

SIEMENS

SIPROTEC 5

Process Bus

V9.70 and higher

Manual

Preface

Table of Contents

Process Bus

1

Parameterization of Process Bus

2

Synchronization

3

Network Topology

4

Diagnostic Data via the Browser-Based
User Interface

5

Restrictions and Recommendations

6

Technical Data

7

Literature

Glossary

Index



NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

Disclaimer of Liability

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

Document version: C53000-H3040-C054-F.02

Edition: 12.2023

Version of the product described: V9.70 and higher

Copyright

Copyright © Siemens 2023. All rights reserved.

The disclosure, duplication, distribution and editing of this document, or utilization and communication of the content are not permitted, unless authorized in writing. All rights, including rights created by patent grant or registration of a utility model or a design, are reserved.

Trademarks

SIPROTEC, DIGSI, SIGRA, SIGUARD, SIMEAS, SAFIR, SICAM Insights Hub, and OT Companion are trademarks of Siemens. Any unauthorized use is prohibited.

Preface

Purpose of the Manual

This manual contains information about:

- Communication within the SIPROTEC 5 family of devices and to higher-level control centers
- Installation of the modules
- Setting parameters in DIGSI 5
- Information on commissioning

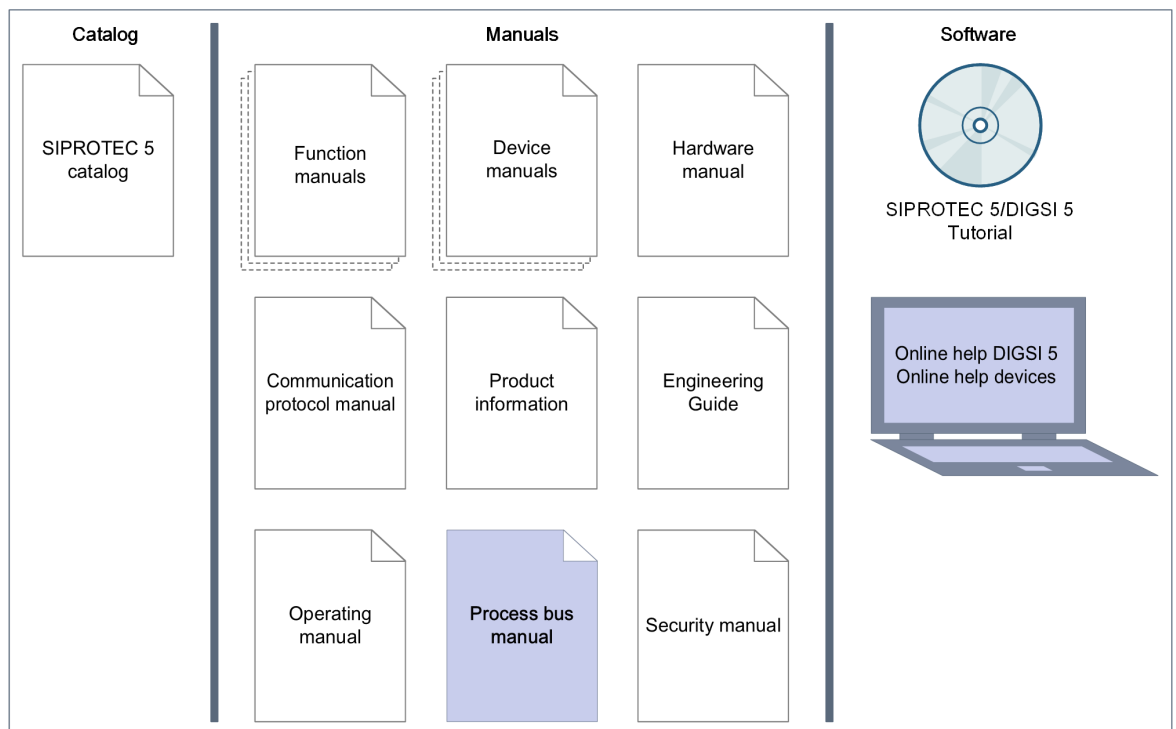
Target Audience

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



[dw_product-overview_SIP5_process-bus, 2, en_US]

- **Device manuals**
Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.
- **Hardware manual**
The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.
- **Operating manual**
The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.
- **Communication protocol manual**
The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.
- **Security manual**
The Security manual describes the security features of the SIPROTEC 5 devices and DIGSI 5.
- **Process bus manual**
The process bus manual describes the functions and applications specific for process bus in SIPROTEC 5.
- **Product information**
The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.
- **Engineering Guide**
The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.
- **DIGSI 5 online help**
The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.
The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.
- **SIPROTEC 5 catalog**
The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.

Indication of Conformity



This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States concerning electromagnetic compatibility (EMC Directive 2014/30/EU), restriction on usage of hazardous substances in electrical and electronic equipment (RoHS Directive 2011/65/EU), and electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive), the standard EN IEC 63000 (for RoHS directive), and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Standards

IEEE Std C 37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see ul.com
You can find the product with the **UL File Number E194016**.



IND. CONT. EQ.
69CA

Additional Support

For questions about the system, contact your Siemens sales partner.

Customer Support Center

Our Customer Support Center provides a 24-hour service.

Siemens Electrification & Automation

Global Support

Single entry point

Phone: +49 9131 1743072

E-mail: support.ea.si@siemens.com

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG

Siemens Power Academy TD

Humboldtstraße 59

90459 Nuremberg

Germany

Phone: +49 911 9582 7100

E-mail: poweracademy@siemens.com

Internet: www.siemens.com/poweracademy

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:



DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

- ✧ Comply with all instructions, in order to avoid death or severe injuries.



WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

- ✧ Comply with all instructions, in order to avoid death or severe injuries.



CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

- ✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

- ✧ Comply with all instructions, in order to avoid property damage.



NOTE

Important information about the product, product handling or a certain section of the documentation which must be given attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this document are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result:

- The equipment must be grounded at the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current-transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current-transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.

Table of Contents

	Preface.....	3
1	Process Bus.....	11
1.1	System Overview.....	12
1.2	Configuration.....	14
1.2.1	Introduction.....	14
1.2.2	Structure of the Merging-Unit IID File.....	14
1.2.3	Information in IED Nodes.....	16
1.2.3.1	Introduction.....	16
1.2.3.2	IED-Node Attributes.....	17
1.2.4	IED Subnodes.....	17
1.2.4.1	Required Information in an SV Control Block based on IEC 61850-7-4.....	17
1.2.4.2	Required Information in an SV Dataset based on IEC 61850-7-4.....	18
1.2.4.3	Required Information in LNs of a Device Providing SV Data.....	19
1.2.4.4	LSVS.....	20
1.2.4.5	LPHD.....	22
1.2.5	Required Information in the Communication Node.....	23
1.3	Special Case IEC 61850-9-2 LE.....	26
1.4	Handling of Quality Information from the SV Stream.....	27
1.5	Measuring-Point Specific Sampled-Values Status.....	28
1.6	Behaviors in SMV Processing during Test with the Process-Bus Connection.....	29
2	Parameterization of Process Bus.....	31
2.1	Parameterization in DIGSI.....	32
2.1.1	General Configuration.....	32
2.1.2	Process-Bus Client in SIPROTEC 5.....	33
2.1.2.1	Configuration.....	33
2.1.2.2	Application and Setting Notes.....	38
2.1.3	Merging Unit in SIPROTEC 5.....	38
2.1.3.1	Configuration.....	38
2.1.3.2	Stop Publishing of Merging Units (SvEna).....	44
2.1.3.3	Application and Setting Notes.....	47
2.1.4	General Application and Setting Notes.....	50
2.1.4.1	Voltage-Transformer Circuit Breaker.....	50
2.1.4.2	Definition of IN within a Stream.....	51
2.1.4.3	Configurations for Seamless Changeover.....	52
2.1.4.4	Design Recommendations for Testing according to IEC TR 61850-10-3.....	57
2.1.5	Exporting an IID File.....	61
2.1.6	9-2 Client Instrument Transformer Settings Editor.....	63
2.1.7	Merging Unit 6MU805 in DIGSI 4.....	72
2.2	Process Bus in SCD Files.....	77
2.2.1	Introduction.....	77

2.2.2	Definition of Client Access Points.....	77
2.2.3	IEC 61850 System Configurator.....	78
2.2.4	Import of SCD File from Third-Party IEC 61850 System Configurator.....	88
2.2.4.1	Preparing and Starting the Import.....	88
2.2.4.2	Configuring the SCD Import.....	89
2.3	Single-Line Configuration for Process-Bus System.....	92
2.3.1	SMV Publisher Block.....	93
2.3.2	SMV Subscriber Block.....	94
2.3.3	Connecting the SMV Publisher with the SMV Subscriber Measuring Points.....	95
2.3.4	Automatic SMV Mapping in IEC 61850 System Configurator.....	95
3	Synchronization.....	97
3.1	Sample Synchronization.....	98
3.2	Sample Synchronization Using IEEE 1588v2/PTP.....	103
3.2.1	General Configuration.....	103
3.2.2	General Application and Setting Notes.....	104
3.2.2.1	Use of OCSO and OCGC in the Same Device.....	104
3.2.2.2	Multiple OCGC in the Same Device.....	105
3.2.2.3	Multiple OCGC in the Ethernet Network – Best Master Clock Algorithm (BMCA).....	106
3.3	Sample Synchronization Using PPS or IRIG B.....	111
3.3.1	General Information.....	111
3.3.2	Optical PPS using USART Plug-In Modules.....	111
3.3.2.1	Receiving of Optical PPS.....	111
3.3.2.2	Generation of Optical PPS.....	111
3.3.2.3	Configuration.....	111
3.3.2.4	Application and Setting Notes.....	113
3.3.3	Electrical PPS.....	114
3.3.3.1	Electrical PPS using Port G of the Device.....	114
3.3.3.2	Configuration.....	114
3.3.3.3	Application and Setting Notes.....	114
3.3.4	IRIG B.....	115
3.3.4.1	IRIG B using Port G.....	115
3.3.4.2	Configuration.....	115
3.3.4.3	Application and Setting Notes.....	116
3.3.4.4	Settings.....	117
3.3.4.5	Information List.....	118
4	Network Topology.....	119
4.1	Topology Hints.....	120
4.2	Network Usage.....	125
5	Diagnostic Data via the Browser-Based User Interface.....	127
5.1	Content and Structure.....	128
5.2	Application Diagnosis Section for Ethernet Modules.....	134
5.2.1	Structure	134
5.3	Application Diagnosis – Process-Bus Client.....	135
5.3.1	Structure of the Application Diagnosis Section.....	135
5.3.2	PB-Client Status.....	136
5.3.3	PB-Client Sync Status.....	140
5.3.4	PB-Client Config.....	142

6	Restrictions and Recommendations.....	143
6.1	Recommendations.....	144
6.2	Restrictions.....	145
7	Technical Data.....	147
7.1	SIPROTEC 5 Merging Unit Functionality.....	148
7.2	SIPROTEC 5 Process-Bus Client.....	149
	Literature.....	151
	Glossary.....	153
	Index.....	157

1 Process Bus

1.1	System Overview	12
1.2	Configuration	14
1.3	Special Case IEC 61850-9-2 LE	26
1.4	Handling of Quality Information from the SV Stream	27
1.5	Measuring-Point Specific Sampled-Values Status	28
1.6	Behaviors in SMV Processing during Test with the Process-Bus Connection	29

1.1 System Overview

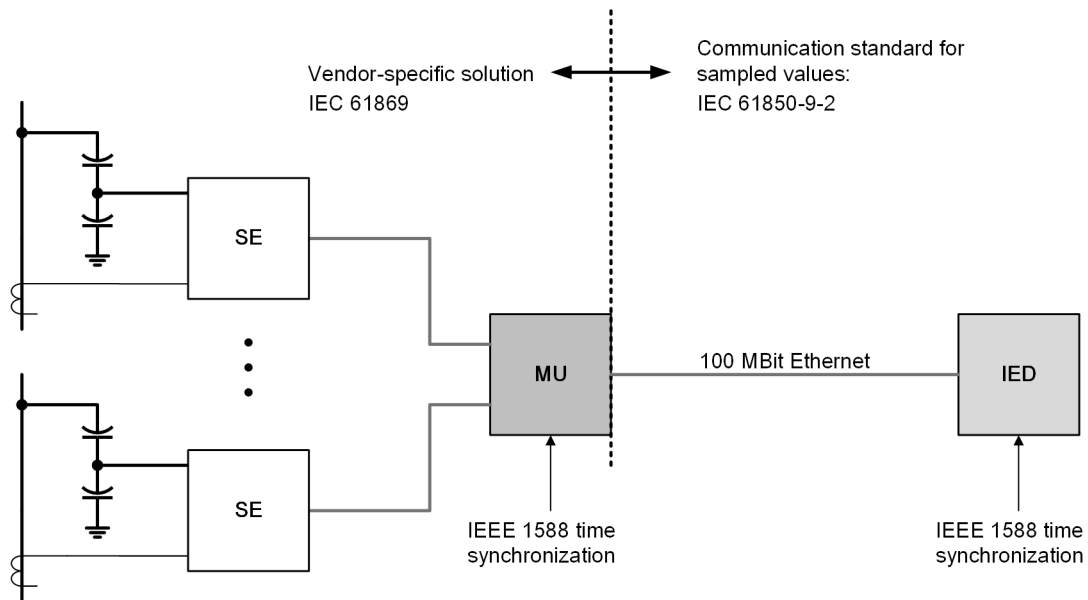
The Ethernet communication module ETH-BD-2FO provides the IEC 61850-9-2 process-bus functionality for SIPROTEC 5 modular devices, besides other communication protocols like IEC 61850-8-1 and IEEE 1588v2/PTP. The following process-bus functionality is provided:

- Process-bus client functionality:
The process-bus client allows a subscription of current-sampled and voltage-sampled values published by a merging unit (MU) complying with the IEC 61850-9-2 and IEC 61869-9 standards.
- Process-bus merging unit functionality:
The process-bus merging unit allows a publishing of current-sampled and voltage-sampled values on a process-bus network according to the IEC 61850-9-2 and IEC 61869-9 standards.

Additionally to the process-bus functionality, the following main Ethernet functionality can be used at the same time:

- IEC 61850-8-1 GOOSE
- IEEE 1588v2/PTP
- Parallel Redundancy Protocol (PRP) or Line Mode
- High Availability Seamless Redundancy Protocol (HSR)

The following figure shows the general approach of the IEC 61850-9-2 standard for interconnection of a merging unit publishing sampled values (SV) and a process-bus client that uses these Sampled Values.



[dw_overview, 4, en_US]

Figure 1-1 System Overview

SE	Sensor electronic
MU	Merging unit
IED	Intelligent Electronic Device

For more information regarding the connection possibilities of the different components and the configuration, refer to [2 Parameterization of Process Bus..](#)

To measure currents and voltages in a primary system, a merging unit can use a vendor-specific primary equipment. The merging unit provides the sampled measured values as Ethernet data packets as defined in the IEC 61850-9-2 and IEC 61869-9 standards. To use these signals as voltage or current inputs in a SIPROTEC 5 device, the device must subscribe to signals provided by the merging unit.

In this document, you can find information on how to configure a SIPROTEC 5 device that subscribes or publishes time-coherent data streams according to IEC 61850-9-2 and IEC 61869-9. To do this, IID files (IID – Instantiated IED Description) provide a description of merging-unit streams (when a merging unit is configured) or requested subscriptions (when a process-bus client is configured).

The IID files contain the following information:

- Self description of the signals provided by a merging unit
- Data-packet formats published by a merging unit in a standardized format
- Process-bus client inputs to be subscribed with a merging-unit signal by a system configurator

A SIPROTEC 5 client can receive and process data streams of merging units complying with the IEC 61869-9 standard. For a merging unit that only sends data streams according to IEC 61850-9-2, additional engineering steps can be necessary, for example, if the parameters for the instrument-transformer ratios are not exposed in the IID file of the merging unit.

In this manual, you can find the following information:

- Configuration of the SIPROTEC 5 device to act as a process-bus client
- Configuration of the SIPROTEC 5 device to act as a merging unit
- Export of the IID files to be used in a process-bus client
- Configuration of the sampled-value subscription using the Siemens IEC 61850 System Configurator

1.2 Configuration

1.2.1 Introduction

IID files deliver an IEC 61850 standard-compliant description of the SV data packets provided by a particular merging unit (MU). This IID file is required for every MU instance, because the data delivered by a merging unit depends on configuration settings like primary rated values in a concrete installation and other settings. This IID file provides a manufacturer-independent self description of a particular MU. This self description contains the following major parts:

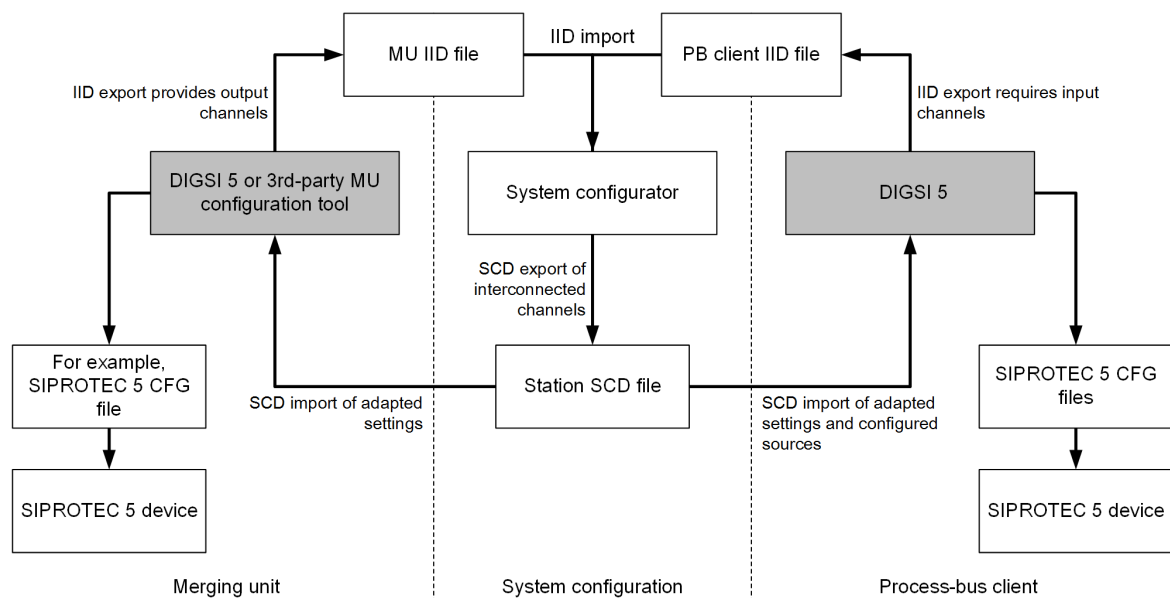
- Ethernet ports (referred to as **access points** in the following sections) provided by an MU and their configuration data
- Assignment of access points to separated network sections (referred to as **subnetworks** in the following chapters)
- Description of current transformers (CT) and voltage transformers (VT) providing instrument-transformer signals
- Description of data packets delivered by an MU

These IID files are used in an IEC 61850 System Configurator in order to interconnect current and voltage signals provided by merging units to devices that are subscribing to those MU signals. This is done in order to substitute local CT and VT inputs with data streams received from an MU. These devices are further named as process-bus clients.

These process-bus clients also provide an IID file describing the required CT and VT inputs.

You use the System Configurator tool to subscribe the required CT and VT inputs of process-bus clients to the signals published by a merging unit.

The following figure shows the basic engineering workflow, as it is defined within IEC 61850. The workflow diagram guides you through the necessary steps to parametrize a process-bus system, by highlighting the specific topic section in the workflow diagram.



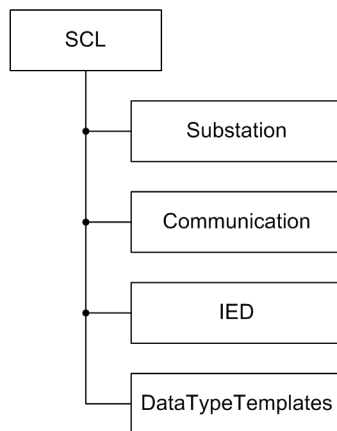
[dw_process-bus_engineering, 4, en_US]

Figure 1-2 Basic Engineering Workflow Defined in IEC 61850

1.2.2 Structure of the Merging-Unit IID File

IID files are XML files with a predefined structure. This structure is defined by a so-called XML schema.

This XML schema contains a detailed structure definition and allows a syntax check to see whether an IID file complies to this definition.



[dw_Structure_IID_File, 1, en_US]

Figure 1-3 Top-Level Structure of IID Files

The IID file contains the following nodes:

- **Substation**
The **Substation** node contains definitions regarding the assignment of a particular MU to a primary-system equipment like voltage level, bay, and primary CTs or VTs.
- **Communication**
The **Communication** node contains the assignment of the access points provided by the MU to the communication-network topology.
The following data are defined in this node:
 - IP addresses
 - Assignment of access points to subnetworks
 - MAC addresses used by the MU for publishing SV data:
These addresses are multicast addresses.
- **IED**
The **IED** node contains the definition of the IED functions like provided or subscribed CTs, VTs, and their settings. The IED node is structured in so-called logical devices (LDs). These logical devices contain logical nodes (LNs). Every CT or VT is represented by an LN. Every LN has a list of settings and outputs represented by data objects (DOs). If a device acts as a process-bus client, the LN representing a CT or VT contains external references to the subscribed MU signal wrapped by an input node.
Every logical device contains an **LNO** node with definitions that are valid for the whole logical device. The LNO node contains the definition of every SV stream sent out by the merging unit. This includes overall definitions for this stream like sampling rate and the assembly of CT and VT signals included in this stream.
- **DataTypeTemplates**
The **DataTypeTemplates** node contains a hierarchical definition of the following types:
 - LN types
 - DO types (data-object types) used in a particular LN
 - DA types (data-attribute types) used as data structures in a particular DO type

1.2.3 Information in IED Nodes

1.2.3.1 Introduction

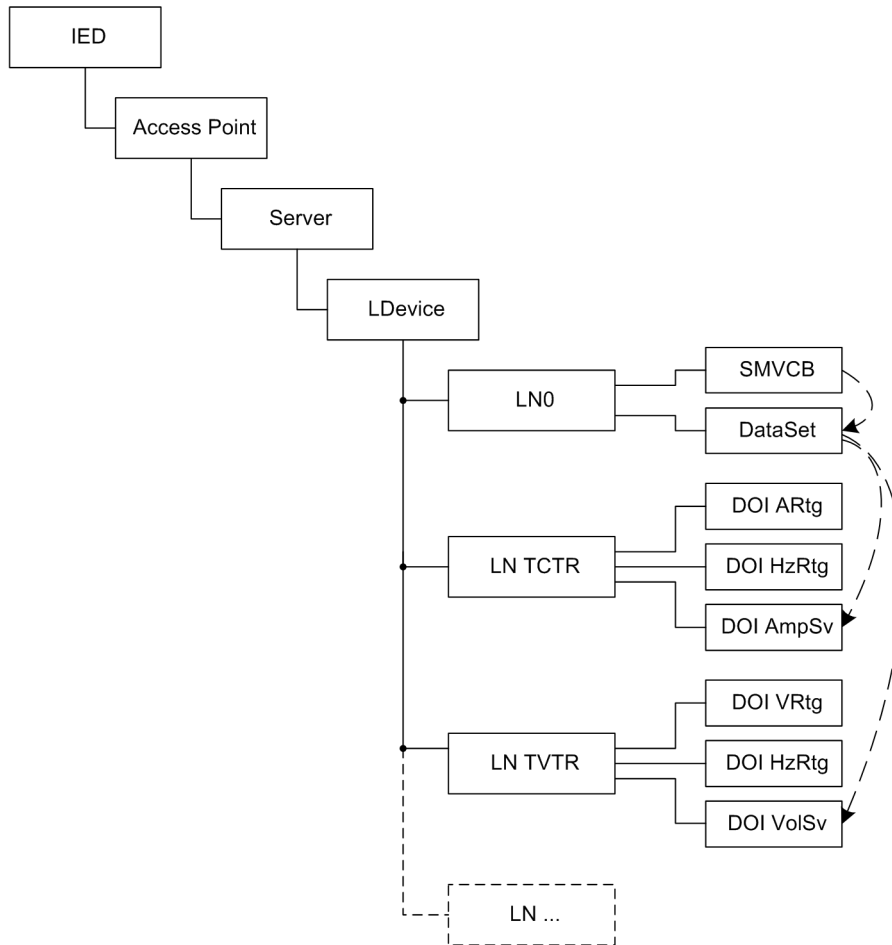


Figure 1-4 Basic Structure of an IED Node in an IID File

For each access point providing SV streams, the **IED** node contains an **Access Point** node with a **Server** node as child node (1 access point per Ethernet port) or a reference to a **Server** node.

The **Server** node contains at least 1 **LDevice** node.

The **LDevice** node provides the SV data stream. This node contains 1 **SMVCB** node (Sampled Measures Control Block) per SV data stream provided. The **SMVCB** node contains a reference to the **DataSet**. The **DataSet** defines the CT and VT signals included in the data stream.

Each **DataSet** entry contains a reference to an SV data object included in an LN **TCTR** or LN **TVTR**. A particular LN instance is characterized by the following attributes:

Table 1-1 Attributes of an LN Instance

Attribute	Description
Inst	Instance number of the LN This number must be unique within the instances of an LN class.
InClass	The LN class characterizes a particular class of LNs. For merging units, at least the following classes are required: • TCTR (current transformer) • TVTR (voltage transformer) • LPHD (name plate and health description)
InType	Assigned type template A particular LN instance cannot define DO instances that are not predefined in the assigned type template. LN instances include all DO instances that are defined in the assigned type template (even if the instance does not contain a DOI definition).
desc	Short text describing the particular instance

Streams in a process-bus client can be supervised at client side. If this supervision is configured in a system configurator, the supervision LD of the client IED contains LSVS LNs for every subscribed stream. The DOIs of this LN provide information about the current state of the subscribed stream.

1.2.3.2 IED-Node Attributes

IEC 61850 defines optional attributes for the vendor and the revision at the **IED** node. In order to identify the vendor of a particular merging unit, these attributes must be filled. Otherwise, merging units complying with IEC 61850-9-2 LE (Lite Edition) that are using a static IID file for self-description cannot be distinguished between different vendors.

1.2.4 IED Subnodes

1.2.4.1 Required Information in an SV Control Block based on IEC 61850-7-4

An LNO of a particular logical device contains SV control blocks. An SV control block must be defined for every SV data stream sent out by a merging unit.

Table 1-2 Required Information in an SV Control Block

xPath	Description
@name	Name of the SV control block The name must be unique within a particular IED instance.
@svID	Name of the SV data source The name must be unique within the whole SCD file. The merging unit uses the SV ID in the sent data stream. Clients receiving merging-unit data use the SV ID to distinguish different data streams.
@smpRate	Sampling rate The unit of the sampling rate depends on the setting of the smpMod attribute: • SmpPerPeriod: Samples per signal period of the rated frequency • SmpPerSec: Samples per s or Hz
@nofASDU	Number of sample blocks transmitted in the same datagram

xPath	Description
@multicast	The MU transmits SV values using a multicast address. The address range must be within 01:0C:CD:04:00:00 and 01:0C:CD:04:FF:FF.
@smpMod	Defines the unit for the sampling rate When the attribute is missing, samples per period (SmpPerPeriod) are assumed.
@datSet	Dataset name defining the transmitted SV values
SmvOpts/@*	Attributes are not used for the client configuration, but shall be used in the IEC 61850 System Configurator in order to allow or deny changing the sampling rate (attribute smpRate) or changing the dataset content.

1.2.4.2 Required Information in an SV Dataset based on IEC 61850-7-4

The definition of the SV dataset describes the SV data included in the datagram of the SV control block that references the dataset. It defines also the content of the sent data stream.

There are 2 methods for selecting the contained data:

- The 1st method addresses a particular data attribute included in the sent SV datagram by the attribute name.
- The 2nd method addresses contained attributes using a functional constraint (FC). This functional constraint must be defined in the DO type assigned to the referenced data-object instance (DOI).

Every dataset entry is included in an **FCDA** node.

Table 1-3 Attributes of a Dataset Entry

Attribute	Description
Inst	Instance name of the parent LD of the referenced LN
Prefix	A name grouping a set of LNs into an addressable group The referenced LN must belong to this group.
InClass	LN class of referenced LN instance LN classes are defined in IEC 61850-7-4. For an MU application, at least the following LN classes are relevant: • TCTR (current transformer) • TVTR (voltage transformer) • LPHD (name plate and health description)
InInst	LN instance number of the referenced LN
doName	DOI name of the referenced DO instance
daName	Referenced data attribute within the DO instance, mutually exclusive to the Fc attribute
Fc	Functional constraint name of assigned data attributes This functional constraint is defined in the DO type assigned to the referenced DOI characterized by the following attributes: • IdInst • prefix • InClass • InInst • doName Each attribute having an identical Fc attribute in the DO type is assigned to the SV data stream.

1.2.4.3 Required Information in LNs of a Device Providing SV Data

The following table describes the required settings of the different LNs used in a merging unit in order to describe the provided sample data. These settings are the minimum settings required for a usage with the Siemens Process-bus client interface.

Table 1-4 Settings of a CT (LN TCTR)

LNClass	DOI	SDI	DAI	Description
TCTR	AmpSv	sVC	scaleFactor	The scale factor defines the fractional of 1 A representing the value of 1 LSB For example: a value of 0.01 means that a primary value of 1 A is represented by a value of 100 LSB in the datagram sent by the merging unit.
			offset	Currently not used for process-bus client configuration Reserved for offset compensation values inside the merging unit
TVTR	VolSv	sVC	scaleFactor	The scale factor defines the fractional of 1 V representing the value of 1 LSB For example: a value of 0.01 means that a primary value of 1 V is represented by a value of 100 LSB in the datagram sent by the merging unit.
			offset	Offset for the integer representation of analog value.
TCTR	ARtg	setMag	f or i	Primary rated current with unit defined in SIUnit and multiplier defined in multiplier
		units	SIUnit	Unit shall be A .
			multiplier	Defines the scaling of the setMag value The following value results: $val = setMag \cdot 10^{multiplier}$
TVTR	VRtg	setMag	f or i	Primary rated voltage with unit defined in SIUnit and multiplier defined in multiplier
		units	SIUnits	Unit shall be V
			multiplier	Defines the scaling of the setMag value The following value results: $val = setMag \cdot 10^{multiplier}$
TCTR, TVTR	HzRtg	setMag	f or i	Rated frequency for the current input This attribute is required, if the smpMod attribute of the referencing SV control block is set to SmpPerPeriod (default value, if the smpMod attribute is missing). If smpMod is set to another value, this attribute can be missed.
		units	SIUnit	Unit Hz is expected. Another value or a missing unit value leads to warnings during the SCD/CID import.
			multiplier	–

LNClass	DOI	SDI	DAI	Description
TCTR, TVTR	Clip	setMag	f or i	Clipping value as defined in IEC 61869-9 If unit A is used, this setting means an absolute primary current. If the empty unit is used, this setting represents the overcurrent factor relative to the rated current. The full-scale value of the ADC used in a merging unit shall correspond to: • $\text{Sqrt}(2)^1 \cdot \text{Clip}$ (with unit A) • $\text{Sqrt}(2) \cdot \text{Clip} \cdot \text{ARtg}$ (with empty unit)
		units	SIUnit	Unit of the clipping value: A or empty is allowed. Another value leads to a warning during the import.
			multiplier	–
LPHD	MaxDI		setVal	Useful characteristic: The maximum processing delay time of samples (typically in micro seconds)
		units	SIUnits	Shall be s
			multiplier	Typically -6
TCTR	ScndTm ms		setVal	Useful characteristic: The specified secondary loop time constant in millisecond. Lowest time constant of the internal CT and external CT shall be used.
		units	SIUnits	Shall be s
			multiplier	Shall be -3
TCTR	AccMeas		setVal	Useful characteristic: Measuring accuracy class rating
TCTR	AccPro		setVal	Useful characteristic: Protection accuracy class rating
TCTR, TVTR	HoldTm ms		setVal	Useful characteristic: Rated holdover time

1.2.4.4 LSVS

The logical node (LN) **LSVS** is defined in the IEC 61850 standard. The logical node is used to supervise if a sampled value subscription (SV subscription) operates normally. Different state values are provided and can be seen in the **IEC Browser** if you connect to the device. If you activate the protocol **9-2 Client** on the ETH-BD-2FO module, the LN **LSVS** is configured automatically. No further configuration is needed. Routings to the ComSupervisionLog (communication supervision log) are done automatically.

The LN **LSVS** works similar to the LN **LGOS** for GOOSE supervision.

The following data objects are useful:

- **St:**
The status of the subscription (BOOL) can be **true** or **false**. If this value is **true**, the LSVS indicates that the monitored sampled values are provided and that the status is OK.
- **SimSt:**
The simulated or true data (BOOL) can be **true** or **false**. For further information, refer to the IEC 61850-7-1 standard. When **true**, the subscription is forwarding simulated data to the application.
- **ConfRevNum:**
Revision number of the configuration
The MU sends data with configuration revision. The client expects a certain configuration revision. A mismatch of the ConfRevNum can be solved with a roundtrip in the IEC 61850 System Configurator.
- **SvCBRef:**
Reference of the supervised subscribed SV stream

¹ Sqrt = square root

- Siemens-specific error status:
These error status can be:
 - General errors on the subscription, with information of the cause for **false**
 - Time-synchronization errors

The **LSVS** can have the following Siemens-specific error status. These error status show specifically what went wrong.

Error	Status	Meaning
DiagErrSmv	LDES_NoError = 0	The SV subscription works without errors.
	LDES_WaitingForTelegram = 1	At the moment, no telegrams are received for the corresponding SV subscription.
	LDES_SmpCntJump = 6	SV data for the corresponding SV subscription has been lost.
	LDES_Initializing = 7	The corresponding SV subscription is being initialized.
	LDES_GeneralError = 9	A general error has been detected for the corresponding SV subscription.
	LDES_ConfRev mism.	Not being used currently, will be hidden or enabled in future version
	LDES_ConfRev miss.	
	LDES_SV ID mism.	
	LDES_Appl. ID mism.	
	LDES_Broken telegr.	
	LDES_Data delay error = 10	Currently, there is an internal problem with data buffering of the SV Stream. If this indication persists for a longer period of time, it is possible that publisher and/or subscriber of the affected SV stream are not correctly time-synchronized. However, a temporary occurrence of this indication does not indicate an error and is possible in the following cases: • The publisher and/or subscriber of the SV stream are switched on. • The time source changes. • The time-source status changes.

Error	Status	Meaning
DiagSynch	LDS_Initializing = 0	The time synchronization of the corresponding SV subscription is being initialized.
	LDS_GlobalTimeSynch = 1	The synchronization of the corresponding SV subscription meets the required accuracy, namely: • PTP time source clock class is 6 or 7. • PPS is assumed to represent SmpSynch = 2. • IRIG-B is synchronized to a global reference.
	LDS_LocalTimeSynch = 2	The time-synchronization source of the corresponding SV subscription meets the required accuracy. The conditions for LDS_GlobalTimeSynch are not given.
	LDS_GeneralError = 3	The time synchronization of the corresponding SV subscription indicates a general error.
	LDS_NoTimeSynch = 4	The time synchronization of the corresponding SV subscription is not active or does not meet the required accuracy.
	LDS_SmpSynchMismatch = 5	The time synchronization of the SV subscription is in a state other than global and this state is not allowed in the subscriber per 102.1031.0.106 SmpSynchId.
	LDS_SynchSrcIdMismatch = 6	The time synchronization of the SV subscription is in state local but is synchronized from a different time source compared to the subscriber.

**NOTE**

For the use of the **IEC Browser**:

The logical device **ComSupervision_SV** contains the supervision logical-node instances **LSVS** (1 **LSVS** per stream). The process bus can process several streams, so there can be several **LSVS** blocks. The subscription is supervised stream-specifically.

The LN **CALH1** in the **ComSupervision_SV** logical device offers the following grouped indications:

- **GrAlm**:
Group alarm (BOOL). When **true**, it indicates that at least one subscribed stream is not received properly. The not received stream(s) are marked as LSVS<x>.St = false.
- **GrInd**:
Group indication (BOOL). When **true**, it indicates that at least one subscribed stream is using simulated value. The simulated stream(s) are marked as LSVS<x>.SimSt = true.

1.2.4.5 LPHD

A SIPROTEC 5 device provides a single **LPHD** instance in an LD application.

The **Sim** DOI of this LN can be used to switch a device containing a process-bus client into simulation mode. When the simulation mode is activated, the process-bus clients in this device accept SV streams marked with the simulation bit. The device continues accepting streams of the process bus until a stream with simulation bit set is recognized. Then, the originally subscribed stream without simulation bit is ignored and the stream with set simulation bit is used instead.

**NOTE**

Before sending a simulated stream, make sure the SIM bit is set. When used in combination with the test mode functionality, make sure the test flag is set as well.

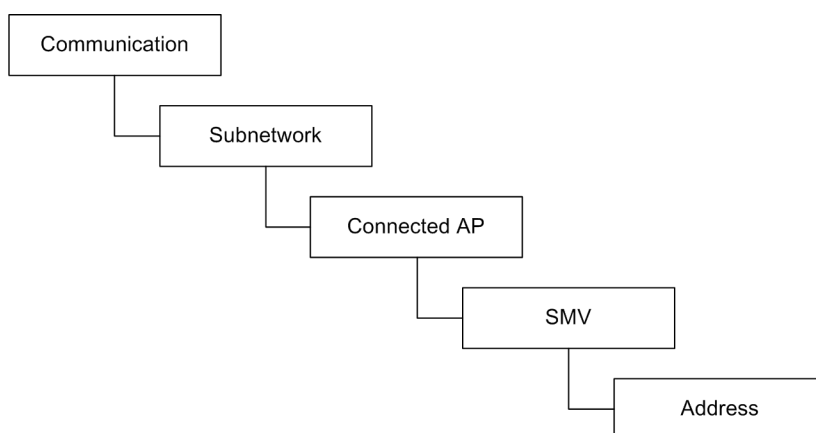
If a merging unit is configured on the BD module, SIPROTEC 5 devices contain further **LPHD** instances (one per BD module). The following table shows the relevant DOIs.

Name	Description
NamVariant	Configurable combination of sampling rate and signals contained in the provided SV stream according to IEC 61869
NamHzRtg	Configurable rated frequencies according to IEC 61869
NamHoldRtg	Time span after loosing second pulse, where sent SVs keep time synchronization according to IEC 61869
NamMaxDIRtg	Sampling delay of SVs in a merging-unit stream as name-plate information according to IEC 61869
MaxDI	Sampling delay of SVs in machine readable form

1.2.5 Required Information in the Communication Node

Structure

The **Communication** node contains a subnode **Subnetwork**.

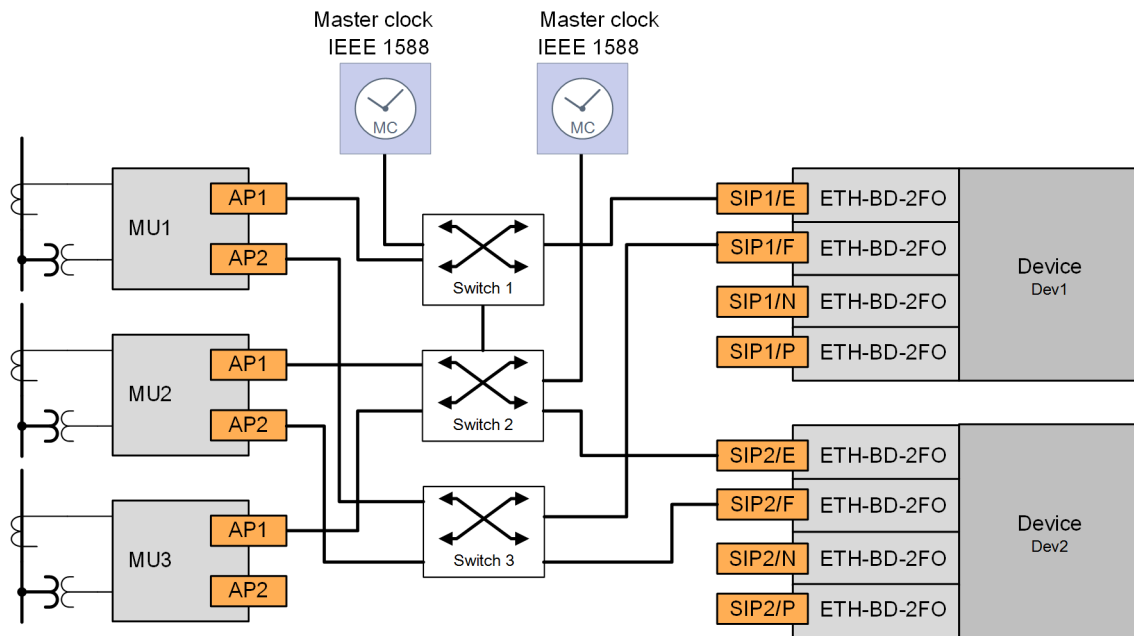


[dw_Communication_Node, 1, en_US]

Figure 1-5 Structure of the Communication Node

Subnetworks

IEC 61850 defines the use of named subnetworks for isolated network segments. The following figure gives an example for 2 subnetworks between 3 merging units and 2 devices consuming the SV data streams provided by the merging units.

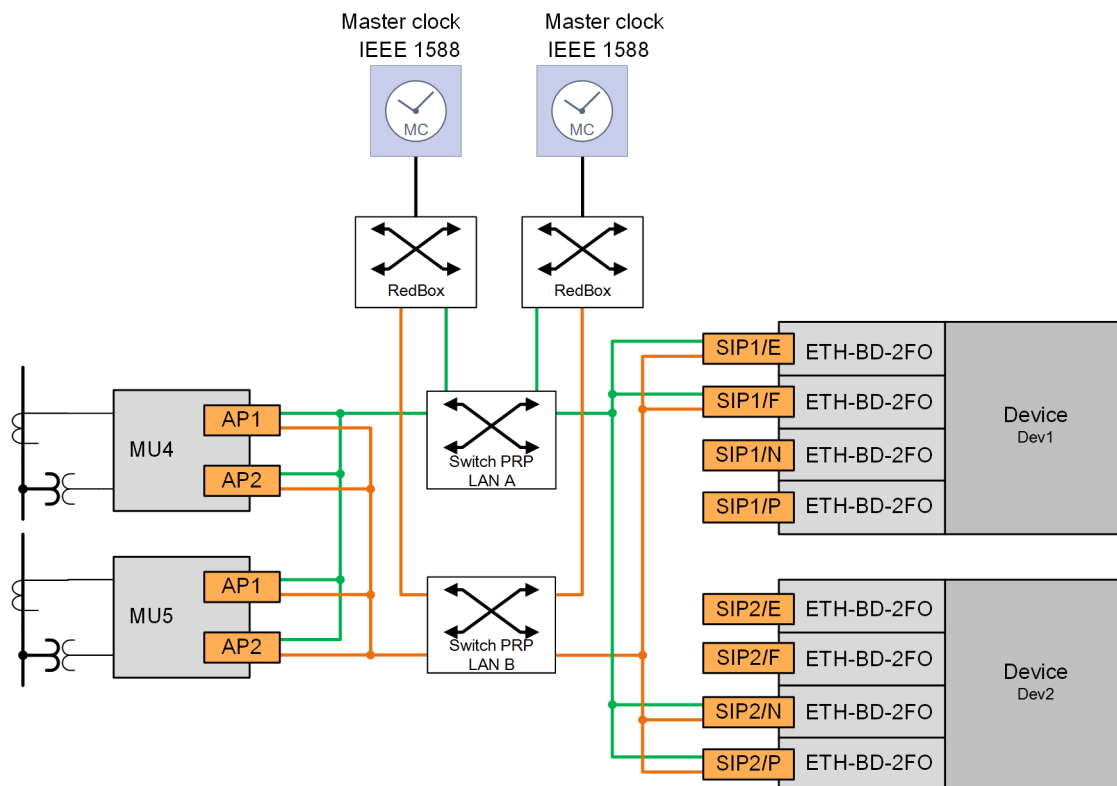


[dw_network-topology, 3, en_US]

Figure 1-6 Example of a Network Topology

In this example, the switches 1 and 2 additionally distribute IEEE 1588 synchronization to all devices as Transparent clock.

The preceding figure shows an example of a process-bus network topology without communication redundancy. 3 merging units are publishing and 2 IEDs are consuming SV streams. The merging units and IEDs are interconnected via Ethernet switches. 2 IEEE 1588 master clocks are connected to different Ethernet switches, to avoid a single-point-of-failure. These switches are in the IEEE 1588 transparent clock role. The SIPROTEC 5 IEDs are equipped with multiple ETH-BD-2FO modules, but only one of them per device is used for IEEE 1588 synchronization (in IEEE 1588 slave clock role).



[dw_network-topology_PRP, 1, en_US]

Figure 1-7 Example of a Network Topology for PRP

The preceding figure shows an example of a network topology with PRP redundancy. 2 merging units are publishing and 2 IEDs are consuming SV streams. The merging units and IEDs are simultaneously connected to one switch in PRP LAN A and to another switch in PRP LAN B. 2 IEEE 1588 master clocks are connected via PRP RedBoxes to these 2 switches. The switches are in the IEEE 1588 transparent clock role. One ETH-BD-2FO module per device is used for IEEE 1588 synchronization (slave clock role).

1.3 Special Case IEC 61850-9-2 LE

IEC 61850-9-2 LE (Lite Edition) was defined in order to simplify the device engineering for merging units. The intention was to use static IID files for merging units having a fixed configuration with the following properties:

- Fixed dataset with 4 currents and 4 voltages
- Fixed SV configuration with 4-kHz sampling rate ($f_n = 50$ Hz) or 4.8-kHz sampling rate ($f_n = 60$ Hz)
- Fixed sample scaling
- APPID = 4000 (hex)

However, you must configure the following data also for IEC 61850-9-2 LE installations:

- TCTR/TVTR settings
- Multicast addresses
- SV ID

Therefore, using IEC 61850-9-2 LE simplifications allows an easier MU engineering, as the device engineering tools must not handle structural changes in IID files.

The following minimum requirements must also be handled during configuration of the IEC 61850-9-2 LE devices:

- IID export resulting in an IID file
This IID file contains the setting values that are currently configured.
- SCD/CID import in order to adapt settings changed in the substation configuration, for example:
 - Multicast addresses
 - SV ID

As specified in [1.2.4.3 Required Information in LNs of a Device Providing SV Data](#), the model of the MU must contain the ratio setting extended by the process-bus interface.

