro motive force
<b>EMI</b>	Electro magnetic interference
<b>EnFP</b>	End fault protection
<b>ESD</b>	Electrostatic discharge
<b>FOX 20</b>	Modular 20 channel telecommunication system for speech, data and protection signals
<b>FOX 512/515</b>	Access multiplexer
<b>FOX 6Plus</b>	Compact, time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers
<b>G.703</b>	Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines
<b>GCM</b>	Communication interface module with carrier of GPS receiver module
<b>GDE</b>	Graphical display editor within PCM600

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<b>GI</b>	General interrogation command
<b>GIS</b>	Gas insulated switchgear
<b>GOOSE</b>	Generic object oriented substation event
<b>GPS</b>	Global positioning system
<b>HDLC protocol</b>	High level data link control, protocol based on the HDLC standard
<b>HFBR connector type</b>	Plastic fiber connector
<b>HMI</b>	Human machine interface
<b>HSAR</b>	High speed auto reclosing
<b>HV</b>	High voltage
<b>HVDC</b>	High voltage direct current
<b>IDBS</b>	Integrating dead band supervision
<b>IEC</b>	International Electrical Committee
<b>IEC 60044-6</b>	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
<b>IEC 61850</b>	Substation Automation communication standard
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>IEEE 802.12</b>	A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable
<b>IEEE P1386.1</b>	PCI Mezzanine card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common mezzanine card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical EMF Electro Motive Force.
<b>IED</b>	Intelligent electronic device
<b>I-GIS</b>	Intelligent gas insulated switchgear
<b>Instance</b>	When several occurrences of the same function are available in the IED they are referred to as instances of that function. One instance of a function is identical to another of the same kind but will have a different number in the IED user interfaces. The word instance is sometimes defined as an item of information that is representative of a type. In the same way an instance of a function in the IED is representative of a type of function.
<b>IP</b>	1. Internet protocol. The network layer for the TCP/IP protocol suite widely used on Ethernet networks. IP is a connectionless, best-effort packet switching protocol. It

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	provides packet routing, fragmentation and re-assembly through the data link layer.
	2. Ingression protection according to IEC standard
<b>IP 20</b>	Ingression protection, according to IEC standard, level 20
<b>IP 40</b>	Ingression protection, according to IEC standard, level 40
<b>IP 54</b>	Ingression protection, according to IEC standard, level 54
<b>IRF</b>	Internal fail signal
<b>IRIG-B:</b>	InterRange Instrumentation Group Time code format B, standard 200
<b>ITU</b>	International Telecommunications Union
<b>LAN</b>	Local area network
<b>LIB 520</b>	High voltage software module
<b>LCD</b>	Liquid crystal display
<b>LDD</b>	Local detection device
<b>LED</b>	Light emitting diode
<b>MCB</b>	Miniature circuit breaker
<b>MCM</b>	Mezzanine carrier module
<b>MVB</b>	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains.
<b>NCC</b>	National Control Centre
<b>OCO cycle</b>	Open-close-open cycle
<b>OCP</b>	Overcurrent protection
<b>OLTC</b>	On load tap changer
<b>OV</b>	Over voltage
<b>Overreach</b>	A term used to describe how the relay behaves during a fault condition. For example a distance relay is over-reaching when the impedance presented to it is smaller than the apparent impedance to the fault applied to the balance point, i.e. the set reach. The relay “sees” the fault but perhaps it should not have seen it.
<b>PCI</b>	Peripheral component interconnect, a local data bus
<b>PCM</b>	Pulse code modulation
<b>PCM600</b>	Protection and control IED manager
<b>PC-MIP</b>	Mezzanine card standard
<b>PISA</b>	Process interface for sensors & actuators
<b>PMC</b>	PCI Mezzanine card
<b>POTT</b>	Permissive overreach transfer trip