1.4 Handling of Quality Information from the SV Stream

The following table shows the mapping to the IEC 61850-9-2 stream.

Merging Unit		Health of Protection Function	Device Display
Validity	Detailed Quality		
Good (00)	All	OK	Value
Questionable (11)	No error	OK	Value
	Overflow	OK	Value
	OutOfRange	Depends on function	> Value
	BadReference	OK	Value
	Oscillatory	OK	Value
	Failure	OK	Value
	OldData	OK	Value
	Inconsistent	OK	Value
	Inaccurate	Depends on function	~ Value
Invalid (01 and 10)	All	Alarm	Failure

1.5 Measuring-Point Specific Sampled-Values Status

In the information routing matrix below each measuring point subscribing to a sampled-values stream, the node **SV Status** provides the following sampled-values related indications:

- Qualities
- Synchronization state
- Test-flag
- Sim-mode

These indications are a sum of the measuring-point individual channels (for example, Phase A, Phase B, Phase C for a 3-phase measuring point).

These indications are all prerouted to the operational log and part of the alarm list.

Information				Destination							
				Recorder				Logs			
Signals		Fav	Number	Type	Fault recorder	O	F	U1	U2	G	S
SV Status		..	(All)	...	(All)	...	...	...	...	...	...
Power system			11		*	*					
Meas.point I-3ph 1			11.931		*	*					
Meas.point I-3ph 2			11.932		*	*					
SV Status			11.932.26641			*					
SV.q good		☆	11.932.26641.301	SPS							
SV.q out of range		☆	11.932.26641.302	SPS		X					
SV.q inaccurate		☆	11.932.26641.303	SPS		X					
SV.q invalid		☆	11.932.26641.304	SPS		X					
SV.q test		☆	11.932.26641.305	SPS		X					
SV simulated		☆	11.932.26641.306	SPS		X					
SV not synchronized		☆	11.932.26641.307	SPS		X					
SV invalid internal		☆	11.932.26641.308	SPS		X					

[sc_SV_status, 1, en_US]

Figure 1-8 Information Routing Matrix – Measuring Point Subscribing to a Sampled-Values Stream

Indication	Description
<i>SV.q good</i>	Is true if <i>SV.q out of range</i> , <i>SV.q inaccurate</i> , and <i>SV.q invalid</i> are false .
<i>SV.q out of range</i>	Is true if at least one channel of the MP is set to out of range in the stream.
<i>SV.q inaccurate</i>	Is true if at least one channel of the MP is set to inaccurate in the stream.
<i>SV.q invalid</i>	Is true if at least one channel of the MP is set to invalid in the stream.
<i>SV.q test</i>	Is true if at least one channel of the MP is set to test in the stream.
<i>SV simulated</i>	Is true if at least one channel of the MP is received with a simulation bit set to true and LPHD.sim of the device is set to true .
<i>SV not synchronized</i>	Is true if at least one channel of the MP is not synchronized to the process-bus client according to the parameter Accepted SmpSynch of the PB Client settings (refer to 3.1 Sample Synchronization).
<i>SV invalid internal</i>	Is true if at least one channel of the MP cannot be received or processed (for example, data delay error). The <i>SV.q invalid</i> is set to true as well.



NOTE

Usually, the individual channels are subscribed from the same stream and not composed from various streams. In this most common case, the indications *SV simulated*, *SV not synchronized*, or *SV invalid internal* are valid for all channels of the MP.

1.6 Behaviors in SMV Processing during Test with the Process-Bus Connection

For more information, refer to the chapter 2.1 in the Application Note **Mode Behavior Compliant with IEC 61850** under <https://support.industry.siemens.com/cs/document/109811596/siprotec-5-appnotes?dti=0&lc=en-US>.

2 Parameterization of Process Bus

2.1	Parameterization in DIGSI	32
2.2	Process Bus in SCD Files	77
2.3	Single-Line Configuration for Process-Bus System	92

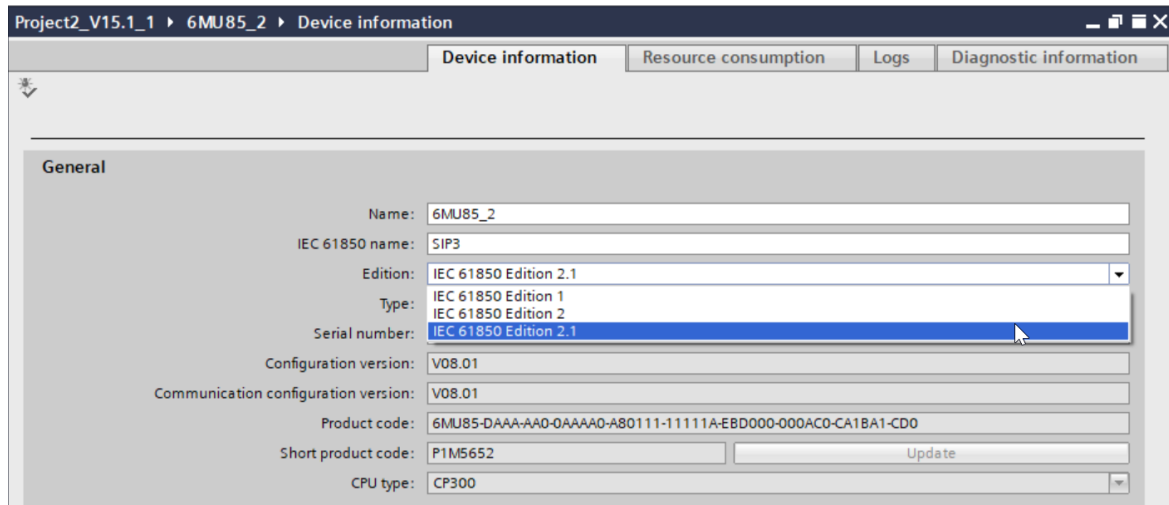
2.1 Parameterization in DIGSI

2.1.1 General Configuration

Changing the IEC 61850 Edition of the Device

Siemens recommends using the IEC 61850 Edition 2.1 (default setting). If a change of the IEC 61850 Edition is required, proceed as follows:

- ✧ In the **Project tree**, navigate to the device and open the **Device information**.
- ✧ Select IEC 61850 Edition 2 or IEC 61850 Edition 2.1.

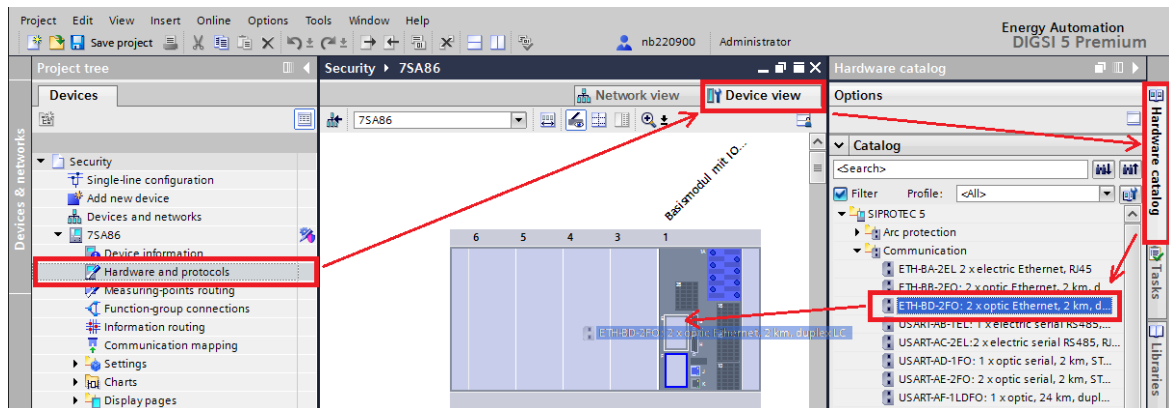


[sc_select_IECEdition, 1, en_US]

Figure 2-1 Selection of the IEC 61850 Edition for the Device

Adding a Process-Bus-Capable Ethernet Module to a Device

- ✧ Open the **Hardware and protocols Editor** and select **Device view**.
- ✧ Drag an Ethernet communication module **ETH-BD-2FO** from the **Hardware catalog** to the device HW configuration as shown in the following figure.



[sc_Adding_process_bus_client, 3, en_US]

Figure 2-2 Adding an ETH-BD-2FO Module into a SIPROTEC 5 Device

2.1.2 Process-Bus Client in SIPROTEC 5

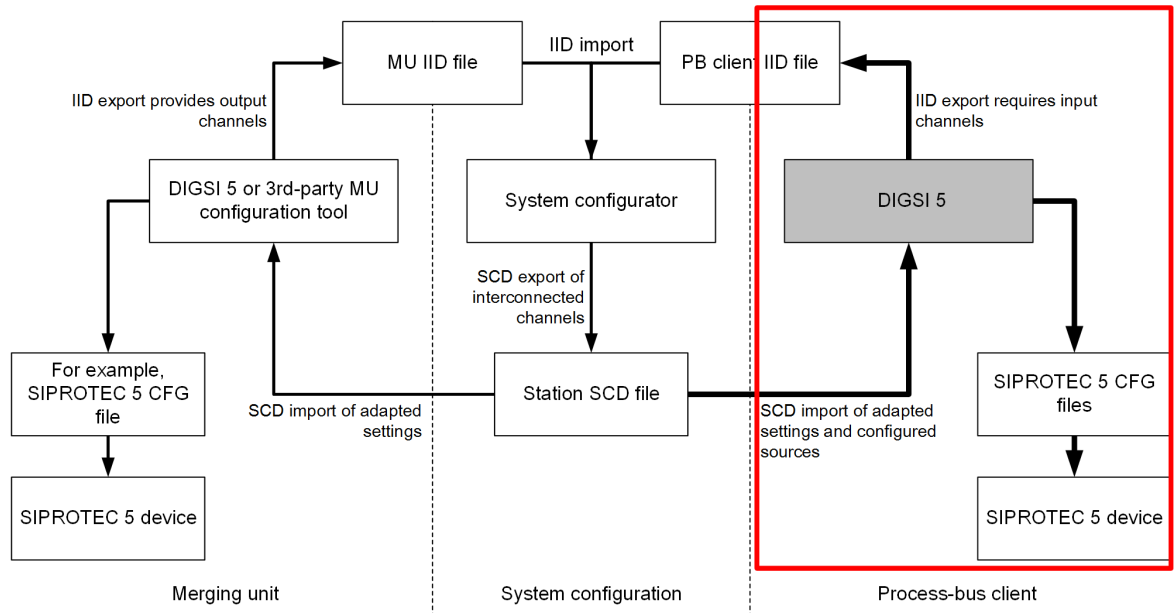
2.1.2.1 Configuration

In order to use a SIPROTEC 5 device as a process-bus client, configure the process-bus client functionality in a device first. The following figure shows the part of the engineering workflow which is covered in this section.



NOTE

You can configure the merging unit and the process-bus client on the same module.
For more information, refer to chapter [7 Technical Data](#).



[dw_process-bus_engineering_Client_DIGSI_1_en_US]

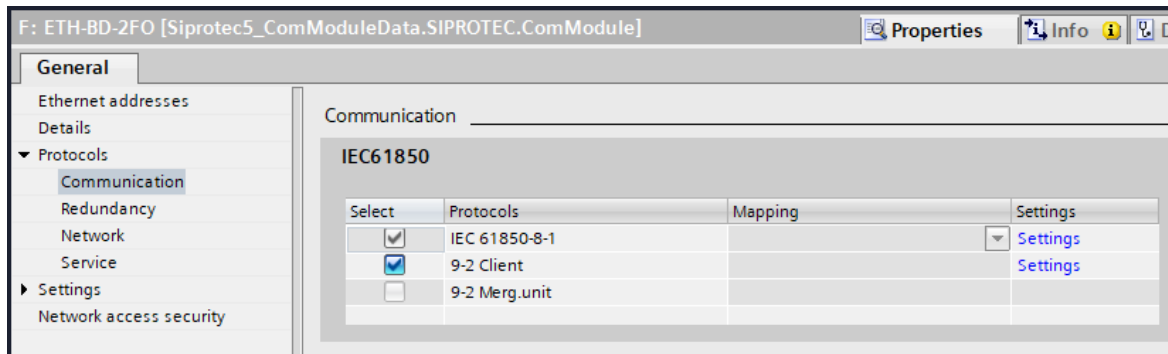
Figure 2-3 Process-Bus Client Configuration in DIGSI 5

Parameterizing a Process-Bus Client in DIGSI 5

- ✧ Add a SIPROTEC 5 device from the Global DIGSI 5 Library to the project.
- ✧ In the **Hardware and protocols** Editor, select the **Device view** tab.
- ✧ Add an Ethernet communication module ETH-BD-2FO to the device HW configuration, as described in the section [2.1.1 General Configuration](#).

Configuring the ETH-BD-2FO Module

- ✧ In the **Hardware and protocols** Editor, click the ETH-BD-2-FO module.
- ✧ In the **Inspector window** section, go to **Protocols > Communication**.
- ✧ Mark the check box for **9-2 Client**.

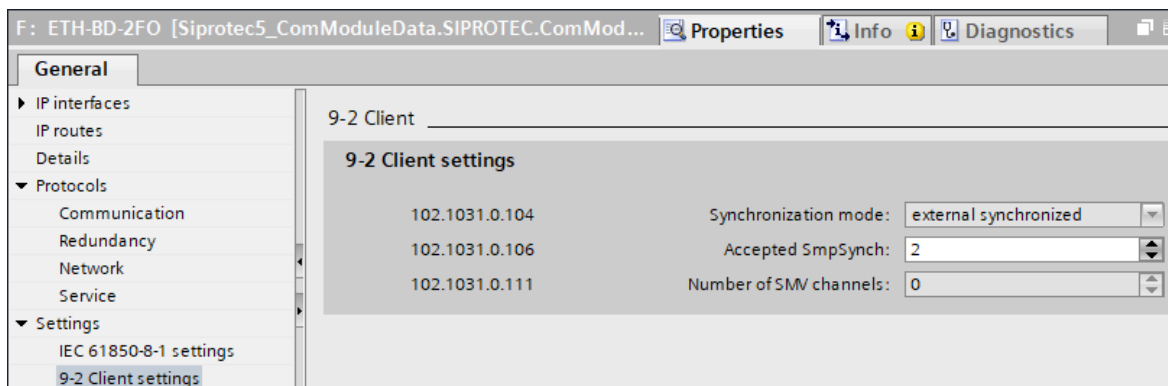


[sc_9-2-Client, 1, en_US]

Figure 2-4 Communication-Protocol Activation

When the client is activated, the **IEC 61850-8-1** protocol is activated automatically.

- ✧ Go to **Settings > 9-2 Client settings** and adjust the settings if necessary.



[sc_9-2-Client_settings, 2, en_US]

Figure 2-5 IEC 61850-9-2 Process-Bus Client Settings



NOTE

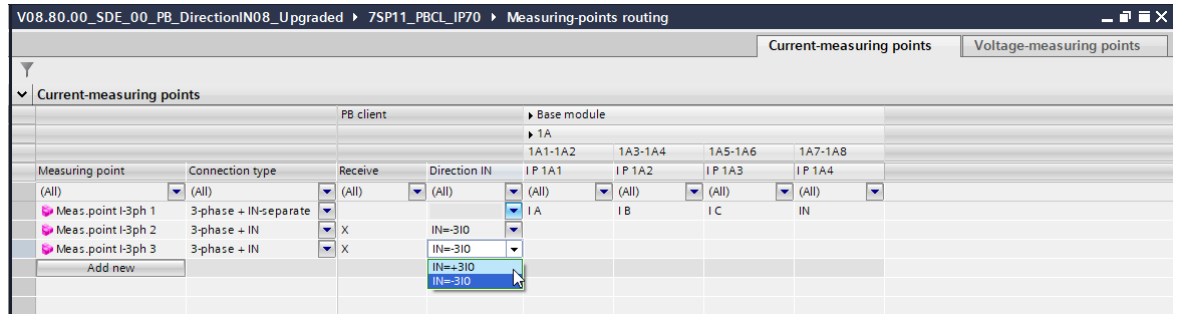
For a description of the process-bus client settings, refer to chapter [2.1.2.2 Application and Setting Notes](#).

- ✧ Synchronize the hardware in the **Measuring-points routing** Editor.

Adding and Routing of Measuring Points

To receive sampled measured values, you must assign current and voltage measuring points to the process-bus client. If no voltage or current measuring points are available, you must add them according to your application. The first 2 steps of the following procedure are necessary only if you are adding new measuring points.

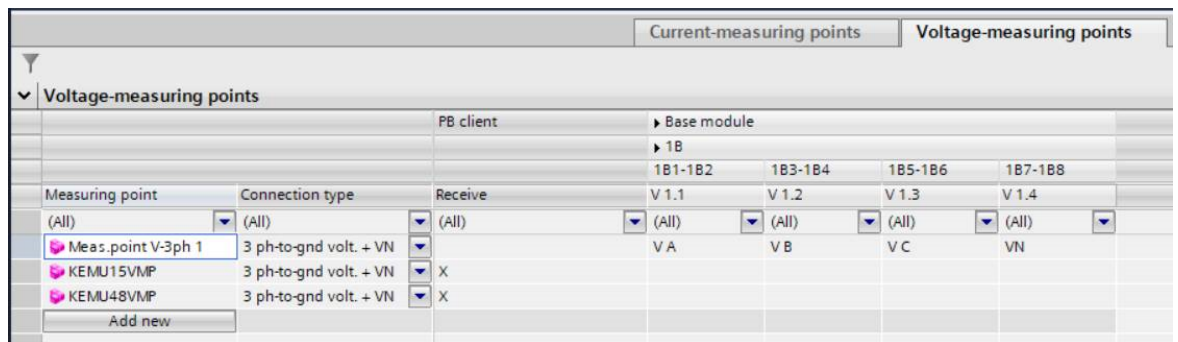
- ✧ In the **Measuring-points routing** Editor, in the **Current-measuring points** tab, click **Add new**.
- ✧ Select the appropriate connection type for your measuring point.
If the sampled values stream contains measured IN channel, for example, 3-phase + IN, use a connection type including IN. Otherwise, use a connection type without IN, for example, 3-phase.
- ✧ Mark the **PB client** column of the new measuring point with **X**.
- ✧ If you use the measured IN, set the IN direction as it is provided within the stream as either IN = +3I0 or IN = -3I0 in the column **Direction IN**.



[sc_measuring_points_routing_PBClient, 2, en_US]

Figure 2-6 Routing of Current-Measuring-Points

- Repeat these steps for the **Voltage-measuring points**.
An assignment of the neutral-element direction is not necessary.



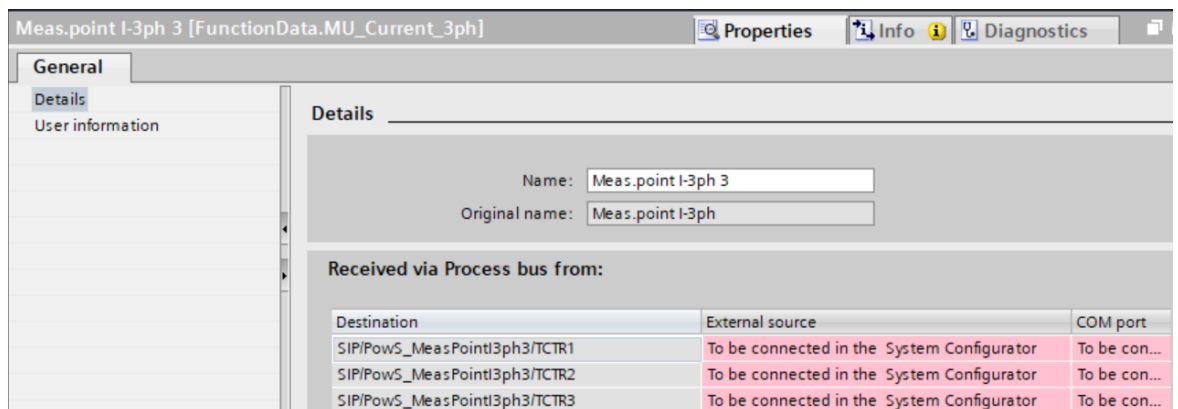
[sc_voltage_measuring_points_routing_PBClient, 1, en_US]

Figure 2-7 Routing of Voltage-Measuring-Points



NOTE

As long as the defined measuring points assigned to the process-bus client are not routed to a sampled-value stream in the IEC 61850 System Configurator, the **Properties** tab shows an information that the measuring point must be routed in the IEC 61850 System Configurator. Additionally, an inconsistency **Source not configured in system configurator** is present.



[sc_Missing_SysCon_connection, 2, en_US]

Figure 2-8 Missing Connections to Streams

- Go to **Settings > Device settings** and adapt the **Rated frequency** if necessary.
- Go to **Settings > Power system** and set the corresponding settings for the measuring points.

CT 3-phase

General

11.931.8881.115	CT connection:	3-phase + IN		
11.931.8881.127	Tracking:	active		
11.931.8881.130	Measuring-point ID:	1		

CT phases

11.931.8881.101	Rated primary current:	2000.0	A		
11.931.8881.102	Rated secondary current:	5 A			
11.931.8881.117	Current range:	100 x IR			
11.931.8881.118	Internal CT type:	CTIEC 61850-9-2			
11.931.8881.142	Invert current polarity:	no			
11.931.8881.114	Inverted phases:	none			

MP disconnection

11.931.8881.173	Current check:	active			
11.931.8881.112	I< threshold:	0.50	A		

Add new stage

Delete stage

CT 1

11.931.3841.101	Rated primary current:	2000.0	A		
11.931.3841.109	Rat:	400.0			
11.931.3841.103	Magnitude correction:	1.00000			
11.931.3841.117	Phase:	I A			
11.931.3841.102	Rated frequency:	60.00	Hz		
11.931.3841.118	Ratio of clipping limit:	100.00			
11.931.3841.119	Meas. accuracy class:	0.25			
11.931.3841.120	Prot. accuracy class:	1			
11.931.3841.121	Second. loop time const.:	0.21	s		
11.931.3841.122	Holdover time:	1.0	s		
11.931.3841.123	Transient perform. class:	TPS			

[sc_IMP_setting, 2, en_US]

Figure 2-9 Settings for a Current Measuring Point

VT 3-phase

11.941.8911.101	Rated primary voltage:	13.800	kV			
11.941.8911.102	Rated secondary voltage:	115	V			
11.941.8911.103	Matching ratio Vph / VN:	1.73				
11.941.8911.104	VT connection:	3 ph-to-gnd volt. + VN				
11.941.8911.106	Inverted phases:	none				
11.941.8911.111	Tracking:	active				
11.941.8911.130	Measuring-point ID:	2				
11.941.8911.136	Internal VT type:	VTIEC 61850-9-2				

Add new stage

Delete stage

VT 1

11.941.3811.101	Rated primary voltage:	13.80	kV			
11.941.3811.109	Rat:	120.0				
11.941.3811.103	Magnitude correction:	1.00000				
11.941.3811.108	Phase:	V A				
11.941.3811.102	Rated frequency:	60.00	Hz			
11.941.3811.118	Ratio of clipping limit:	1.74				
11.941.3811.119	Meas. accuracy class:	0.25				
11.941.3811.120	Prot. accuracy class:	1				
11.941.3811.122	Holdover time:	1.0	s			

[sc_VMP_setting, 2, en_US]

Figure 2-10 Settings for a Voltage Measuring Point



NOTE

The transformer ratios are adopted after the subscription to a sampled-value stream, based on the information within the SCD file for the according merging unit.

If the connection of the neutral point is wrong, you can invert the phases here with the parameter **Inverted phases**.

Loading Configuration to Devices

After you have finished the parameterization of the process-bus client and merging unit (refer to chapter [2 Parameterization of Process Bus](#)) including the round trip via the IEC 61850 System Configurator (refer to chapter [2.2.3 IEC 61850 System Configurator](#)), load the configuration to the devices.

If no round trip has been executed, the subscription to the streams from the merging unit is missing.

You can load the configurations one by one or all at the same time.

- ✧ In the project tree, click **Load configuration to devices**.
- ✧ Select the device(s) by marking the corresponding check box in the **Selection** column to define the configurations to be loaded.
- ✧ Enter the **Confirmation ID** in the corresponding cell in the column and click **Update device(s)**.

An initial restart of the device is performed.

You can check the result of the installation in the diagnostic data of the client.



NOTE

All devices must be up-to-date and synchronized.

2.1.2.2 Application and Setting Notes

Parameter: Synchronization mode

- Default setting () **Synchronization mode** = **external synchronized**

The process-bus client requires an external synchronization via IEEE 1588v2/PTP, PPS, or IRIG B. The parameter **Synchronization mode** cannot be changed.

The parameter indicates the synchronization mode for received sampled measured values.

Parameter: Accepted SmpSynch

- Default setting () **Accepted SmpSynch** = **2**

The **Accepted SmpSynch** defines the accepted synchronization status of subscribed sampled value streams.

The **Accepted SmpSynch** indicates the sample synchronization value that the client accepts in the received sampled values additionally to the global synchronization.

The following settings are possible:

Parameter Value	Description
1	This setting is used to allow local synchronization. The device accepts sampled values which are locally synchronized and forwards them to the protection applications.
2	This setting is used to allow global synchronization. The device accepts sampled values which are globally synchronized and forwards them to the protection applications.

For more information, refer to chapter [3.1 Sample Synchronization](#).

Parameter: Number of SMV channels

- Default setting () **Number of SMV channels** = **0**

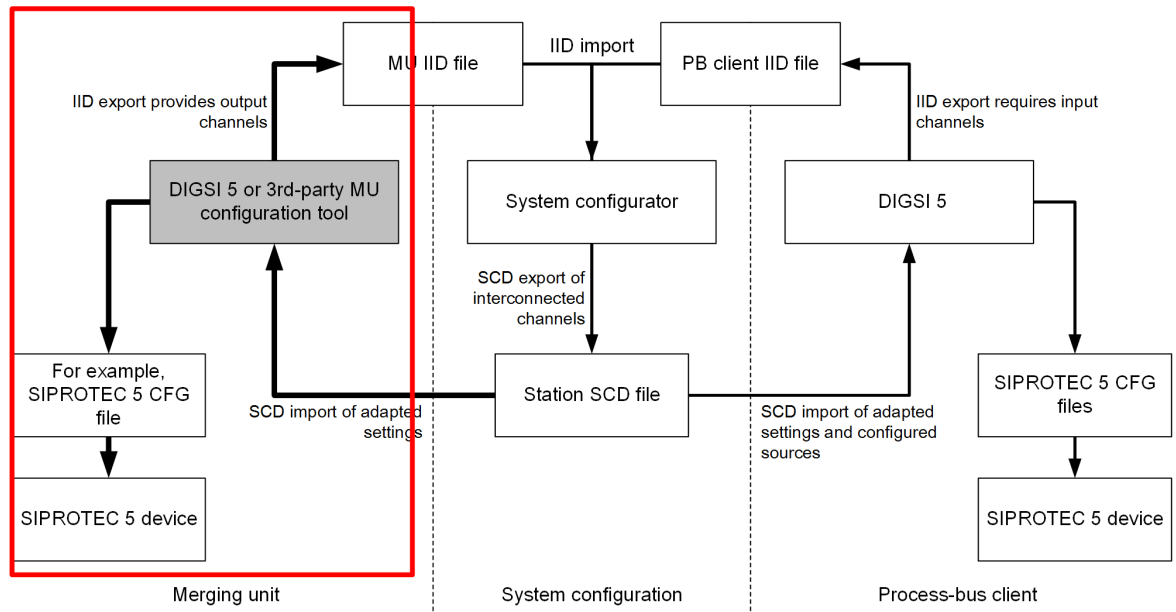
The **Number of SMV channels** indicates the number of sampled measured-value channels after the subscription to sampled measured values from the merging units.

The parameter **Number of SMV channels** cannot be changed. The parameter **Number of SMV channels** shows the total number of subscribed sampled value channels to the particular process-bus client interface, after successful executed roundtrip with an IEC 61850 System Configurator.

2.1.3 Merging Unit in SIPROTEC 5

2.1.3.1 Configuration

In order to use a SIPROTEC 5 device as a merging unit (MU), configure the merging-unit functionality in a device first. The following figure shows the part of the engineering workflow which is covered in this section.



[dw_process-bus_engineering_MU_1_en_US]

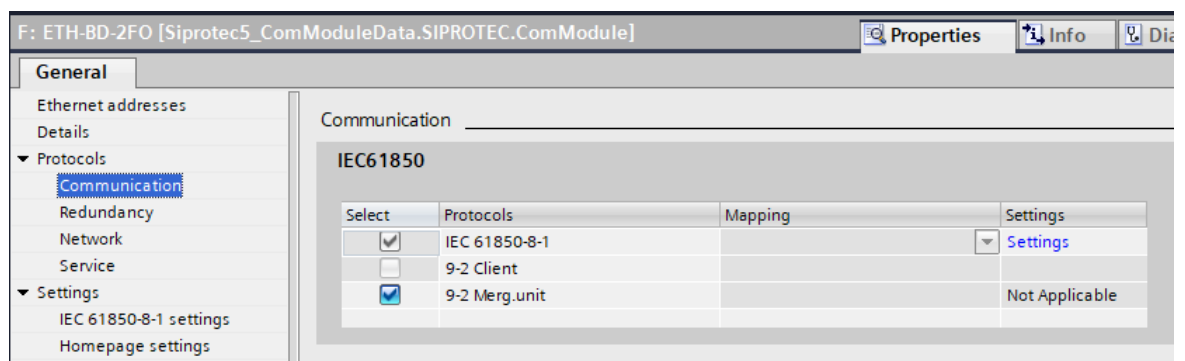
Figure 2-11 Merging Unit Configuration

Parameterizing a Merging Unit in DIGSI 5

- ✧ Add a SIPROTEC 5 device from the Global DIGSI 5 Library to the project.
- ✧ In the **Hardware and protocols** Editor, select the **Device view** tab.
- ✧ Add an Ethernet communication module ETH-BD-2FO to the device HW configuration, as described in the section [2.1.1 General Configuration](#).

Configuring the ETH-BD-2FO Module

- ✧ In the **Hardware and protocols** Editor, click the ETH-BD-2-FO module.
- ✧ In the **Inspector window** section, go to **Protocols > Communication**.
- ✧ Mark the check box for **9-2 Merg.unit**.



[sc_9-2-MergingUnit_1_en_US]

When the merging unit is activated, the **IEC 61850-8-1** protocol is activated automatically.

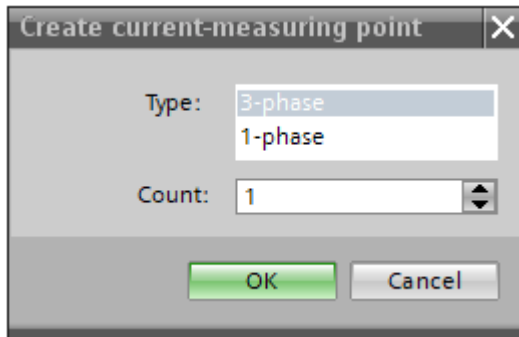
Defining Measuring Points

For example, 4 currents and 4 voltages are required for the fixed configuration of an IEC 61850-9-2 LE sampled-value stream.

- ✧ Go to the **Measuring-points routing** Editor.

- ✧ In the **Current-measuring points** tab, click **Add new** to add a new current measuring point.

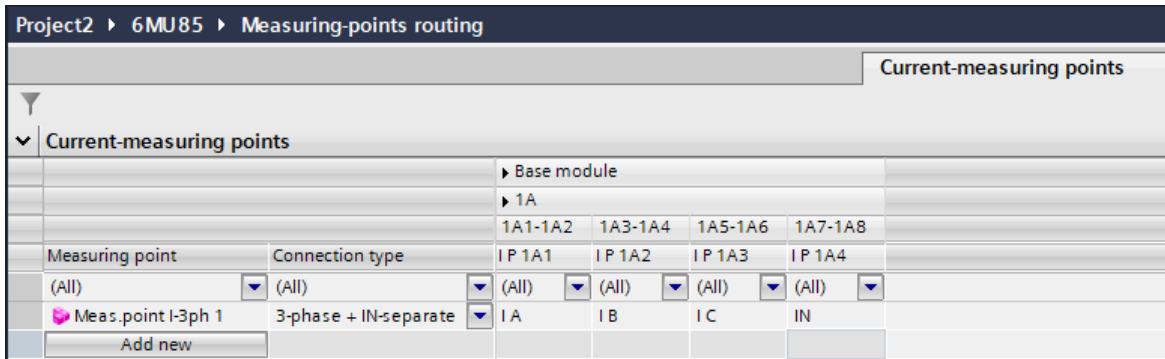
The **Create current-measuring point** dialog opens.



[sc_Create_current_measuring_point, 1, en_US]

- ✧ Select the type of the current measuring point (3-phase or 1-phase) and the amount of measuring points you want to create and click **OK**.

The measuring point **Meas.point I-3ph** is created.



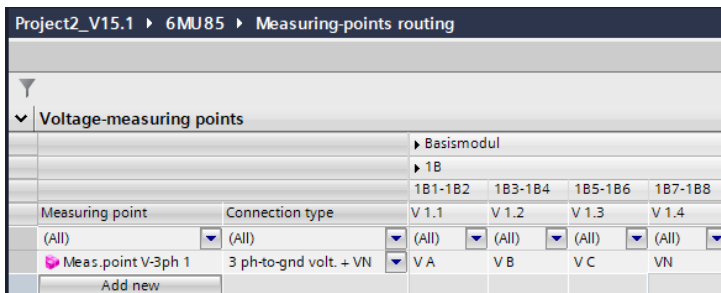
[sc_routing_current_measuring_points, 1, en_US]

- ✧ In the **Voltage-measuring points** tab, click **Add new** to add a new voltage measuring point.

The **Create voltage-measuring point** dialog opens.

- ✧ Select the type of the voltage measuring point (3-phase or 1-phase) and the amount of measuring points you want to create and click **OK**.

The measuring point **Meas.point V-3ph** is created.



[sc_routing_voltage_measuring_points, 1, en_US]

Project2_V15.1_1 ▸ 6MU85_3 ▸ Settings ▸ Power system ▸ Meas.point I-3ph 1

Edit mode: secondary Active: settings group 1

CT 3-phase

General

11.931.8881.115	CT connection:	3-phase + IN	
11.931.8881.127	Tracking:	active	
11.931.8881.130	Measuring-point ID:	1	

CT phases

11.931.8881.101	Rated primary current:	1000.0	A		
11.931.8881.102	Rated secondary current:	1 A			
11.931.8881.117	Current range:	100 x IR			
11.931.8881.118	Internal CT type:	CT protection			
11.931.8881.116	Neutr.point in dir.of ref.obj:	yes			
11.931.8881.114	Inverted phases:	none			
11.931.8881.107	CT error changeover:	1.00			
11.931.8881.108	CT error A:	5.0	%		
11.931.8881.109	CT error B:	15.0	%		

[sc_JMP_setting_MU, 1, en_US]

Figure 2-12 Settings for a Current Measuring Point

Project2_V15.1_1 ▸ 6MU85_3 ▸ Settings ▸ Power system ▸ Meas.point V-3ph 1

Edit mode: secondary Active: settings group 1

VT 3-phase

11.941.8911.101	Rated primary voltage:	400.000	kV		
11.941.8911.102	Rated secondary voltage:	100	V		
11.941.8911.103	Matching ratio Vph / VN:	1.73			
11.941.8911.104	VT connection:	3 ph-to-gnd volt. + VN			
11.941.8911.106	Inverted phases:	none			
11.941.8911.111	Tracking:	active			
11.941.8911.130	Measuring-point ID:	2			
11.941.8911.136	Internal VT type:	Voltage transformer			

Add new stage Delete stage

VT 1

11.941.3811.103	Magnitude correction:	1.000			
11.941.3811.108	Phase:	V A			
11.941.3811.122	Holdover time:	1.0	s		

[sc_VMP_setting_MU, 1, en_US]

Figure 2-13 Settings for a Voltage Measuring Point



NOTE

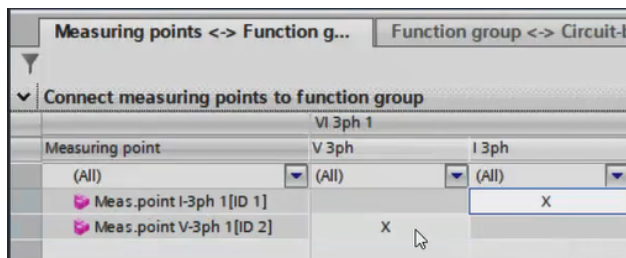
For IEC 61850-9-2 LE streams, you can select the following connection types:

- Current measuring points:
3-phase + IN-separate or **3-phase + IN**
- Voltage measuring points:
3 ph-to-gnd volt. + VN

Function-Group Connections

You must connect the measuring points to at least a function group **Circuit breaker**. A backup protection function might require protection function groups additionally, for example the FG **VI 3ph**.

- ✧ In the DIGSI 5 Global library, select the function group that you need in the device, for example, the FG **VI 3ph**.
- ✧ Go to the **Function-group connections** Editor and connect the measuring points to the function group.



[sc_connecting_measuring_points, 1, en_US]

Routing of Measuring Points to Streams

- ✧ In the project tree, under the specific device, select the element **Merging-unit routing**. In this Editor, you define which current and voltage information is published by a sampled-value stream.

			Current-measuring points	Voltage-measuring points
			Meas.point I-3ph 1	Meas.point V-3ph 1
Stream name	Stream type	Consumed channels	3-phase + IN	3 ph-to-gnd volt. + VN
▼ F:ETH-BD-2FO				
Merging unit 1[SMV Stream]	IEC 61869-9	8(32)	X	X
Add New				
▼ E:ETH-BD-2FO				
Merging unit 1[SMV Stream]	IEC 61869-9	8(32)	X	X
Add New				

[sc_merging_unit_routing, 2, en_US]

Figure 2-14 Merging-Unit Routing Editor

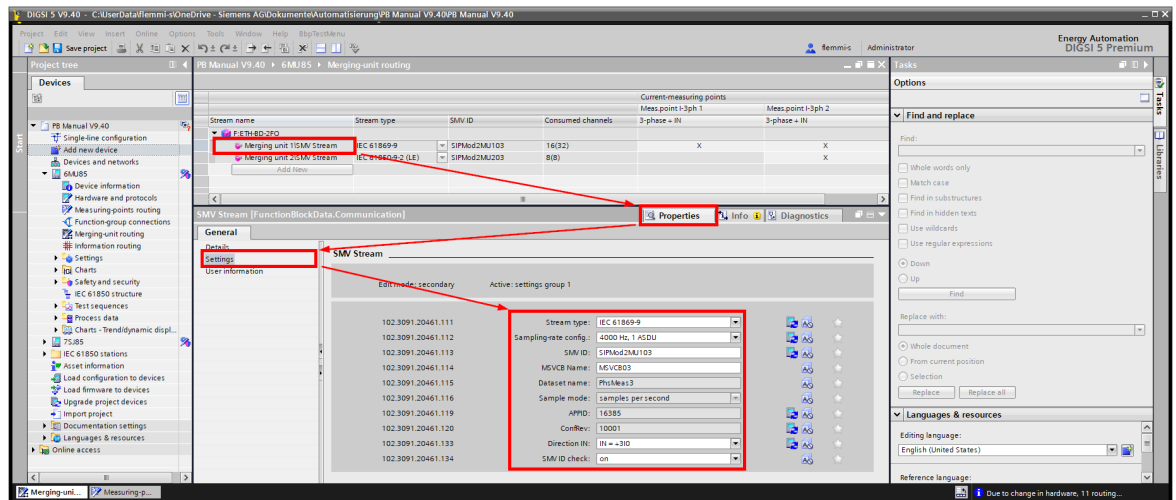
A list of streams is shown for each module where the merging unit is enabled.



NOTE

2 sampled-value streams per ETH-BD-2FO module are supported. If more than 2 streams must be published, additional instances of ETH-BD-2FO modules are required.

- ✧ Select a stream in the Merging-unit routing and go to **Properties > Settings** in the **Inspector window** section to change the stream type to either IEC 61850-9-2 LE, IEC 61869-9, or IEC 61869-9 (LE comp.).
- ✧ Set the **Sampling rate** and **SMV ID**.
- ✧ Select the definition of the direction for IN. For more details, refer to [2.1.4.2 Definition of IN within a Stream](#).



[sc_sampling rate, 2, en_US]

Figure 2-15 Merging-Unit Stream Settings



NOTE

The sampling rate of the IEC 61850-9-2 (LE) and IEC 61869-9 (LE comp.) stream type depends on the rated frequency setting. Set the rated frequency to 50 Hz or 60 Hz. This is used to define the sampling frequency of the stream.

For more details, refer to chapter [2.1.3.3 Application and Setting Notes](#).

To adapt or review the rated frequency, go to **Settings > Device settings** of the device if necessary.

- ✧ Route the **Current-measuring points** or the **Voltage-measuring points** to the stream by setting an **X** for the measuring point to be published in the stream.

Project2 ▶ 6MU85 ▶ Merging-unit routing				
			Current-measuring points	Voltage-measuring points
			Meas.point I-3ph 1	Meas.point V-3ph 1
			3-phase + IN	3 ph-to-gnd volt. + VN
F:ETH-BD-2FO				
Merging unit 115MV Stream	IEC 61869-9	0(32)		

[sc_merging_unit_routing_missing, 1, en_US]

Figure 2-16 Merging-Unit Routing Editor – No Routings

Project2_V15.1 ▶ 6MU85 ▶ Merging-unit routing				
			Current-measuring points	Voltage-measuring points
			Meas.point I-3ph 1	Meas.point V-3ph 1
			3-phase + IN	3 ph-to-gnd volt. + VN
F:ETH-BD-2FO				
Merging unit 115MV Stream	IEC 61869-9	8(32)	X	X

[sc_merging_unit_routing_stream, 1, en_US]

Figure 2-17 Merging-Unit Routing Editor – Routing Done



NOTE

The measuring points are published in the order from left to right of the assigned measuring points.

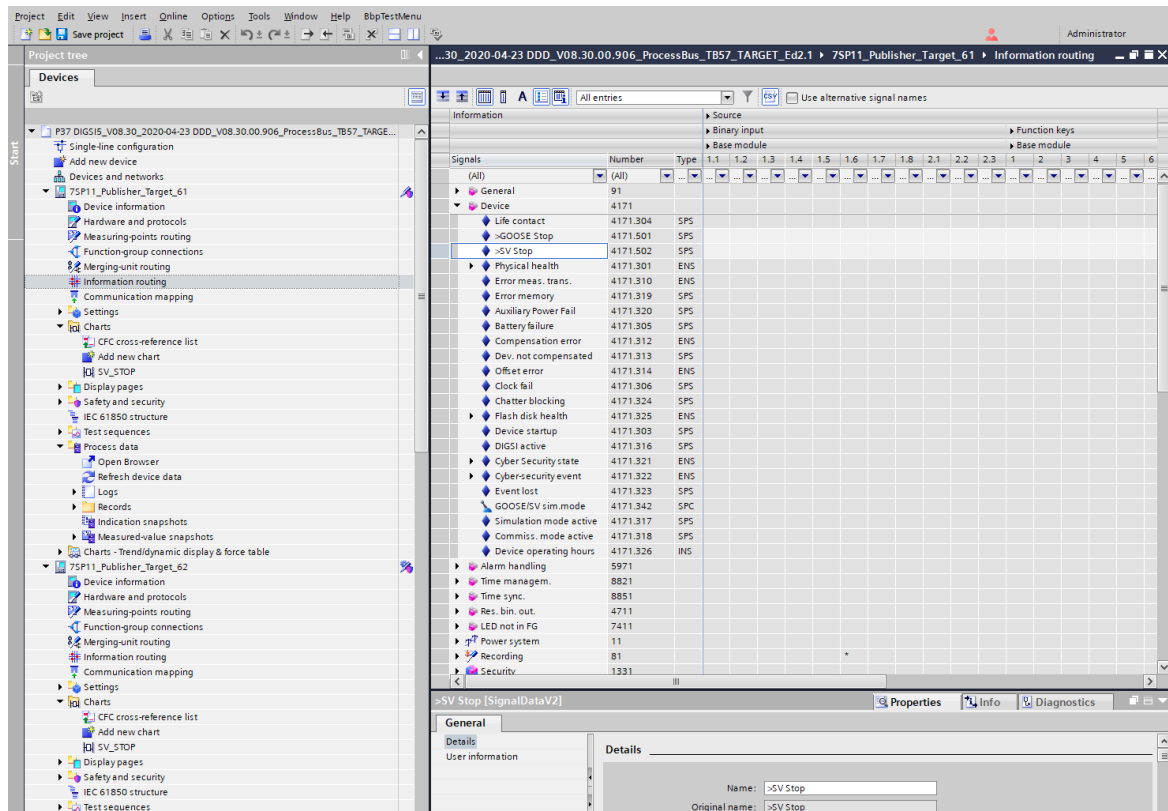
2.1.3.2 Stop Publishing of Merging Units (SvEna)

The merging unit can publish multiple streams. With the **SvEna** element, you can switch off streams selectively, for example, for a test. The streams can be switched off only for the a specific merging-unit function (stream) or for the complete device.

Routing in DIGSI

To route the signal **>SV Stop** for the device, proceed as follows:

- ✧ Go to the **Information routing** matrix in DIGSI.
- ✧ Under **Device**, you can find the **>SV Stop** signal to stop publishing all sampled-value streams of the device.



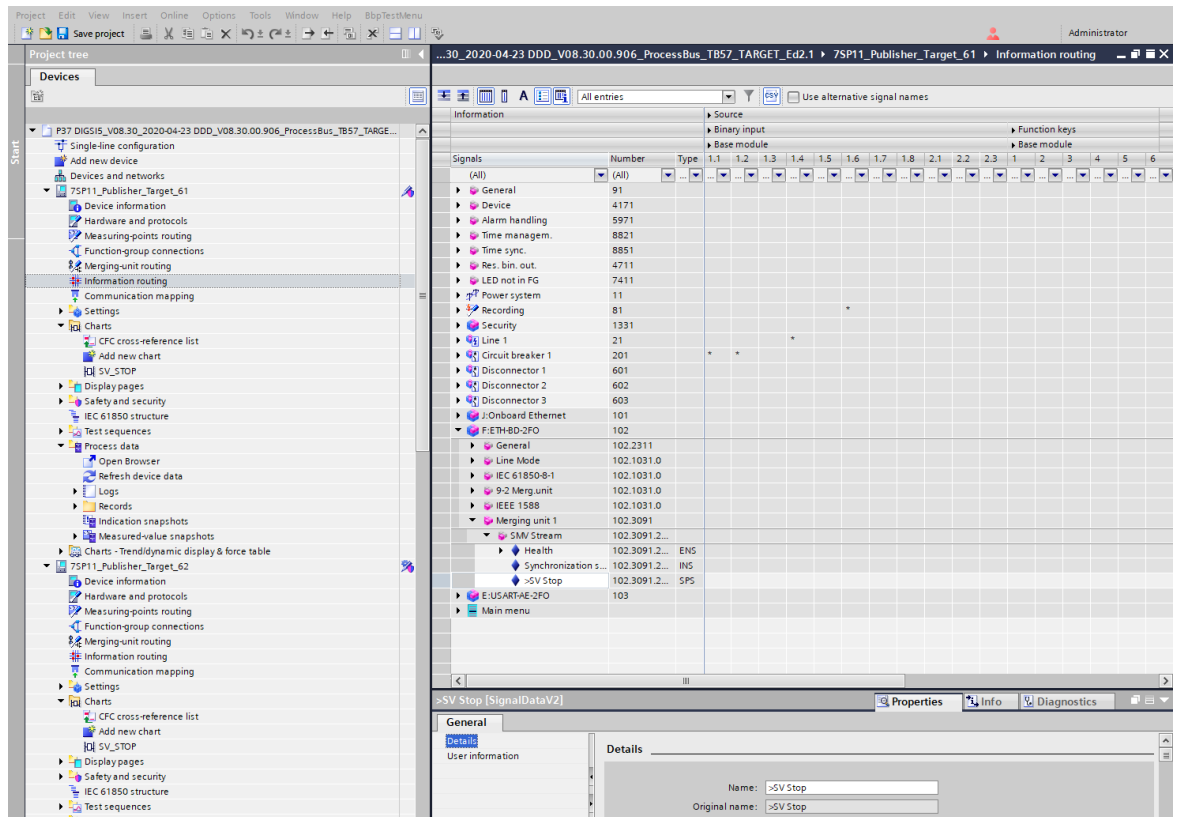
[sc_DIGSI_Device_SvStop, 1, en_US]

Figure 2-18 >SV Stop Signal for the Device

- ✧ Route the signal to a binary input or function key.

To route the signal **>SV Stop** for a specific merging unit, proceed as follows:

- ✧ Go to the **Information routing** matrix in DIGSI.
- ✧ Under the communication module, select the according **Merging Unit > SMV Stream**. You can find the **>SV Stop** signal there.



[sc_DIGSI_Stream_SvStop, 1, en_US]

Figure 2-19 >SV Stop Signal for the Merging Unit

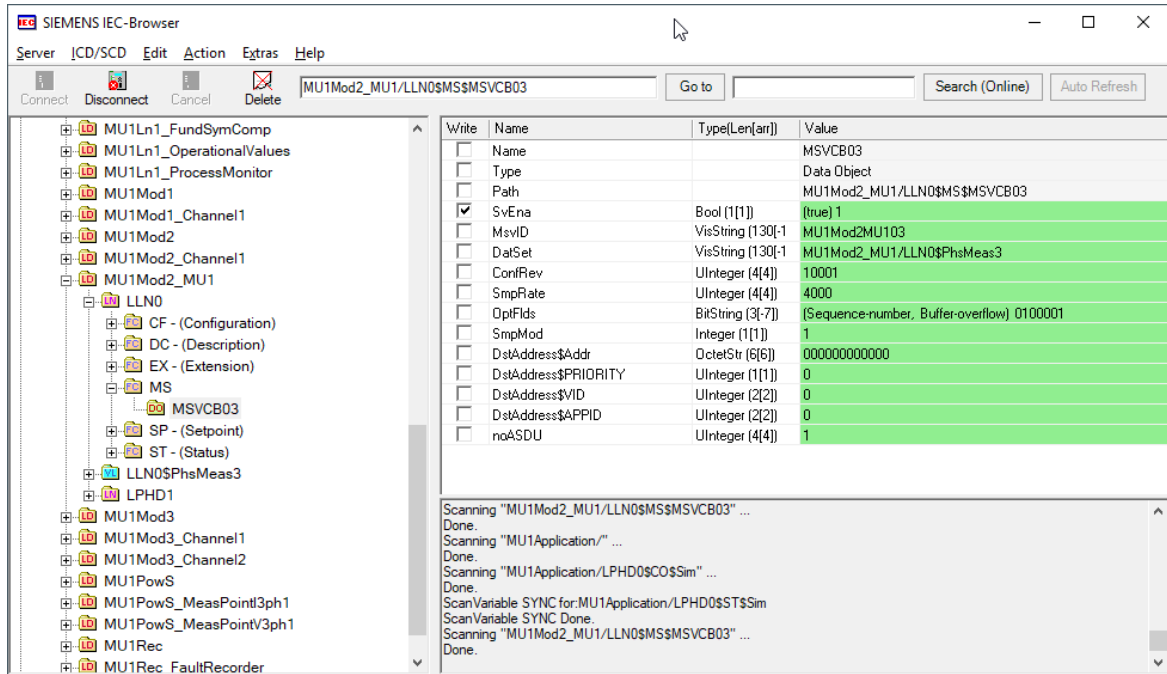
- ✧ Route the signal to a binary input or function key.

Control the SvEna via Substation Control or IEC Browser

Under the logical device for the merging unit, you can find a block **MS**. This block contains a control block **MSVCB03** with the **SvEna** property.

The following workflow describes the control of the **SvEna** property in the IEC Browser as an example.

- ✧ To switch the stream ON, set the **SvEna** property to **1**.
- or -
- ✧ To switch the stream OFF, set the **SvEna** property to **0**.
- ✧ Activate the check box next to the value.

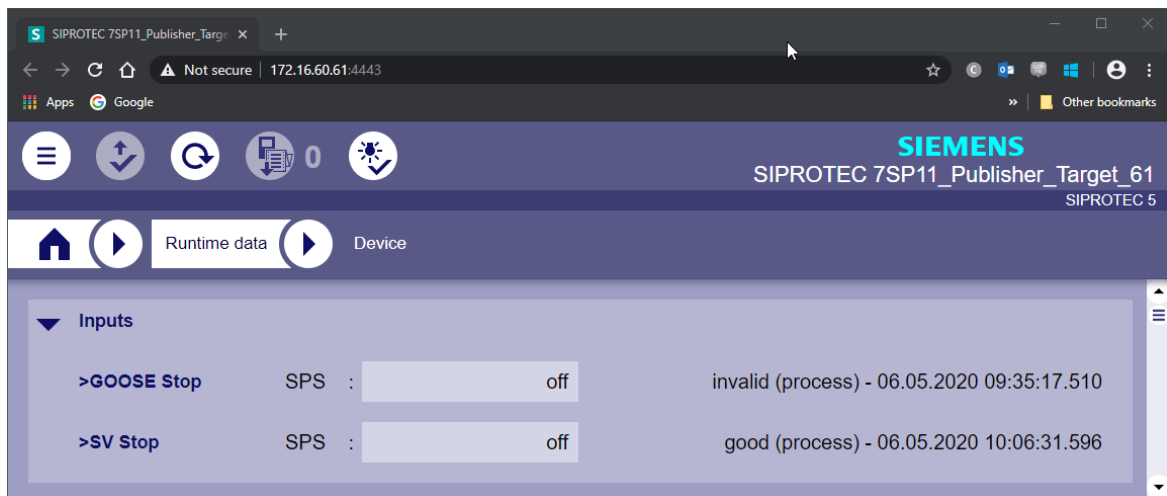


[sc_IECBrowser_SvEna, 1, --]

Figure 2-20 SvEna Property in the IEC Browser

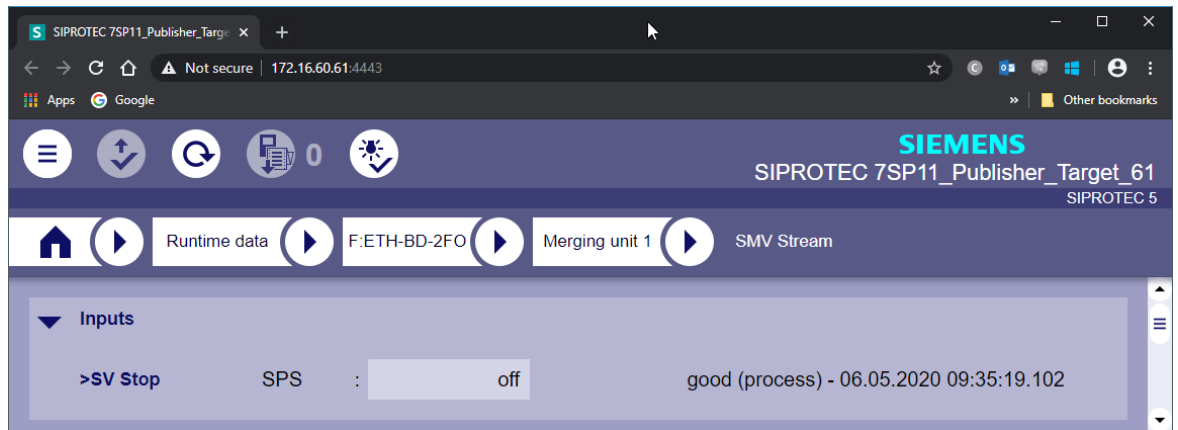
- ✧ Right-click.
- ✧ Select **Write tagged Lines**.

If the **SvEna** property is switched off, you can see it on the Web UI of the device:



[sc_WebUI_Device_SvStop, 1, en_US]

Figure 2-21 >SV Stop Signal Switched off for the Device



[sc_WebUI_Stream_SvStop, 1, en_US]

Figure 2-22 >SV Stop Signal Switched off for the Merging Unit

2.1.3.3 Application and Setting Notes

Parameter: Stream type

- Default setting () **Stream type** = *IEC 61869-9*

The parameter **Stream type** defines the type of stream the merging-unit functionality publishes. The following stream types are supported:

Parameter Value	Description
IEC 61869-9	With this stream type, it is possible to publish up to 32 current and voltage indications in any combination. For example, it is also possible to publish only current or voltage indications. The following measuring points can be routed to this stream type: • Current measuring points: – 3-phase + IN – 3-phase – 3-phase + IN-separate – 3-phase, 2 primary CT – 3ph,2prim.CT + IN-sep – 1-phase • Voltage measuring points: – 3 ph-to-gnd volt. + VN – 3 ph-to-gnd voltages – 3 ph-to-ph volt. + VN – 3 ph-to-ph voltages – 1-phase
IEC 61850-9-2 (LE)	The stream type is providing a stream able to publish 4 current and 4 voltage indications as defined in IEC 61850-9-2 LE. Each measuring point is allowed to be assigned only once to an IEC 61850-9-2 (LE) stream type. The following measuring points can be routed to this stream type: • Current measuring points: – 3-phase + IN – 3-phase + IN-separate • Voltage measuring points: – 3 ph-to-gnd volt. + VN
IEC 61869-9 (LE comp.)	The stream type is providing a stream able to publish 4 current and 4 voltage indications as defined in IEC 61850-9-2 LE. As difference to the stream type IEC 61850-9-2 LE, measuring points are allowed to be assigned multiple times to an IEC 61869-9 (LE comp.) stream type. The following measuring points can be routed to this stream type: • Current measuring points: – 3-phase + IN – 3-phase + IN-separate • Voltage measuring points: – 3 ph-to-gnd volt. + VN The exported IID file complies with IEC 61869-9. It does not follow the restriction of IEC 61850-9-2 (LE).



NOTE

- The stream type **IEC 61869-9 (LE comp.)** improves the interoperability with third-party process-bus clients, which do not accept IEC 61869-9 streams. As example in a breaker-and-a-half layout, 8 current and 4 voltage indications have to be published. Due to the limitations of the analog channels of IEC 61850-9-2 LE, this means the use of 2 streams to submit the current and voltage information.
 - With the stream type **IEC 61850-9-2 (LE)** for each current and voltage indication, exclusive measuring points (current and voltage inputs), respectively additional hardware might be required.
 - With the stream type **IEC 61869-9 (LE comp.)**, measuring points (current and voltage inputs) can be reused, to reduce the required hardware.
- For the example mentioned in the preceding sentences: The **IEC 61850-9-2 (LE)** stream requires 8 CT inputs and 8 voltage inputs, **IEC 61869-9 (LE comp.)** requires 8 CT inputs and 4 voltage inputs.

Parameter: Sampling-rate config.

- Default setting () **Sampling-rate config. = 4000 Hz, 1 ASDU**

The parameter **Sampling-rate config.** defines the sampling rate of the stream. The sampling rate of the **IEC 61850-9-2 (LE)** and **IEC 61869-9 (LE comp.)** stream type depends on the rated-frequency setting. Set the rated frequency to 50 Hz or 60 Hz. This is used to define the sampling frequency of the stream as per the following table. To adapt or review the rated frequency, go to **Settings > Device settings** of the device if necessary.

Table 2-1 Samples per Cycle and Samples per Second for LE Streams

Rated Frequency	Sampling-rate config.	Sampling Frequency of the Stream
50 Hz	80 samples, 1 ASDU	4000 Hz, 1 ASDU
	256 samples, 8 ASDU	12 800 Hz, 8 ASDU
60 Hz	80 samples, 1 ASDU	4800 Hz, 1 ASDU
	256 samples, 8 ASDU	15 360 Hz, 8 ASDU

The following settings are possible:

Stream Type	Description
IEC 61869-9	4000 Hz, 1 ASDU 4800 Hz, 1 ASDU 4800 Hz, 2 ASDU 12 800 Hz, 8 ASDU 14 400 Hz, 6 ASDU 15 360 Hz, 8 ASDU
IEC 61850-9-2 (LE)	80 samples, 1 ASDU 256 samples, 8 ASDU
IEC 61869-9 (LE comp.)	80 samples, 1 ASDU 256 samples, 8 ASDU

Parameter: SMV ID

The parameter **SMV ID** must be 1 to 34 characters long.

Parameter: MSVCB Name

The parameter **MSVCB Name** is based on the configuration of the IEC 61850 System Configurator.

Parameter: Dataset name

The parameter **Dataset name** is based on the configuration of the IEC 61850 System Configurator and cannot be changed in DIGSI.

Parameter: Sample mode

The setting of the parameter **Sample mode** changes automatically based on the stream type.

Stream Type	Setting
IEC 61869-9	<i>samples per second</i>
IEC 61850-9-2 (LE)	<i>samples p. nom. period</i>
IEC 61869-9 (LE comp.)	<i>samples p. nom. period</i>

Parameter: APPID

The parameter **APPID** is based on the configuration of the IEC 61850 System Configurator and cannot be changed in DIGSI.

Parameter: ConfRev

The parameter **ConfRev** is based on the configuration of the IEC 61850 System Configurator and cannot be changed in DIGSI.

Parameter: Direction IN

With the parameter Direction IN, you define if the neutral-point current is published as either IN = +3I0 or IN = -3I0.

Parameter: SMV ID check

DIGSI ensures by default that the SMV ID is unique for all SMV publishers in a DIGSI project as required by the IEC 61850 standard. For some special applications, such as the realization of a busbar-voltage distribution from the measured voltages of individual bays (see application note APN-094), it can be necessary to disable the check for uniqueness. By disabling the SMV ID check, it must be ensured by design that at any time, only unique SMV IDs are published across the IEDs.

2.1.4 General Application and Setting Notes

2.1.4.1 Voltage-Transformer Circuit Breaker

The function **Voltage-transformer circuit breaker** detects the tripping of the voltage-transformer circuit breaker due to short circuits in the voltage-transformer secondary circuits.

The function **Voltage-transformer circuit breaker** works independently of the function **Measuring-voltage failure detection** and is intended to be used – if possible – in parallel to it.

The acquisition of analog values like the voltage measured values is done in a process-bus system at the merging unit. Therefore, the **Voltage-transformer circuit breaker** function is intended to be used in the merging unit device. The quality information of a published voltage signal is sent as **invalid** depending on the status of the voltage-transformer circuit breaker status.



NOTE

The details of the **Voltage-transformer circuit breaker** function is described in the individual device manuals.

To use the **Voltage-transformer circuit breaker** function, you have to configure the following at the merging unit and process-bus client device for each voltage measuring point:

Required Configuration at the Merging Unit Device

The input signal (**_ : 500**) **>Open** of the **Voltage-transformer circuit breaker** function (at the merging unit) must be connected to the trip contact of the voltage-transformer circuit breaker. As a rule, this occurs via the routing to a binary input.

Consider the application and setting notes of the **Voltage-transformer circuit breaker** function.

Required Configuration at the Process-Bus Client Device

Some protection functions use settings to control their reaction to the status of voltage-transformer circuit breaker, therefore the process-bus client device requires the binary status input from the voltage-transformer circuit breaker.

The input signal (**_ : 500**) **>Open** of the **Voltage-transformer circuit breaker** function (at the process-bus client) must be received via GOOSE subscription from the according voltage-transformer circuit breaker (source measuring point at the merging unit).

Set the parameter (**_ : 101**) **Response time** of the **Voltage-transformer circuit breaker** function (at the process-bus client).



NOTE

If the merging unit does not provide a **Voltage-transformer circuit breaker** function and does not adjust the quality of the published voltage signal, you must configure the **Voltage-transformer circuit breaker** function in the process-bus client as described in the individual device manuals.



NOTE

The voltage-transformer circuit breaker signal must be made available to the process-bus client (usually via GOOSE from the merging unit).

2.1.4.2 Definition of IN within a Stream

The current IEC 61850 Edition 2.1 standard does not clearly define the definition of the direction of the neutral-point current (IN). As a result of the unclear situation in standardization, different implementations across the vendors exist. In one of the subsequent revisions of the IEC 61850 standard, the direction is defined as IN = +3I0. To ensure interoperability between different vendors the direction can be defined in DIGSI 5 for the merging unit and process-bus client independently.

It is important that the merging unit and process-bus client are using the same convention for IN direction. Either they are both set to IN = -3I0 or both are set to IN = +3I0 (recommended).



NOTE

Do not mix the direction IN in the merging unit and process-bus client.

A mix of the direction IN in the merging unit and process-bus client can lead to a malfunction of the protection functions.

Compatibility of Different Versions

The following table provides an overview how direction IN is operating for older released versions, after firmware update, after configuration upgrade, and for newly added streams in the merging unit, respectively for newly added measuring points in the process-bus client.

Firmware (FW) Version	Configuration (CFG) Version	Merging Unit	Process-Bus Client	Comments
< V08.80	< V08.80	IN = -3I0	IN = -3I0	Direction IN is not changeable
≥ V08.80	< V08.80	IN = -3I0	IN = -3I0	Direction IN is not changeable. New FW is downward compatible

Firmware (FW) Version	Configuration (CFG) Version	Merging Unit	Process-Bus Client	Comments
≥ V08.80	≥ V08.80 upgraded from < V08.80	IN = -3IO	IN = -3IO	After CFG upgrade: Direction IN is changeable. To be downward compatible the upgrade keeps the settings at IN = -3IO.
≥ V08.80	≥ V08.80	IN = +3IO	IN = +3IO	Newly added stream merging unit/Newly added measuring point in process-bus client: Direction IN is changeable. New streams or new measuring points will have the default value IN = +3IO

**NOTE**

If both sides (merging unit and process-bus client) are correctly configured, the device internally operates and shows the IN measured value as IN = -3IO even if both settings are set to IN = +3IO. This represents the definition of IN within SIPROTEC 5 as IN = -3IO.

For the specific settings, refer to:

- Process-bus client, see [2.1.2.1 Configuration](#)
- Merging unit, see [2.1.3.3 Application and Setting Notes](#)

**NOTE**

The SIPROTEC 4 Merging Unit 6MU805 publishes IN = -3IO.

2.1.4.3 Configurations for Seamless Changeover

To activate the Seamless changeover between 2 OCGC devices (OCGC A and OCGC B), activate the parameter **Seamless changeover** in **IEEE 1588 settings**. To avoid blocking of the protection functions due to an unabsolute-simultaneous switch to a new OCGC device, the PB-client devices (SMV subscriber) require information about the seamless time base change from the OCGC devices. In addition to activating the parameter **Seamless changeover**, the following configurations are required:

- Configurations of the GOOSE publishing in the OCGC devices
- Configurations of the GOOSE subscription in the PB-client devices (SMV subscriber)
- Creation of the GOOSE connections in the IEC 61850 system configurator

The following information is required to be transmitted from the OCGC devices to the PB-client devices. These signals are visible in the **Information routing** under **IEEE 1588**.

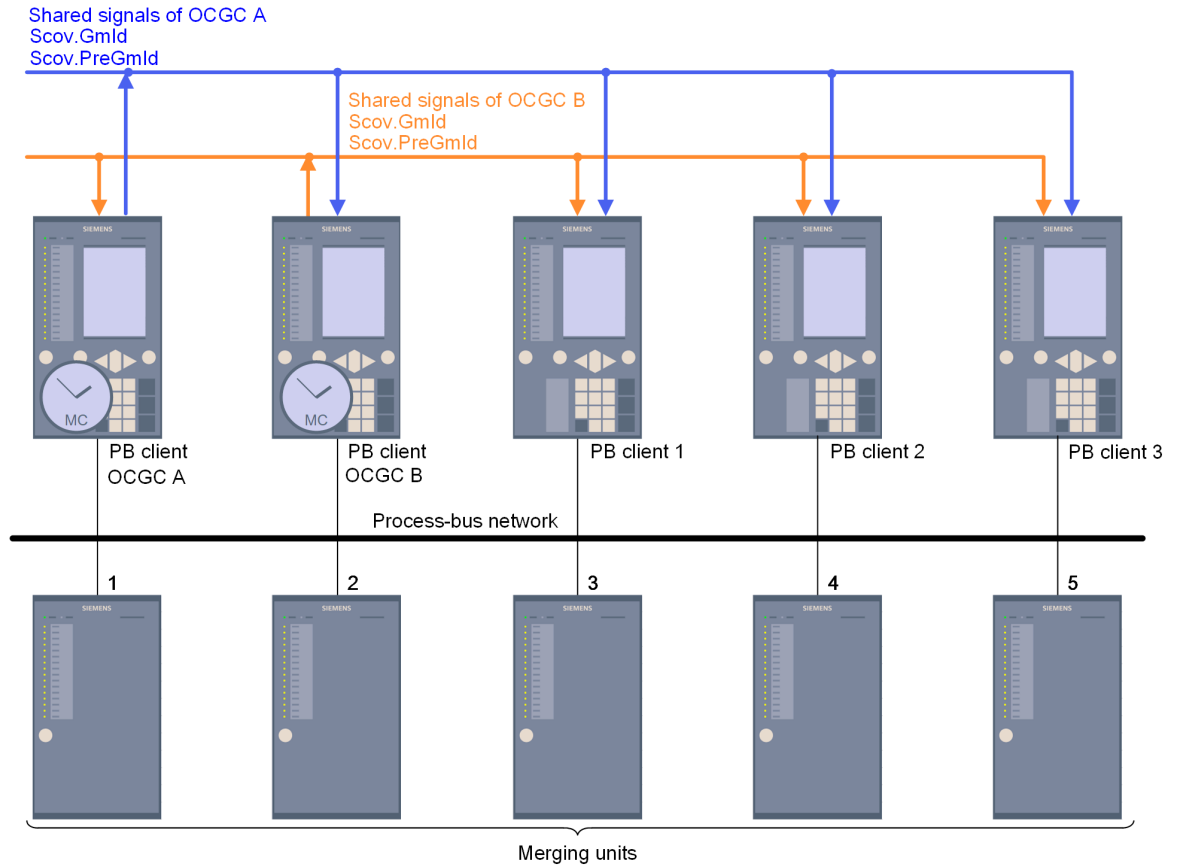
Information	Signal	Description	Type	I/O	Role in GOOSE Configuration
Gmldenty output pair of OCGC A or OCGC B	Scov.Gmld	Current Gmldentity	VSS	Output	GOOSE publisher
	Scov.PreGmld	Previous Gmldentity	VSS	Output	GOOSE publisher

The following destination information is required in the PB-client devices. These signals are visible in the **Information routing** under **IEEE 1588**.

Information	Signal	Description	Type	I/O	Role in GOOSE configuration
Gmldenty pair received from OCGC A	>Scov.GmldInA	Current Gmldentity from OCGC A	VSS	Input	GOOSE subscriber
	>Scov.PreGmldInA	Previous Gmldentity from OCGC A	VSS	Input	GOOSE subscriber

Information	Signal	Description	Type	I/O	Role in GOOSE configuration
Gmldenty pair received from OCGC B	>Scov.GmldInB	Current Gmldenty from OCGC B	VSS	Input	GOOSE subscriber
	>Scov.PreGmldInB	Previous Gmldenty from OCGC B	VSS	Input	GOOSE subscriber

The following example uses a process-bus application with 2 PB-client devices simultaneously as OCGC A and OCGC B. Also, 3 other PB-Client devices and 5 merging units are part of the application.



[dw_seamless_changeover_application, 2, en_US]

Figure 2-23 Process-Bus Application of the Functionality Seamless Changeover

All devices within this network are synchronized via the built-in SIPROTEC 5 grandmaster clock (MC).

Configurations of the GOOSE Publishing in the OCGC Devices

- ✧ For each device with OCGC, open the **IEC 61850 Structure**.
- ✧ Activate the data objects (DOs) *ScovGmOut* and *ScovPreGmOut* in **PTP_LTPC1**.

Name	Active on interface	Description	Comment
(All...)	(All...)	(All...)	(All...)
Mod2_Channel1	☒	E:ETH-BD-2FO:Channel 1	
LLN0	☒	Mod2_Channel1/LLN0	
LCCH1	☒	E:ETH-BD-2FO:Channel 1:IEC 61850-8-1	
PBCL_LCCH1	☒	E:ETH-BD-2FO:Channel 1:9-2 Client	
PTP_LTPC1	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588	
Mod	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588:Mode (status only)	Mode control value
Beh	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588:Behavior	Behavior
Health	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588:Health	Health
NamPlt	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588:Name plate	Name plate
ClkAcc	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588:Clock accuracy	Clock time accuracy
:	:	:	:
:	:	:	:
ScovGmA	☐	E:ETH-BD-2FO:Channel 1:IEEE 1588:Scov.GmIdInA	Current GmIdentity from OCGC1
ScovPreGmA	☐	E:ETH-BD-2FO:Channel 1:IEEE 1588:Scov.PreGmIdInA	Previous GmIdentity from OCGC1
ScovGmB	☐	E:ETH-BD-2FO:Channel 1:IEEE 1588:Scov.GmIdInB	Current GmIdentity from OCGC2
ScovPreGmB	☐	E:ETH-BD-2FO:Channel 1:IEEE 1588:Scov.PreGmIdInB	Previous GmIdentity from OCGC2
ScovGmOut	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588:Scov.GmId	Current GmIdentity output from OCGC
ScovPreGmOut	☒	E:ETH-BD-2FO:Channel 1:IEEE 1588:Scov.PreGmId	Previous GmIdentity output from OCGC

[sc_Seamless Changes_GOOSE_publisher_configuration, 1, en_US]

The activated DOs are to be published via GOOSE.

Configurations of the GOOSE Subscription in the PB-Client Devices (SMV Subscriber)

- ✧ For the SMV-subscriber devices (9-2 Client), open the **Information routing**.
- ✧ In the column **GOOSE**, set the signals **>Scov.GmIdInA**, **>Scov.PreGmIdInA**, **>Scov.GmIdInB**, and **>Scov.PreGmIdInB** to **1**.

Information				Source																								Function keys								GOOSE	
				Binary input																Base module																	

[sc_Seamless Change_GOOSE_subscriber_configuration, 1, en_US]

With this step, you have defined a single later binding for each of these 4 signals. The number in brackets indicates the currently available number of later-binding connections for the information.

These 2 pairs of signals are used to inform the PB-client devices (SMV participant) that the OCGC has successfully synchronized with a previous OCGC in active master role. Therefore, the grandmaster identity of the previously active OCGC (*Scov.PreGmId*) and the current OCGC (*Scov.GmId*) are transmitted from the OCGCs via GOOSE. *>Scov.GmIdInA* and *>Scov.PreGmIdInA* are used for subscribing GOOSE signals from the OCGC A device, while *>Scov.GmIdInB* and *>Scov.PreGmIdInB* are used for subscribing GOOSE signals from the OCGC B device.

Creation of the GOOSE Connections in the IEC 61850 System Configurator

After configuring the GOOSE Publishers and GOOSE Subscribers, you must create the GOOSE connection in the IEC 61850 System Configurator.

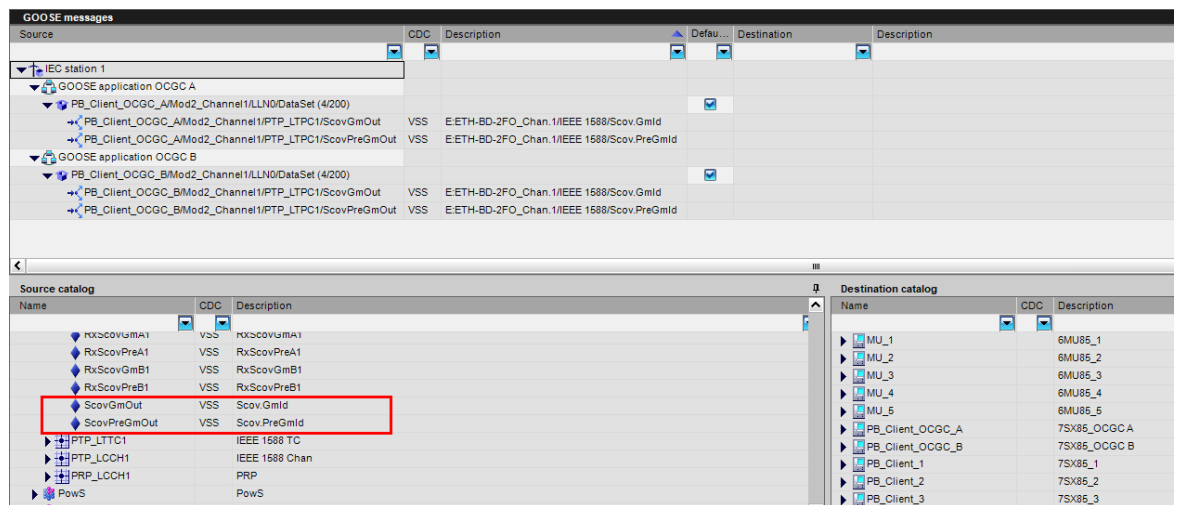
For the example, the following GOOSE links must be configured by the PB-client (OCGC A) device:

Source Device	Signal	Destination Device	Signal
PB Client OCGC A	Scov.Gmld	PB Client OCGC B	>Scov.GmldInA
		PB Client 1	>Scov.GmldInA
		PB Client 2	>Scov.GmldInA
		PB Client 3	>Scov.GmldInA
	Scov.PreGmld	PB Client OCGC B	>Scov.PreGmldInA
		PB Client 1	>Scov.PreGmldInA
		PB Client 2	>Scov.PreGmldInA
		PB Client 3	>Scov.PreGmldInA

The following GOOSE links must be configured by the PB-client (OCGC B) device:

Source Device	Signal	Destination Device	Signal
PB Client OCGC B	Scov.Gmld	PB Client OCGC A	>Scov.GmldInB
		PB Client 1	>Scov.GmldInB
		PB Client 2	>Scov.GmldInB
		PB Client 3	>Scov.GmldInB
	Scov.PreGmld	PB Client OCGC A	>Scov.PreGmldInB
		PB Client 1	>Scov.PreGmldInB
		PB Client 2	>Scov.PreGmldInB
		PB Client 3	>Scov.PreGmldInB

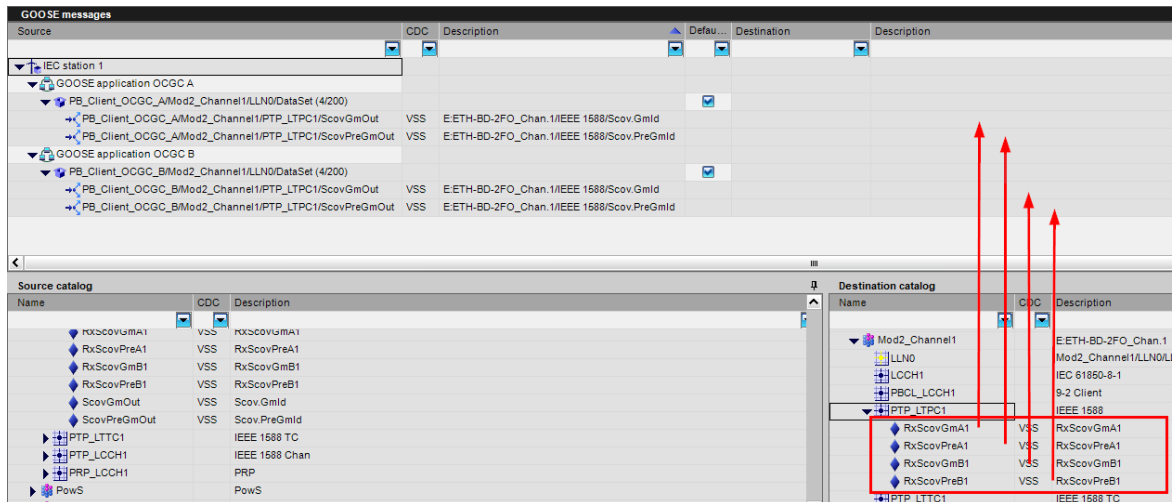
- ✧ Open the IEC 61850 SCD file of your project in the IEC 61850 System Configurator.
- ✧ Click the tab **GOOSE**.
- ✧ Drag and drop the DOs *ScovGmOut* and *ScovPreGmOut* of each GOOSE Publisher from the **Source catalog** to the GOOSE application in the column **Source** in the section **GOOSE messages**.



[sc_Seamless Change_IEC station GOOSE publisher, 1, en_US]

The GOOSE signals that are to be published are created.

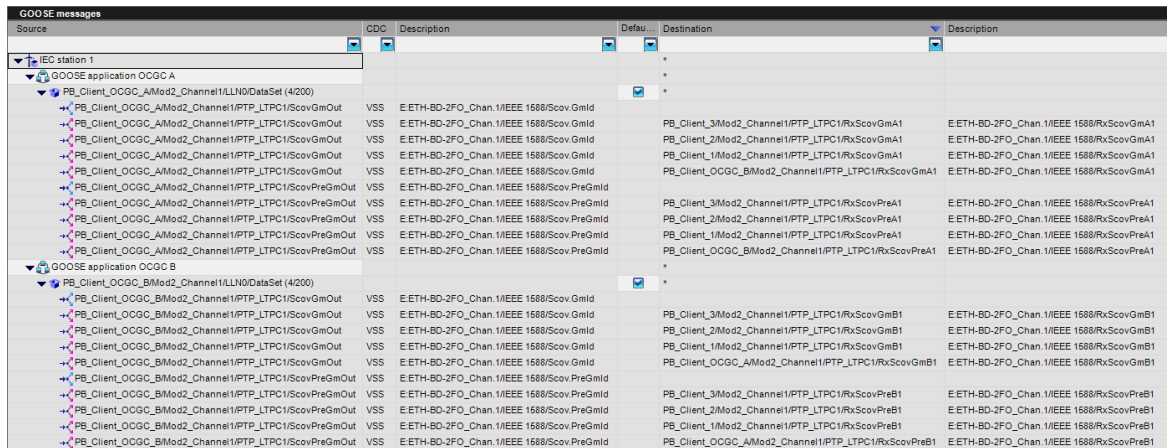
- ✧ Drag and drop the RX signals of the GOOSE Subscribers from the **Destination catalog** to the column **Destination** in the section **GOOSE messages**.



[sc_Seamless Change_IEC station GOOSE destinations, 2, en_US]

The 1st GOOSE dataset is for the OCGC A device to publish messages to all 9-2 client devices.

The 2nd GOOSE dataset is for the OCGC B device to publish messages to all 9-2 client devices.



[sc_Seamless Change_IEC station GOOSE subscriptions done, 1, en_US]

It is mandatory that all OCGC devices are connected to all PB client devices (SV subscribers) via those GOOSE signals. An exception is that for OCGC devices that are PB clients at the same time, only the signals of the other OCGC devices must be connected.



NOTE

Connect *ScovGmOut* to *>Scov.GmIdInA* or *>Scov.GmIdInB*.

Connect *ScovGmPreOut* to *>Scov.PreGmIdInA* or *>Scov.PreGmIdInB*.

To connect one OCGC device to multiple PB-Client devices, you must drag and drop the DOs *ScovGmOut* and *ScovGmPreOut* of the OCGC device again to the same GOOSE application. Thus, another pair of the GOOSE signals is created and you are able to connect the signals of another PB-client device to the same OCGC device.

- ✧ Import the configuration file back to DIGSI 5.

Information				Source																								GOOSE
				Binary input												Function keys												
				Base module												Base module												
Signals	Fav	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3	1	2	3	4	5	6	7	8						
(All)	▼	(All)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	(All)	▼				
▼ E:ETH-BD-2FO		102																					*					
▶ General		102.2311																										
▶ IEC 61850-8-1		102.1031.7...																										
▶ 9-2 Client		102.1031.2...																										
▼ IEEE 1588		102.1031.1...																					*					
▶ Health	☆	102.1031.1...	ENS																									
▶ Channel Live	☆	102.1031.1...	SPS																									
▶ Clock accuracy	☆	102.1031.1...	INS																									
:		:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:					
:		:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:					
▶ Clock servo status	☆	102.1031.1...	INS																									
▶ >Scov.GmIdInA	☆	102.1031.1...	VSS																				1					
▶ >Scov.PreGmIdInA	☆	102.1031.1...	VSS																				1					
▶ >Scov.GmIdInB	☆	102.1031.1...	VSS																				1					
▶ >Scov.PreGmIdInB	☆	102.1031.1...	VSS																				1					
▶ Scov.GmId	☆	102.1031.1...	VSS																									
▶ Scov.PreGmId	☆	102.1031.1...	VSS																									

[sc_Seamless Change_GOOSE_subscriber_configuration done, 1, en_US]

In the column **GOOSE**, because the GOOSE subscription is configured, the **(1)** has disappeared and only **1** is shown to represent the single configured GOOSE link.

2.1.4.4 Design Recommendations for Testing according to IEC TR 61850-10-3

To ensure the correct operation of a substation protection system, it is essential to test the system during the commissioning phase. The protection system might need to get tested also during the lifetime of the system to verify the correct operation after a system modification. Therefore, the IEC 61850 standard defines various testing features. Some of these testing features are not mandatory.

This chapter focuses on 2 of the main testing features, listed in the following, and provides recommendations for the design of the system to allow a testing according to IEC TR 61850-10-3:

- Operating modes, controlled via LLN0.Mod
- Simulation-based testing

Operating Modes

To test DUTs (devices under test) isolated without interfering other equipment, IEC 61850 provides the following operating modes. The operating modes can be changed via the LLN0.Mod of an LD (Logical Device) or protection LN (Logical Node). The behavior (LLN0.Beh) of the LLN0.Mod is inherited according to the IEC 61850 hierarchical model, which can be adapted using the IEC 61850 flexible engineering capacities in DIGSI 5 to adjust the device testing behavior as required by the application. For details, refer to chapter 11 in the *DIGSI Online Help* and to the Application Note **DIGSI 5 - IEC 61850 flexible engineering** under <https://support.industry.siemens.com/cs/document/109811596/siprotec-5-appnotes-?dti=0&lc=en-US>.

The following operating modes are provided:

- On
 - The function/device is operational, data is sent **without** test flag.
 - The function/device accepts only data **without** a set test flag.
 - The operation of the binary outputs is granted.
- On-Blocked
 - The function/device is operational, data is sent **without** test flag.
 - The function/device accepts only data **without** a set test flag.
 - The operation of binary outputs is blocked.
- Test
 - The function/device is operational, data is sent **with** test flag.
 - The function/device accepts only data **with or without** a set test flag.
 - The operation of the binary outputs is granted.

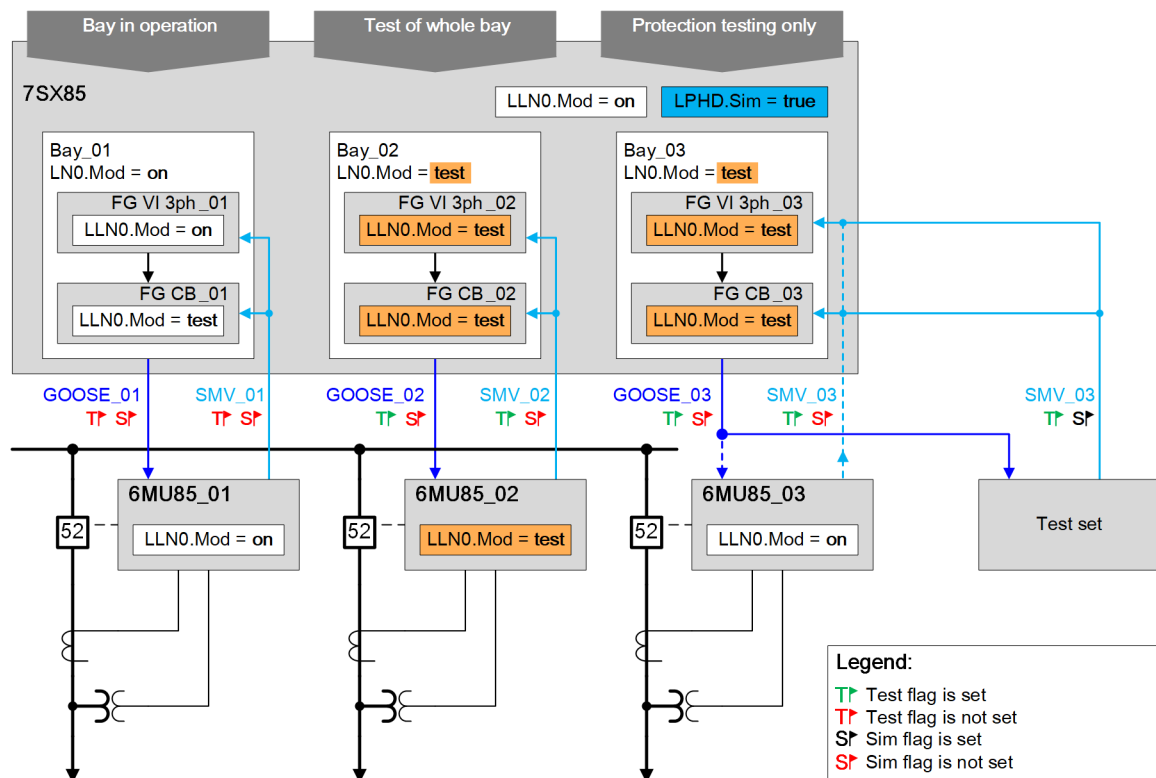
- Test/Blocked
The function/device is operational, data is sent **with** test flag.
The function/devices accepts only data **with or without** a set test flag.
The operation of binary outputs is blocked.
- Off
The function/device is disabled and not operational.
No signals and information are processed and binary outputs are not operated by the function/device.

Simulation-Based Testing

The simulation-based testing is the capability to switch the device into simulation mode using LPHD.Sim. For more information, refer to [1.2.4.5 LPHD](#).

Common Use Cases of Simulation-Based Testing Using the Different Operating Modes

The following figure uses a centralized protection device with 3 bays to illustrate the most common testing scenarios. Each bay in this example consists of a function group **Circuit breaker** (FG CB) and a protection function group (FG VI-3-ph). The acquisition of the currents, voltages, and the binary information is done with a merging unit located as close as possible to the primary process.



[dw_IEC-61850_testing_capabilities, 1, en_US]

Figure 2-24 IEC 61850 Testing Capabilities

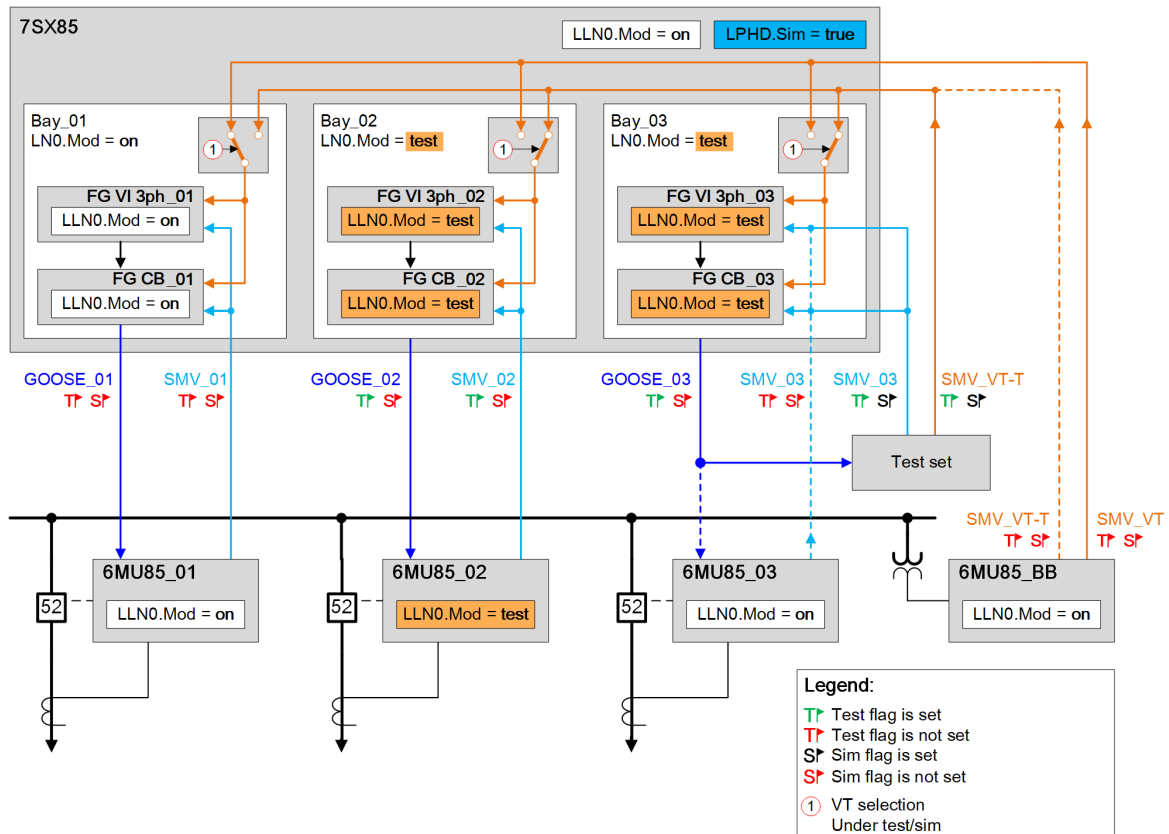
The individual bays are in the following states, as shown in the preceding figure.