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<b>Process bus</b>	Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components
<b>PSM</b>	Power supply module
<b>PST</b>	Parameter setting tool within PCM600
<b>PT ratio</b>	Potential transformer or voltage transformer ratio
<b>PUTT</b>	Permissive underreach transfer trip
<b>RASC</b>	Synchrocheck relay, COMBIFLEX
<b>RCA</b>	Relay characteristic angle
<b>REVAL</b>	Evaluation software
<b>RFPP</b>	Resistance for phase-to-phase faults
<b>RFPE</b>	Resistance for phase-to-earth faults
<b>RISC</b>	Reduced instruction set computer
<b>RMS value</b>	Root mean square value
<b>RS422</b>	A balanced serial interface for the transmission of digital data in point-to-point connections
<b>RS485</b>	Serial link according to EIA standard RS485
<b>RTC</b>	Real time clock
<b>RTU</b>	Remote terminal unit
<b>SA</b>	Substation Automation
<b>SC</b>	Switch or push-button to close
<b>SCS</b>	Station control system
<b>SCT</b>	System configuration tool according to standard IEC 61850
<b>SMA connector</b>	Subminiature version A, A threaded connector with constant impedance.
<b>SMT</b>	Signal matrix tool within PCM600
<b>SMS</b>	Station monitoring system
<b>SNTP</b>	Simple network time protocol – is used to synchronize computer clocks on local area networks. This reduces the requirement to have accurate hardware clocks in every embedded system in a network. Each embedded node can instead synchronize with a remote clock, providing the required accuracy.
<b>SRY</b>	Switch for CB ready condition
<b>ST</b>	Switch or push-button to trip
<b>Starpoint</b>	Neutral point of transformer or generator
<b>SVC</b>	Static VAr compensation
<b>TC</b>	Trip coil

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<b>TCS</b>	Trip circuit supervision
<b>TCP</b>	Transmission control protocol. The most common transport layer protocol used on Ethernet and the Internet.
<b>TCP/IP</b>	Transmission control protocol over Internet Protocol. The de facto standard Ethernet protocols incorporated into 4.2BSD Unix. TCP/IP was developed by DARPA for internet working and encompasses both network layer and transport layer protocols. While TCP and IP specify two protocols at specific protocol layers, TCP/IP is often used to refer to the entire US Department of Defense protocol suite based upon these, including Telnet, FTP, UDP and RDP.
<b>TNC connector</b>	Threaded Neill Concelman, A threaded constant impedance version of a BNC connector
<b>TPZ, TPY, TPX, TPS</b>	Current transformer class according to IEC
<b>Underreach</b>	A term used to describe how the relay behaves during a fault condition. For example a distance relay is under-reaching when the impedance presented to it is greater than the apparent impedance to the fault applied to the balance point, i.e. the set reach. The relay does not "see" the fault but perhaps it should have seen it. See also Overreach.
<b>U/I-PISA</b>	Process interface components that deliver measured voltage and current values
<b>UTC</b>	Coordinated universal time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals. UTC is derived from International Atomic Time (TAI) by the addition of a whole number of "leap seconds" to synchronize it with Universal Time 1 (UT1), thus allowing for the eccentricity of the Earth's orbit, the rotational axis tilt (23.5 degrees), but still showing the Earth's irregular rotation, on which UT1 is based. The Coordinated Universal Time is expressed using a 24-hour clock and uses the Gregorian calendar. It is used for aeroplane and ship navigation, where it also sometimes known by the military name, "Zulu time". "Zulu" in the phonetic alphabet stands for "Z" which stands for longitude zero.
<b>UV</b>	Undervoltage
<b>WEI</b>	Weak end infeed logic
<b>VT</b>	Voltage transformer
<b>X.21</b>	A digital signalling interface primarily used for telecom equipment

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<b><math>3I_0</math></b>	Three times zero-sequence current. Often referred to as the residual or the earth-fault current
<b><math>3U_0</math></b>	Three times the zero sequence voltage. Often referred to as the residual voltage or the neutral point voltage





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