	Bay 01	Bay 02	Bay 03
Use case	Normal operation The bay 01 is in operation and the protection is active.	Testing of a whole bay, during commissioning, revision, maintenance. The whole bay is under test and executes trip commands unless LLN0.Mod of the 6MU85_02 is set to test/blocked .	Testing of the protection functionality for setting changes, revisions, or maintenance work. The bay-related protection is operating on simulated values and therefore out of service.
6MU85 Merging Unit	LLN0.Mod = on Is in operation and publishes GOOSE and SMV only without test flag set. Accepts GOOSE only without test flag set.	LLN0.Mod = test Is in test and publishes GOOSE and SMV with test flag set. Accepts GOOSE with or without test flag set.	LLN0.Mod = on Is in operation and publishes GOOSE and SMV only without test flag set. Accepts GOOSE only without test flag set.
7SX85 with LPHD.Sim = True	LLN0.Mod = on Is in operation and publishes GOOSE only without test flag set. Accepts GOOSE and SMV only without test flag set.	LLN0.Mod = test Is in test and publishes GOOSE with test flag set. Accepts GOOSE and SMV with or without test flag set.	LLN0.Mod = test Is in test and publishes GOOSE with test flag set. Accepts GOOSE and SMV with or without test flag set. With LPHD.Sim = true of the 7SX85 and the SMV_03 stream (from a test set) with active Sim-Bit flag, the bay 03 uses the supplied SMV stream of the test set.
Impact to other protection	None	The 6MU85 02 is in test mode and therefore, its data (GOOSE/SMV) cannot be used by other IEDs (for example, 7SS85 for 87B), which are in operating mode.	The 6MU85 03 is in operating mode and therefore, its data (GOOSE/SMV) can be used from other IEDs (for example, 7SS85 for 87B), which are in operating mode.

SMV Stream Design Recommendation for Central Voltage Measurement

The example in the preceding section is simple in terms of the design for independent testing. The situation is a bit different if the voltage is measured centrally directly at the busbar and not at each individual bay. In this case, independent testing is no longer possible, at least not for those function relying on voltage measurement. The reason for this is that the SMV stream with the voltage is only available once. At the time when a test set provides the SMV stream with the simulation-flag set, all bays also switch to the simulated stream accordingly.

A possible solution is to have the merging unit publishing the busbar voltage as 2 streams. Both streams provide the voltage measurement. One of the streams is used for operation with real values and the other one for testing purpose. With the voltage selection, the individual bays can be fed either with the voltage stream for operation or the voltage stream for testing.



[sc_optimized_SMV_design_voltage_measurement, 1, en_US]

Figure 2-25 Optimized SMV Design for Voltage Measurement Using a Busbar Voltage Transformer

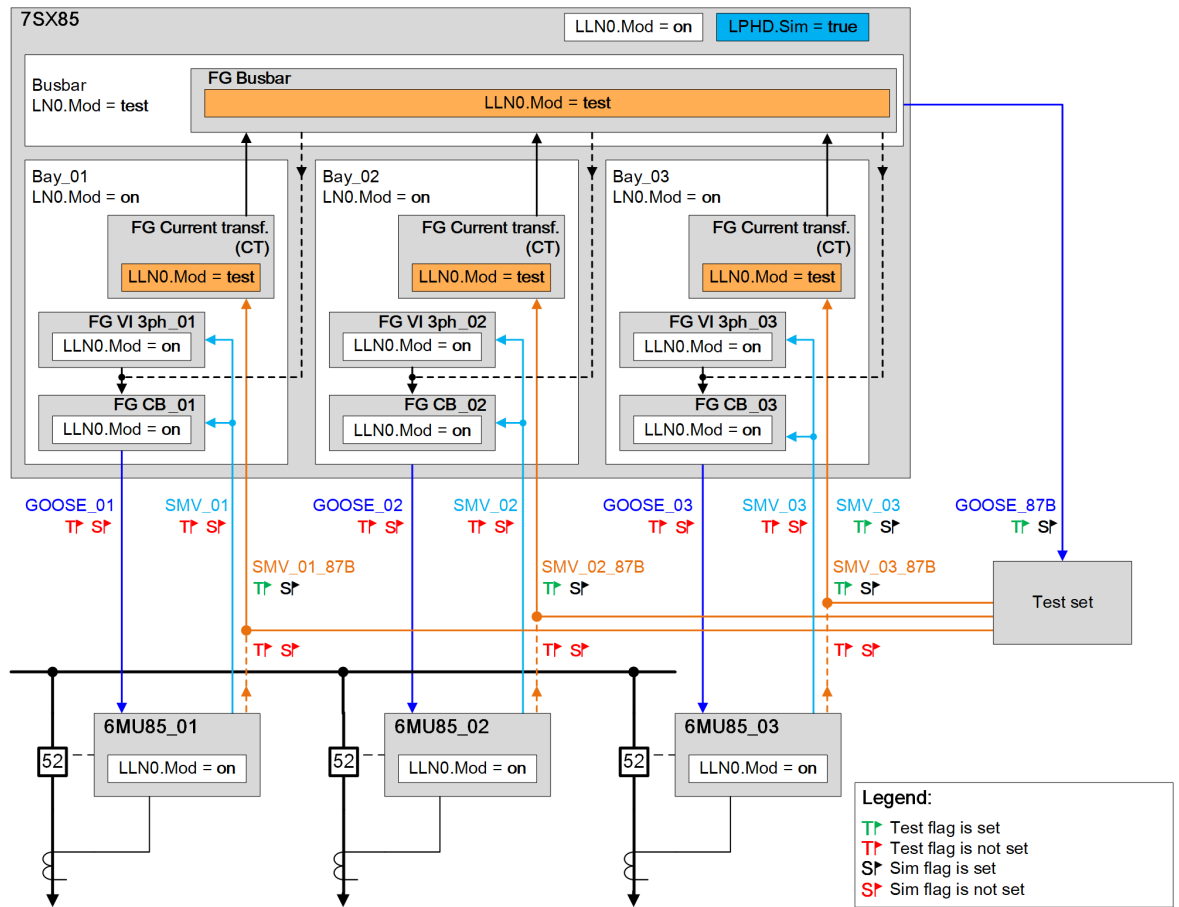
The preceding figure shows the same substation as [Figure 2-24](#), when a voltage transformer on the busbar is used instead of the bay-related voltage transformers and the additional merging unit **6MU85_BB** publishes 2 SMV streams, with the same voltage information. The device uses the voltage-selection functionality to switch between the 2 streams **SMV_VT** (for operation) and **SMV_VT-T** (for testing). The 3 bays are shown in the same states as in the previous example.

SMV Stream Design Recommendation for Joint Use of Current Measurement

If the current measurement is shared by different protection functions and individual testing is required, the equal approach as for the central voltage measurement distribution must be used.

As shown in the following figure, the current measured from a single current transformer is provided by 2 independent SMV streams:

- SMV_Bay01, SMV_Bay02, and SMV_Bay03 provide the measurement for the bay protection.
- SMV_Bay01_87B, SMV_Bay02_87B, and SMV_Bay03_87B provide the measurement for the busbar protection.



[sc_SMV_design_shared_current_measurement, 1, en_US]

Figure 2-26 SMV Design for Joint Current Measurement



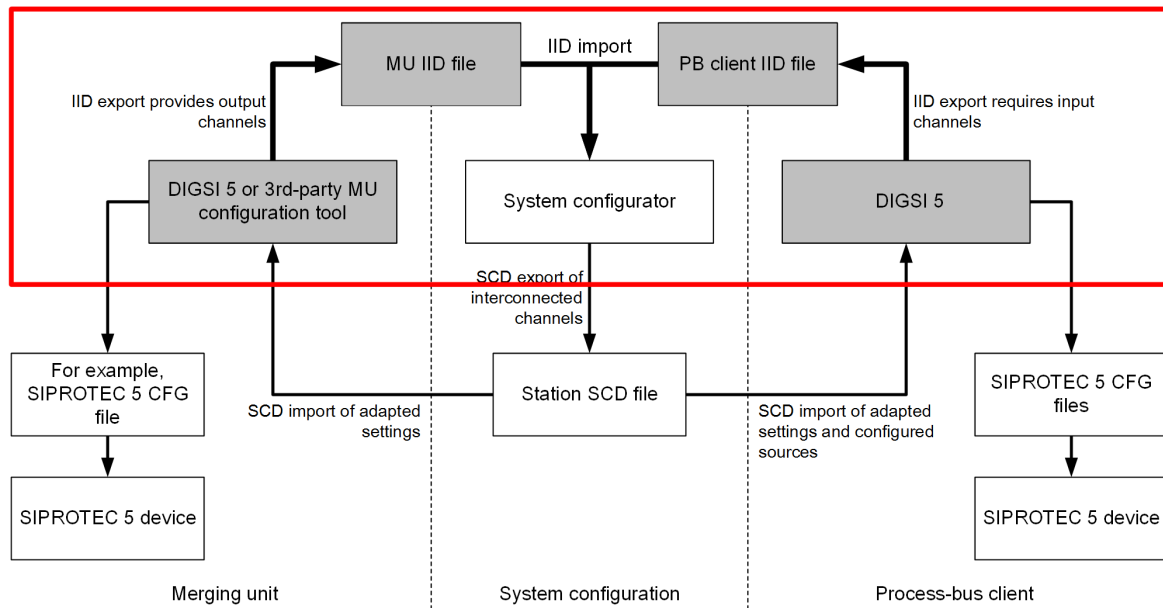
NOTE

If the analog values are supplied by dedicated current transformers to achieve individual testing of protection elements, the approach to provide the current measurement in individual streams must also be used.

2.1.5 Exporting an IID File

The following figure shows the part of the engineering workflow which is covered in this section.

Exporting an IID File



[dw_process-bus_engineering_MU_IID, 1, en_US]

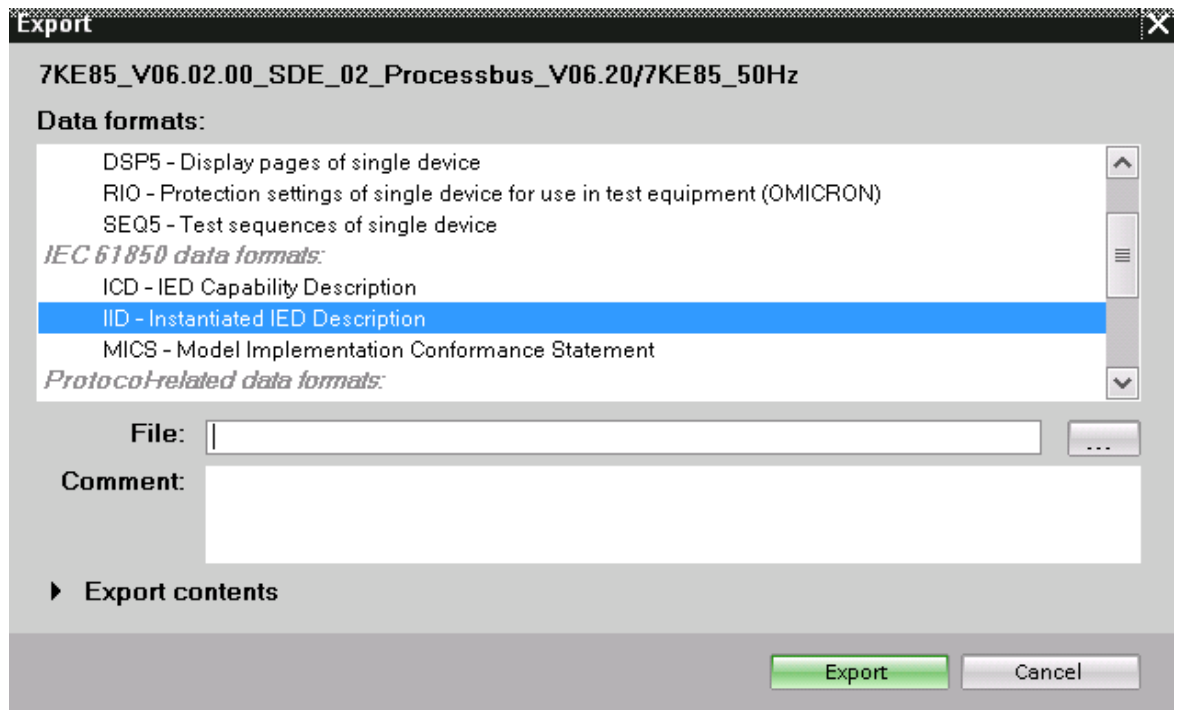
Figure 2-27 Exporting IID Files

If you have finished the device configuration, you must export an IID file from the device project in order to provide the required process-bus inputs or outputs for this device to the third-party substation engineering. If you use the Siemens IEC 61850 System Configurator, refer to [Adding and Configuring a New IEC 61850 Station in DIGSI 5, Page 79](#).

To export the IID file, proceed as follows:

- ✧ Right-click the device in the project tree and select **Export...** from the context menu.

The following export dialog appears:



[sc IEC61850_IID_Export, 1, en_US]

Figure 2-28 IEC 61850 IID Export

- ✧ Select IID.
- ✧ To select the file path, click the ... button.
- or -
- ✧ Change the file path manually.
- ✧ Click **Export**.

The exported IID file provides the required inputs or the process-bus client to be interconnected to merging-unit signals using the IEC 61850 System Configurator.

2.1.6 9-2 Client Instrument Transformer Settings Editor

The SIPROTEC 5 process-bus solution relies on IEC 61850 Ed. 2.1 and IEC 61869 standards which provide settings to ensure maximal interoperability of different vendors. For vendors who did not yet support the full standard for their merging units, the usual roundtrip process via the IEC 61850 System Configurator might not be finished successfully or measuring errors might occur during operation.

For these cases, a 9-2 Client Instrument Transformer Settings functionality in DIGSI 5 provides means to add or correct specific settings and store them in a local database for later use. Known settings of selected vendors are provided in a database.

If the 9-2 Client function is enabled and after the first completion of a round trip with the IEC 61850 System Configurator, the **9-2 Client Instrument Transformer Settings Editor** is available in the DIGSI 5 project tree under **IEC 61850 stations**. The Editor provides views for merging-unit specific settings and for measuring-point specific settings.



NOTE

The measuring-point tabs of the Editor do not show the measuring points participating in the DBBP system (7SS85CU distributed busbar protection with the significant features F to K).



NOTE

The Editor has no dependency to the SIPROTEC device drivers, this means it can be used with firmware versions V08.80 and lower.

During the import of the SCD file, DIGSI evaluates the content of the SCD file regarding the required settings for the subscribed sampled measured value streams. If the SCD file does not contain entries for the required settings, they are replaced by the values of the database.

The database currently provides the settings as listed in following table.

	Siemens		General Electric		SEL	ABB	
Merging-Unit Type	6MU805	6MU85	MU320	MU320E	SEL-401	SMU615	SAM600
Max. Delay time [ms]	2.3	1.15	0.8	1.2	0.9	1.8	1.0
Min. Delay time [ms]	1.7	0.8	0.5	1.0	0.6	1.4	0.8
ScndTmms current [ms]	210	210	10 000	10 000	764	590	10 000
ScndTmms voltage [ms]	210	210	10 000	10 000	10 000	10 000	10 000

If there is no data available for a specific merging unit in the database, the missing settings are set as 0 and marked with red color indicating inconsistency.

The secondary loop time constant for voltage channels is not part of the standard, but important to ensure a save protection operation. The constant is taken over from the database or must be entered manually.

The merging-unit-specific settings provide the settings for all merging units of the same type within the DIGSI 5 project.

Parameter	IEC 61850 Setting	Description	Comment
Max. time delay [ms]	(M) LPHD.MaxDI	Maximum merging unit delay setting (mandatory as per the standard)	This setting determines the buffer size for incoming packets and contributes to the overall protection delay. When set too low, the merging-unit stream might not be received or sampled-value packet gaps might occur.
Min. time delay [ms]	Not applicable	Additional setting describing the delay jitter of the incoming stream	Contributes to the buffer size for incoming packets. When not known, the value 0 can be set as a safe value.
Secondary loop time constant current [ms]	(M) TCTR.ScndTmms	Time constant of the current input filter of the merging unit described in IEC 61869-13 as Tsec and in IEC 61850-7-4 as ScndTmms .	The required phase correction for current inputs is calculated automatically based on the set secondary TMMS and rated frequency. When set incorrectly, the transient behavior of the received stream will not match the transient behavior of the SIPROTEC 5 measured values. Also, a phase-measurement error will be present.

Parameter	IEC 61850 Setting	Description	Comment
Phase correction current [°]	Not applicable	Additional correction for the current inputs	Additional phase correction to fine-tune the calculated phase correction caused by the time constant (ScndTmms) of the internal and the external current transformers of the merging unit.
Secondary loop time constant voltage [ms]	TVTR.ScndTmms	Time constant of the voltage input filter of the merging unit	The required phase correction for voltage inputs will be calculated automatically based on the set secondary TMMS and rated frequency. When set incorrectly, the transient behavior of the received stream will not match the transient behavior of the SIPROTEC 5 measured values. Also, a phase-measurement error will be present.
Phase correction voltage [°]	Not applicable	Additional correction for the voltage inputs	Additional phase correction to fine-tune the calculated phase correction caused by the time constant (ScndTmms) of the internal and the external voltage transformers of the merging unit.
HzRtg	(M) TCTR.HzRtg (M) TVTR.HzRtg	Rated frequency (mandatory as per the standard)	All devices of a project have the same rated frequency.

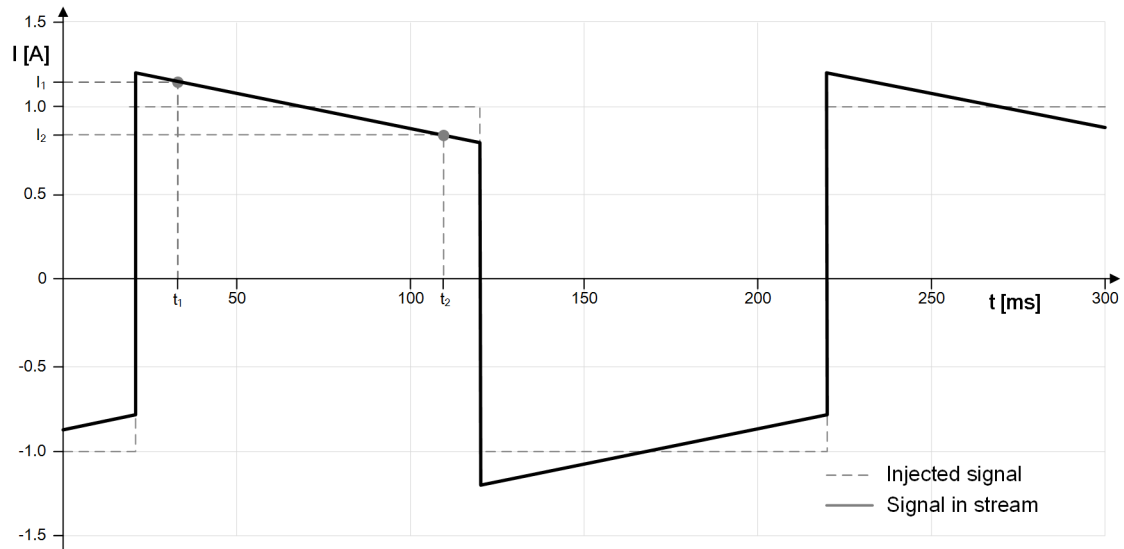
How to Derive Merging-Unit Related Settings

For merging units not covered in the database, the settings that must be derived can be derived using the following instructions:

- **Max. Delay time [ms]**
The maximum delay time is usually provided in the technical specification of the merging unit. If it is not available from the technical documentation, contact the vendor of the merging unit.
- **Min. Delay time [ms]**
The setting describes the delay jitter of the incoming stream and contributes to the buffer size for incoming packets. If the delay jitter is unknown, the value 0 can be set as a safe value.
- **ScndTmms current [ms]**
If the secondary loop time constant for the current channels is not provided by the merging-unit vendor, it can be measured by applying a square wave current signal, for example, with an amplitude of rated current and a frequency of 5 Hz. The calculation follows the following formula. If there is no time constant, the maximum value of 10 000 ms must be set.

$$\text{ScndTmms} = \frac{(t_1 - t_2)}{\ln(I(t_1)/I(t_2))}$$

[fo_ScndTmms-current, 1, en_US]



[dw_char_ScndTmms-current, 3, en_US]

Figure 2-29 Characteristic Curve for ScndTmms current [ms]

- **ScndTmms voltage [ms]**

In case the secondary loop time constant for the voltage channels is not provided by the merging unit vendor it can be measured by applying a square wave voltage signal, with an amplitude of rated voltage at a frequency of 5 Hz, for example. The calculation follows the same principle as described for the **ScndTmms current** setting. If there is no time constant the maximum value of 10 000 ms must be set.

- **HzRtg [Hz]**

The rated frequency of the merging unit must be used.

The measuring-point specific settings provide settings for individual current or voltage measuring points which are sourced by a merging unit stream.

Settings	IEC 61850 Setting	Description	Comment
Primary [A]	(M) TCTR.Artg	Primary rated current ARTg, mandatory as per the standard	
Secondary [A]	Not applicable	Secondary rated current for ratio verification	Not editable
Ratio CT	(O) TCTR.Rat	Ratio between primary and secondary rated value, optional as per the standard	Affects the display of secondary measured values
MaxRMS	Not applicable	Additional setting for verification of the clip value	Automatically calculated from the primary rated value and the clip value, shows the max. measured value Not editable
Clip	(M) TCTR.Clip	Clipping factor related to the rated value, mandatory as per standard	Determines the maximal measured value and internal resolution of the measured values

Setting	IEC 61850 Setting	Description	Comment
Primary-PhPh [KV]	(M) TVTR.Vrtg	Primary rated voltages as phase-to-phase value The value is $\sqrt{3}$ * primary phase-to-ground. The primary rated voltage Vrtg is mandatory as per the standard.	Depending on the selection made in column Vrtg reference , the value is: - Editable (light gray background) - Read-only (dark gray background)
Primary-PhGnd [KV]	(M) TVTR.Vrtg	Primary rated voltages as phase-to-ground value The primary rated voltage Vrtg is mandatory as per the standard.	
Secondary-PhPh [V]	Not applicable	Secondary rated voltages as phase-to-phase value The value is $\sqrt{3}$ * secondary phase-to-ground. The value displayed is the verified secondary rated voltage.	This column is read only. The values are automatically calculated from the primary rated value and the ratio.
Secondary-PhGnd [V]	Not applicable	Secondary rated voltages as phase-to-ground value The value displayed is the verified secondary rated voltage.	
Vrtg reference	Derived from LN TVTR prefix	Sets the reference for the TVTR.Vrtg setting to either phase-to-phase or phase-to-ground.	Depending on the selection made in the column Vrtg reference , either ph-ph or ph-gnd , the rated primary and rated secondary voltage columns as well as the clip column will be either displayed as editable or read-only.
Ratio VT	(O) TVTR.Rat	Ratio between primary and secondary rated value, optional as per standard	Effects the display of secondary measured values
MaxRMS	Not applicable	Additional setting for verification of the clip value	Automatically calculated from the primary rated value and the clip value, shows the max. measured value This column is read-only.

Setting	IEC 61850 Setting	Description	Comment
Clip-PhPh[*Vnom]	(M) TVTR.Clip	Clip factor as phase-to-phase value	Determines the max. measured value and internal resolution of the measured values. Depending on the selection made in column Vrtg reference , the value is: • Editable (light gray background) • Read-only (dark gray background)
Clip-PhGnd[*Vnom]	(M) TVTR.Clip	Clip factor as phase-to-ground value	

How to Derive Measuring-Point Related Settings

The settings in the **Current measuring points** and **Voltage measuring points** tab of the **9-2 Client Instrument Transformer Settings** Editor must be derived individually using the following instructions.

- **Primary rated current [A]**
The primary rated current of the instrument transformer connected to the merging unit must be used.
- **Ratio Current**
The ratio between primary and secondary rated current must be used. In case of LPIT, a **virtual** ratio based on a secondary current of either 1 A or 5 A must be entered.
- **Clip Current**
The clip current value describes the measuring range of current inputs in relation to the rated value.
Example:
Current measuring range = 200 A
Rated current = 5 A
→ Clip current = 200 A/5 A = 40
- **Primary rated voltage [kV]**
The primary rated voltage of the instrument transformer connected to the merging unit must be used.
The value must be entered according to the setting **VRtg reference**.
- **VRtg reference**
If the subscribed merging unit does not serve the TVTR prefix that defines the type of voltage (ph-ph or ph-gnd), DIGSI interprets the voltages as ph-gnd. If the published voltage is ph-ph, the setting **VRtg reference** must be changed accordingly.
- **Ratio voltage**
The ratio between primary and secondary rated voltage must be used. In case of LPIT, a **virtual** ratio based on a secondary voltage between 80 V to 230 V ph-ph must be entered.
- **Clip voltage**
The clip voltage value describes the measuring range of current inputs in relation to the rated value.
Example:
Voltage measuring range = 0 V to 230 V
Rated voltage = 115 V
→ Clip voltage = 230 V/115 V = 2

Handling of the 9-2 Client Instrument Transformer Settings Editor

To avoid inconsistent settings across various IEDs the IEC 61850 engineering workflow must be followed:

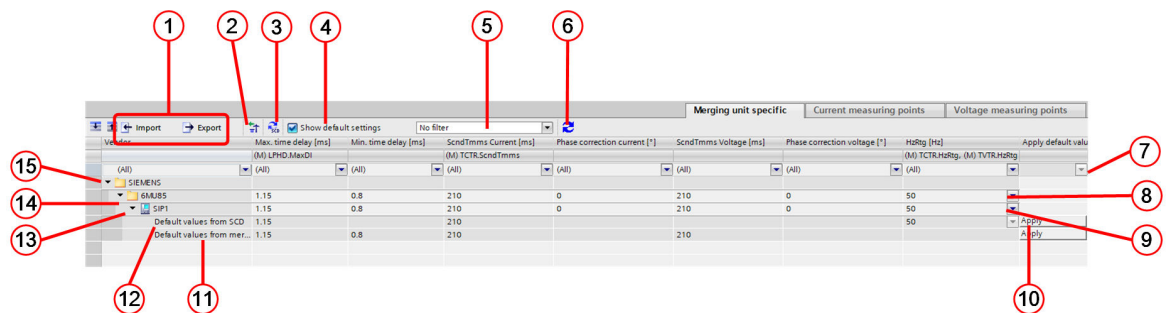
- Adjust the settings in the source device (merging unit)
- Update the IEC station file (SCD) with the adjusted settings
- Import the changes from the SCD to update the process bus client (SMV subscriber)

If the settings are not present in the ICD/SCD file and the MU is available in the database, DIGSI can use the settings from the merging-unit database.

If a setting is not available in either the ICD/SCD file or the merging-unit database, it is set as 0 and marked with red color to indicate the inconsistency. You can enter it into the Editor after importing it from the SCD file.

How to Use the 9-2 Client Instrument Transformer Settings Editor

Besides the possibility to enter individual values, the Editor also provides capabilities for bulk editing. The following screenshot describes the individual fields and buttons of the Merging-Unit-specific tab.



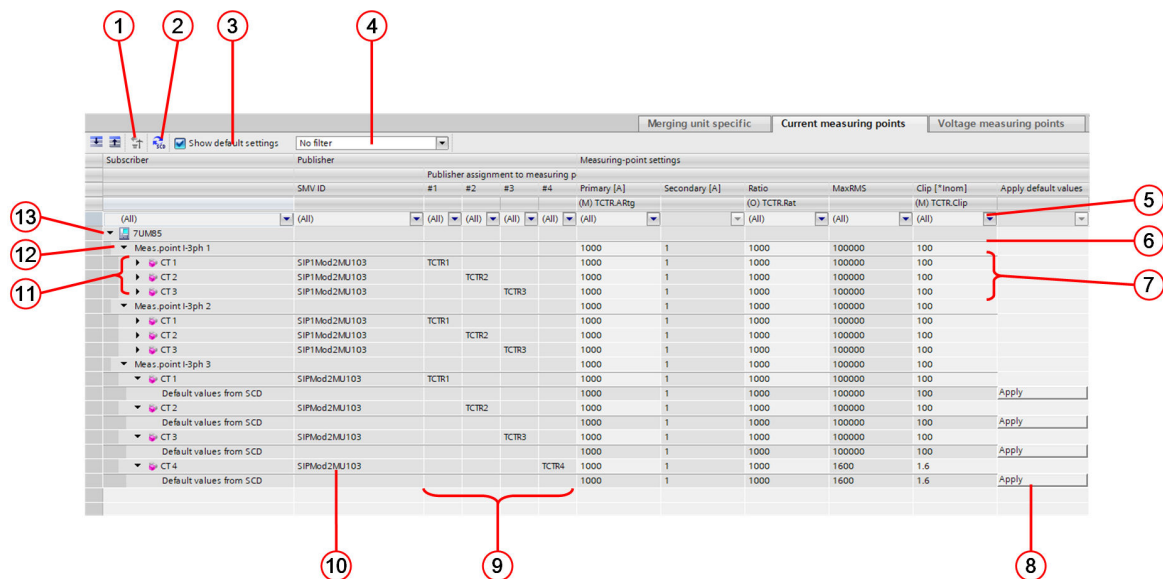
[ie_handl-9-2-client-instrument-transf-set-editor_01_2_en_US]

Figure 2-30 Fields in the Merging-Unit-Specific Tab

Item	Functionality	Description
1	Import/export of the merging-unit data-base	Imports/exports data of the merging-unit database
2	Apply changes from the Editor	Applies the manual changes of the settings in the 9-2 Client Instrument Transformer Settings Editor to the configuration.
3	Apply all default values	All settings are set to the default values from the merging-unit database and the SCD file. This also links the settings back to the SCD values and allows an automatic update if setting values have changed in the SCD file.
4	Show default settings	Shows/hides the default values from the merging-unit database and the SCD file in separate lines below the used setting of the device
5	Global filter	Allows filtering for differences between the default values (merging-unit database and the SCD file) and the actual values
6	Update merging-unit database	The merging-unit database is updated from the Siemens cloud to use the latest merging-unit data-base.
7	Filter	Allows filtering of individual settings
8	Change settings for all subelements	Shows the currently used settings for all subelements
9	Change settings for individual elements	Shows the currently used settings for the individual element

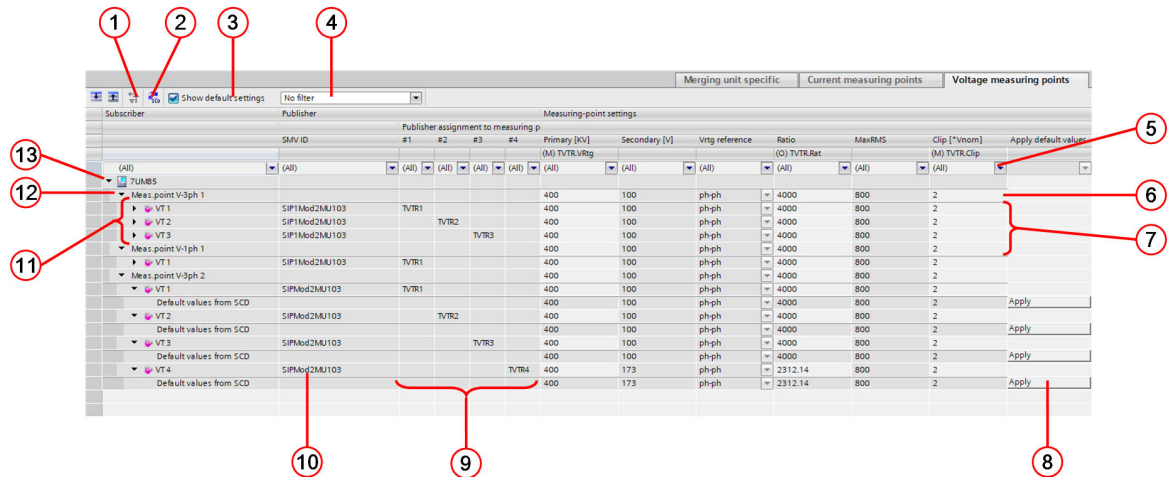
Item	Functionality	Description
10	Apply default values	Takes over default values either from the merging-unit database or from the SCD file (for the line for which the button Apply has been used). This also links the settings back to the SCD values and allows an automatic update if setting values changed in the SCD file.
11	Default values from the merging-unit database	Shows/hides the default values from the merging-unit database and the SCD file in separate lines below the used settings of the device
12	Default values from SCD	
13	Individual MU	
14	MU type	
15	MU vendor	Subscribed merging units of the project are displayed in a hierarchical structure by MU vendor, MU type, and individual MU.

The following 2 figures show the individual fields and buttons of the **Current measuring points** and **Voltage measuring points** tabs.



[le_handl-9-2-client-instrument-transf-set-editor_02_2_en_US]

Figure 2-31 Fields in the Current Measuring Points Tab



[file_handl-9-2-client-instrument-transf-set-editor_03_2_en_US]

Figure 2-32 Fields in the Voltage Measuring Points Tab

Item	Functionality	Description
1	Apply changes from the Editor	Applies the manual changes of the settings in the 9-2 Client Instrument Transformer Settings Editor to the configuration.
2	Apply all default values	All settings are set to the default values from the merging-unit database and SCD file. This also links the settings back to the SCD values and allows an automatic update if setting values have changed in the SCD file.
3	Show default settings	Shows/hides the default values from the merging-unit database and the SCD file in separate lines below the used setting of the device
4	Global filter	Allows filtering for differences between the default values (merging-unit database and SCD) and the actual values
5	Filter	Allows filtering of individual settings
6	Change settings for all subelements	Shows the currently used settings for all subelements
7	Change settings for individual elements	Shows the currently used settings for the individual element
8	Apply default values	Takes over default values either from the merging-unit database or from the SCD file (for the line for which the button Apply has been used). This also links the settings back to the SCD values and allows an automatic update if setting values changed in the SCD file.
9	Publisher assignment to measuring point	Indicates the individual TCTR/TVTR of the subscribed SMV stream to the individual element of the measuring point
10	SMV ID	Displays the SMV ID of the subscribed SMV stream
11	Subelement of measuring point	Individual subelements of the current or voltage measuring point
12	Current measuring point (in the Current measuring point tab) Voltage measuring point (in the Voltage measuring point tab)	Displays the individual measuring points (current or voltage) of the respective SMV subscriber IED
13	PB Client IED (SMV subscriber)	Displays the SMV subscriber IED



NOTE

If values have been entered manually or changed in the **9-2 Client Instrument Transformer Settings** Editor, DIGSI always uses these values and does not update changes provided via the SCD file import until the default values have been applied via either the individual **Apply** buttons or the general **Apply** button. With one exception, if a value within the SCD file from the merging unit (SMV publisher) has changed from the previous imported SCD file, that updated value is used regardless of whether the value was manually entered or changed.



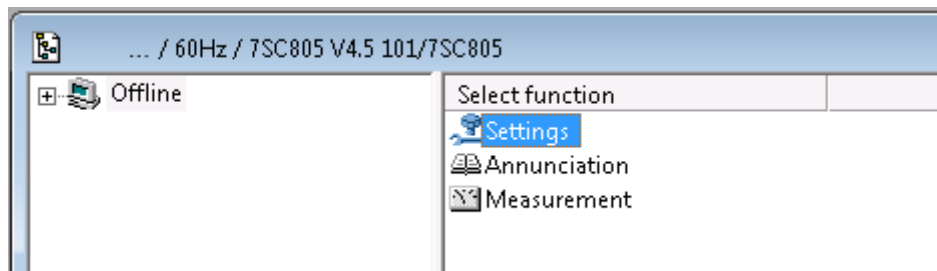
NOTE

After manual changes in the **9-2 Client Instrument Transformer Settings** Editor, the settings changes must be applied using the button **Apply changes** of the Editor.

For further information on the 9-2 Client Instrument Transformer Settings Editor, refer to the *DIGSI Online Help*

2.1.7 Merging Unit 6MU805 in DIGSI 4

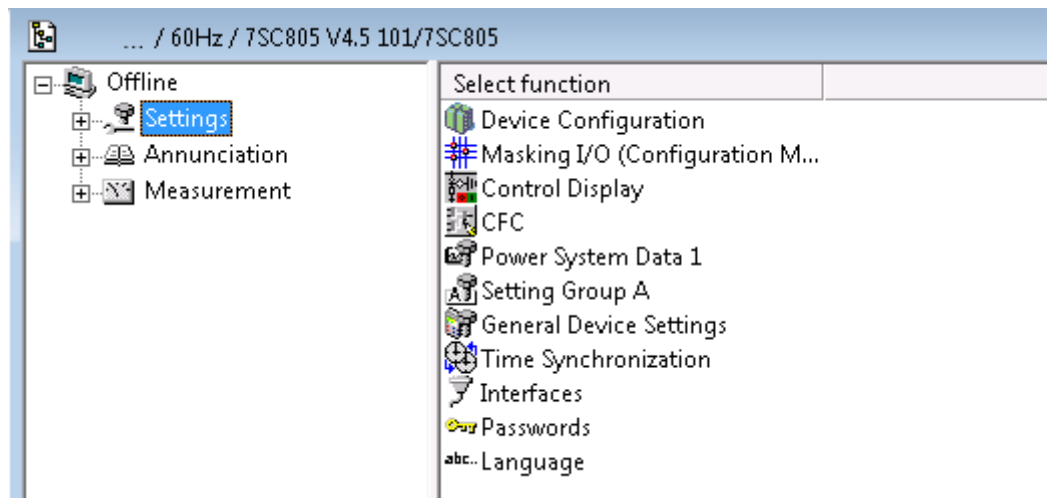
- ✧ Open the **DIGSI 4 Manager**.
- ✧ Insert a new merging unit 6MU805 from the device catalog.
- ✧ Open the device in **Offline** mode.



[sc_DIGSI4_Offline_Device_Settings, 1, ...]

Figure 2-33 Offline View of a Device

- ✧ Double-click **Settings**.



[sc_DIGSI4_Offline_Device_Settings_Select_Function, 1, ...]

Figure 2-34 Settings of a Device

- ✧ Double-click **Device Configuration** and enable **SYSCON Conf..** For more information, refer to the *SIPROTEC 4 6MU805 Manual*.

Parameterizing the Power System Data 1

- ✧ Double-click **Power System Data 1**.
- ✧ Set the values in the **Power System Data 1** dialog.

Power System Data 1

Power System | CT's | VT's | SMV-settings | MU-settings

Settings:

No.	Settings	Value
0214	Rated Frequency	60 Hz ▼

☐ Display additional settings

About

OK Apply DIGSI -> Device Cancel Help

[sc_DIGSI_PowerSystemData1, 1, en_US]

Figure 2-35 Power System Data Dialog



NOTE

In the tab **SMV-settings**, set the parameter 0454A **Number of ASDU** to 1.

Parameterizing the Time Synchronization

- ✧ In the **DIGSI 4 Manager**, select **Time Synchronization**.
- ✧ Set the values for the time synchronization as follows:

Time Synchronization & Time Format

Source of time synchronization:
 IRIG B
 Internal Clock
 IRIG B
 Ethernet NTP
 GPS

Monitoring
 Fault indication after:
 10 (>1/min)

Pulse
 via binary input:
 Not configured

Time format for display
☒ dd.mm.yy
☐ mm/dd/yy
☐ yy-mm-dd

Time Correction
 Offset to time signal:
 00:00 hh:mm

Time zone and daylight saving time
☐ Use PC time zone and daylight saving time
 Time zone offset to GMT: +01:00 hh:mm
☐ No daylight saving time switchover
 Daylight saving time offset to GMT: +02:00 hh:mm
 Start of daylight saving: Last Sunday in March at 02:00 o'clock
 End of daylight saving: Last Sunday in October at 03:00 o'clock

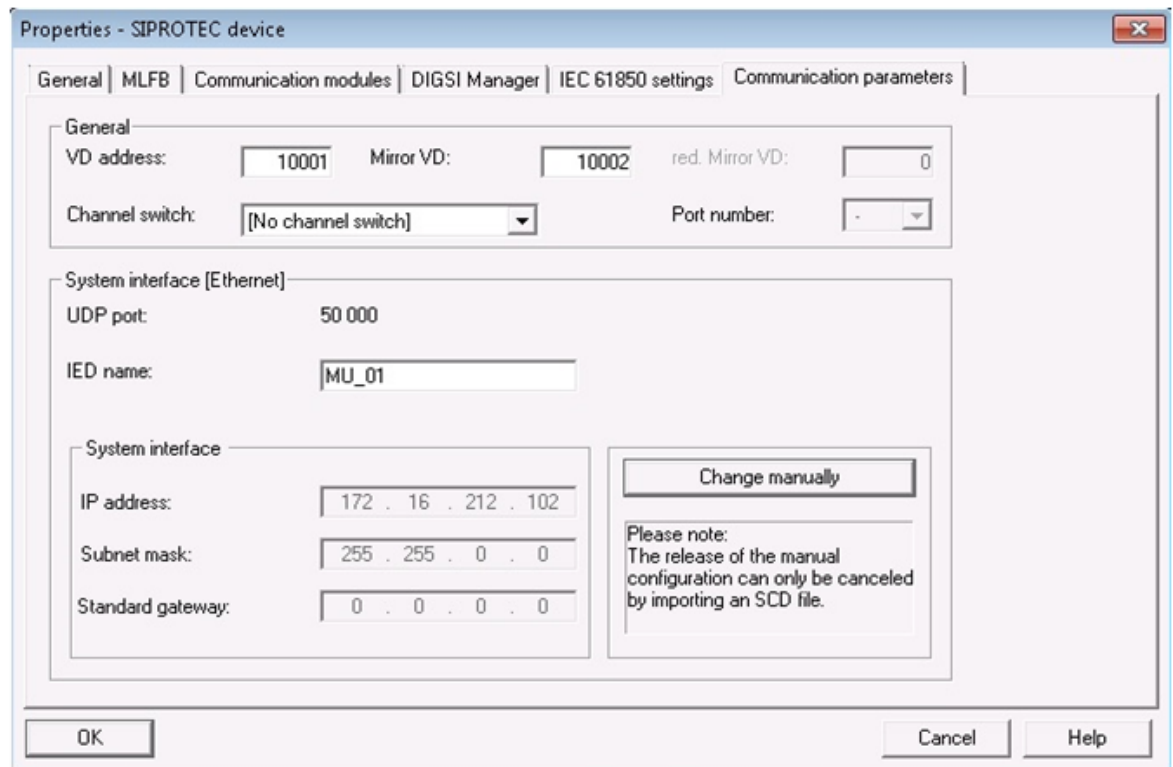
OK DIGSI -> Device Cancel Help

[sc_DIGSI_TimeSynchronization, 1, en_US]

Figure 2-36 Time Synchronization & Time Format Dialog

Parameterizing the Device Properties

- ✧ In the **DIGSI 4 Manager**, right-click in the right window section and select **Object Properties...**
- ✧ In the **IEC 61850 settings** tab, select the IEC 61850 Edition 2.
- ✧ Open the **Communication parameters** tab to see the following data:



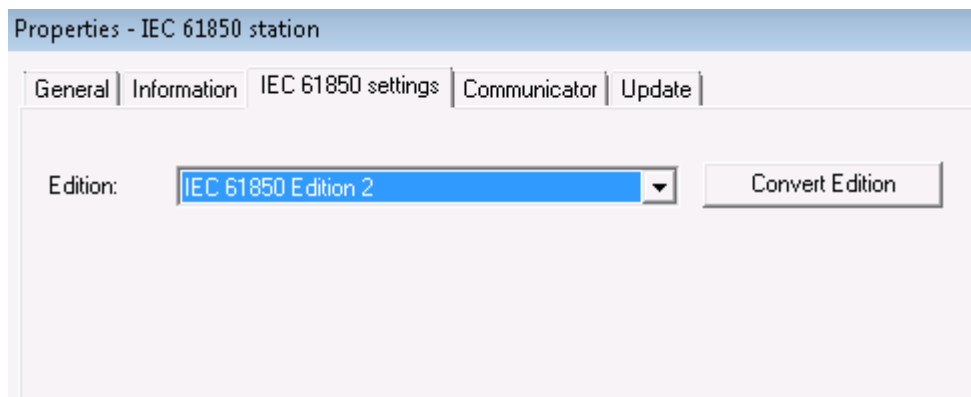
[sc_DIGSI_properties, 1, en_US]

Figure 2-37 Communication Parameters Tab

- ✧ Enter an IED name.
- ✧ Click **OK**.

IEC 61850 station

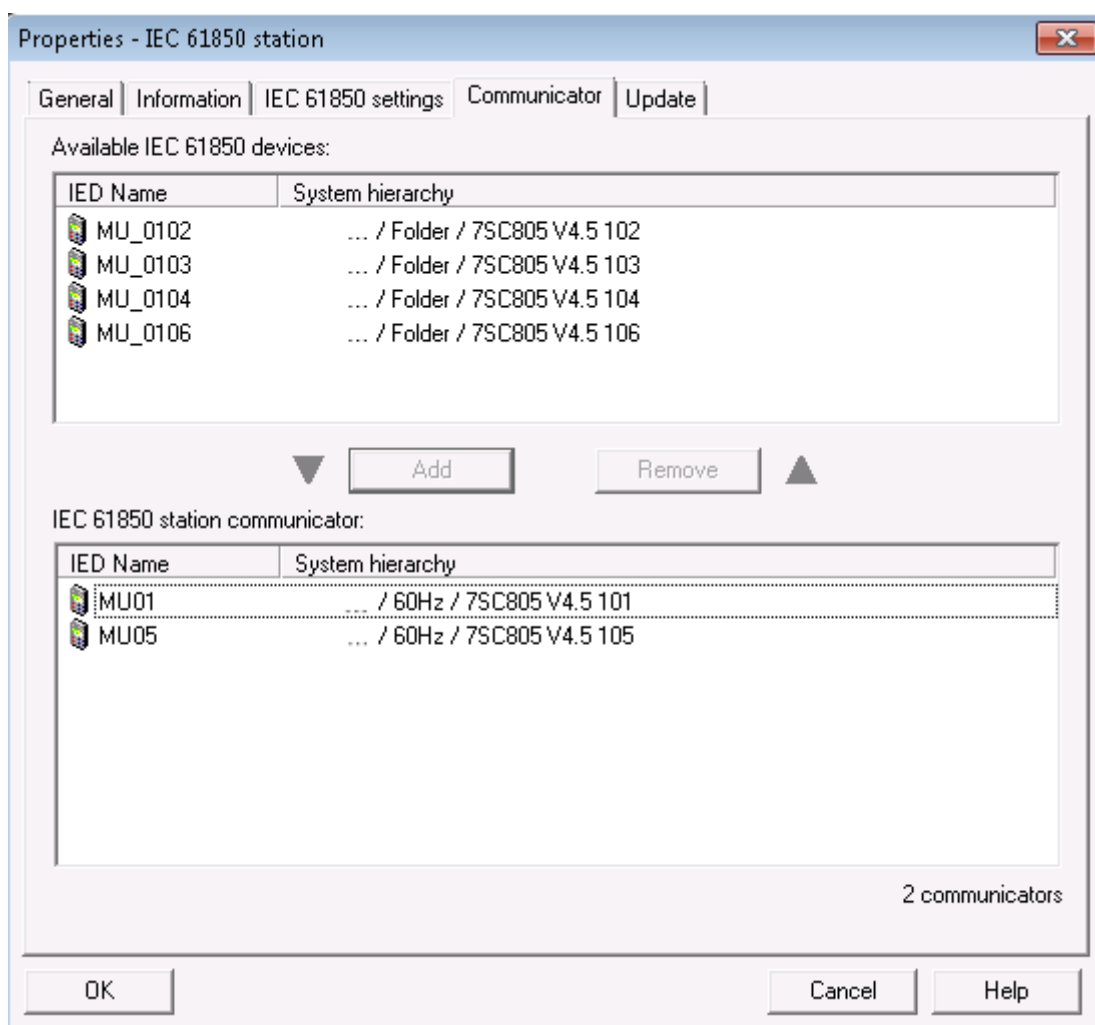
- ✧ In DIGSI 4, right-click the device and select **Insert New Object > IEC 61850 station**.
- ✧ Right-click the IEC 61850 station and select **Properties....**
- ✧ Change the edition of the IEC 61850 station to IEC 61850 Edition 2 and click **Convert Edition**.



[sc_DIGSI4_IECEdition, 1, --]

Figure 2-38 Changing the IEC 61850 Edition for the IEC 61850 Station

- ✧ Open the **Communicator** tab and select the MUs.



[sc_DIGSI4_Communicator_tab, 1, ...]

Figure 2-39 Communicator Tab

- ✧ Click **Add** and then click **OK**.
- ✧ Open the IEC 61850 station and enter a storage path for the SCD file.

The IEC 61850 System Configurator opens.

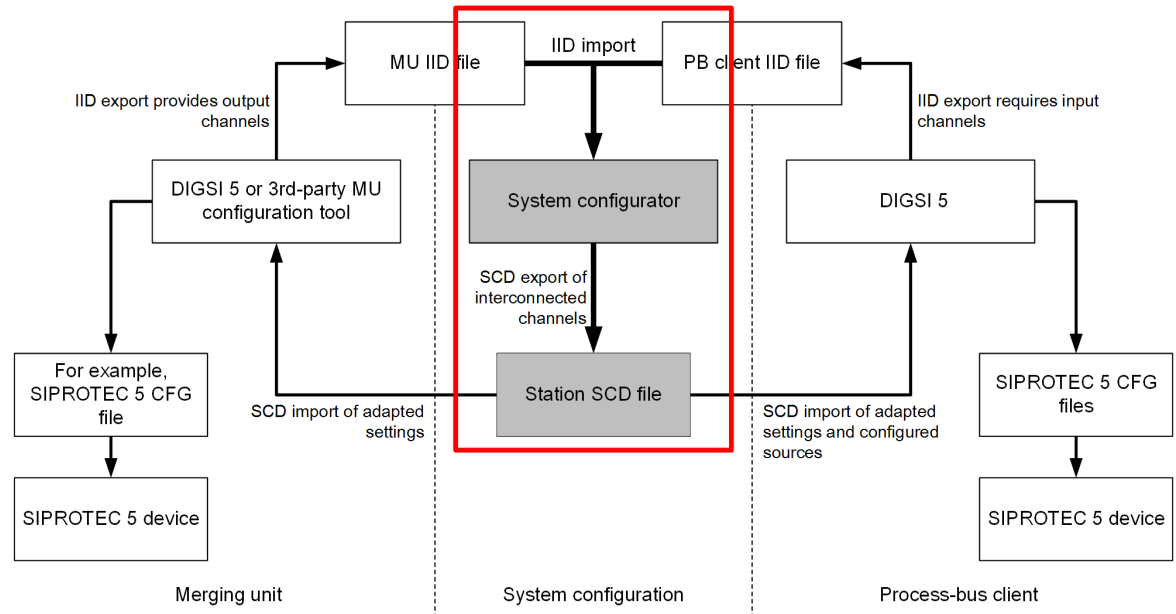
2.2 Process Bus in SCD Files

2.2.1 Introduction

This chapter describes the integration of the SIPROTEC 5 process bus into substation engineering with the following programs:

- DIGSI 5
- IEC 61850 System Configurator

The following figure shows the part of the engineering workflow which is covered in this section.



[dw_process-bus_engineering_SCD_1_en_US]

Figure 2-40 Export of SCD Files

You must distinguish between the export from DIGSI 5 to the IEC 61850 System Configurator and the import from the IEC 61850 System Configurator into DIGSI 5.

The export from DIGSI 5 to the IEC 61850 System Configurator provides the CT and VT output channels of a merging unit device and the required CT and VT input channels for each process-bus client device (using later-binding input interfaces as specified by IEC 61850-6). Interconnect these channels in the IEC 61850 System Configurator.

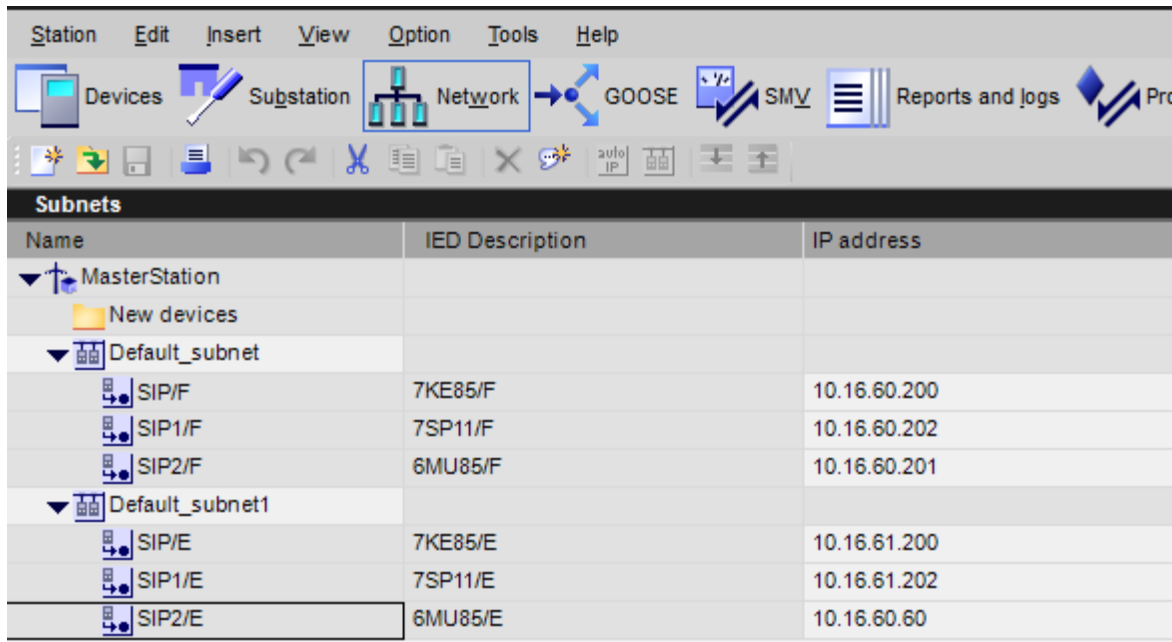
The import from the IEC 61850 System Configurator to DIGSI 5 provides the interconnections between merging units and process-bus clients for the whole substation. DIGSI 5 must extract the mapping from the client device of the current device project and updated parameters for the MUs.

If you activate the process-bus client functionality on several ETH-BD-2FO modules, the device provides multiple access points that can be used for process bus. Therefore, the mapping of current and voltage channels to access points is also described in chapter [2.2.3 IEC 61850 System Configurator](#).

2.2.2 Definition of Client Access Points

To allow a mapping between process-bus module slots used in DIGSI 5 and in the IEC 61850 System Configurator, a naming convention is used. Access-point names are assigned only in DIGSI 5 during device HW configuration.

The access-point names are equal to the COM module plug position in the DIGSI 5 Hardware configurator.



Name	IED Description	IP address
MasterStation		
New devices		
Default_subnet		
SIP/F	7KE85/F	10.16.60.200
SIP1/F	7SP11/F	10.16.60.202
SIP2/F	6MU85/F	10.16.60.201
Default_subnet1		
SIP/E	7KE85/E	10.16.61.200
SIP1/E	7SP11/E	10.16.61.202
SIP2/E	6MU85/E	10.16.60.60

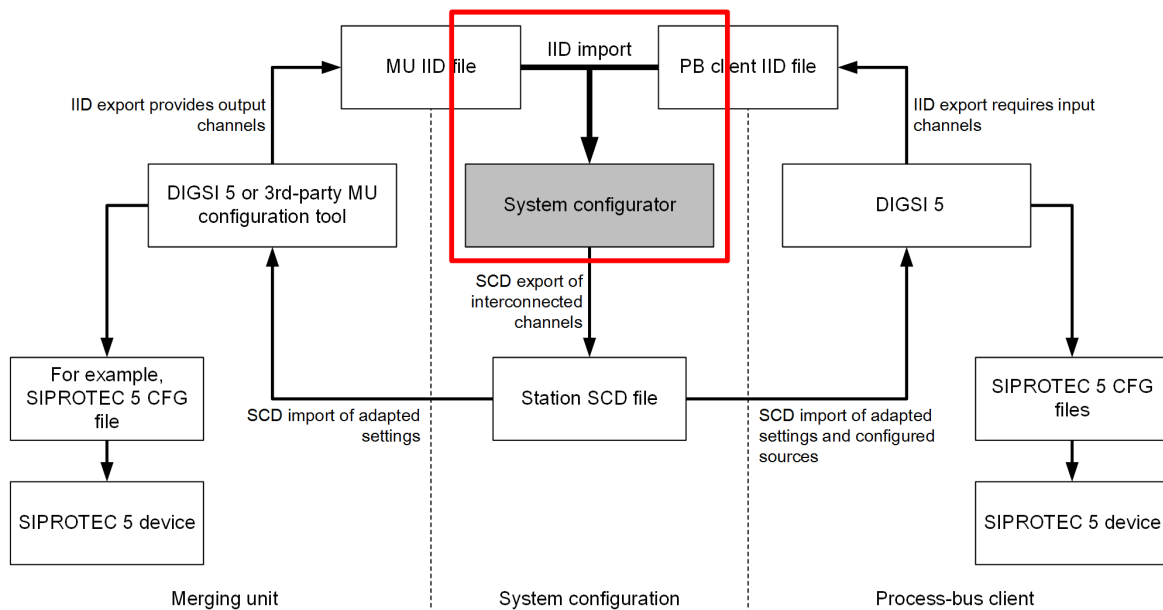
[sc_module_position_syscon, 1, en_US]

Figure 2-41 Example for the Module Positions in the IEC 61850 System Configurator

In the preceding figure, the access-point name consists of the IEC device name and the port name, for example SIP1/F.

2.2.3 IEC 61850 System Configurator

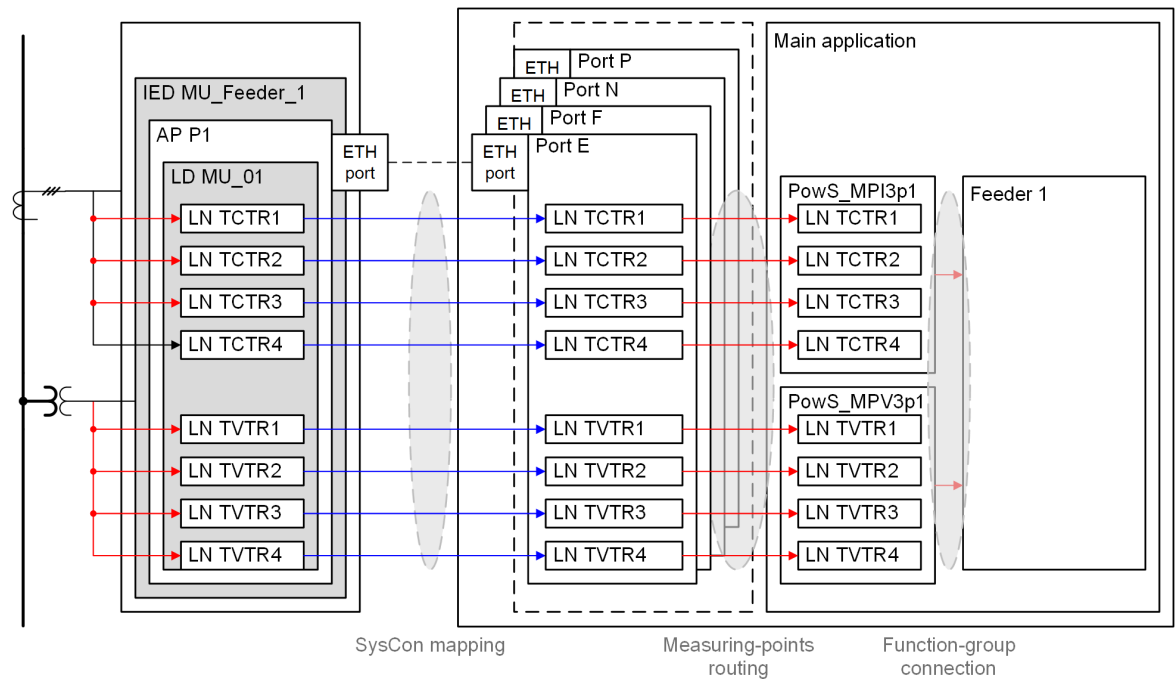
The following figure shows the part of the engineering workflow which is covered in this section.



[dw_process-bus_engineering_syscon, 1, en_US]

Figure 2-42 Configuration in the System Configurator

The following figure describes the basic principle for signal interconnection between an MU input and a process-bus client input in a SIPROTEC 5 device.



[dw_runtime-signal-flow, 2, en_US]

Figure 2-43 Runtime Signal Flow from a Merging Unit to a SIPROTEC 5 Application

The first mapping is done within the merging unit. Signals from the primary CTs and VTs are interconnected to a merging unit. Current and voltage signals are represented by TCTR and TVTR instances within the IID file describing the merging-unit instance.

A particular CT or VT can be identified by the following data:

- IED name of the merging-unit instance
- Access-point name providing the CT and VT instances
The CT and VT instances are collected in a dataset assigned to an SV control block.
This SV control block is located at this access point.
- LN class and LN instance of a particular LN instance

If provided by the IED configurator of a merging unit, the substation section of the IID file describes the relation between the primary equipment and the LN instances.

The IEC 61850 System Configurator is used to interconnect LN instances provided by merging units to LN instances in a process-bus client representing defined measuring points of a SIPROTEC 5 device. The LN instances are provided by merging units via the IEC 61850-9-2 SMV protocol.

Adding and Configuring a New IEC 61850 Station in DIGSI 5

- ✧ Add a new IEC 61850 station by selecting **IEC 61850 stations** → **Add new station** in the project tree.

The new station is displayed in the project tree.

The IEC 61850 Edition of the station is preconfigured to IEC 61850 Edition 2.1.

- ✧ Right-click the IEC station in the project tree and select **Properties** from the context menu.

The IEC station properties appear.

- ✧ Either assign the IEC station to an existing SCD file using the ... icon or create a new IEC station by clicking **Create new IEC 61850 station description (SCD)**....

The IEC 61850 System Configurator opens automatically and can be closed.



NOTE

In IEC 61850 projects, both the DIGSI 5 and IEC 61850 configuration are essential parts of the engineering. Therefore, Siemens recommends using one common folder to store the DIGSI 5 project and the IEC 61850 System Configurator project.

Assigning Devices to the IEC 61850 Station

- ✧ Double-click the station in the project tree.
- ✧ Click >> to add all the devices to the IEC 61850 station.
 - or -
- ✧ Select individual devices and click >.

Opening the IEC 61850 Station

- ✧ Right-click the IEC station in the project tree and select **Export changes to IEC 61850 System Configurator** from the context menu.
 - or -
- ✧ Click the icon

The IEC 61850 System Configurator opens the IEC 61850 station (SCD file).

The station is opened in the **IEC 61850 System Configurator** and a **Report** window is displayed.

You can close this **Report** window.

- ✧ Select the IED in the **Network** view of the IEC 61850 System Configurator.

The **Properties** of the IED (Intelligent Electronic Device) are displayed and can be modified in the right window section.

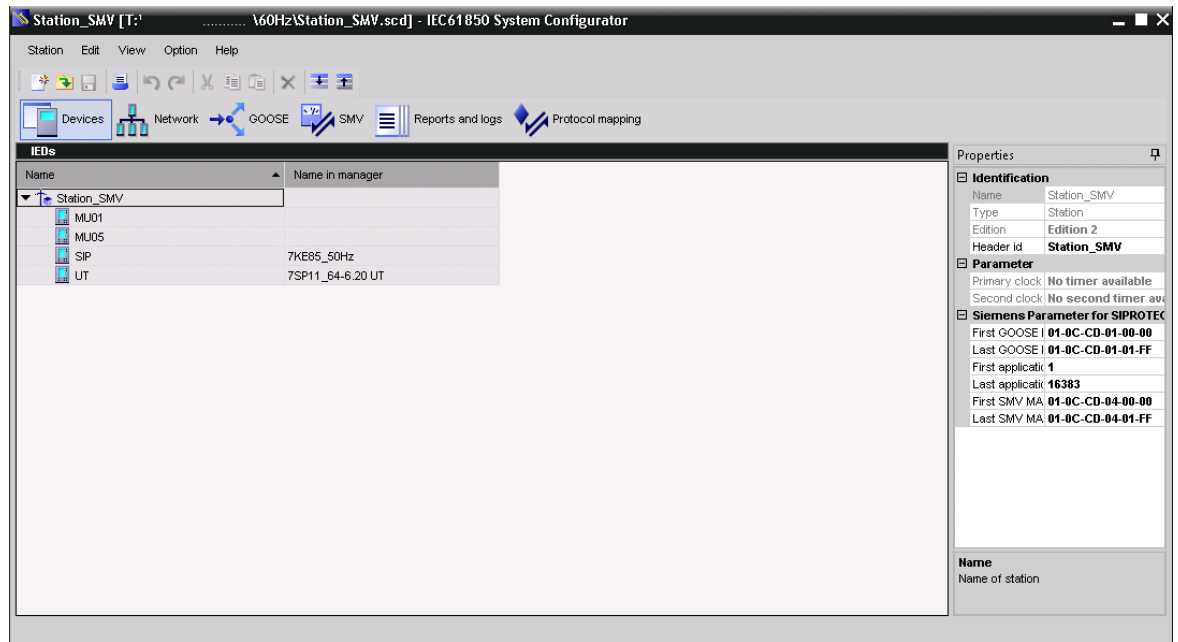
Importing an IID File from Third-Party Vendors

To import an IID file of a merging unit or process-bus client device, proceed as follows:

- ✧ Open the **Devices** view in the IEC 61850 System Configurator.
- ✧ Right-click the station in the **Name** column and select **Add IEC 61850 device(s)**.

The **Import IEC 61850 device description(s)** dialog opens.

- ✧ Select an IID file of a merging unit and click **Open**.
- ✧ After importing devices, you must assign the access points of the devices to the corresponding network. To do this, change to the **Network** view.



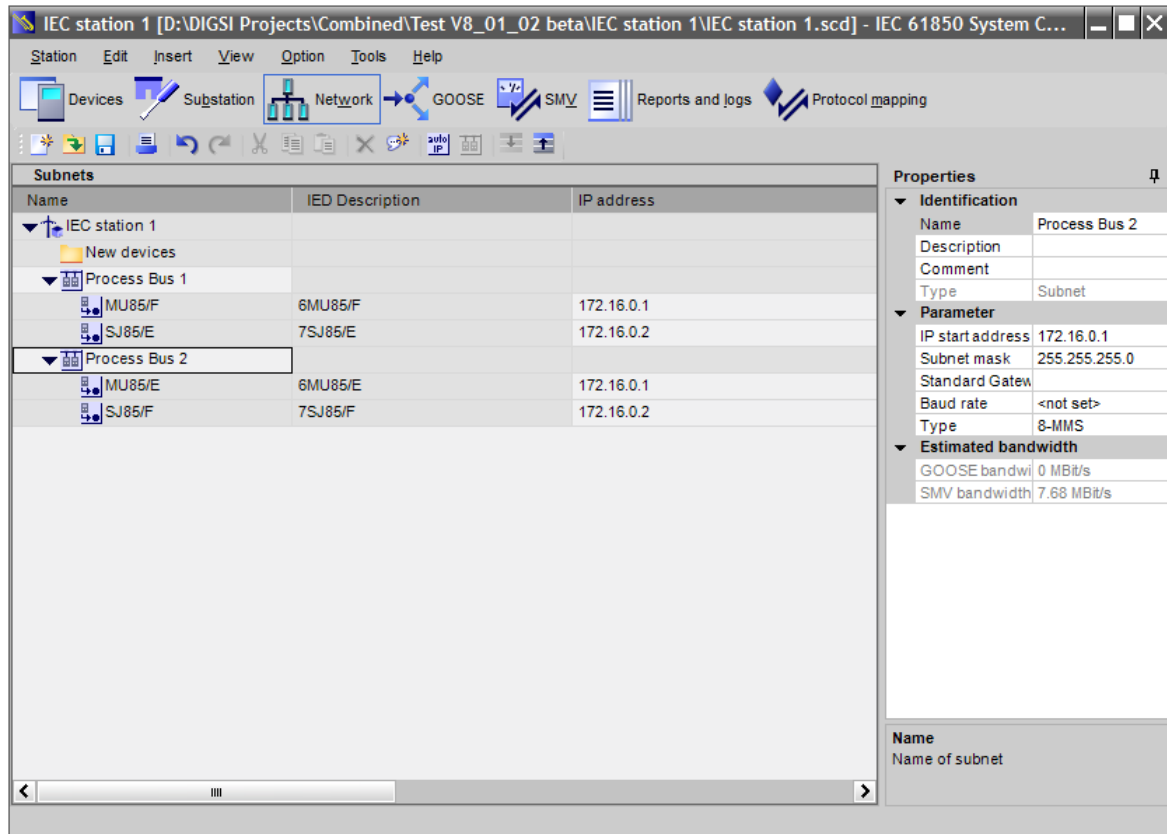
[sc_SystemConfigurator_Device_View, 1, en_US]

Figure 2-44 IEC 61850 System Configurator Devices View

Assigning the Access Points to the According Networks

In the **Network** view, you must assign the access points of the devices to a subnetwork.

- ✧ Add a new network or remove not necessary networks.
- ✧ Assign the merging unit and process-bus client devices access points using drag and drop to the same subnetwork.
- ✧ Rename the networks to improve usability.
- ✧ Change network-related settings in the properties windows on the right side.



[sc_Syscon_Network_View, 1, en_US]

Figure 2-45 IEC 61850 System Configurator Network View

Interconnecting Sampled Measured Value Signals

In the **SMV** view (SMV – Sampled Measured Value), you can interconnect CT or VT signals provided by a merging unit to an input of a process-bus client.

The **Destination catalog** lists the devices containing a process-bus client. **TCTR** stands for current measuring points, **TVTR** for voltage measuring points.

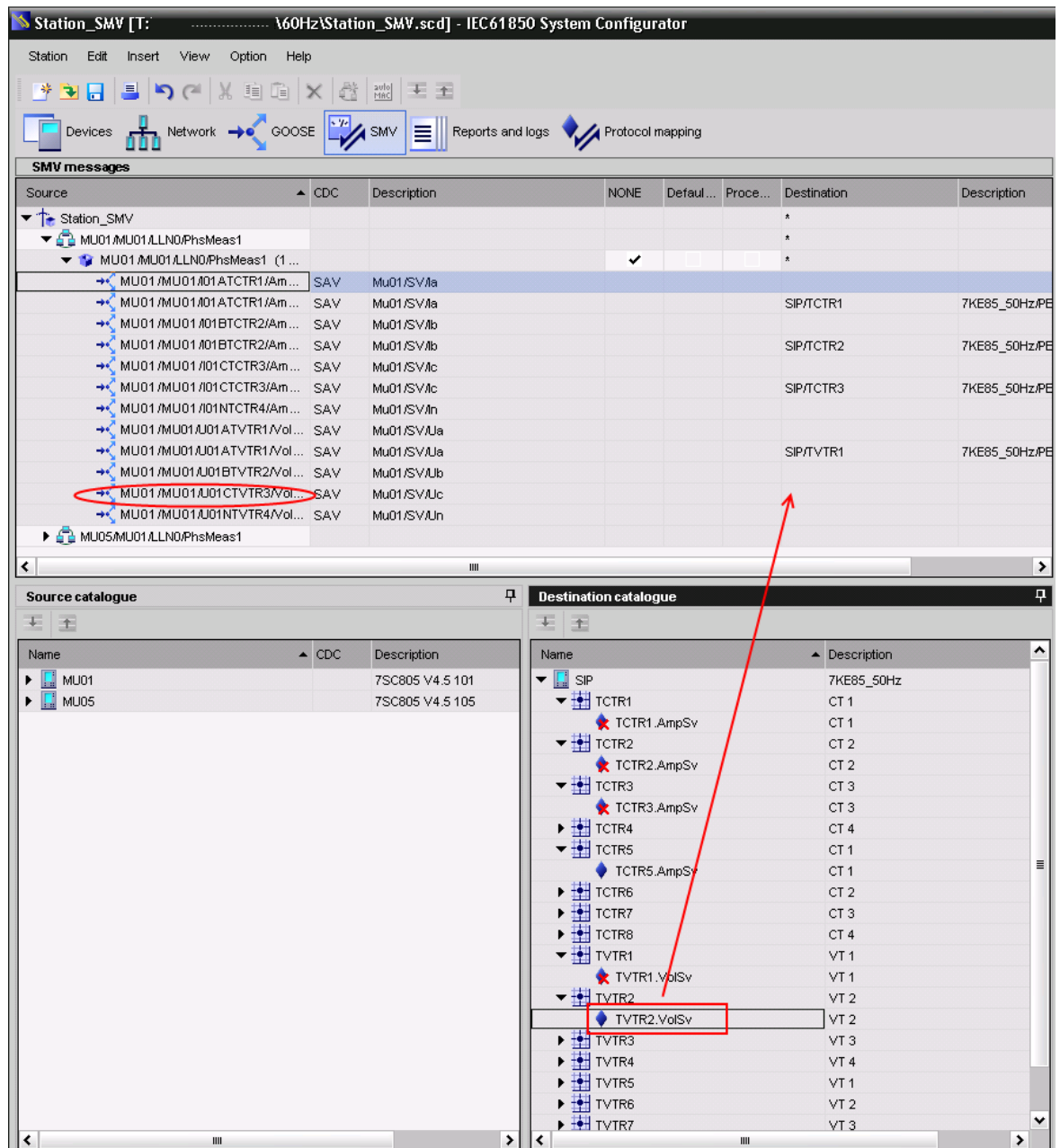
Sampled-value signals published by the merging units are listed in the **SMV messages** table.

- ✧ To connect a source signal of a merging unit to a process-bus client, drag a signal from the **Destination catalog** into the **SV messages** table.

Drop the destination signal in the row of the source signal that must be connected to this destination.

If a subscription is already present, an empty line is shown. In this way, a source signal can be connected to multiple destinations.

- ✧ Repeat this for all measuring points.
- ✧ Save the changes.



[sc_SystemConfigurator_routing_process_bus_connections, 1, en_US]

Figure 2-46 Routing of Process-Bus Connections in the IEC 61850 System Configurator



NOTE

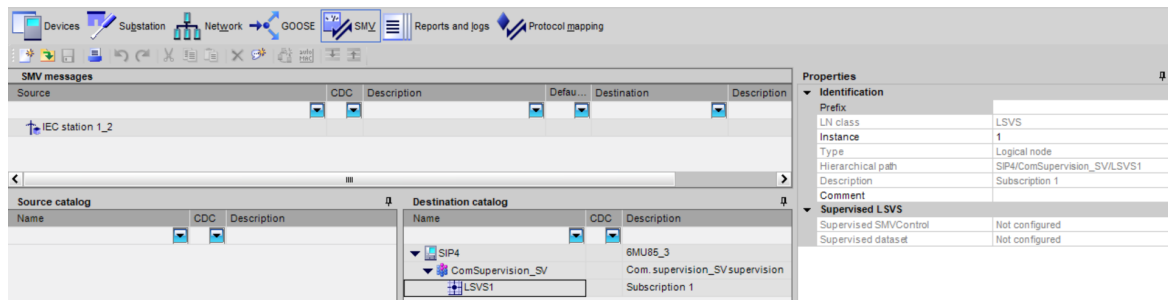
A signal can only be dropped, when both source and destination port are part of the same subnetwork. If not, you can change the network configuration in the **Network** view. This view shows all defined subnetworks.



NOTE

If the entire measuring point from the **Destination catalog** is used for drag and drop, all inputs are connected automatically.

The sampled-value supervision is automatically instantiated in the process-bus client. You can review the **Supervised LSVS** in the properties of each signal in the **Destination catalog**.



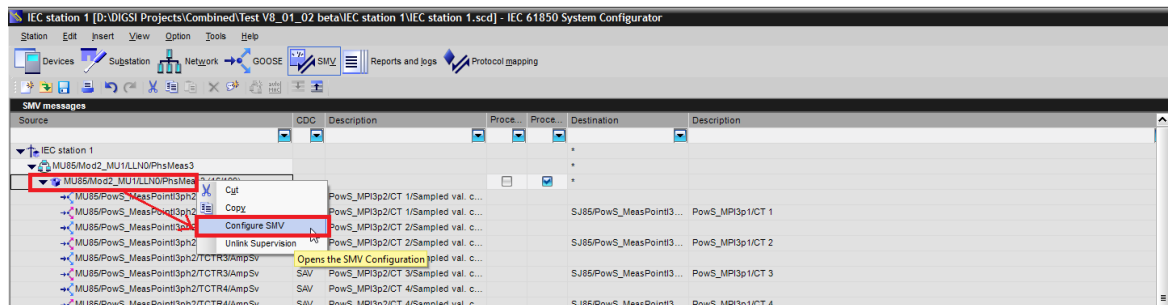
[sc_supervision, 1, en_US]

Figure 2-47 Supervised LSVS

Configuring Sampled-Value Streams

In the **SMV** view, you can change the sampled-value stream specific configuration. These settings are used to define the sampled-value streams published from a merging unit and to finish the subscription in the process-bus client.

- ✧ Go to the **SMV** view in the IEC 61850 System Configurator.
- ✧ Right-click the SMV stream and select **Configure SMV**.



[sc_configure SMV streams, 1, en_US]

Figure 2-48 Configure SMV

The SMV stream configuration window opens.

- ✧ Configure the following settings of the SMV stream according to your application:
 - SMV Identifier (SmvID)
 - Application Number (AppID)
 - MAC address
 - Configuration Revision
 - VLAN ID and VLAN priority

SMV control/ Su...	SMV Identifier/ Ap...	MAC address	Configu...	VLAN		smpRate	nofASDU	smpMod	multicast	refreshTime	sampleRate	dataSet	security	synchSourceId
MSVCB03	SIPMod2MU103		10001	ID	Priority	4800	2	SmpPerSec	Yes	No	No	No	No	No
Process...	16385	01-0C-CD-04-00-01		0	4									

[sc_configure SMV streams_2, 1, en_US]

Figure 2-49 Configure SMV Stream Settings



NOTE

The **MAC address** and **SmvID** must be unique.
The sampled value stream type and analog value content is defined in DIGSI 5 in the Merging Unit function.



NOTE

Use the VLAN ID to manage the network load. For more details, refer to chapter [4.2 Network Usage](#).

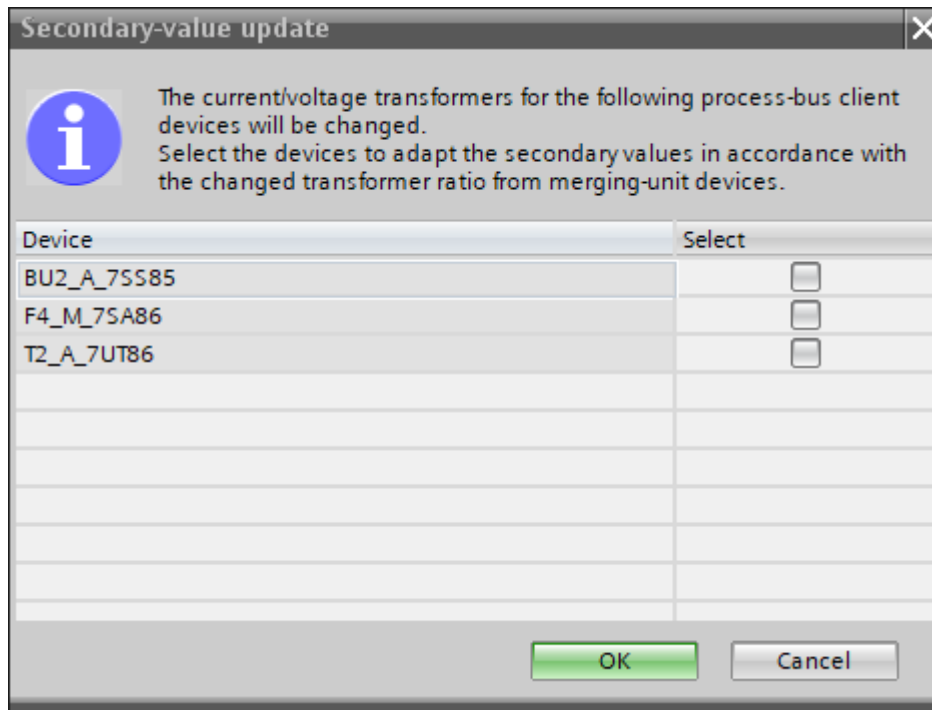
Importing the Changes to DIGSI

If a station has been changed in the IEC 61850 System Configurator, the station is marked with an icon:



- ✧ Right-click the IEC station in the project tree and select **Import changes from IEC 61850 System Configurator** from the context menu.
- or -
- ✧ Click the icon

A validation dialog appears to decide whether possible changes in the instrument-transformer ratio must be taken over with or without adaptations of the secondary setting values according to the changes in the instrument-transformer ratio.



[sc_validation_secondary_value_update, 1, en_US]

Figure 2-50 Validation Dialog

Example for changed secondary values:

- Existing settings in DIGSI
 - CT Ratio 2000:1
 - 50-1 stage set to 1.2 A (secondary)
- Setting in SCD station:
 - CT Ratio 3000:1

Reaction to the settings:

- Device is selected in the dialog:
 - CT ratio will be changed to 3000:1
 - 50-1 stage will be changed to 0.8 A (secondary)
 - Device is not selected in the dialog
 - CT ratio will be changed to 3000:1
 - 50-1 stage will remain at 1.2 A (secondary)
- ✧ Select the devices requiring an adaption of the secondary settings and click **OK**.

An import report is displayed.

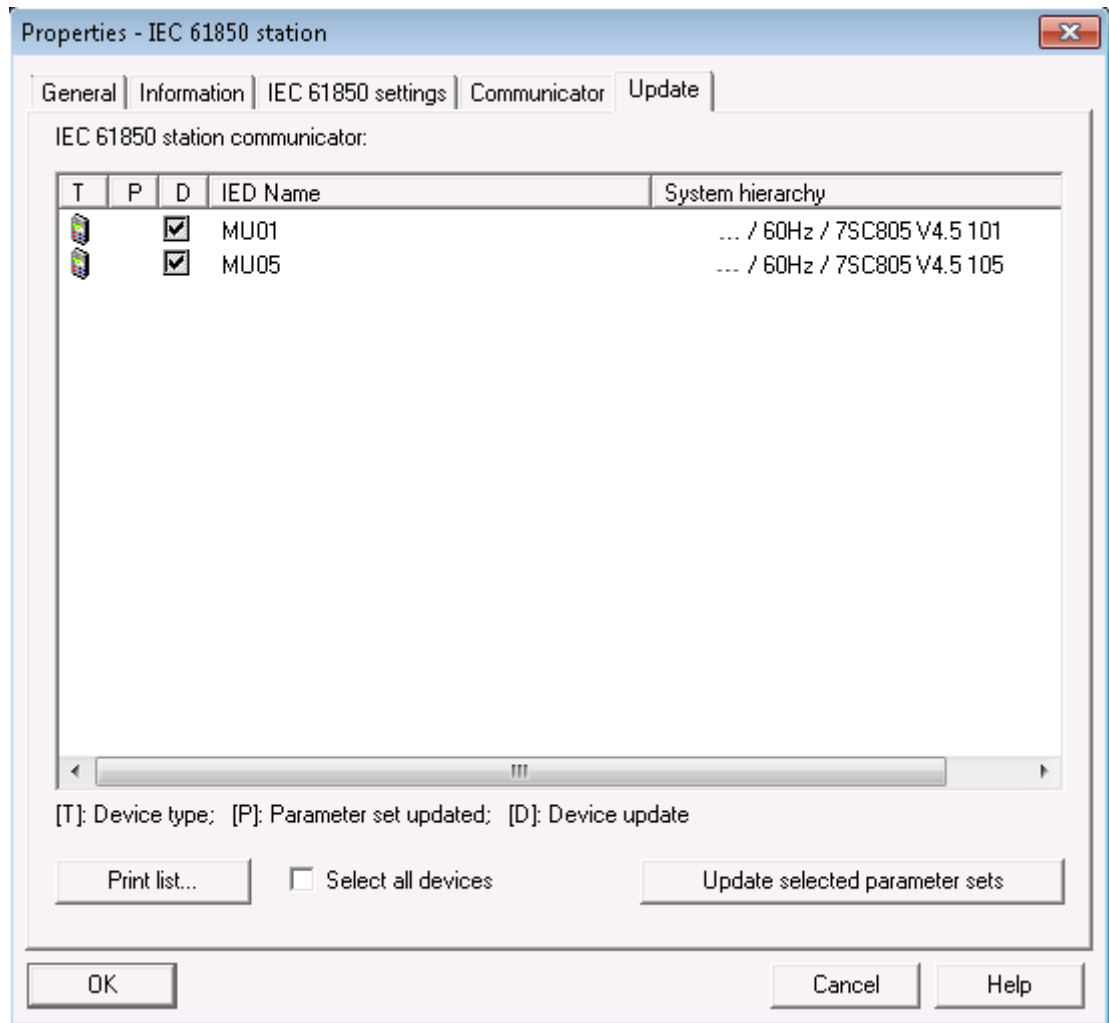
- ✧ Click **OK**.

In the **Measuring-points routing** Editor, you can see from which merging unit and from which channel or TCTR/TVTR the signal is sent.

Importing CID Files in DIGSI 4 for SIPROTEC 4 Merging Unit

- ✧ Right-click the IEC 61850 station in DIGSI 4 and select **Object Properties...**
- ✧ Go to the **Update** tab.

(The check boxes of the MUs with changes are checked automatically.)



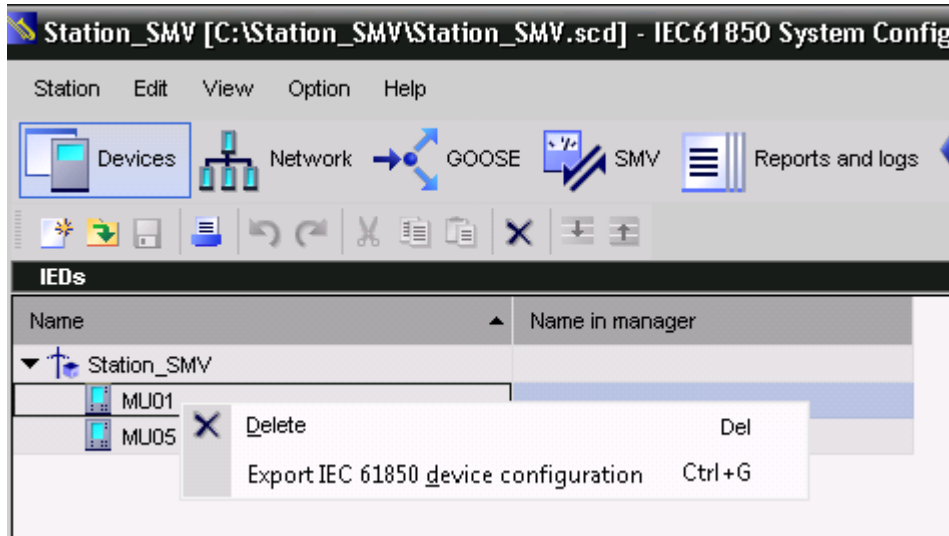
[sc_DIGSI4_Update_tab, 1, ...]

Figure 2-51 Update Tab

- ✧ Click **Update selected parameter sets** and then click **OK**.

Exporting CID Files for Third-Party Devices

- ✧ Go to the **Devices** view in the IEC 61850 System Configurator.
- ✧ Right-click the IED (for example, **MU01** in the following figure) and select **Export IEC 61850 device configuration**.



[sc_SystemConfigurator_Export_IEC_deviceconfig, 1, ...]

Figure 2-52 Exporting to CID File

- ✧ Select a storage path for the CID file and click **Save**.

2.2.4 Import of SCD File from Third-Party IEC 61850 System Configurator

This chapter describes the import of an SCD file from a third-party IEC 61850 System Configurator.

2.2.4.1 Preparing and Starting the Import

Before importing data, you must decide if you wish to import the data into an individual SIPROTEC 5 device or into the project. You can select from various data formats depending on the decision you have made. For instance, the **ELCAD** format can be used to import entire projects, while the **DSP5** format can be used only for a single SIPROTEC 5 device.

First select the import file with a file dialog.

An import dialog then provides you with the following information about the selected file:

- **Date**
This field shows the date and the time when the data was exported.
- **Comment**
This field shows any comment, which was added during the export.
- **Contains**
This field gives an overview of the data contained in the file. It shows individual data categories, for example, **Primary topology** or **Routings**.
- **Target**
This field shows the target of the import, that is, the name of the project or of a SIPROTEC 5 device.

For some data formats, the import dialog offers you additional import options which you can configure. You can also select a different import file with the import dialog.

Selecting the Import File

- ✧ Right-click the device name in the project tree to import data into a specific SIPROTEC 5 device.
- or -
- ✧ Right-click the project name in the project tree to import data into an entire project.

In both cases, the context menu opens.

- ✧ In the context menu, click **Import**.

The default file dialog **Select import file** opens.

- ✧ Select the desired import file with this dialog.
- ✧ Click **Open**.

The default file dialog **Select import file** closes. The **Import** dialog opens.

Selecting a Different Import File

- ✧ The name and the path of the currently selected import file are displayed in the text box **File**. To open a different import file, click the ... button.

The default file dialog **Select import file** opens again.

- ✧ Select the desired import file with this dialog.
- ✧ Click **Open**.

The default file dialog **Select import file** closes. The information displayed in the dialog **Import** is updated.

Configuring the Import

- ✧ If you have selected one of the formats **SEQ5**, **TEA-X**, **TCF**, **DSP5**, **SCD**, or **UAT**, the prompt **Import contents** appears. Click on this prompt.

Additional options or settings will be displayed. These depend on the selected import format.

- ✧ You can configure the import with these options and settings. You can learn more about this in the following topic descriptions in this Help document.

Starting the Import and Checking the Result

- ✧ Click **Import**.

The import starts. If data which does not have an obvious connection to the import will be overwritten during the import, you receive a prompt for confirmation.

- ✧ To overwrite the existing data with the new data and to continue the import process, click **Yes**.

Status reports will show the progress of the import. As soon as the import is complete, the **Status** dialog opens.

- ✧ Click **OK**.

The status dialog closes.

2.2.4.2 Configuring the SCD Import

When you import data in SCD format, you can show additional import options in the **Import contents** field of the dialog **Import**.

You can import SCD files using the  icon in the toolbar of the **IEC station** Editor or using the IEC station context menu **Import changes from IEC 61850 System Configurator** in the project tree. For a successful import of the IEC 61850 file, the status of the following parameters is checked and displayed in the **Importing** dialog:

- Validating XML structure
- Validating against schema
- Validating IEC 61850 Edition
- Checking consistency
- Resolving GOOSE references

In case of any errors or warnings, specific error messages are displayed. You must resolve these issues to proceed further.



NOTE

Using the  **Import** in the **Project** menu or  in the **DIGSI 5 toolbar**, you can import any SCD file which is not created by the IEC 61850 System Configurator tool. If you import an SCD file manually with this option for any IEC station that is already associated with an IEC 61850 System Configurator project, the association and the existing configuration is lost. If the imported SCL file is of unknown edition, a dialog appears with the respective message. Click **Yes** to proceed with the conversion to the latest edition.

Selecting SIPROTEC 5 Devices for Import

- ✧ To select or deselect a SIPROTEC 5 device, click the relevant check box in the **Devices to import** list box.
- or -
 - ✧ To select or deselect all SIPROTEC 5 devices, click the **Select all** check box in the **Devices to import** list box.
-



NOTE

If a check box is marked, the corresponding SIPROTEC 5 device is selected for import. At least one SIPROTEC 5 device must be selected to start the import.

Specifying the Processing of the Device Data

- ✧ Click the desired option **Create as new device(s)** or **Update matching device(s)**.

Importing SCD via IEC 61850 Station

- ✧ Double-click the **IEC stations** folder in the project tree.
- ✧ Right-click any IEC station (for example, IEC station 1) that is already associated with the IEC 61850 System Configurator project.
- ✧ Click  **Import changes from IEC 61850 System Configurator** from the context menu.
- or -
- ✧ Click  from the **IEC station Editor**.

A confirmation prompt appears.

- ✧ Select the desired option to start importing.

Creating a New Device via SCD Import

- ✧ Select any IEC station in the project tree.
- ✧ Select  **Import** in the **Project** menu.
- or -
- ✧ Select  in the **DIGSI 5 toolbar**.

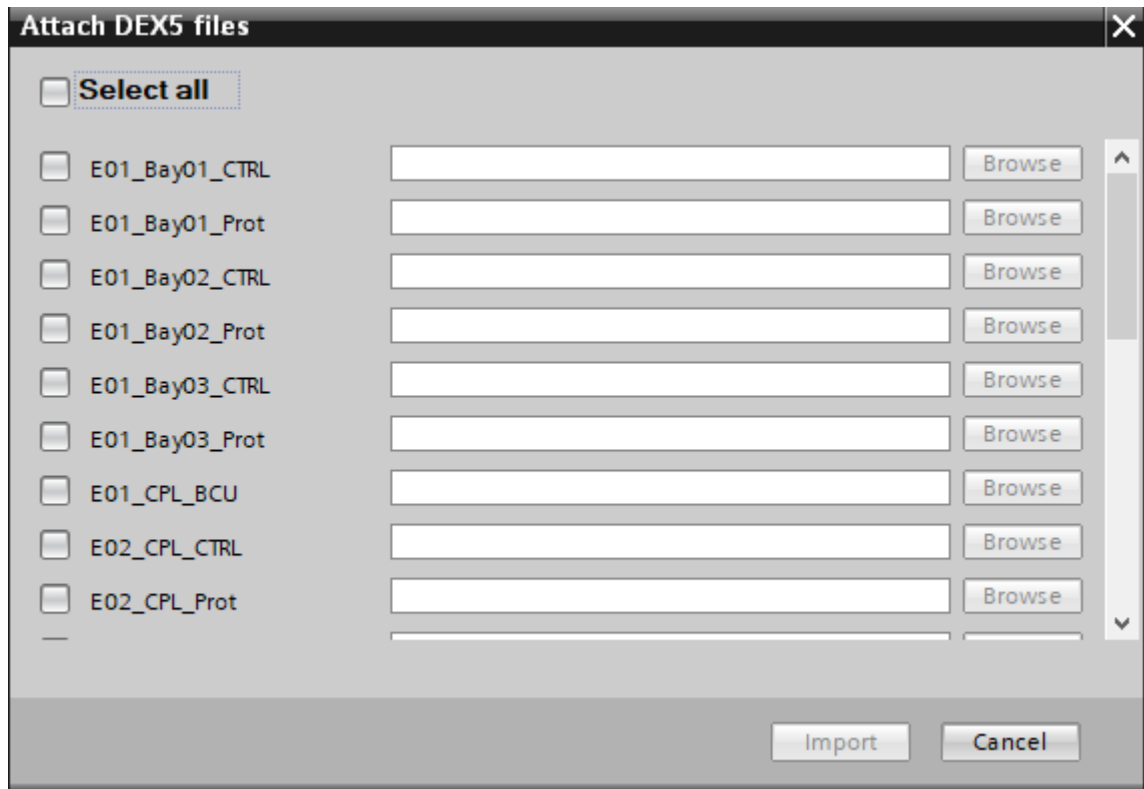
The **Select import file** dialog opens.

- ✧ Select the desired SCD file created using the ICD typical (created using an ICD and a DEX file). For more information, refer to **Configuring ICD export** in the *DIGSI Online Help*.
- ✧ Click **Open**.

The **Import** dialog appears.

- ✧ In this dialog, click **Attach DEX files....**

The Attach DEX5 files dialog appears displaying the devices available in the SCD file. Using the check box, you can select the desired device or group of typical devices, browse, and then select the desired DEX files for import.



[sc_digsi_attach_dex, 1, en_US]

- ✧ The **Import** dialog appears displaying the import status.
- ✧ Click **OK**.

The device is added successfully and displayed in the project tree.



NOTE

- The device name created for the imported device is based on the **Description** configured for the device in the IEC 61850 System Configurator.
- On importing the changes via the options **Import changes from IEC 61850 System Configurator** or **Import all devices from IEC 61850 Configurator**, the IP address of **Time source 1** and **Time source 2** displayed under **SNTP** settings is automatically assigned with the IP address of the primary and secondary clock master configured in the IEC 61850 System Configurator for the devices enabled with the IEC 61850 and SNTP protocols on the communication module and/or Port J.
- The IED is created in the newly created project group based on the substation configuration (Voltage level and the LPHD LNode configuration under the bay) in the IEC 61850 System Configurator.

2.3 Single-Line Configuration for Process-Bus System

The DIGSI 5 Single-Line Editor, with the IEC 61850 System Configurator software from Siemens, allows an automated assignment of sampled measured values from the publishing merging units to the subscribing protection devices.

To allow the IEC 61850 System Configurator to assign the sampled measured values automatically based on the information in the DIGSI 5 Single-Line Editor, it is necessary to model the substation with the single-line elements which create the topology of the substation as the basis for the automated assignment of the sampled values.

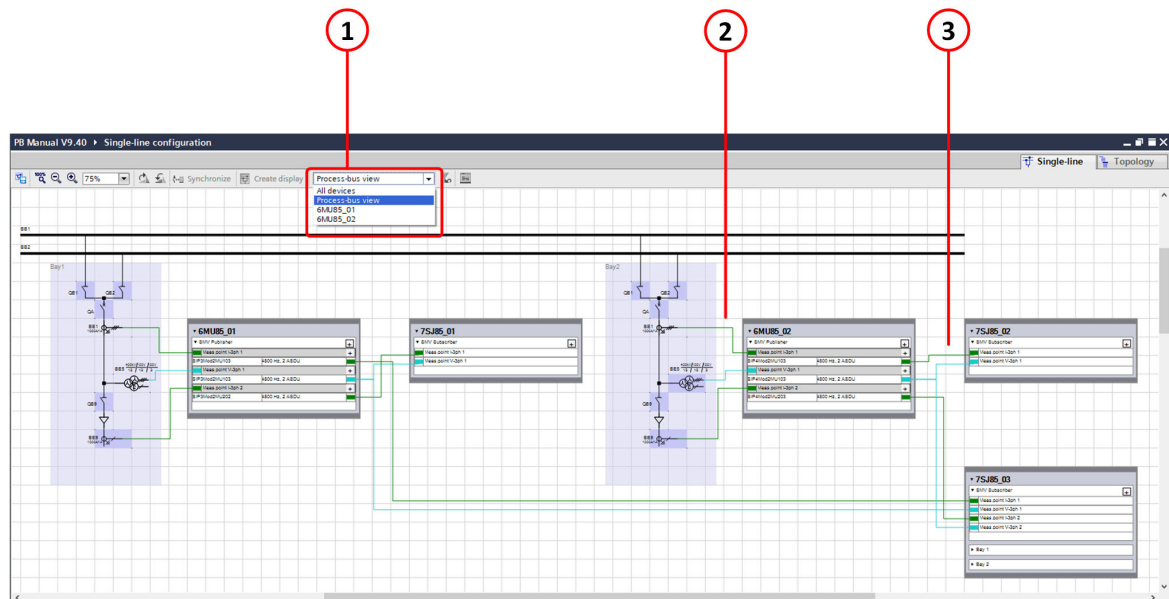
This allows an efficient process-bus configuration of the following tasks:

- Connecting topological devices (current and voltage transformers) to the measuring points of SMV streams in the SMV Publisher (functionality **Merging Unit**)
- Connecting the measuring points of an SMV stream to the measuring points of the SMV Subscriber (functionality **PB Client**)
- Managing the measuring points for the SMV Subscriber
- Automatic creation of SMV subscriptions using the Siemens IEC 61850 System Configurator

The Single-Line Editor offers the following filter capabilities.

Selected Filters	Description
All devices	No filter is used and all devices are visible.
Process-Bus view	Only devices with the functionality Merging Unit and/or PB Client are visible. The content of the device UI blocks is reduced to the UI blocks SMV Subscriber and SMV Publisher .
List of Merging Units	Only the selected device with functionality Merging Unit and the linked devices with functionality PB Client are visible. The content of the device UI blocks is reduced to the UI blocks SMV Subscriber and SMV Publisher .

The filter type can be set via the list box at the top of the Editor window.

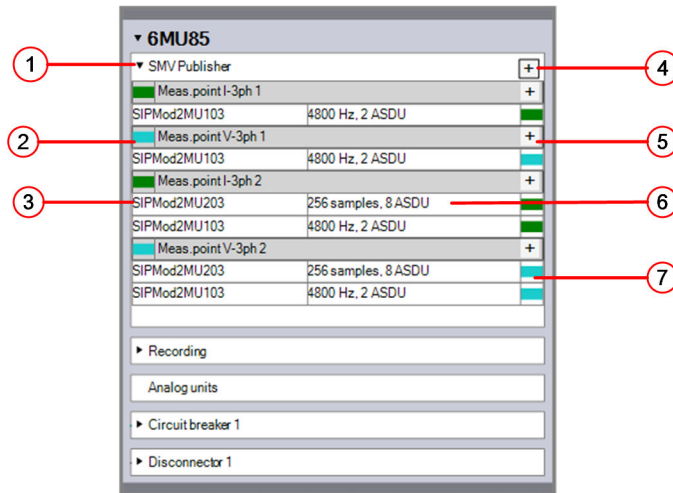


[dsw_SLE_filter_PB_view, 1, en_US]

- (1) List box to apply filters
- (2) Connection links to topological equipment, for example, current transformers and voltage transformers
- (3) Connection links between SMV Publisher and SMV Subscriber

2.3.1 SMV Publisher Block

For devices with enabled **9-2 Merg.unit** protocol, a UI block **SMV Publisher** is displayed in the single-line diagram configuration. The **SMV Publisher** displays the SMV streams grouped by the routed measuring points. Each measuring point displayed in the **SMV Publisher** can be connected to the topology equipment. The connection between the topology equipment, such as current transformer and voltage transformer, and the measuring points is a one-to-one connection.



[sc_digsi_publisher, 3, en_US]

- (1) UI block **SMV Publisher**
- (2) Connection point of measuring point to the current transformer or voltage transformer
- (3) **SMV ID** of the streams publishing the measuring point. To access the settings of the stream directly in the Single-Line Editor, click the stream and go to the tab **Properties > Settings** in the **Inspector** window.
- (4) Shortcut to open the Editor **Merging unit routing** directly from the Single-Line Editor for adding new streams.
- (5) Opens the stream-selection dialog to assign a measuring point to a stream
- (6) Changing the properties of the SMV stream properties within the UI block **SMV Publisher**.
- (7) Connection point of the measuring point to connect to one or more **SMV Subscribers**.



NOTE

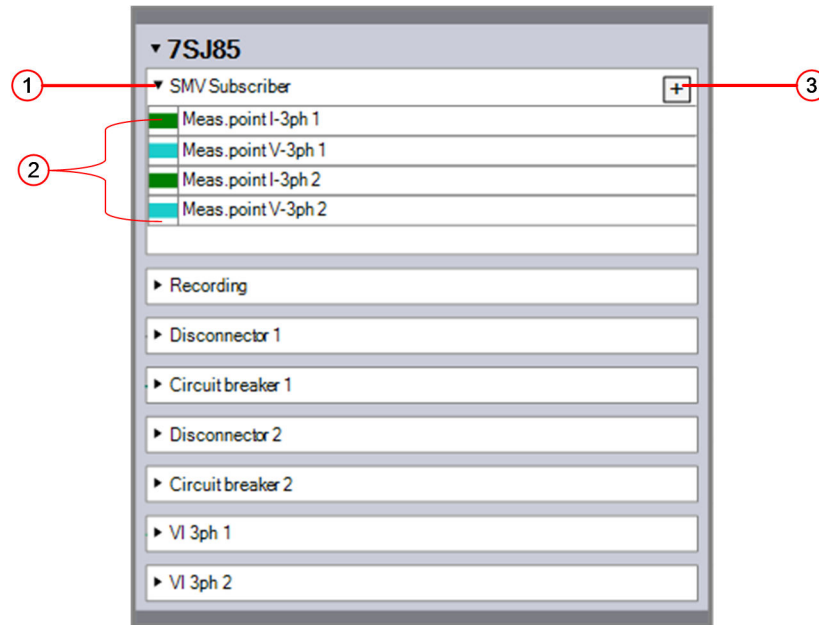
- The UI block **SMV Publisher** is displayed in the Single-Line Editor once you enable the protocol **9-2 Merg.unit**.
- If you delete the communication module in the tab **Hardware and protocols** editor (tab **Device view**), the UI block **SMV Publisher** is not displayed in the device single-line diagram anymore.
- In the Single-Line Editor, you can change the **Sampling-rate config** value by selecting from the available sampling rates.
- Measuring points routed from the **SMV Publisher** can be connected to several **SMV Subscriber** measuring points.
- Newly created SMV streams require measuring points to be assigned in the editor **Merging unit routing** to be displayed in the UI block **SMV Publisher**.

Click the icon + displayed next to the **SMV Publisher** and the dialog **Sampled value stream selection** appears. Click **Ok** if you wish to navigate to the Editor **Merging unit routing**. If you click the icon + displayed next to the measuring point in each row, the dialog **Sampled value stream selection** appears and displays the list of all the SMV streams available in the device.

The activated check boxes reflect the selection of the routed measuring points to the SMV streams. You can add or delete the routing between the measuring point and the SMV stream by selecting or unselecting the **SMV IDs** in the **Sampled value stream selection** dialog. Click **OK** to continue the process. Click **Cancel** if you wish to cancel the process. Click the **Merging-unit routing** Editor link if you wish to add an additional stream.

2.3.2 SMV Subscriber Block

For devices with enabled **9-2 Client** protocol, a UI block **SMV Subscriber** is displayed in the single-line diagram configuration. The **SMV Subscriber** displays all the measuring points which are routed to the column **PB Client** in the editor **Measuring points routing**. Each measuring point shown in **SMV Subscriber** can be connected to only one measuring point of an SMV stream from the **SMV Publisher**.



[sc_digsi_subscriber, 2, en_US]

- (1) UI block **SMV Subscriber**
- (2) Connection point of measuring points from a UI block **SMV Publisher**. To access the details of the subscription, click the measuring point and go to the tab **Properties > Settings** in the **Inspector** window.
- (3) Opens the dialog **Measuring-points routing** to selection and assign a measuring point to the **SMV Subscriber (PB Client)**



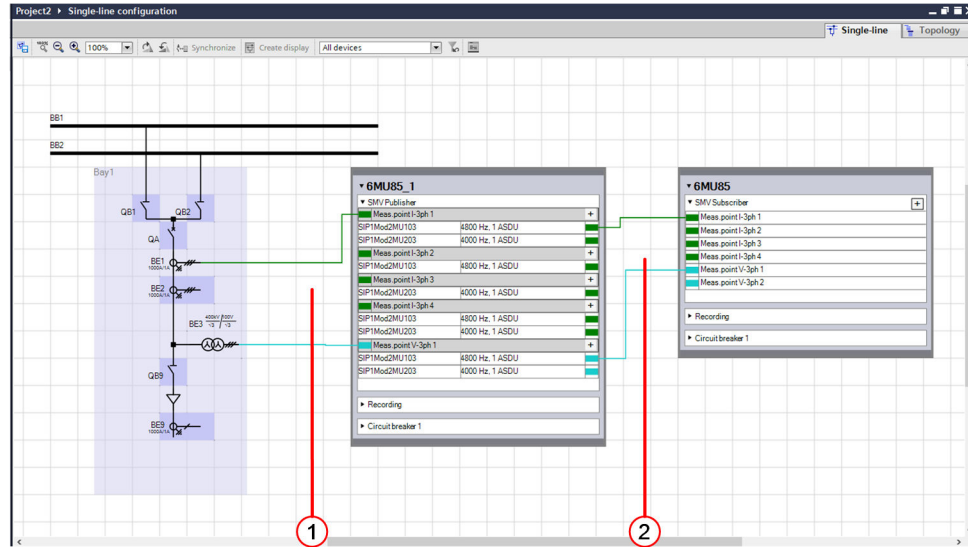
NOTE

- The UI block **SMV Subscriber** is displayed in SLE once you enable the protocol **9-2 Client**.
- If you delete the communication module in the tab **Hardware and protocols** editor (tab **Device view**), the UI block **SMV Publisher** is not displayed in device single-line diagram.

If you click the + icon in the upper right corner of the **SMV Subscriber** UI block, the **Manage sampled value subscriptions** dialog appears and displays the list of all the measuring points available in the device. The activated check boxes reflect the selection of the routed measuring points to the column **PB Client** in the editor **Measuring point routing**. You can add or remove the measuring point to subscribe by selecting or unselecting any current or voltage measuring points in the **Manage sampled value subscriptions** dialog. Click **OK** to continue the process. Click **Cancel** if you wish to cancel the process. Click the **Measuring-points routing** editor link if you wish to add an additional measuring point.

2.3.3 Connecting the SMV Publisher with the SMV Subscriber Measuring Points

To connect a measuring point from a UI block **SMV Publisher** (Merging Unit) to a UI block **SMV Subscriber** (PB Client), use your mouse and draw a line between the source (**SMV Publisher**) and destination measuring point (**SMV Subscriber**). Existing connections are represented as colored connection link between the measuring point of the **SMV Publisher** and the measuring point of the **SMV Subscriber**.



[sc_digsi_publisher_subscriber, 1, en_US]

- (1) Connection links to topological equipment. For example, current transformers and voltage transformers.
- (2) Connection links between **SMV Publisher** and **SMV Subscriber**



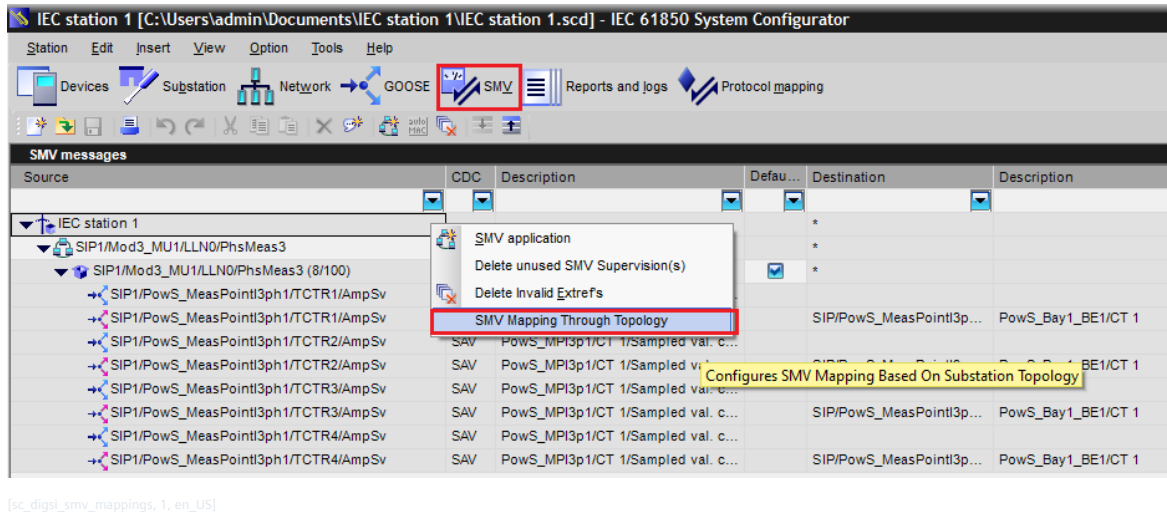
NOTE

- To delete a connection link, right-click the connection link and select **Delete**.
- To adjust the route of the connection link, click the connection link and move the parts of the line as desired.

2.3.4 Automatic SMV Mapping in IEC 61850 System Configurator

Follow the steps described in [2.2.3 IEC 61850 System Configurator](#):

- ✧ Add and configure a new IEC 61850 station.
 - ✧ Assign devices to the IEC 61850 station.
 - ✧ Open the IEC 61850 station.
 - ✧ Assign the access points to the according networks.
- Instead of the manual interconnection of the sampled measured values from the publisher to the subscriber devices, follow the steps described in the following sections to create the automatic mapping of SMV using the topological information from the single-line configuration.
- ✧ Open the SMV editor in the IEC 61850 System Configurator.
 - ✧ Right-click the station and select **SMV Mapping Through Topology** from the context menu for automatic subscriber mapping.



- ✧ Save the station and import the changes from IEC 61850 System Configurator to DIGSI 5.

The resulting configuration of the SMV subscription can be seen in:

- ✧ Single-line configuration editor (click the measuring point, then, in the **Inspector** window, go to the tab **Properties** > group **Details** > section **Received via Process Bus**)

- Or -

- ✧ The **Measuring-point routing** editor (click the measuring point, then, in the **Inspector** window, go to the tab **Properties** > group **Details** > section **Received via Process Bus**).

For more information about online SLE monitoring, refer to the *DIGSI Online Help*.

3 Synchronization

3.1	Sample Synchronization	98
3.2	Sample Synchronization Using IEEE 1588v2/PTP	103
3.3	Sample Synchronization Using PPS or IRIG B	111

3.1 Sample Synchronization

In order to align sample positions of local analog channels with channels subscribed via process bus in a process-bus client, the client needs also a timing reference provided via the IEEE 1588v2/PTP protocol, Pulse per Second (PPS), or IRIG B (as explained in [3.3 Sample Synchronization Using PPS or IRIG B](#)).

Sampled values (SV) in any device must be aligned to a common time for all channels.

In process-bus applications, SV streams from different merging units are subscribed in a process-bus client.

For the sample synchronization IEEE 1588v2/PTP is defined in the IEC 61850-9-2 standard, IEC 61850-9-2 LE allows also a synchronization using PPS (Pulse per Second).

For more information on the supported PTP profiles, refer to the *SIPROTEC 5 Communication Protocols* manual.

The IEEE 1588 precision time protocol in the process-bus client is required for the alignment of SV sampling positions over different subscribed streams from various merging units. In order to align sample positions of local analog channels with channels subscribed via process bus in a process-bus client, the client needs also a timing reference provided via the IEEE 1588 PTP protocol. SIPROTEC 5 supports the IEEE 1588 profiles IEC 61850-9-3 (PTP power utility profile) and IEEE C37.238-2017 (PTP Power Profile).

The SIPROTEC 5 Merging unit functionality uses the common time base provided by the PTP protocol for SV sampling position alignment as defined in the IEC 61850-9-2 standard. SIPROTEC 4 Merging Unit (6MU805) uses either PPS or a GNSS signal for the sampling position alignment.



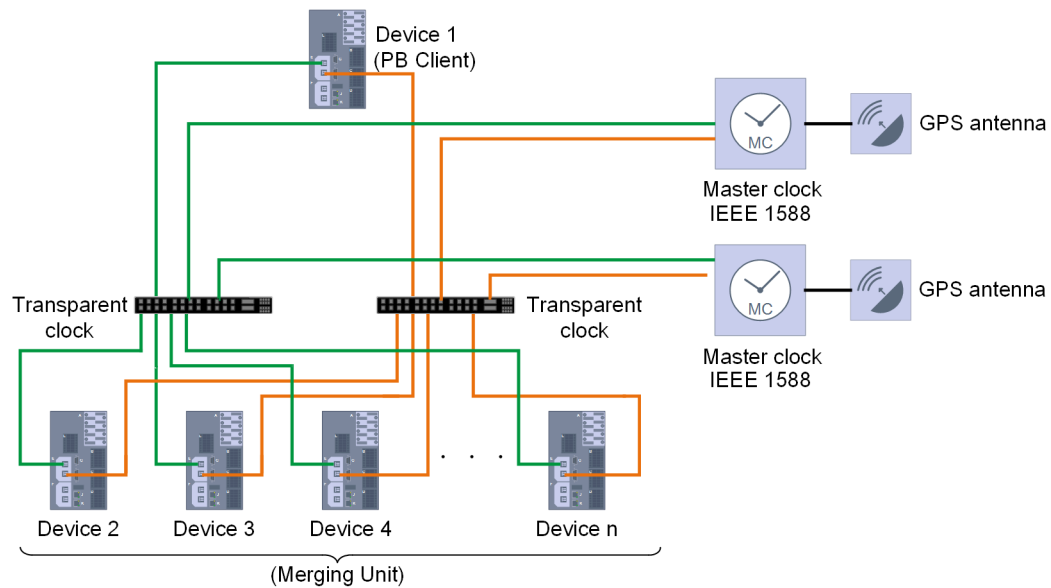
NOTE

The indication on high accuracy from the IEEE 1588v2/PTP protocol is not relevant for process-bus applications.

As the synchronization state of sampling positions of signals subscribed via process bus depends on the interoperation of multiple devices, synchronization can fail and must therefore be supervised. In order to get synchronized samples, the following preconditions must be fulfilled:

- Merging units and clients involved in a process-bus configuration must be synchronized by the same master clock.
- Merging units must send an SMV stream with samples synchronous to this clock.
- The client must receive stream with synchronized samples.

Methods for detecting and handling of unsynchronized samples in a process-bus client depend on the used network topology and on the properties of the subscribed merging units. The following figure shows a simple topology example using 2 double attached PTP grandmaster clocks in a PRP process-bus subnetwork:



[dw_simple topology-e-g_2-PTP-masterclock_1-PRP process-bus, 2, en_US]

Figure 3-1 PRP Process-Bus Subnetwork with 2 PTP Grandmaster Clocks

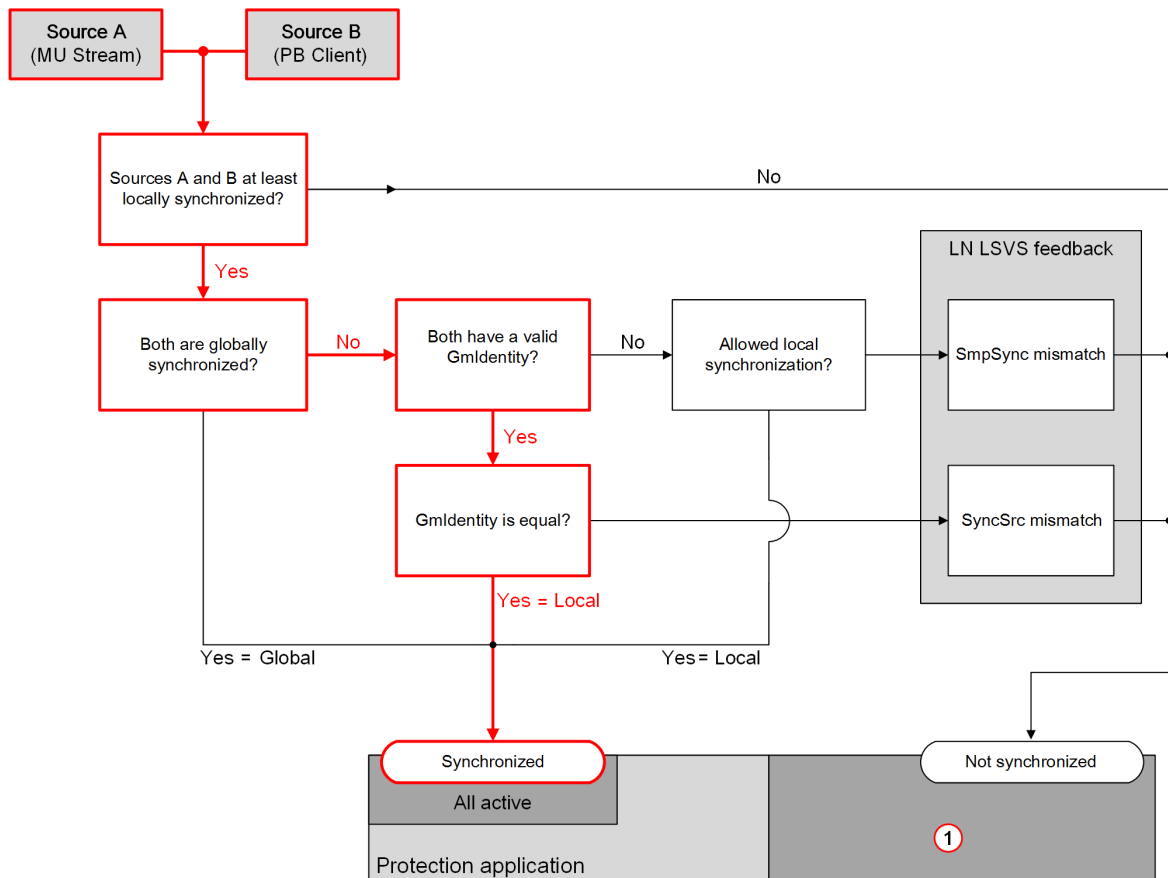
Siemens recommends using at minimum 2 independent master clocks in order to fulfill the N-1 criteria. Additional ETH-BD-2FO modules in a SIPROTEC 5 device can be interconnected to further subnetworks. Only one ETH-BD-2FO module can be used for PTP synchronization.

If the SIPROTEC 5 merging unit is not synchronized after startup, it will send a stream with SmpSynch = 0 until the synchronization is available.

For the shown example topology, the following 2 cases of synchronization handling must be distinguished:

- The merging units support IEC 61850 Ed. 2.1:
In this case, a merging unit can send the grandmaster clock ID of the PTP master clock used for synchronization of samples in the merging-unit stream. A client can observe the synchronization source of a merging-unit stream and compare this grandmaster clock ID with the ID used for the synchronization of the client. If IDs are matching, a SIPROTEC 5 client can align samples from the merging-unit stream with locally sampled channels. Samples can also be aligned, when clock IDs are different, but both clocks (as seen by the merging unit and the client) are sufficiently synchronized for a globally synchronized state. In all other cases, the process-bus client marks received samples as unsynchronized (because realignment of received streams to local samples fails in cases of different clocks).

The red path in the following figure indicates the case of SmpSync = 1 with identical grandmaster ID:



[dw_diagram_SmpSync_2_en_US]

Figure 3-2 Alignment of Samples with IEC 61850 Edition 2.1

- (1) Most protection applications are blocked except basic backup portection functions which do not mix signals, for example, the non-directional overcurrent protection function.



NOTE

For more information on the behavior of the major protection functions, refer to [7 Technical Data](#).

- The merging unit sends only IEC 61850 Ed. 2.0 or IEC 61850-9-2 LE streams.
In this case, a merging unit sends only the synchronization state:

- 0: not synchronized
- 1: synchronous to a non time-traceable PTP clock
- 2: synchronous to a traceable PTP clock

If both client and merging unit are synchronized with a traceable clock, a SIPROTEC 5 client can align samples to locally sampled channels and received streams are treated as synchronized.

If either the client or the merging unit is synchronized with a non-traceable clock, there is no knowledge of common time reference. Therefore, the samples cannot be aligned and the protection functionality is blocked.

To achieve the knowledge of common time reference and prevent blocking of the protection functionality, the following scenarios are possible:

- A maximum of 1 IEEE 1588 time source is available in the network.
- The common time source is achieved by means of network engineering and parameterization of the clock source.

In both cases, in the section **9-2-Client Setting**, you can set the **Accepted SmpSynch** to **1** (local).

If all of the following conditions are fulfilled, a common time source in a redundant network can be achieved:

- PTP clocks assigned to the corresponding subnetwork have different **priority 1** settings, so that the **ClockAccuracy** is ignored for the best master clock algorithm.
- The clock with the highest priority has the longest hold-over time.
- Both clocks are GNSS-controlled or the clock with the highest priority is a rubidium clock.



NOTE

In case of some network double-fault scenarios, the selected clocks can still be different which could lead to wrong synchronization. Siemens recommends using IEC 61850 Ed. 2.1, if possible. This allows to provide the synchronization source with the sampled-values stream and prevent maloperation in such cases.

Holdover

Holdover is the ability of the device to maintain synchronized condition while the sample synchronization source becomes unavailable or is switching the time base.

Synchronization Source becomes Unavailable

The internal oscillator inaccuracy is considered, so that the holdover duration can extend to up to 26 s, depending on the previous synchronization quality.

Synchronization Source is Switching the Time Base

The holdover duration is sufficient to drive through the clock class change of the connected grandmaster clock. In many cases this is possible without the need to switch to unsynchronized conditions and consequently block protection functions.

Holdover Disable

For backward compatibility scenarios, it might be necessary to switch to unsynchronized conditions and block protection functions more strictly, for example

- SynchSrcId is not available for some streams
- the process bus subscriber cannot evaluate SynchSrcId

Otherwise in ambiguous situations synchronization sources with different time bases could not be distinguished in the process-bus client and therefore an unwanted tripping could occur. By setting **Holdover** to

Disable you can ensure dropping out to SmpSynch = 0 within 3 s after the time base change was detected. If the difference is greater than 4 μ s compared to the previous time base, a time-base change is detected. After such a drop out the SmpSynch = 0 condition is held for at least 10 s, so that all merging units and process-bus clients have enough time to synchronize to the new time base.

Time configuration

General

Date format: DD.MM.YYYY

Time source

Time source 1: none

Sync. latency time src.1: 0.00 μ s

Time zone time source 1: local

Time source 2: none

Sync. latency time src.2: 0.00 μ s

Time zone time source 2: local

Fault indication after: 600 s

Time zone and daylight saving time

Time zone offset to UTC: 60 min

Switch daylight sav. time: ☒

Start of daylight sav. time: Last Sunday in Mar

End of daylight sav. time: Last Sunday in Oct

Offset daylight sav. time: 60 min

Sample Synchronization

Pulse per second (Port G)

Sync. latency PPS: 0.00 μ s

Assumed SmpSynch: global

Sample Synchronization

Holdover: Disable

[sc_samsync-210618, 1, en_US]

Figure 3-3 Sample Synchronization

3.2 Sample Synchronization Using IEEE 1588v2/PTP

3.2.1 General Configuration

Activation of the IEEE 1588v2/PTP Precision Time Protocol

The SIPROTEC 5 process-bus client and merging-unit functionality requires the synchronization with IEEE 1588v2/PTP or Pulse per Second (PPS) to be able to operate.

Activate the IEEE 1588v2/PTP protocol in SIPROTEC 5 devices by selecting the PTP protocol in the **Properties** window of the **Hardware and Protocols** Editor in DIGSI 5.

- ✧ Open the **Hardware and protocols** Editor of the device.
- ✧ Select the ETH-BD-2FO module.
- ✧ In the **Inspector window > Properties**, go to **Protocols > Network** and check **IEEE 1588**.
- ✧ Go to **Settings > IEEE 1588 settings**.

Device Operates as Ordinary Clock Slave Only (OSCO)

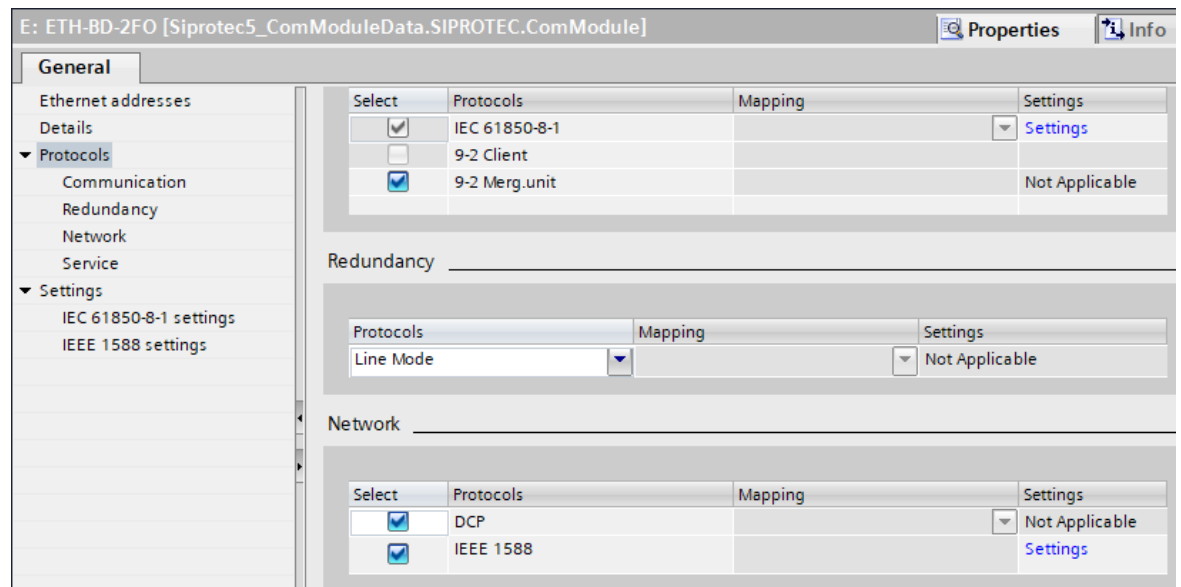
This workflow is used to synchronize with an external IEEE 1588v2/PTP grandmaster-capable clock.

Set the following parameter according to the IEEE 1588 grandmaster clock settings:

- ✧ Select the check box **Slave only**.

The resulting clock type is selected automatically depending on the configured network redundancy.

- ✧ Select the **Profile**:
IEC 61850-9-3 or C37.238:2017, depending on the IEEE 1588v2/PTP profile used
- ✧ Select the **Domain number**:
OCGC, MUs, and PB clients of the same network must be configured with the same domain number.



[sc_IEEE1588_MU, 1, en_US]

Figure 3-4 Selecting the IEEE 1588 Protocol for a Module



NOTE

A maximum of 1 instance of OSCO on the ETH-BD-2FO modules per device is allowed.

Device Operates as Ordinary Clock Grandmaster-Capable (OCGC)

This workflow is used if the SIPROTEC 5 device must act as a grandmaster-capable clock. This enables a free running grandmaster-capable clock on the ETH-BD-2FO Ethernet plug-in module, which is based on the device-internal oscillator. You can activate the grandmaster-capable function on more than one ETH-BD-2FO module of a device. The internal oscillator ensures that the multiple instances are operating synchronously. The best master clock algorithm is supported for the use with other SIPROTEC 5 devices with activated OCGC or external grandmaster-capable clocks.

Set the following parameter according to the IEEE 1588 grandmaster clock settings:

- ✧ Set the **Clock type** to **OC grandmaster-capable**.
- ✧ Set the **Profile** to **IEC 61850-9-3**.
- ✧ Select the **Domain number**.
OCGCs, MUs, and PB clients of the same network must be configured with the same domain number.
- ✧ Set the parameters **Clock priority 1** and **Clock priority 2**.
- ✧ To avoid the time jump that can cause slave clocks to resynchronize and protection functions to be temporarily blocked when a master clock returns, activate the parameter **Seamless changeover**.
For more information, refer to [2.1.4.3 Configurations for Seamless Changeover](#) and to the *SIPROTEC 5 Communication Protocols manual*.

If multiple physical Ethernet networks must be synchronized by a SIPROTEC 5 device, the grandmaster-capable clocks (OCGC) cannot be distributed across multiple SIPROTEC 5 devices to ensure synchronization among the OCGC instances. For more application and setting notes, refer to [3.2.2.2 Multiple OCGC in the Same Device](#).

For more application and setting notes, refer to [3.2.2.3 Multiple OCGC in the Ethernet Network – Best Master Clock Algorithm \(BMCA\)](#).



NOTE

The IEEE C37.238:2017 profile is not supported by the grandmaster-capable clock (OCGC).



NOTE

If external grandmaster-capable clocks are in the same PTP domain, the functionality **Seamless changeover** must not be activated.

For further information on how to use IEEE 1588v2/PTP, refer to the *SIPROTEC 5 Communication Protocols manual*.

3.2.2 General Application and Setting Notes

3.2.2.1 Use of OCSO and OCGC in the Same Device

In a SIPROTEC 5 device, an OCSO, for example, a station-bus network, is configured on one ETH-BD-2FO and an OCGC, for example, a process-bus network, is configured on a 2nd ETH-BD-2FO. The OCGC is used by default for synchronization of the samples. The OCSO can be configured to be used for date and time synchronization.

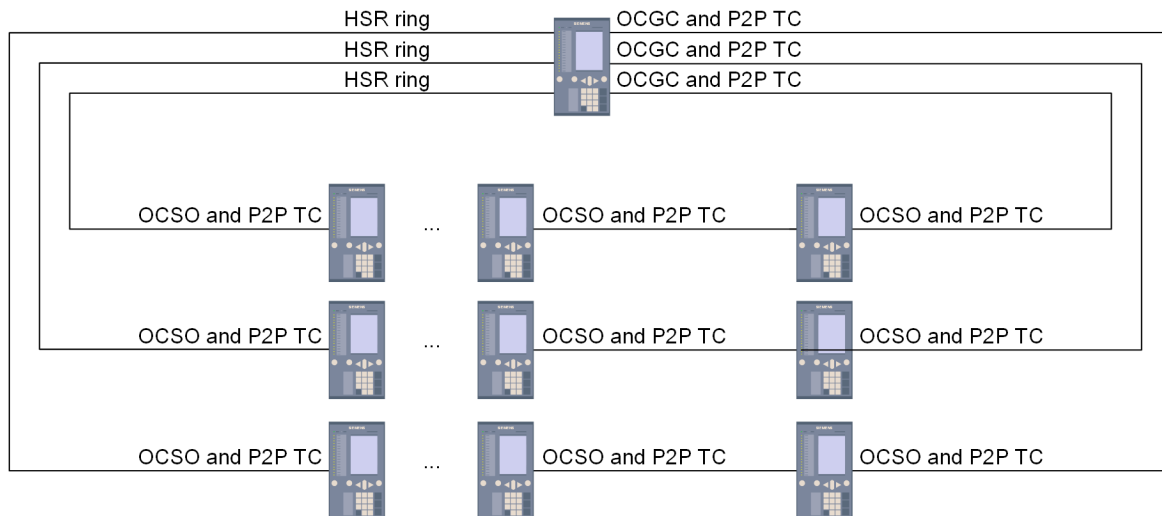


NOTE

If an OCGC is configured on one ETH-BD-2FO for the station-bus network (Siemens recommends using ETH-BA-2EL or ETH-BB-2FO and not ETH-BD-2FO for a station bus) and date and time synchronization, you must not configure an OCSO on a 2nd ETH-BD-2FO for the process-bus network. For more information, refer to the COM user manual *Time Source Configurations of the IEEE 1588 Protocol*.

3.2.2.2 Multiple OCGC in the Same Device

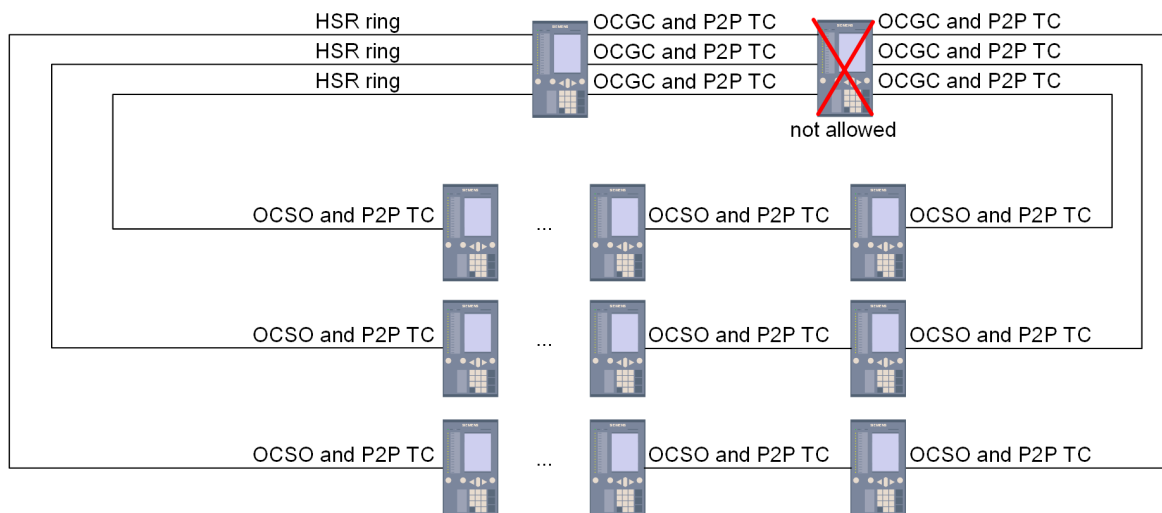
It is possible to use multiple instances of the OCGC in a single SIPROTEC 5 device to use centralized sampling synchronization of multiple physically separated Ethernet networks. For example, the distributed busbar protection can synchronize all bay/merging units connected via HSR networks, see [Figure 3-5](#). Each of these HSR rings can contain a maximum of 16 bay/merging units plus 2 RedBoxes and the central device with the OCGC.



[dw_HSRB_example_OCGC_HSR_rings, 1, en_US]

Figure 3-5 IEEE 1588 Time Synchronization via HSR Rings, Using SIPROTEC 5 as the Grandmaster-Capable Clock

If several grandmaster-capable clocks are used in one device, no other grandmaster clocks are allowed in these networks. [Figure 3-6](#) shows such a non-allowed configuration.

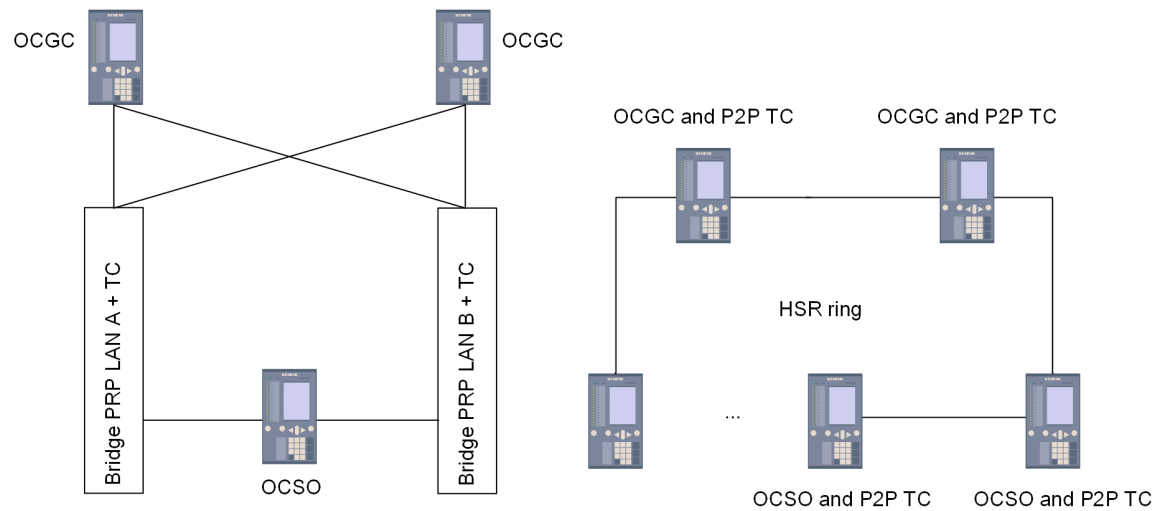


[dw_HSRB_example_OCGC_HSR_rings_not_allowed, 1, en_US]

Figure 3-6 Not Allowed Configuration: Several OCGC in a Single Device and Additional OCGC in the Ethernet Networks

3.2.2.3 Multiple OCGC in the Ethernet Network – Best Master Clock Algorithm (BMCA)

For the use of multiple SIPROTEC 5 OCGCs in an Ethernet network, the best master clock algorithm (BMCA) is used between the multiple OCGCs. [Figure 3-7](#) shows example network configurations for a PRP and HSR network.



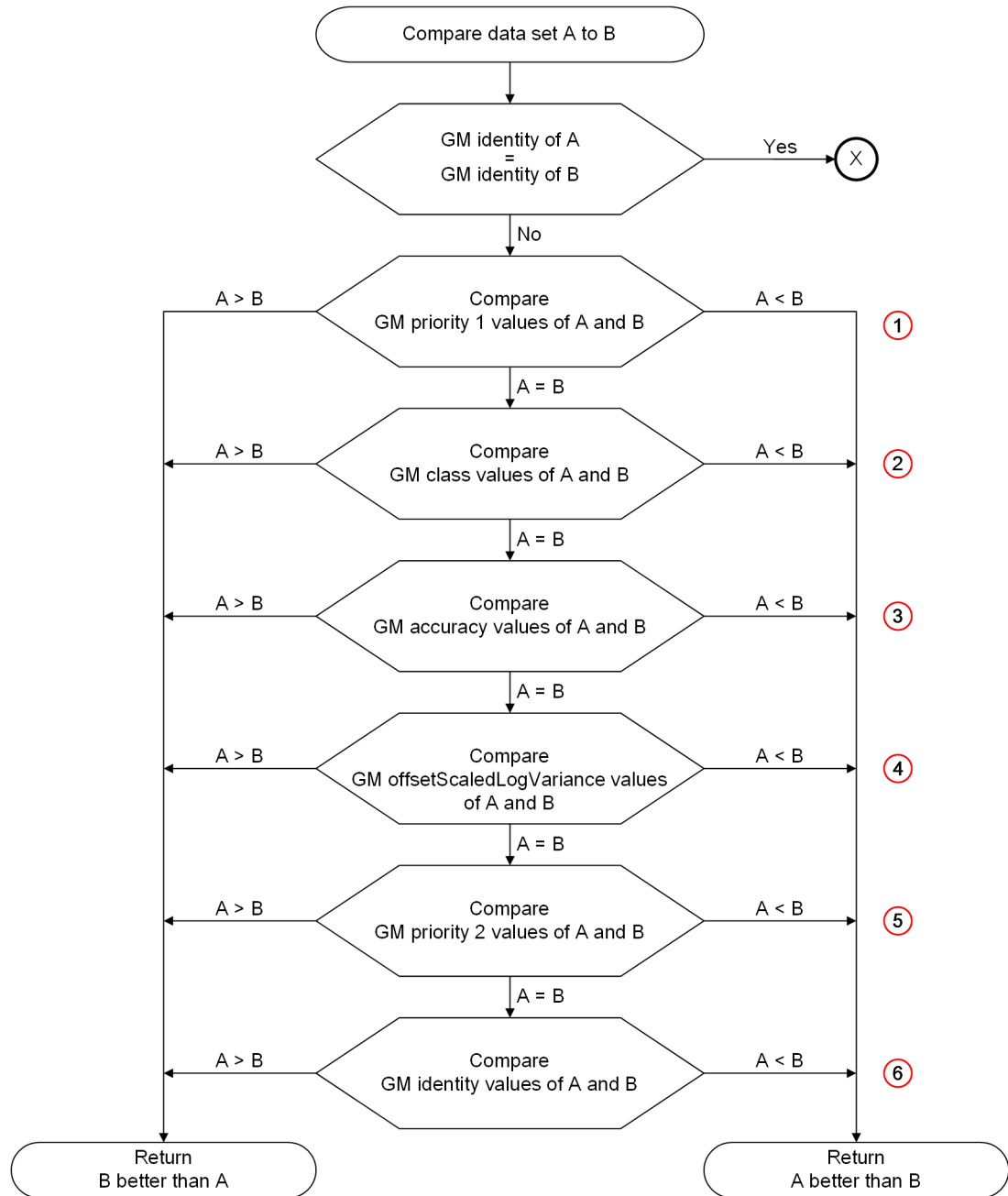
[dw_PRP_HSR_example_multiple_OCGCs, 1, en_US]

Figure 3-7 Example Network Configurations of Multiple SIPROTEC 5 OCGCs in a PRP or HSR Network

Such a configuration requires special care when configuring the OCGC and PB client devices (SMV subscribers) to allow correct operation with the least possible blocking of protection.

IEEE 1588v2/PTP OCGC Setting

Siemens recommends adjusting either the default settings of **128** for **Clock priority 1** or **Clock priority 2** to allow a controlled behavior of the BMCA. [Figure 3-8](#) shows the decision tree of the BMCA and the possible influence of settings in the device. Only **Clock priority 1** and **Clock priority 2** can be directly influenced by you. Siemens recommends using one of the 2 clock priorities to define an active master if all OCGCs are in operation.



[dw_BMCA_decision-tree, 1, en_US]

Figure 3-8 BMCA Decision Tree According to IEEE 1588

- (1) Priority 1: Configurable by DIGSI 5
- (2) Clock class = 248: Not configurable
- (3) GM accuracy = 254: Not configurable
- (4) Variance = 65 535: Not configurable
- (5) Priority 2: Configurable by DIGSI 5
- (6) GM identity = ETH-BD-2FO MAC address inserted with 0xFFFFE
(for example: MAC = B4:B1:5A:14:BA:A7 a GM identity = B4:B1:5A:FF:FE:14:BA:A7)

The graphic is taken from the IEEE 1588 standard from 2008.

With the parameter **Seamless changeover** activated, a recovered or reconnected grandmaster-capable clock first synchronizes to the current PTP grandmaster before it takes over the active master role. In this way,

the grandmaster switchback can avoid the jump in the time base which can result in slave-clock resynchronization and intermediate protection-function blocking in process-bus applications.

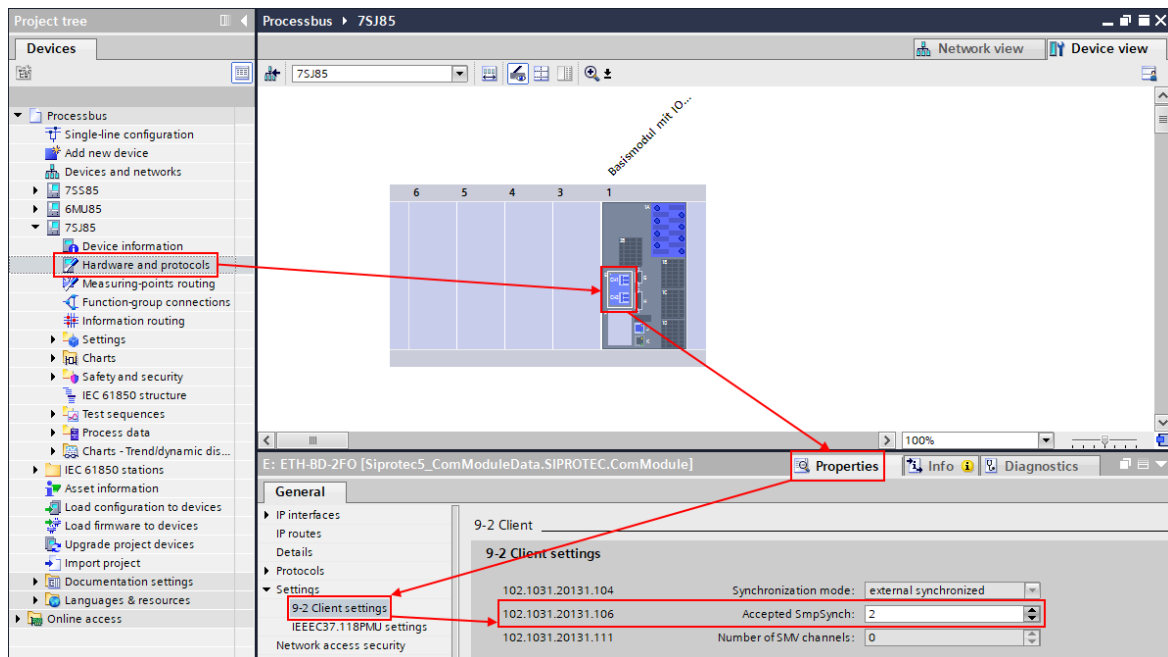
**NOTE**

If external grandmaster-capable clocks are in the same PTP domain, the functionality **Seamless change-over** must not be activated.

Process-Bus Client (SMV Subscriber) Settings

SIPROTEC 5 OCGC has a fixed clock class of 248. Therefore, the merging units synchronized by a SIPROTEC 5 OCGC publish their sampled measured values with **SmpSync** = 1. In order to prevent maltrip at synchronization mismatch while allowing normal operation, the parameter **Accepted SmpSync** must be set to **Accepted SmpSync** and **SynchSrcID** must be enabled in the Merging Unit. These settings ensure the usage of **SynchSrcID** in the Sample Synchronization Logic, see [Figure 3-2](#). Protection blocking during grandmaster switchover can be additionally prevented using the functionality Seamless changeover.

You can find the setting **Accepted SmpSync** in the device settings under **Hardware and Protocols**: Select the ETH-BD-2FO hosting the PB Client functionality and select **Properties** in the inspector window. Then, navigate in the settings to the PB Client. Set **Accepted SmpSync** to 2, which represents *global*. The sample synchronization source (SynchSourceID) must be set to **yes** under the SMV configuration using the IEC 61850 System Configurator.



[sc_accepted_smpsych_PBclient_2_en_US]

Figure 3-9 **Accepted SmpSync** Settings for PB Client

Functional Description of the IEEE 1588v2/PTP Best Master Clock without Activated Functionality Seamless changeover

	State	Device 1 with OCGC A Clock priority 1 = 127	Device 2 with OCGC B Clock priority 1 = 128	Protection in SMV Subscriber Devices
1	Device 1: Start up Device 2: Start up	Active Master	Backup Master in slave state (synchronized by OCGC A)	Operational as soon as SMVs are synchronized
2	Device 1: Operational Device 2: Operational	Active Master	Backup Master in slave state (synchronized by OCGC A)	Operational
3	Device 1: Out of service Device 2: Operational	Out of service	Active Master	SyncSrc. mism. can block the protection functions for up to 2 s
4a	Device 1: Return after 30 min Device 2: Operational	Active Master	Backup Master in slave state (synchronized by OCGC A)	Data delay errors caused by the conver- gence to OCGC A, will block the protection functions for up to 9 s.
4b	Device 1: Return after 2 hours Device 2: Operational	Active Master	Backup Master in slave state (synchronized by OCGC A)	Data delay errors caused by the conver- gence to OCGC A, will block the protection functions for up to 12 s.
4c	Device 1: Return after 15 hours Device 2: Operational	Active Master	Backup Master in slave state (synchronized by OCGC A)	Data delay errors caused by the conver- gence to OCGC A, will block the protection functions for up to 15 s.
5	Device 1: Operational Device 2: Operational	Active Master	Backup Master in slave state (synchronized by OCGC A)	Operational
6	Device 1: Warm reboot Device 2: Operational	Out of service	Active Master	SyncSrc. mism. can block the protection functions for up to 2 s
7	Device 1: Operational Device 2: Operational	Active Master	Backup Master in slave state (synchronized by OCGC A)	Data delay errors caused by the conver- gence to OCGC A, will block the protection functions for up to 15 s.

Functional Description of the IEEE 1588v2/PTP Best Master Clock with Activated Functionality Seamless changeover

	State	Device 1 with OCGC A Clock priority 1 = 127	Device 2 with OCGC B Clock priority 1 = 128	Protection in SMV Subscriber Devices
1	Device 1: Start up Device 2: Start up	Active Master	Backup Master in slave state (synchronized by OCGC A)	Operational as soon as SMVs are synchronized
2	Device 1: Operational Device 2: Operational	Active Master	Backup Master in slave state (synchronized by OCGC A)	Operational
3	Device 1: Out of service Device 2: Operational	Out of service	Active Master	Operational

	State	Device 1 with OCGC A Clock priority 1 = 127	Device 2 with OCGC B Clock priority 1 = 128	Protection in SMV Subscriber Devices
4	Device 1: Returns Device 2: Operational	Operates as slave clock to synchronize to OCGC B	Active Master	Operational
5	Device 1: Operational Device 2: Operational	Active Master (after reaching synchroniza- tion with OCGC B)	Backup Master in slave state (synchronized by OCGC A)	Operational
6	Device 1: Warm reboot Device 2: Operational	Out of service	Active Master	Operational
7	Device 1: Reboot finished Device 2: Operational	Operates as slave clock to synchronize to OCGC B	Active Master	Operational
8	Device 1: Operational Device 2: Operational	Active Master (after reaching synchroniza- tion with OCGC B)	Backup Master in slave state (synchronized by OCGC A)	Operational

For more information on how to activate the functionality Seamless changeover, refer to [2.1.4.3 Configurations for Seamless Changeover](#).

3.3 Sample Synchronization Using PPS or IRIG B

3.3.1 General Information

Besides the recommended sample synchronization using IEEE 1588v2/PTP, a synchronization using optical PPS (Pulse per Second) via the USART plugin-module, electrical PPS via Port G of the device, or IRIG B via Port G of the device can be used.



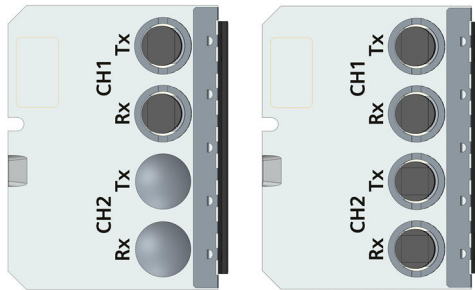
NOTE

If multiple options for sample synchronization (IEEE 1588v2/PTP, IRIG B, PPS), not date/time synchronization, are parametrized, the actual sample synchronization is used in the order of IEEE 1588v2/PTP (OCGC), IEEE 1588v2/PTP (OSCO), IRIG B, optical or electrical PPS.

3.3.2 Optical PPS using USART Plug-In Modules

3.3.2.1 Receiving of Optical PPS

A dedicated USART-AD-1FO or USART-AE-2FO plug-in module is required as interface to receive the optical PPS. The connection of the optical PPS signal must be applied on the Rx interface (ST connector) of the selected channel.



[dw_USART-AD-1FO_AE-2FO, 1, ...]

Figure 3-10 Plug-In Module USART-AD-1FO (on the Left), USART-AE-2FO (on the Right)

PPS can be used for:

- Line-differential applications to stabilize unbalanced protection interface communication paths
- Sample synchronization of process-bus applications (merging unit/process-bus client)

Received signals at the Rx connector are immediately, without any delay, mirrored to the Tx connector. In this way, several devices can be cascaded.

3.3.2.2 Generation of Optical PPS

A dedicated USART-AD-1FO or USART-AE-2FO plug-in module is required as interface to generate the optical PPS. With the PPS **Generator** function, a free running optical PPS is sent on the Tx interface (ST connector). The light-on duration is 0.1 s and the light-off duration is 0.9 s. The Rx interface has no functionality in the PPS mode **Generator**.

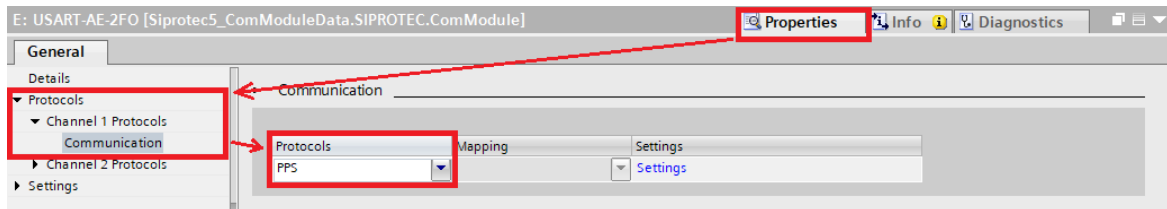
The generated PPS is also used internally from the device for sample synchronization (rising light-on edge). The PPS **Generator** function can be used to synchronize a couple of devices like merging units without an external synchronization reference.

3.3.2.3 Configuration

To use the optical PPS, you must configure the PPS function in your device.

Adding a USART-AD-1FO or USART-AE-2FO Plug-In Module

- ✧ Open the **Hardware and Protocols Editor** of your device.
- ✧ Select the tab **Hardware catalog** from the task cards.
- ✧ Drag and drop the USART plug-in module to the device.
- ✧ Select the inserted USART plug-in module, go to the **Inspector Window** and open the tab **Properties**.
- ✧ In the tree, navigate to **Protocols > Communication**.
- ✧ From the list box, select the **PPS** protocol. The USART-AE-2FO module provides 2 independent channels. Select the correct channel before selecting the PPS protocol.

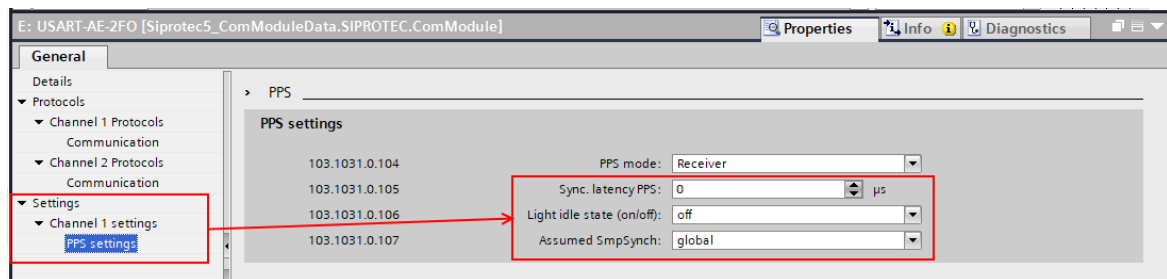


[sc_add_USART-AD-1FO_AE-2FO, 1, en_US]

Figure 3-11 Selecting the Protocol for the USART Module

Use as PPS Receiver

- ✧ In the tree, navigate to **Settings > PPS settings** and set the **PPS mode** to **Receiver**.
- ✧ Adjust the settings for **Sync latency**, **Light idle state**, and/or **Assumed SmpSync**, if required.

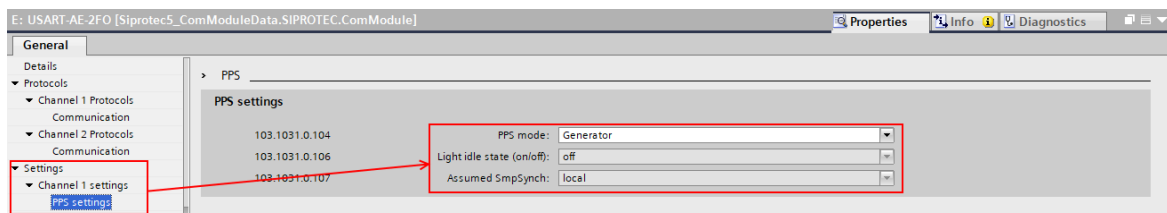


[sc_USART-AD-1FO_AE-2FO_settings, 2, en_US]

Figure 3-12 Setting Sync Latency, Light Idle State, and Assumed SmpSync

Use as PPS Generator

- ✧ In the tree, navigate to **Settings > PPS settings** and set the **PPS mode** to **Generator**. The **Generator** function has no settings.



[sc_USART-AD-1FO_AE-2FO_generator_settings, 1, en_US]

For a description of the parameters, refer to [3.3.2.4 Application and Setting Notes](#).

3.3.2.4 Application and Setting Notes

Parameter: Sync. latency PPS (only for PPS Receiver)

- Default setting () **Sync. latency PPS** = 0

With the parameter **Sync. latency PPS**, you can move the received PPS signal to the past. This is required to compensate a possible delay during the distribution of the PPS signal. The PPS signal can be delayed, for example, by cables or star couplers which are part of the distribution chain. The typical delay caused by the fiber-optic cables can be calculated and is about 5 ns/m. For external PPS distribution equipment, you can find the latency for PPS signals in the according technical data. The latency must be compensated. All delays must be added and entered as **Sync. latency PPS**.

Parameter: Light idle state (on/off)

- Default setting () **Light idle state (on/off)** = *off*

The parameter **Light idle state (on/off)** defines, if the trigger for a new second is the light-on or light-off edge of the received PPS signal.

Parameter Value	Description
<i>off</i>	Trigger light-on edge
<i>on</i>	Trigger light-off edge



NOTE

In the PPS **Generator** mode, this parameter is read only and is set to *off*.

Parameter: Assumed SmpSynch

- Default setting () **Assumed SmpSynch** = *global*

The parameter **Assumed SmpSynch** defines the interpretation of a received PPS signal according to IEC 61850-9-2, Edition 2.1, paragraph "9 Synchronization".

Parameter Value	Description
<i>global</i>	The PPS signal is assumed to be received from a device, synchronized to the required accuracy to a global time reference. Notice: The device is not able to distinguish between the PPS synchronization states <i>local</i> and <i>global</i> . If the synchronization state of a received PPS signal is not <i>global</i> , maloperation of protection functions is possible!
<i>local</i>	The PPS signal is assumed to be received from a device, not synchronized to the required accuracy to a global time reference.



NOTE

In the PPS **Generator** mode, the parameter **Assumed SmpSynch** becomes read-only and is set to *local*.



NOTE

If the **Assumed SmpSynch** is set to *global*, the PPS source must be parameterized to stop sending PPS signals if the conditions for a global synchronization state are not fulfilled, for example, loss of GPS.

3.3.3 Electrical PPS

3.3.3.1 Electrical PPS using Port G of the Device

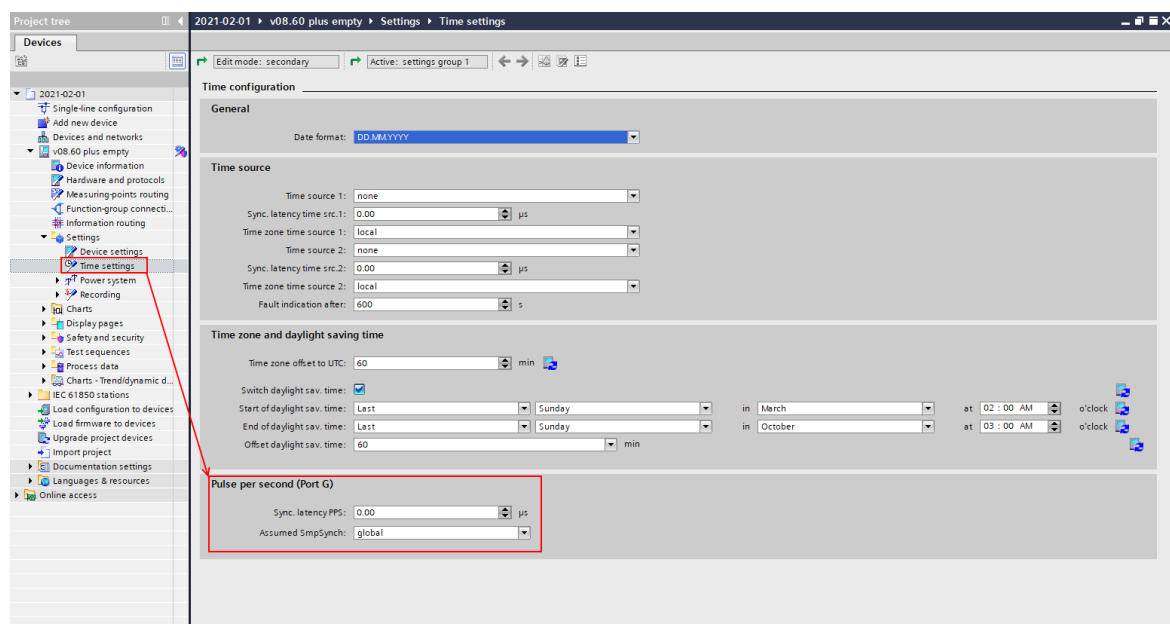
Port G on the rear side of the device is used as an interface for the electrical PPS. The connection pins of port G for the electrical PPS are pin 4 (M-TSYNC) and pin 8 (P-TSYNC). For more details about the pin layout and signal level, refer to the *SIPROTEC 5 Hardware Manual*.

3.3.3.2 Configuration

Activation of Electrical PPS at Port G

It is not necessary to activate the electrical PPS using port G within the parametrization of the device. The device automatically detects an existing PPS signal at port G.

- ✧ To adjust the settings for **sync latency** if necessary, select the device and go to **Settings > Time Settings**.



[sc_activate_electrical_PPS_Port_G, 2, en_US]

For a description of the setting parameters, refer to chapter [3.3.3.3 Application and Setting Notes](#).

3.3.3.3 Application and Setting Notes

Parameter: Sync. latency PPS

- Default setting () **Sync. latency PPS** = 0

With the parameter **Sync. latency PPS**, you can move the received PPS signal to the past. This is required to compensate a possible delay during the distribution of the PPS signal. The PPS signal is delayed by cables, star couplers, etc. which are part of the distribution chain. The delay caused by the cables can be calculated. The typical delay is about 5 ns/m. You can find the latency for PPS signals in the technical data of the PPS distribution equipment. The latency must be compensated. All delays must be added and entered as **Sync. latency PPS**.

Parameter: Assumed SmpSynchron

- Default setting () **Assumed SmpSynchron** = *global*

The parameter **Assumed SmpSynchron** defines the interpretation of a received PPS signal according to IEC 61850-9-2, Edition 2.1, paragraph "9 Synchronization".

Parameter Value	Description
global	The PPS signal is assumed to be received from a device, synchronized to the required accuracy to a global time reference. Notice: The device is not able to distinguish between the PPS synchronization states local and global . If the synchronization state of a received PPS signal is not global , maloperation of protection functions is possible!
local	The PPS signal is assumed to be received from a device, not synchronized to the required accuracy to a global time reference.



NOTE

If the **Assumed SmpSynch** is set to **global**, the PPS source must be parameterized to stop sending PPS signals if the conditions for a global synchronization state are not fulfilled, for example, loss of GPS.

3.3.4 IRIG B

3.3.4.1 IRIG B using Port G

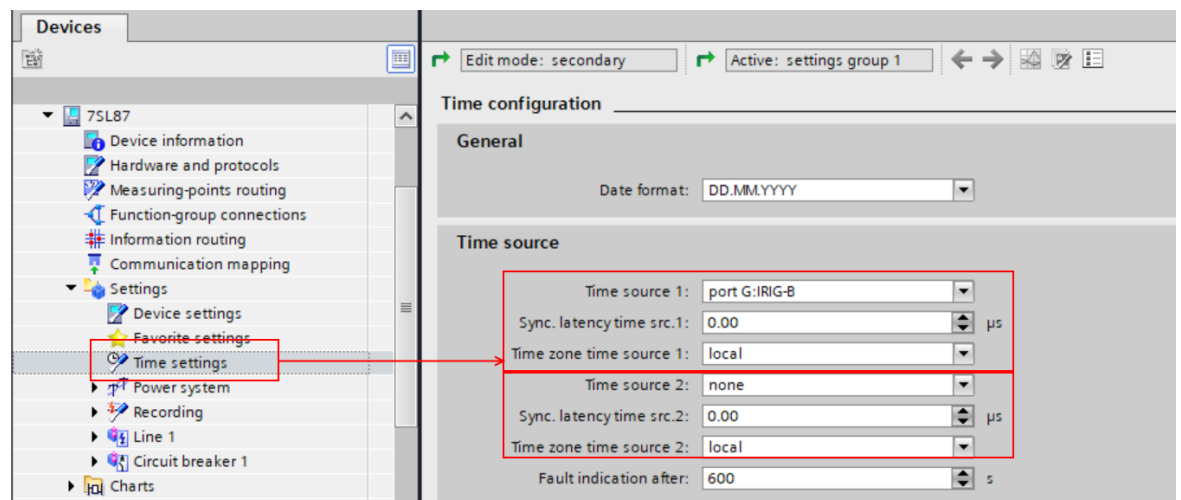
Port G on the rear side of the device is used as interface for IRIG B. The connection pins of port G for IRIG are pin 1 (P24-TSIG), pin 2 (P5-TSIG), or pin 7 (P12-TSIG) and pin 3 (M-TSIG). For more details about the pin layout and signal level, refer to the *SIPROTEC 5 Hardware Manual*.

3.3.4.2 Configuration

To use IRIG B, you must configure IRIG B at port G in your device. For further information about date and time synchronization, refer to the *SIPROTEC 5 Device manuals* or the *DIGSI 5 Online Help*.

Activation of IRIG B at Port G

- ✧ To activate IRIG B at port G, open the **Time settings** of your device under **Settings** in the project tree.
- ✧ Select **Time source 1 = Port G:IRIG B**.
- or -
- ✧ Select **Time source 2 = Port G:IRIG B**.
- ✧ Set the appropriate **Sync. latency time src.** and **Time zone**.



[sc_activate_IRIG-B_Port_G_1_en_US]

Figure 3-13 Activating IRIG B on Port G

3.3.4.3 Application and Setting Notes

Parameter: Date Format

- Default setting **Date format** = **YYYY-MM-DD**

With the parameter **Date format**, you define the local customary format of the date display.

Parameter Value	Description
DD.MM.YYYY	Day.Month.Year: Typical European display Example: 24.12.2010
MM/DD/YYYY	Month/Day/Year: Typical US representation Example: 12/24/2010
YYYY-MM-DD	Year-Month-Day: Typical Chinese display Example: 2010-12-24

Parameter: Time zone time source 1, Time zone time source 2

- Default setting **Time zone time source 1** = **local**, **Time zone time source 2** = **local**

With the parameters **Time zone time source 1** and **Time zone time source 2**, you define the handling of time zones of the external timer.

Parameter Value	Description
local	Local time zone and daylight saving time are considered as time zone offsets to GMT.
UTC	Time format according to UTC (universal time)

Parameter: Time source 1, Time source 2

- Default setting **Time source 1** = **none**, **Time source 2** = **none**

With the parameters **Time source 1** and **Time source 2**, you configure a time source.

Parameter Value	Description
none	The time source is not configured.
IRIG-B	Time synchronization by an external GPS receiver: SIPROTEC 5 devices support several protocol variants of the IRIG-B standard: • IRIG-B 002(003) The control function bits of the signal are not occupied. The missing year is formed from the current device time. In this case, it is possible to set the year via the online access in DIGSI 5. • IRIG-B 006(007) The bits for the calendar year are not equal to 00. The calendar year is set automatically by the time protocol. • IRIG-B 005(004) with extension according to IEEE C37.118-2005 If, in the time signal, other control function bits are occupied in addition to the calendar year, then the device takes the additional information into consideration for leap seconds, daylight saving time, time offset (zone, daylight saving time), and time accuracy. Time zone time source 1 or Time zone time source 2: The value of this setting is not evaluated by the device, since this protocol either transmits in UTC or in the case of local time, specifies the appropriate offset to UTC in each set time telegram.

Parameter: Fault indication after

- Default setting **Fault indication after** = **600 s**

With the parameter **Fault indication after**, you set the time delay after which the unsuccessful attempts of time synchronization with external time sources configured are indicated.

Parameter: Time Zone and Daylight Saving Time

This parameter block contains all the settings for the local time zone and daylight saving time of your SIPROTEC 5 device. In addition to the individual parameters, configure the basic settings by preselecting via the option buttons or check box.

[sc_time_zo, 1, en_US]

Figure 3-14 Settings for Time Zone and Daylight Saving Time in DIGSI

Selection Button	Description
Manual settings (local time zone and daylight saving time regulation)	This setting must be selected if you want to select the local time zone and daylight saving time zone regulations of your SIPROTEC 5 device regardless of the PC settings. Input: Offset time zone for GMT [min] Selection: Switchover to daylight saving time [yes/no] via check box ☒ Switch daylight sav. time • Input: Start of daylight saving time [Day and time] • Input: End of daylight saving time [Day and time] • Input: Offset daylight saving time [min] • Default settings as in the picture above

3.3.4.4 Settings

Addr.	Parameter	C	Setting Options	Default Setting
Time sync.				
_:102	Time sync.:Time source 1		• none • IRIG-B • SNTP • IEC 60870-5-103 • Modbus • DNP3 • IEC 60870-5-104	none
_:103	Time sync.:Time source 1 port		• port F • port E	
_:104	Time sync.:Time source 1 channel		• Ch1 • Ch2	

Addr.	Parameter	C	Setting Options	Default Setting
_:105	Time sync.:Time source 2		• none • IRIG-B • SNTP • IEC 60870-5-103 • Modbus • DNP3 • IEC 60870-5-104	none
_:106	Time sync.:Time source 2 port		• port F • port E	
_:107	Time sync.:Time source 2 channel		• Ch1 • Ch2	
_:108	Time sync.:Time zone time source 1		• UTC • local	local
_:109	Time sync.:Time zone time source 2		• UTC • local	local
_:101	Time sync.:Fault indication after		0 s to 3600 s	600 s

3.3.4.5 Information List

No.	Information	Data Class (Type)	Type
Time managem.			
_:300	Time managem.:Daylight saving time	SPS	O
_:301	Time managem.:Clock set manually	SPS	O
Time sync.			
_:303	Time sync.:Status time source 1	SPS	O
_:304	Time sync.:Status time source 2	SPS	O
_:305	Time sync.:Time sync. error	SPS	O
_:306	Time sync.:Leap second	SPS	O
_:307	Time sync.:High accuracy	SPS	O

4 Network Topology

4.1	Topology Hints	120
4.2	Network Usage	125

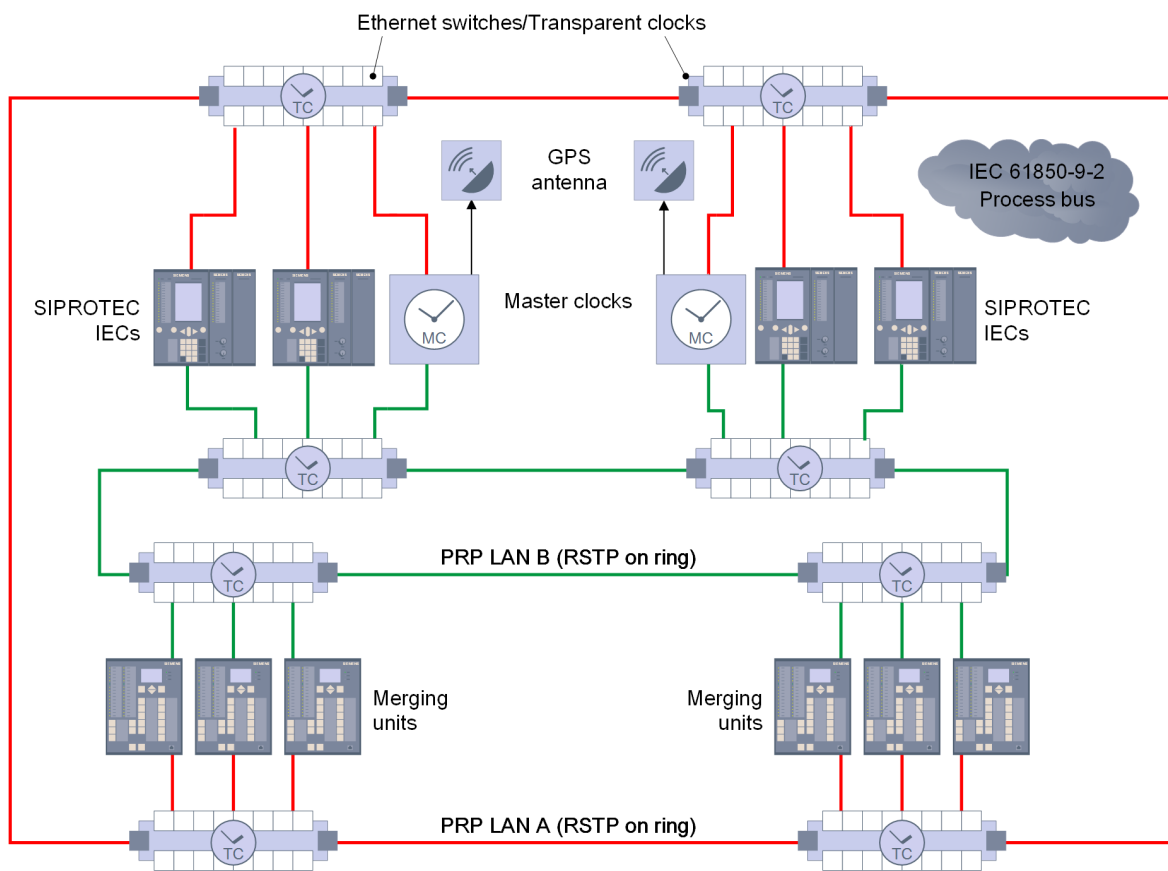
4.1 Topology Hints

Process-Bus Communication Network Topologies (with PTP Time Synchronization and PRP Redundancy)

This section describes 2 examples of typical process-bus communication network topologies. These Ethernet networks use IEEE 1588v2/PTP for time synchronization of SIPROTEC 5 protection devices (process-bus clients) and merging units. The PTP profiles IEC 61850-9-3:2016 and IEEE C37.238:2017 are supported. IEC 62439-3 PRP is used for redundancy. This section provides some guidance and recommendations on how to operate PTP time synchronization in process-bus networks. The recommendations can apply also to other network topologies.

Stand-Alone Process-Bus Communication

The following figure shows a **stand-alone** process-bus communication scenario. In this context, **stand-alone** means that the participating devices and network elements do not have any connectivity to other networks, for example the station bus.



[dw_standalone_ProcessBusComm-scenario, 2, en_US]

Figure 4-1 Stand-Alone Process-Bus Communication Scenario

The PRP redundancy protocol is used for seamless communication. PRP LAN A and LAN B contain several Ethernet switches which are connected in 2 separate, mutually isolated Ethernet rings. IEEE 802.1Q RSTP (Rapid Spanning Tree Protocol) runs across the Ethernet switches on the rings, for additional redundancy and loop avoidance. RSTP is not used between the switches and the connected devices.

SIPROTEC 5 protection devices and merging units are directly connected to 1 switch in PRP LAN A and to 1 switch in LAN B. They are in the DANP role (Double Attached Node PRP).

PTP is used for high-precision time synchronization of protection devices and merging units. All devices and network elements must be PTP-capable in conformance to IEC 61850-9-3:2016 or IEEE C37.238:2017, depending on the selected PTP profile. The synchronized protection devices and merging units are in the

role of double-attached ordinary slave clocks, according to IEC 62439-3, Annex A. The Ethernet switches are forwarding PTP messages and are in the transparent-clock role for this purpose.

For avoiding single-point-of-failure, there are at least 2 PTP grandmaster clocks, driven by primary synchronization references, for example, GNSS (Global Navigation Satellite System). They are simultaneously attached to PRP LAN A and LAN B and in this way act as double-attached master clocks, according to IEC 62439-3, Annex A. If a PTP grandmaster clock does not support PRP and double attachment, then it can be connected via a PRP RedBox (redundancy box), supporting the transparent-clock role, to LAN A and LAN B.

All protection devices, merging units, and grandmasters must be configured to the same PTP domain. The grandmasters must be able to receive PTP messages from each other. The protection devices and merging units must be able to receive PTP messages from all grandmasters.

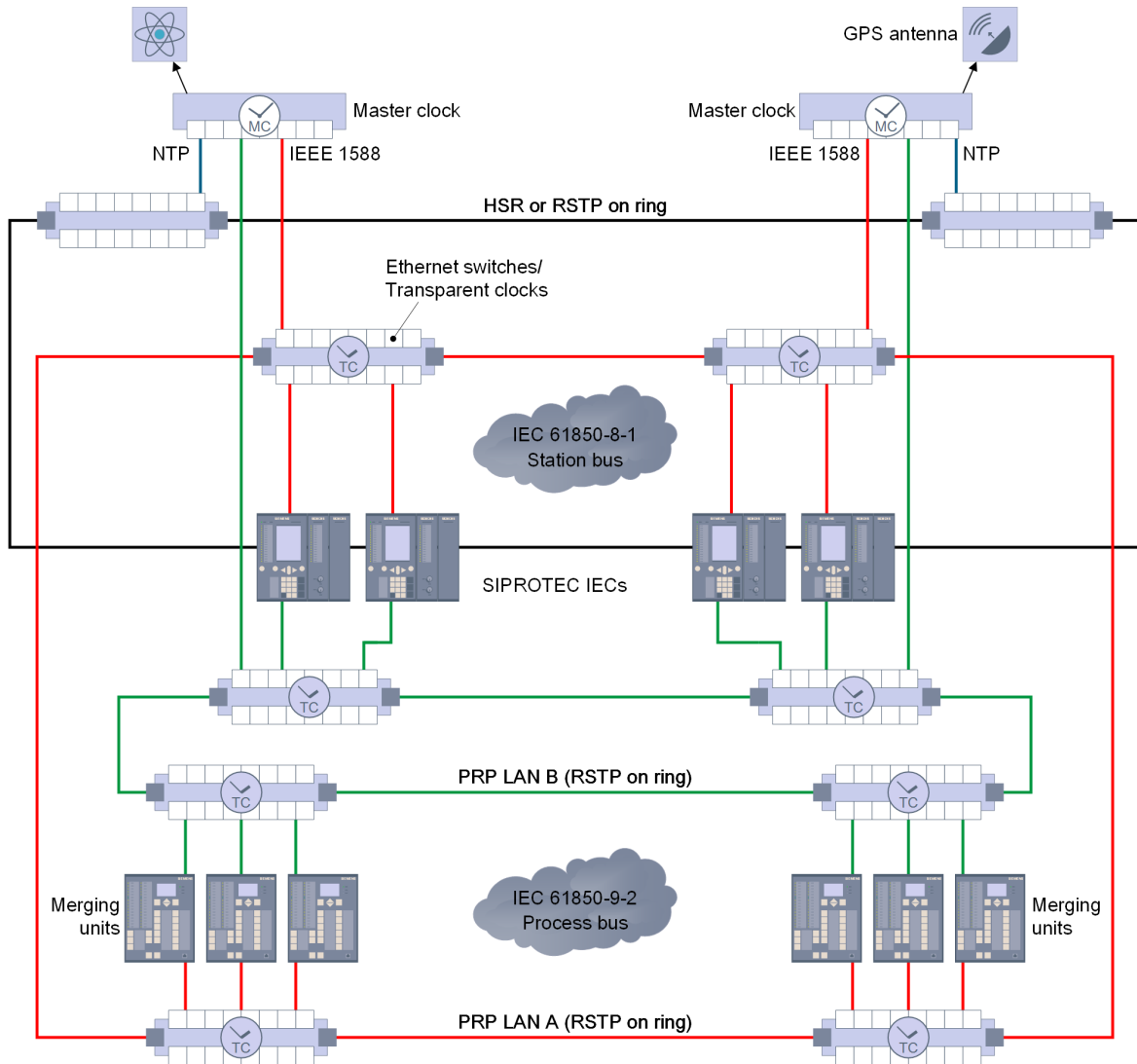
All protection devices, merging units, and grandmasters participate in the best master clock algorithm (BMCA), according to IEEE 1588. Only 1 grandmaster is in the active master role and synchronizing all slave clocks.

In case of a failure of this grandmaster, one of the passive masters becomes active and takes over the synchronization of all slaves. The protection devices and merging units are slave-only clocks and never change into the master role.

It is specific to PRP redundancy that double-attached protection devices and merging units (as slave clocks) receive PTP messages (especially PTP Announce and Sync messages) from the grandmaster via LAN A and LAN B simultaneously. The slaves select one of the paths and use the PTP messages received via this path for time synchronization. If the selected path is interrupted, then the slave continues receiving PTP messages from the other path, via the other PRP LAN, but it remains synchronized by the same active master.

Process-Bus and Station-Bus Communication

The following figure shows another process-bus communication network example. The SIPROTEC 5 protection devices are connected to process bus and to the station bus by separate Ethernet communication modules. In this example, an IEC 62439-3 HSR or RSTP ring is used at the station bus, but other (for example, hierarchical) topologies and other redundancy protocols (especially PRP) are also possible.



[dw_combi_ProcessBus_and_StationBus-Comm-scenario, 1, en_US]

Figure 4-2 Process-Bus and Station-Bus Communication scenario

The process-bus network topology is quite like to that shown in [Figure 4-1](#). The difference is that the process-bus local PTP grandmasters are removed. Instead, there are 2 or more station-level grandmaster clocks. If these grandmasters support PRP and double attachment, then they can directly be connected to switches (in transparent-clock role) in process bus LAN A and LAN B respectively. Otherwise, the grandmasters can be connected via PTP-capable PRP RedBoxes, as mentioned in the previous sections.

These station-level PTP grandmasters can synchronize multiple process-bus systems and the station bus. The grandmasters could be multi-port devices or connected via Ethernet switches in PTP transparent-clock or boundary-clock role to the networks they are serving. In any case, it must be prevented by appropriate measures, for example, VLAN and/or Layer 2 multicast filtering, that undesired communication traffic is forwarded to other networks, for example, GOOSE and SV messages from one process-bus system to another or to the station bus.

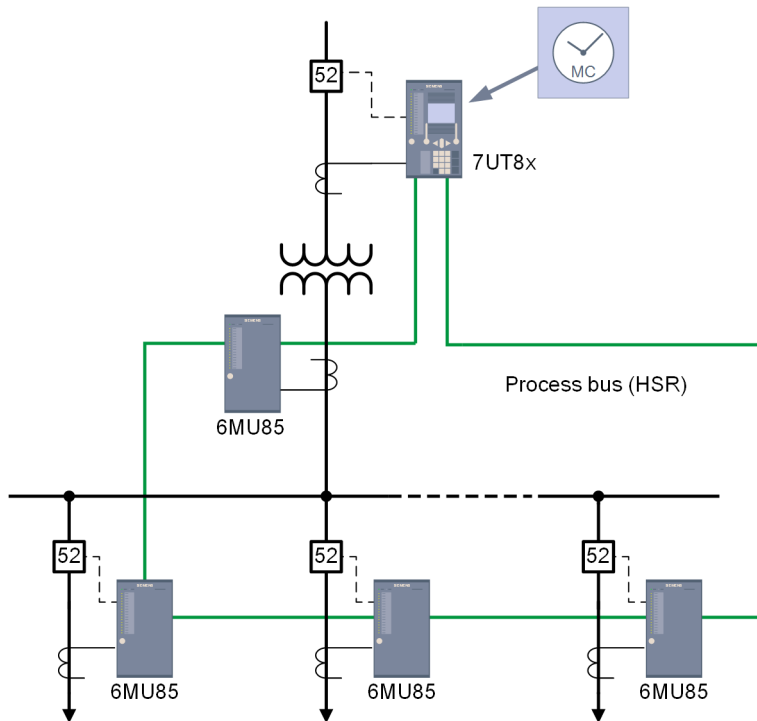
Like in the previous scenario, only 1 of the grandmasters is in the active master role and synchronizing all connected PTP slaves. The PTP slaves must be able to receive PTP messages from all grandmasters and

determine the active master by help of the BMCA. The double-attached PTP slaves receive PTP messages from PRP LAN A and LAN B (under error-free condition) and use one of the paths for time synchronization. Here are some recommendations and limitations which apply to the shown examples but can be valid for other network topologies, too:

- The devices with PTP ordinary clock functionality, for example, protection devices and merging units, which are communicating with each other, and their serving grandmasters must be configured to the same PTP domain. The grandmasters of this domain must be able to receive PTP messages from each other. The protection devices and merging units must be able to receive PTP messages from all grandmasters of their domain. This is important, so that only a single grandmaster clock is active in a PTP domain at any time and all devices are synchronized to this master.
- If you use PRP redundancy, grandmasters must be double-attached. This means they must be simultaneously connected to LAN A and to LAN B (IEC 62439-3, Figure A.3). IEC 62439-3, Figure A.2 shows an alternative approach where masters are single-attached, either to PRP LAN A or LAN B. Siemens does not recommend using this approach, and single-attached grandmasters must not be used. Single-attached masters in PRP LAN A and LAN B do not see each other because the LANs are mutually isolated. Therefore, BMCA cannot consider the clocks in the other PRP LAN and 2 master clocks (1 per PRP LAN) will be active at the same time. It cannot be guaranteed that all PTP slaves (in particular, protection devices and merging units) are synchronized by the same master clock, under all circumstances. Check with the vendor of your PRP-capable PTP grandmaster clock whether it supports double attachment or single attachment (in latter case, it can contain 2 single-attached grandmasters in a single device). Grandmasters which are not supporting PRP redundancy by their own can be double-attached using PTP-capable PRP RedBoxes.
- If you use PRP redundancy, the protection devices and merging units must be double-attached to PRP LAN A and to LAN B. The devices are time-synchronized either via LAN A or LAN B by the active, double-attached master. In SIPROTEC 5 V8.0, the active path to the master is selected by a proprietary procedure and not by comparing quality according to IEC 62439-3, A.7.3.
- Multiple grandmasters (at least 2) must be deployed for avoiding single-point-of-failure. Siemens recommends prioritizing the clocks by Priority 2 configuration for applications using IEC 61850 Ed. 2.1 flexible streams with **SynchSrcId**. For more information, refer to chapter [3.1 Sample Synchronization](#). This predetermines the sequence, in which the clocks take over the active master role, if other BMCA decision attributes like grandmaster class and grandmaster accuracy are equal.
- Grandmaster clocks must be synchronized to a primary reference. For reliability reasons, Siemens recommends using mutually independent primary references, for example, atomic or GNSS, at least for station-level grandmasters.
- All PTP-capable devices and network elements of the same domain must be configured with the same PTP message interval and time-out values. Siemens recommends keeping the default values.
- For high synchronization accuracy, the number of traversed transparent clocks on the path from master to slave clocks must be minimized. The corresponding limits of IEC 61850-9-3:2016 or C37.238:2017 must be considered.
- The network topologies of PRP LAN A and LAN B must be equal. The number of traversed transparent clocks on the path from master to slave clocks at LAN A must be equal to the number at LAN B, under normal conditions.
- Siemens recommends limiting the occupied bandwidth on Ethernet links, for example, by avoiding unnecessary multicast traffic. For example, the Ethernet switch ports, where protection devices and merging units are connected to, must forward only SV and GOOSE messages the devices are subscribed to. This can be achieved by VLAN and/or Layer 2 multicast filtering in the switches. Reduced link-bandwidth consumption results in lower jitter and higher synchronization accuracy.
- In SIPROTEC 5 V8.0, the IEEE 1588 PTP time synchronization is supported by the ETH-BD-2FO module, but not by other Ethernet communication modules. In SIPROTEC 5 V8.0, the ETH-BD-2FO module supports PRP, but does not support HSR and RSTP redundancy.

Small Process-Bus System with Built-In Grandmaster-Capable Clock

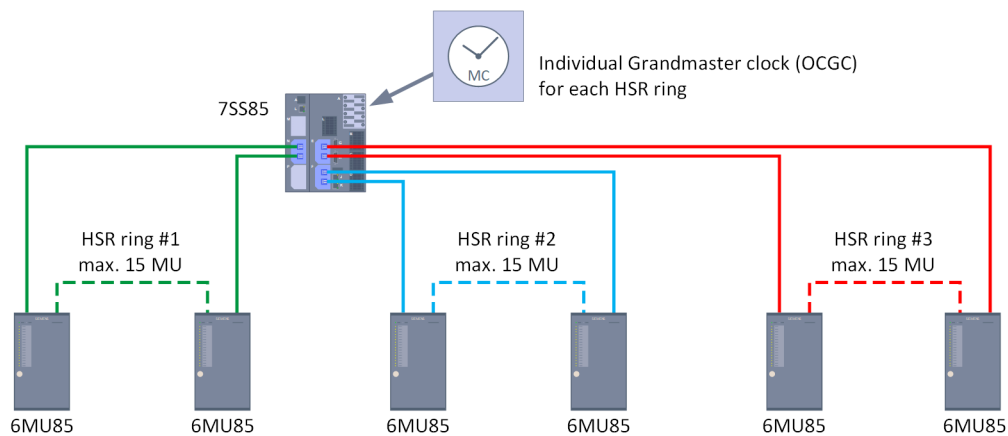
This network setup is ideal for small process bus systems, with only 1 protection device, subscribing to one or multiple merging units.



[dw_self-sync_process-bus-appl, 1, en_US]

Figure 4-3 Self-Synchronizing Process-Bus Application

It is also possible to use multiple HSR rings. The grandmaster-capable functionality must be instantiated in the same device.

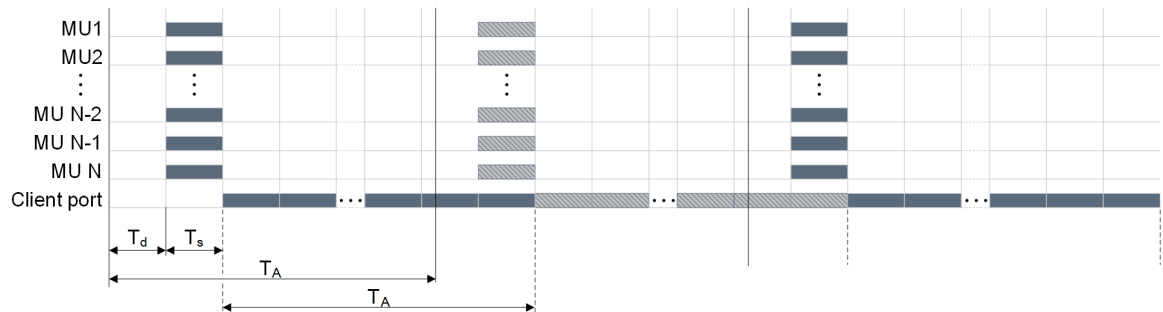


[dw_sync_7ss85_HSR-ring_GMC, 2, en_US]

Figure 4-4 Self-Synchronizing Distributed Busbar Protection with 3 Instances of a Grandmaster-Capable Clock in the 7SS85

4.2 Network Usage

Fast Ethernet links have a bandwidth limited to 100 MBit/s. High network load can occur especially on uplinks from a switch to a process-bus client. The following figure shows an example:



[dw_example_SMV-datagrams_from_merging Units, 1, en_US]

Figure 4-5 Ethernet Links on High Network Load

SV datagrams from merging units are sent on separate links to switches. On the uplink to the process-bus client, datagrams are serialized. If the transmission time of the serialized datagram block for one sampling interval reaches the sampling interval, the link is completely occupied by SV streams.

To avoid link-bandwidth overutilization, check the link usage in the IEC 61850 System Configurator:

In the **Network** view of the IEC 61850 System Configurator, you can check the network load per subnetwork. A SIPROTEC 5 process-bus client can handle network loads up to the total network load for all protocols.

If a 3rd-party system configurator does not provide a network-usage calculation, the following table can be used to get an estimate for the network load. VLAN, PRP, GMID, for example, can influence the load.

SampleRate [Hz]	ASDUs	Payload [Byte]	Frame Size [Byte]	Transmission Rate [Mbit/s]	Max. Possible Streams in 100 Mbit Network with 60 % Load
4000	1	121	169	5.408	11
4800	1	121	169	6.490	9
4800	2	227	275	5.280	11
12 800	8	863	911	11.661	5
14 400	6	651	699	13.421	4
15 360	8	863	911	13.993	4

These estimations include the publication of the optional field for the GmIdentity. The estimations are based on a usage of 8 channels per ASDU and an SVID length of 13 characters.

The table shows the values for the case if only SV streams are used. GOOSE and other network protocols can require bandwidth, too.

The SVID length has a significant influence on the payload and the frame size. The SVID length can be up to 129 characters long and is repeated in each ASDU.



NOTE

In an HSR topology close to 60 % load on the network, Siemens recommends reducing the MTU size to 750 bytes.

5 Diagnostic Data via the Browser-Based User Interface

5.1	Content and Structure	128
5.2	Application Diagnosis Section for Ethernet Modules	134
5.3	Application Diagnosis – Process-Bus Client	135

5.1 Content and Structure

The section **Communication diagnosis** under **Diagnosis & Alarms** in the **browser-based user interface** is used for diagnostic purposes. In this section, you can find information on the communication modules as well as the network and communication protocols that run on the communication modules.

The **browser-based user interface** is accessible using a Web browser via one of the following interfaces:

- Port J
- Port E
- Port F
- Port P
- Port N
- USB

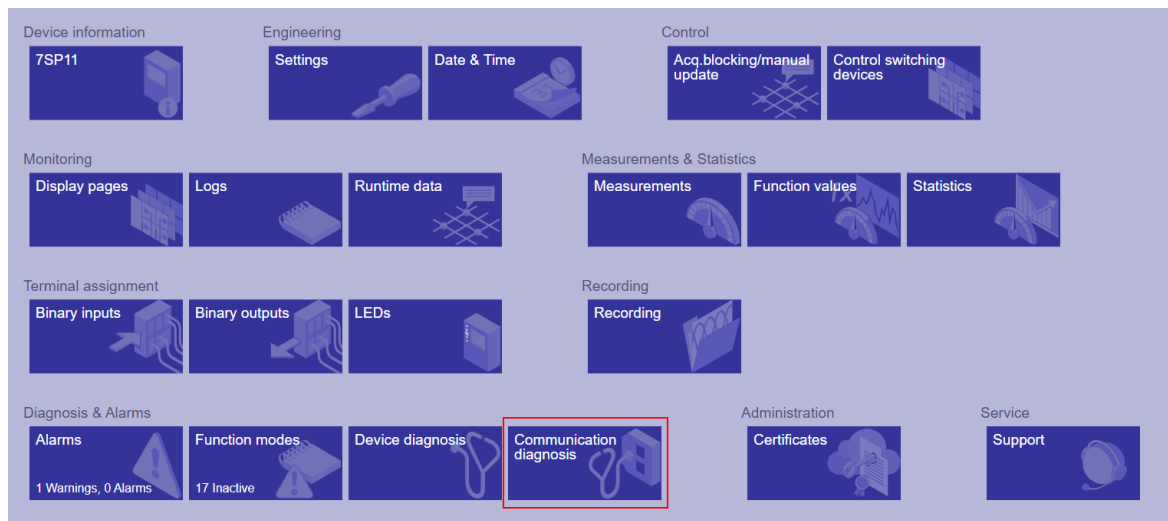
Enter the IP address of the device in the address line of the Web browser, followed by the port number 4443, for example `https://172.16.60.60:4443`. Confirm the entry using the ENTER key.

For more information on operating the device using a Web browser, refer to the chapter *Operation Using a Browser- Based User Interface* in the *SIPROTEC 5 Operation manual*.

If the role-based access control (RBAC) is enabled, only the following roles can access the section **Communication diagnosis** under **Diagnosis & Alarms**.

- Administrator
- Engineer
- Installer
- Operator

If the RBAC is disabled, there is no restriction on access to the section **Communication diagnosis** under **Diagnosis & Alarms**.



[sc_web ui menu, 1, -,-]

Figure 5-1 Menu of the Browser-Based User Interface

In the section **Communication diagnosis**, the instantiated communication modules are visible.



[sc_com diagnosis, 1, --]

Figure 5-2 Section Communication Diagnosis

You can view the diagnosis data of the communication modules from all ports via the section **Communication diagnosis**, no matter via which port you access the **browser-based user interface**. After entering the specific port, you can view the general information, network protocols and communication protocols.



NOTE

Since V9.70, for security purpose, the original **Homepage** (access via HTTP) is not available anymore. Instead, you can access the communication-diagnosis data via the **browser-based user interface**.



NOTE

The section **Communication diagnosis** is available only in English.

Content of Communication Diagnosis

The section **Communication diagnosis** shows the following information of the activated communication protocols:

- System diagnostic values
- Various start or fault logs
- Accessible diagnostic values

The diagnostic values for the protocols in the following table are available:

Protocols	Can Run on the Following Module Types or Slots		
	CPU (Port J)	Ethernet Modules	USART Modules
Network protocols	SNTP	SNTP IEEE 1588 SNMP	–
Redundancy protocols	–	PRP HSR RSTP	–
Communication protocols	IEC 61850 IEC 61850 – GOOSE SUP Ethernet	IEC 61850 IEC 61850 – GOOSE SUP Ethernet DNP3 Ethernet IEC 60870-5-104 Modbus TCP PROFINET IO Process-bus client Process-bus merging unit Process-bus merging unit 7SS85CU Synchrophasor (IEEE C37.118 PMU) Protection interface IEEE 802.1Q(VLAN)	DNP3 IEC 60870-5-103 Modbus RTU SUP Serial Protection interface (IEEE C37.94) PPS

Structure of Communication Diagnosis

Overview > Network Status

Slot Status	Link
CH1	UP
CH2	DOWN

Interfaces

MAC Address: b4-b1-5a-0e-4f-32

--

IP address: 172.16.51.92

Netmask: 255.255.255.0

MTU size: 1500

VLAN tag: not used

VLAN Id & priority: - : -

SFP Statistics

	CH1	CH2	
Vendor	AVAGO		
Identifier	SFP	0x20	
Part Number	QFBR-5750APZ	-5750APZ	
Revision			
Temperature	62.16	--	[°C]
Power Supply	3.27	--	[V]
Tx Bias	0.079	--	[A]
Tx Power	0.026	--	[mW]
Rx Power	0.013	--	[mW]

Routing

No routing is configured

IP Packets

Inet: 172.16.51.92

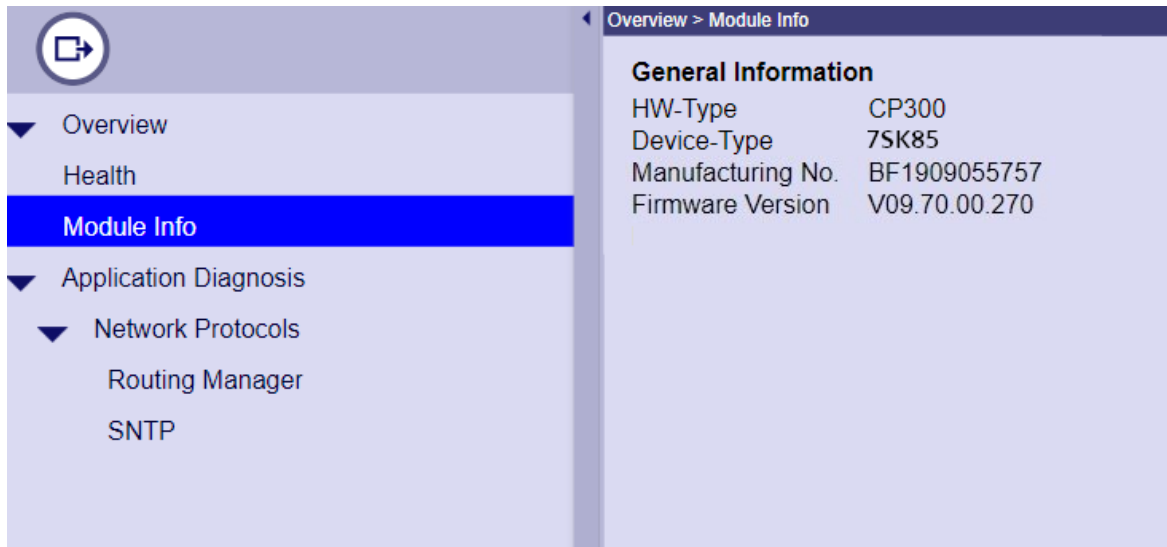
	Rx	Multicast	Error
1941	0	0	
	Tx	Multicast	Error
2	0	0	

INET Sockets

Prot	Recv-Q	Send-Q	Local Address	Foreign Address	State
------	--------	--------	---------------	-----------------	-------

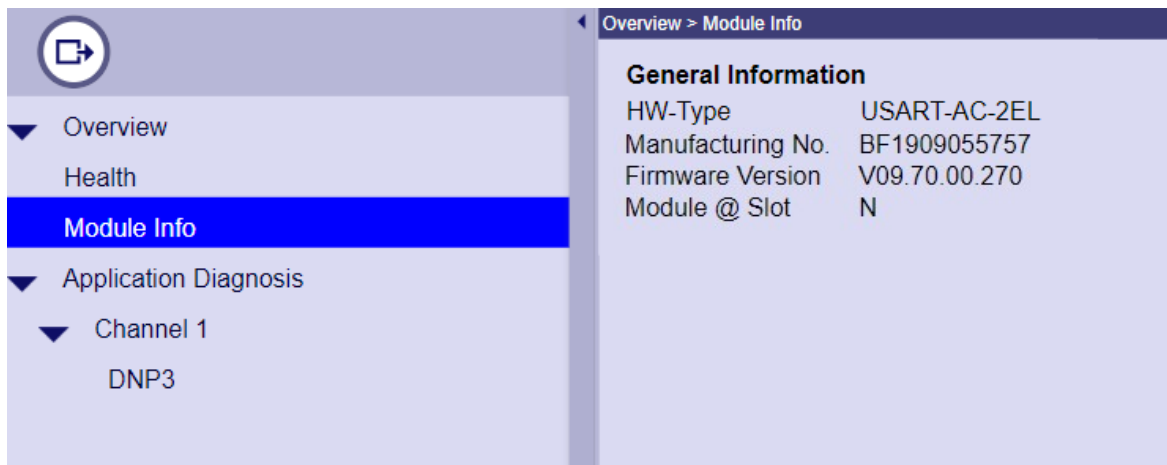
[sc_homepage_port-J, 3, -,-]

Figure 5-3 Structure of the Section Communication Diagnosis for Port J



[sc_homepage, 3, --]

Figure 5-4 Structure of the Section Communication Diagnosis for Ethernet Modules



[sc_homepage_USART, 3, --]

Figure 5-5 Structure of the Section Communication Diagnosis for Serial Modules

The sidebar on the left side is divided into the following sections:

- Overview
 - Health
 - Module Info
 - Network Status (only for Ethernet modules)
- Application Diagnosis
 - Network Protocols
 - Redundancy Protocols
 - Communication Protocols

To display the values of the device on the right side, select the field **Application Diagnosis**. The content on the right side contains the dynamic device information.

For the operation on the **browser-based user interface**, refer to the chapter *Operation Using a Browser-Based User Interface* in the *SIPROTEC 5 Operating manual*.

Refresh and Download



To refresh the displayed page, click at the top on the left.



To download the ZIP file that includes all snapshot pages for further analysis, click at the top on the left.

5.2 Application Diagnosis Section for Ethernet Modules

5.2.1 Structure

The section **Application Diagnosis** contains diagnostic pages for the following protocols:

- **Network protocols:**
 - IEEE 1588
 - SNTP
 - SNMP
- **Redundancy protocols:**
 - PRP
 - HSR
 - RSTP
- **Communication protocols:**
 - IEC 60870-5-104
 - IEC 61850
 - IEC 61850 – GOOSE
 - PROFINET IO
 - DNP3 Ethernet
 - Modbus TCP
 - SUP Ethernet
 - Protection Interface²
 - Process-bus client
 - Process-bus merging unit



NOTE

The section **Application Diagnosis** is structured identically for electrical and optical modules.

² Refer to the device manual of Line Differential Protection

5.3 Application Diagnosis – Process-Bus Client

5.3.1 Structure of the Application Diagnosis Section

The **Application Diagnosis > PB-Client** section contains diagnostic data about the process-bus client.

The tree in the homepage under **Application Diagnosis** contains entries for the **Process-Bus Client** (PB-Client) and the **Merging Unit**, in case the according process-bus function is activated. The PB-Client section contains the following tabs:

- **PB-Client Status:**
Shows status information of the PB client
- **PB-Client Sync Status:**
Shows synchronization information of the PB client
- **PB-Client Config:**
Shows configuration and state information



NOTE

If multiple Ethernet modules are configured as process-bus client or merging unit, you can find the application diagnostic data on the homepage of each individual module. The application diagnostic data contains the information specific for this module only.



NOTE

You can save the content of the application diagnosis using the disk symbol.



NOTE

Accessibility: Port J via forwarding or directly. In the latter case, if PRP is used, the access must be performed via a RedBox or a network interface controller with enabled jumbo frames.

5.3.2 PB-Client Status



[sc_PBClient_status, 4, --]

Figure 5-6 PB-Client Status Tab

Stream Information Section

This section contains detailed information about the subscribed streams.

Application Diagnosis > PB-Client Status					
Stream information :					
Stream	SmpRate	APP_ID	CONF_REV	DMAC	SV_ID
0	4800	0x4002	100001	01:0c:cd:04:00:01	KEMU48
1	4800	0x4003	200001	01:0c:cd:04:00:02	MUMU48

[sc_PBClient_Stream_Information, 2, --]

Figure 5-7 Stream Information Section

Table 5-1 Stream Information Section

Entry	Meaning
Stream	Internally used stream ID
SmpRate	Sampling rate
APP_ID	Application ID
CONF_REV	Configuration revision
DMAC	Destination MAC address
SV_ID	Name of the SV data source

Channel Information Section

This section provides an overview of the subscribed analog channels from the subscribed streams, with valuable information for troubleshooting.

Channel information :

ch	seqNoDev	stream	enabled	activity	sampleCnt	sampleRate	quality	smpCntDiff0	smpCntDiff2	smpCntDiff3
0	12	0	x	x	3475	4800	0	0	0	1
1	13	0	x	x	3475	4800	0	0	0	1
2	14	0	x	x	3475	4800	0	0	0	1
3	15	0	x	x	3475	4800	0	0	0	1
4	28	0	x	x	3475	4800	0	0	0	1
5	29	0	x	x	3475	4800	0	0	0	1
6	30	0	x	x	3475	4800	0	0	0	1
7	31	0	x	x	3475	4800	0	0	0	1
8	16	1	x	x	3475	4800	0	0	0	1
9	17	1	x	x	3475	4800	0	0	0	1
10	18	1	x	x	3475	4800	0	0	0	1
11	19	1	x	x	3475	4800	0	0	0	1

[sc_PBClient_Channel_Information, 2, --]

Figure 5-8 Channel Information Section

Table 5-2 Channel Information Section

Entry	Meaning
ch	Internally used channel from all clients and analog data
seqNoDev	Internally used status information; required if you contact the Customer Support Center.
stream	Internally used stream ID
enabled	This channel is enabled for processing.
activity	Valid data (with changing sampling rate) have been seen for this channel.
sampleCnt	Current sample count (during read of status), is a snapshot value only
sampleRate	Sampling rate
quality	Last bad-quality value seen on this channel
smpCntDiff0	Number of equal (doubled) sample counts seen on this channel
smpCntDiff2	Number of missed single sample counts seen on this channel (single missing sample count will be estimated by the module to not get invalid values)
smpCntDiff3	Number of missed sample counts with difference > 2 seen on this channel (cannot be repaired, will result in invalid values)

Status Section

This section provides a general feedback about the subscription status.

Status :

```
[x] SMC is in running mode
[x] All streams and channels are configured and ready for processing
```

[sc_PBClient_Status_Info, 2, ~,~]

Figure 5-9 Status Information

SMV Decoder Errors/ASN.1 Error Section

These sections show additional information for troubleshooting if subscription to sampled values does not work.

SMV decoder errors :

```
[ ] Packet not completed
[ ] No ASDU header found
[ ] No new ASDU after invalid SVID found
[ ] No CONFREV found
[ ] No SMPSYNCH found (and no sample data too)
[ ] No SMPSYNCH found (sample data follow CONFREV)
[ ] No SMPDATA found after CONFREV
[ ] CONFREV did not match
[ ] No SMPCNT found
[ ] No TIMESTAMP/ASDU_END found
[ ] No APDU_END found
[ ] Packet ended during DMAC field
```

ASN.1 error :

```
[ ] Error detected for APP_ID:0x0000
[ ] Common length error
[ ] ASDU structure length error
[ ] ASDU sequence length error
[ ] PDU length error
```

[sc_PBClient_SMV_decoder_ASN1_error, 2, ~,~]

Figure 5-10 SMV Decoder Errors/ASN.1 Error

ETH Switch Status Section

This section provides feedback to the status of the Ethernet ports of the plug-in module. The Ethernet modules are switches with the following ports:

```
ETH Switch Status :

Internal PORT
[x] Enable Receiver
[x] Enable Transmitter
[ ] Disable CAM Multicast Filter (all Multicasts are transmitted)
3482 Received Packets
638 Transmitted Packets

PORT A
[x] Enable Transmitter
[x] Enable Receiver
[ ] Enable forwarding from Port B
[ ] Block non IEEE Multicast Address forwarding to internal Port
[ ] Block transmitting all packets of Port A (except RSTP, IEEE1588, and LLDP packets)
1740 Received Packets
638 Transmitted Packets
0 Packets with symbol error
0 Packets length error
0 Packets FCS error
1740 In PRP mode: Number of packets with LAN A identifier at Port A
In HSR mode: reserved
0 In PRP mode: Number of packets with LAN B identifier at Port A
In HSR mode: Number of telegrams which are not forwarded since they are duplicates

PORT B
[x] Enable Transmitter
[x] Enable Receiver
[ ] Enable forwarding from Port A
[ ] Block non IEEE Multicast Address forwarding to internal Port
[ ] Block transmitting all packets of Port B (except RSTP, IEEE1588, and LLDP packets)
1740 Received Packets
638 Transmitted Packets
0 Packets with symbol error
0 Packets length error
0 Packets FCS error
1740 In PRP mode: Number of packets with LAN B identifier at Port B
In HSR mode: reserved
0 In PRP mode: Number of packets with LAN A identifier at Port B
In HSR mode: Number of telegrams which are not forwarded since they are duplicates

3 PRP/HSR: Number of supervised nodes (MAC Addresses)

[ ] HSR enable
[x] PRP Enable

[x] Enable extracting of a descriptor and port information for any transmitted frame
[x] Extended Mode : Enable appending timestamp and port information at the end of any received frame

[ ] RSTP Enable
[ ] LLDP Enable
[x] Enable PTP IEEE1588v2 support
[ ] PTP Transparent Clock On
[ ] PTP Transparent Clock Mode : Transparent clock configured for End2End mode
[x] PTP Transparent Clock Mode : Transparent clock configured for Peer2Peer mode
```

[sc_PBCClient_status_ETH, 3, -]

Figure 5-11 Ethernet Switch Status

Table 5-3 Ethernet Switch Status Section

Entry	Meaning
Internal Port	Internal virtual Ethernet port – Interface to the main CPU
Port A	Physical Ethernet port of the Ethernet module labeled with CH1 for Channel 1
Port B	Physical Ethernet port of the Ethernet module labeled with CH2 for Channel 2

General Information Section

This section provides detailed information about the used software version.

```
General informations :

FPGA CM Version.....: 09.70.00.004
FPGA image type.....: -
FPGA image name.....: C53207A_602B112_1x0
FPGA HW_Version.....: 5
VHDL_Version.....: 1.0
SMVProcessor_Version: 256
RegisterSet_Version.: 256
SMCProcessor_Version: 3.0
SMCInterface_Version: 3.0
CompKey.....: 0x00000001
```

[sc_PBClient_status_GeneralInformation, 3, --]

Figure 5-12 General Information

Table 5-4 General Information Section

Entry	Meaning
FPGA CM Version	Internally used status information; required if you contact the Customer Support Center.
FPGA image type	
FPGA image name	
FPGA HW_Version	
VHDL_Version	
SMVProcessor_Version	
RegisterSet_Version	
SMCProcessor_Version	
CompKey	

5.3.3 PB-Client Sync Status

The **PB-Client Sync Status** tab contains synchronization information on the process-bus clients.

Synchronization Information Section

This section provides details of the synchronization status of the SIPROTEC 5 device.

Application Diagnosis > PB-Client Sync Status										
Synchronization information :										
SYS	TDN	Availability	Source	Status	Sync	Accuracy	GMID	PreviousGMID	TDI	TDA
0	1	selected	0	synced	local	< 1 s	50-00-84-FF-FE-0D-0E-C0	50-00-84-FF-FE-0D-0E-C0	+77470	+77500
										TDX
										+78110
									ErrFlag	ErrCnt
									00	0
										Seq
										1625

[sc_PBClient_Synchronization_Information, 3, --]

Figure 5-13 Synchronization Information

Table 5-5 Synchronization Information Section

Entry	Meaning
SYS	Internal synchronization source
TDN	Internal time domain
Availability	Reserved for future applications
Source	Reserved for future applications
Status	Synchronization status
Sync	Synchronization status (global, local, none)

Entry	Meaning
Accuracy	Synchronization accuracy
GMID	Universal unique identifier
PreviousGMID	Universal unique identifier from previously synchronized IEEE 1588v2/PTP grandmaster clock
TDI	Time delay min
TDA	Time delay average
TDX	Time delay max
ErrFlag	Error flag of the internal synchronization source
ErrCnt	Error counter of the internal synchronization source
Seq	Increment of the internal synchronization source

Network Delay Information Section

This section documents the network transmission delay of the subscribed streams.

Network delay information :

Stream	dtNetMin	dtNetMax
0	2196	8187279872
1	458	8187275776
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0

[sc_PBCClient_Network_Delay_Information, 2, --]

Figure 5-14 Network Delay Information

Table 5-6 Network Delay Information Section

Entry	Meaning
Stream	Internally used stream ID
dtNetMin	Minimum measured network time delay in ns
dtNetMax	Maximum measured network time delay in ns

SMC Information Section

This section provides internally used status information of the Synchronization Maintenance Communication (SMC) controller and is required if you contact the Customer Support Center.

```
SMC information :  
  
[x] SMC enabled  
[ ] SMC disabled  
[x] SMC running  
[ ] SMC halted with code : 0x0  
[ ] SMC testmode active  
  
[ ] Missing SW-config done signal  
[ ] PPS missing (TSYNC)  
[ ] SMC version mismatch  
[ ] Channel SID detection wrong: Inconsistent data structure  
  
[ ] PPS out of control range  
[ ] PPS timeout  
[ ] PPS invalid  
[ ] PPS sanity error
```

[sc: PBClient_SMC_Information, 2, -- --]

Figure 5-15 SMC Information Section

5.3.4 PB-Client Config

The **PB-Client Config** tab provides a feedback of the samples value subscription configuration with the following details:

- Version information
- Synchronization configuration
- Assigned signals
- List of connected devices (merging units) to the defined subnetworks
- Details to the subscribed merging units:
 - IED information
 - Information about the signals in the merging unit dataset
 - TCTR and TVTR details

6 Restrictions and Recommendations

6.1	Recommendations	144
6.2	Restrictions	145

6.1 Recommendations

General

- Line Mode, HSR, or PRP can be used as network-redundancy protocols for the process-bus functionality.
- SIPROTEC 5 process-bus client and merging-unit functionality require IEEE 1588v2/PTP or PPS or IRIG-B to operate. Siemens recommends using IEEE 1588v2/PTP.
- On the process-bus network, Siemens recommends using only GOOSE, sampled values, and PTP.
- The network load should not exceed more than 60 % on the individual network segments.
For more information on the bandwidth restrictions, refer to [4.2 Network Usage](#).
- In an HSR topology close to 60 % load on the network, Siemens recommends reducing the MTU size to 750 bytes.

SIPROTEC 4 Merging-Unit Functionality

Siemens recommends using the following components for synchronization of the 6MU805 Merging Unit:

- 7XV5664-1AA00: GPS clock incl. accessories
- 7XV5450-0BA00: Mini Star-Coupler

The following restriction is known:

- Limited environmental capabilities of the Mini Star-Coupler

SIPROTEC 5 Merging-Unit Functionality

- 2 streams per ETH-BD-2FO module using the merging-unit functionality.
If additional streams are required, additional ETH-BD-2FO modules must be used.
- The merging unit does not forward data received from the process-bus client.

6.2 Restrictions



NOTE

PB201 is no longer supported. If you use PB201, use DDD Version V07.80.

General

- RSTP cannot be used.
- Non-modular devices do not support the merging-unit and process-bus client functionalities.
- A sample synchronization using either pulse per second (PPS), IRIG B, or IEEE 1588v2/PTP is required. Siemens recommends using the IEEE 1588v2/PTP sample synchronization method.
- Sampled value traffic in HSR rings is susceptible to disturbance from IP traffic, such as SNMP. Siemens recommends removing IP traffic from the process-bus networks using VLANs or other filtering.

Process-Bus Client Functionality

- If the line differential protection is used with PPS or IRIG B stabilization, then the source of this PPS and PTP used in the process-bus network has to be the same.
- For the line differential protection (87L) with process bus, only two-ended configuration is supported
- Point-on-wave switching (PoW) fed by samples must be implemented in the device that executes the circuit-breaker commands. The measured values required for the function PoW can be connected directly to the device or subscribed as sampled values.
- 7KE85 can record 32 sampled-value channels.
- Power Quality functions in 7KE85: harmonics and interharmonics are not supported.

Merging-Unit Functionality

- The merging-unit functionality cannot be used for rated power frequencies other than 50 Hz and 60 Hz, for example railway application with a rated frequency of 16 2/3 Hz.

IEEE 1588v2/PTP

- Only network equipment with IEEE 1588v2/PTP (switches, RedBoxes etc.) with support of either IEC 61850-9-3:2016 (Power Utility Profile) or IEEE C37.238:2017 (Power Profile) must be used.
- IEEE 1588v2 with either clock type **OC Slave Only** or **OCSO and P2P TC** must be enabled at most on 1 module.
- All used network nodes (switches, RedBoxes) in the PTP part of the network must be at least compatible with IEC 61850-9-3 (Power Utility Profile) or C37.238-2017 (Power Profile) P2P (peer-to-peer) as transparent clock.
- The grandmaster-capable clock does not support the IEEE C37.238:2017 profile.

Further Information

For more information on restrictions, contact the Customer Support Center.

7 Technical Data

7.1	SIPROTEC 5 Merging Unit Functionality	148
7.2	SIPROTEC 5 Process-Bus Client	149

7.1 SIPROTEC 5 Merging Unit Functionality

Supported Sampled-Value Streams for 50 Hz and 60 Hz Rated Power Frequency			
Stream Type	Sampling Rate	ASDU	Analog Channels
IEC 61850-9-2 (LE)/IEC 61869-9 (LE comp.)	80 samples/cycle	1	4 I, 4 V
IEC 61850-9-2 (LE)/IEC 61869-9 (LE comp.)	256 samples/cycle	8	4 I, 4 V
IEC 61869-9	4000 Hz	1	Max. 32
IEC 61869-9	4800 Hz	1	Max. 32
IEC 61869-9	4800 Hz	2	Max. 32
IEC 61869-9	12 800 Hz	8	Max. 16
IEC 61869-9	14 400 Hz	6	Max. 24
IEC 61869-9	15 360 Hz	8	Max. 16



NOTE

The analog-channel number at higher sampling frequencies is limited by the maximal MTU size of 1500 bytes, thus, it is bound by the network.



NOTE

Protection functions using the process-bus technology have typically longer tripping times caused by the latency of the merging unit for publishing the sampled values and the time required to publish and receive GOOSE tripping signals from the process-bus client to the merging unit.

Number of published streams per ETH-BD-2FO	2
Max. number of ETH-BD-2FO with MU functionality per SIPROTEC 5 device	4
Simultaneous support at same ETH-BD-2FO module of - IEEE 1588v2/PTP - GOOSE - Merging Unit functionality	YES
Simultaneous support at same ETH-BD-2FO module of - IEEE 1588v2/PTP - GOOSE - Merging Unit functionality - Process-bus client functionality	YES
Simultaneous support on different ETH-BD-2FO module of - IEEE 1588v2/PTP (only on one ETH-BD-2FO) - GOOSE - Merging Unit functionality - Process-bus client functionality	YES
Use of IEC 61850-8-1 MMS and Reports with MU functionality	NO

7.2 SIPROTEC 5 Process-Bus Client

Supported Sampled-Value Streams for 50 Hz and 60 Hz Rated Power Frequency			
Stream Type	Sampling Rate	ASDU	Analog Channels
IEC 61850-9-2 (LE)/IEC 61869-9 (LE comp.)	80 samples/cycle	1	4 I, 4 V
IEC 61850-9-2 (LE)/IEC 61869-9 (LE comp.)	256 samples/cycle	8	4 I, 4 V
IEC 61869-9	4000 Hz	1	Max. 32
IEC 61869-9	4800 Hz	1	Max. 32
IEC 61869-9	4800 Hz	2	Max. 32
IEC 61869-9	12 800 Hz	8	Max. 16
IEC 61869-9	14 400 Hz	6	Max. 24
IEC 61869-9	15 360 Hz	8	Max. 16

If you have a special MU with different requirements, contact the Customer Support Center.



NOTE

The analog-channel number at higher sampling frequencies is limited by the maximal MTU size of 1500 bytes, thus, it is bound by the network.



NOTE

Protection functions using the process-bus technology have typically longer tripping times caused by the latency of the merging unit for publishing the sampled values and the time required to publish and receive GOOSE tripping signals from the process-bus client to the merging unit.

Max. number of analog channels to be subscribed by an ETH-BD-2FO module (Limitations of the individual device applies and supersede the max. usable analog channels)	64
Max. number of streams able to be subscribed per ETH-BD-2FO	16
Max. number of ETH-BD-2FO with Process-Bus Client functionality per SIPROTEC 5 device	3
Simultaneous support at same ETH-BD-2FO module of - IEEE 1588v2/PTP - GOOSE - Process-bus client functionality	YES
Simultaneous support at same ETH-BD-2FO module of - IEEE 1588v2/PTP - GOOSE - Merging Unit functionality - Process-bus client functionality	YES

Simultaneous support on different ETH-BD-2FO module of • IEEE 1588v2/PTP (only on one ETH-BD-2FO) • GOOSE • Merging Unit functionality • Process-bus client functionality	YES
Use of IEC 61850-8-1 MMS and Reports with MU functionality	NO

Protection-Function Behavior for Unsynchronized Conditions

The logic for unsynchronous conditions is described in [Figure 3-1](#). In addition, the following table shows the behavior of protection functions under unsynchronized conditions.

ANSI	Protection Function	Behavior
21	Distance protection	Blocked
27	Undervoltage protection	Not blocked
49	Thermal overload protection	Not blocked
50/50N and 51/51N	Overcurrent protection	Not blocked
50BF	Circuit-breaker failure protection	Not blocked
59	Overvoltage protection	Not blocked
67/67N	Directional overcurrent protection	Blocked
87BB	Busbar differential protection	Blocked
87L	Line differential protection	Blocked



NOTE

If a current summation is configured (more than 1 current measuring point is routed to a function group), the protection functions hosted by the function group are always blocked.

Literature

- /1/ Distance Protection, Line Differential Protection, and Overcurrent Protection for 3-Pole Tripping – 7SA82, 7SD82, 7SL82, 7SA84, 7SD84, 7SA86, 7SD86, 7SL86, 7SJ86
C53000-G5040-C010
- /2/ Distance and Line Differential Protection, Breaker Management for 1-Pole and 3-Pole Tripping – 7SA87, 7SD87, 7SL87, 7VK87
C53000-G5040-C011
- /3/ Overcurrent Protection – 7SJ82/7SJ85
C53000-G5040-C017
- /4/ Overcurrent Protection – 7SJ81
C53000-G5040-C079
- /5/ Motor Protection – 7SK82/85
C53000-G5040-C024
- /6/ Transformer Differential Protection – 7UT82, 7UT85, 7UT86, 7UT87
C53000-G5040-C016
- /7/ Generator Protection – 7UM85
C53000-G5040-C027
- /8/ Busbar Protection – 7SS85
C53000-G5040-C019
- /9/ High-Voltage Bay Controller – 6MD85/86
C53000-G5040-C015
- /10/ Paralleling Device – 7VE85
C53000-G5040-C071
- /11/ Universal Protection – 7SX82/7SX85
C53000-G5040-C607
- /12/ Merging Unit 6MU85
C53000-G5040-C074
- /13/ Fault Recorder – 7KE85
C53000-G5040-C018
- /14/ Compact Class – 7SX800
C53000-G5040-C003
- /15/ Hardware Description
C53000-G5040-C002
- /16/ Communication Protocols
C53000-L1840-C055
- /17/ Process Bus
C53000-H3040-C054
- /18/ DIGSI 5 – Software Description
C53000-D5040-C001

- /19/ SIPROTEC 5 – Security
C53000-H5040-C081
- /20/ PIXIT, PICS, TICS, IEC 61850
C53000-G5040-C013
- /21/ Operation
C53000-G5040-C003
- /22/ Engineering Guide
C53000-G5040-C004
- /23/ High-Speed Busbar Transfer– 7VU85
C53000-G5040-C090

Glossary

ASDU

ASDU stands for **A**pplication **S**ervice **D**ata **U**nit. An ASDU can consist of one or more identical information objects. A sequence of the same information elements, for example measured values, is identified by the address of the information object. The address of the information object defines the associated address of the 1st information element of the sequence. A consecutive number identifies the subsequent information elements. The number builds on this address in integral increments (+1).

Best Master Clock Algorithm

A PTP network consists of communicating clocks. The best master clock algorithm (BMCA) is used to determine the device that indicates the most precise time. This device serves as a reference clock and is called the grandmaster. In case of changes to the network topology, the BMC algorithm is performed again for network segments which might be cut off from the grandmaster. If a participating device assumes the role of master and slave at the same time, it is also referred to as a boundary clock.

BMCA

Best **M**aster **C**lock **A**lgorithm

Boundary clock

The PTP protocol recognizes different types of clock: An Ordinary Clock (OC), Boundary Clock (BC), and Transparent Clock (TC). The boundary clock transmits time information beyond a network limit. For example in a router which connects different switched networks. As a slave, the clock of the router receives time information and passes it on as a master.

CID

Configured **I**ED **D**escription

DANP

Double **A**ttached **N**ode **P**RP

DIGSI

Configuration software for SIPROTEC

FG

Function group

Function group

Functions are brought together into function groups (FG). The assignment of functions to current and/or voltage transformers (assignment of functions to measuring points), the information exchange between the function groups via interfaces as well as the generation of group indications are important for this bringing together.

Global Navigation Satellite System

A global navigation satellite system or GNSS is a system for determining position and for navigation on the ground and in the air. Position is determined by the receipt of signals from navigation satellites and pseudolites.

GNSS

Global Navigation Satellite System

GOOSE

Generic Object-Oriented Substation Event

HSR

High Availability Seamless Redundancy Protocol

IED

Intelligent Electronic Device

IED stands for a physical part of a device (hardware, etc.)

IID

Instantiated IED Description

Instantiated IED Description

Files in IID format are ICD files adapted for the specific use case in the project. This format is mainly suitable for exchanging data between DIGSI 5 and an external system configurator or a substation automation system such as SICAM PAS. The ICD format uses SCL as the description language for this.

LAN

Local Area Network

LSVS

Logical node Sampled Value Subscription supervision

Master Clock

The **Master Clock (MC)** contains a mechanical or electric mechanism and a contact device, which periodically transmits drive pulses to the slave clocks.

Merging Unit

The **Merging Unit (MU)** is used (also for IEC 61850 plant) for the field-signal bus interface. The publisher/server of the sampled measured values is designated as the merging unit.

MU

Merging Unit

Sampled Measured Value

IEC 61850 is a communication protocol for electrical substation automation systems. The abstract data models defined in IEC 61850 can be mapped with various protocols. At present, there are mappings in the standard for the following protocols:

MMS (Manufacturing Message Specification)

GOOSE (Generic Object Oriented Substation Event)

SMV (Sampled Measured Value)

Web services (coming soon)

These protocols can run with fast-switching Ethernet via TCP/IP networks or substation LANs to achieve the required response times for protection functions of under 4 ms.

Sampling rate

In signal processing, sampling is reducing a continuous time signal (for example current and voltages) to a discrete time signal. A common example is converting soundwave (a continuous signal) into a sampling sequence (a discrete time signal).

SMV

Sampled **M**easured **V**alue

SV Stream

Sampled **V**alue **S**tr**e**am

The SV stream is a set of current and voltage values that are transmitted in a fast and cyclical fashion. Information exchange is based on a publisher/subscriber mechanism. SV transmission is a continuous stream of layer-2 Ethernet telegrams in one direction. The content of an SV stream can be configured in anyway you wish in accordance with IEC 61869-9. IEC 61850-9-2 LE defines a fixed set of 4 voltage and 4 current values for each SV stream.

Transparent clock

The Precision Time Protocol (PTP) recognizes different types of clocks: a standard clock (referred to as Ordinary Clock, OC for short), a Boundary Clock (BC) and a Transparent Clock (TC). The transparent clock was integrated in the specification retrospectively in 2008 and serves to improve the transmission of time information within a network by receiving PTP messages and modifying (correcting) them before passing them on.

VLAN

Virtual **L**ocal **A**rea **N**etwork

Index

A

Application Diagnosis, Electrical modules
PB-Client 135
Application Diagnosis, Ethernet modules
PB-Client 135

C

Communication diagnosis
Electrical Modules 134
Optical modules 134
Communication diagnosis, electrical modules
Application diagnosis 134
Communication diagnosis, optical modules
Application diagnosis 134
Communication node
Information 23
Structure 23
Configure 89, 89

D

DSP5 88, 89

E

ELCAD 88

F

Functionality
IEC 61850-9-2 process bus 12

I

IEC 61850-9-2 process bus
Functionality 12
IED node

Structure 16

IID

File 14
Introduction 14
Structure 14

Import 88, 89

Information

Communication node 23
LNs 19
SV control block 17
SV dataset 18

Introduction

IED node 16
IID 14

M

Merging Unit

Recommendation 144
Restriction 145
Technical data 148

P

Parameterization

Merging unit 38
Merging unit 6MU805 72
Process-bus client 33

Process-bus client

Recommendation 144
Restriction 145
Technical data 149

PTP

Recommendation 144
Restriction 145

R

Recommendation

Merging Unit 144
Process-bus client 144
PTP 144

Restriction

- Merging Unit 145
- Process-bus client 145
- PTP 145

S

- SCD 89, 89
- SEQ5 89
- Start 88
- Structure
 - Communication node 23
 - IED node 16
 - IID file 14

T

- TCF 89
- TEA-X 89
- Technical data
 - Merging Unit 148
 - Process-bus client 149

U

- UAT 89