

Grid Automation Products

SAM600 Process Bus I/O System

Version 1.2

Product guide



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Conformity

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

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1. Document revision history

Document revision	Date	Product revision	History
A	2017-06	1.2.0	First release for product version 1.2
B	2019-04	1.2.1	Document enhancement and corrections
C	2020-05	1.2.2	Document enhancement and corrections
D	2022-05	1.2.2.2	Document enhancement and corrections

2. Overview

SAM600 process bus I/O system is a modular, extensible, and customizable product solution that converts signals from the primary analog process to its digital counterpart according to the IEC 61850 standard.

The product is designed for both AIS and GIS applications. It can be beneficially applied to secondary system upgrades as well as new substation installations, thus integrating seamlessly with modern sensor technology.

SAM600 optimally tailors to different applications, is prepared for placement in harsh outdoor setups and can be deployed in a stepwise manner in marshalling kiosks close to primary apparatus, or in existing secondary system protection and control panels.

3. Features

SAM600 process bus I/O system provides unique features with focus on adaptability to different application types, easy installation and maintenance for integration into existing secondary systems or for new installations.

- A SAM600 module per primary apparatus interfaces conventional current or voltage transformers and provides SAMU functionality according to the IEC 61850-9-2 standard.
- DIN-rail mountable SAM600 modules with a compact form factor can be placed close to the primary apparatus. SAM600 modules support operating temperature ranges between -40°C to +70°C.
- Each SAM600 module terminates main signals from the process (for example, voltages and currents), as well as auxiliary signals (fuse failure and test switch indication), thus avoiding cross-wiring and simplifying replacement and maintenance activities.
- SAM600 modules can be chained into a SAM600 system in order to scale the specific needs of the installation in terms of analog interfaces, communication ports, and time synchronization capabilities needed, supporting IEC 62439-3 PRP and HSR communications.
- A SAM600-TS module can bridge IEC 61850-9-2 traffic for simplifying integration with non-conventional instrument transformers.
- SAM600 provides time synchronization according to IEEE 1588 (according to profile IEC/IEEE 61850-9-3) as well as 1PPS (both inputs and outputs).

4. Typical installations

As depicted in [Figure 1](#), SAM600 modules can be deployed in a variety of scenarios which optimally suit different installation types.

- SAM600 modules installed in a single marshalling kiosk in the field ([Figure 1a](#)) - All SAM600 modules are installed in a marshalling kiosk which is placed in the field close to the primary apparatus. Cabling from the instrument transformers is terminated at the kiosk and fiber optic is used for communication to protection and control equipment. The kiosk requires station battery supply for powering the SAM600 modules.
- SAM600 modules installed in several marshalling kiosks ([Figure 1b](#) and [Figure 1c](#)) - SAM600 modules can be deployed in a physically distributed setup and exchange information over fiber optic communication according to IEC 61850 standard. This deployment optimizes proximity to primary apparatus.
- SAM600 modules installed in secondary system control and protection panels ([Figure 1d](#)) - The existing copper cables from primary apparatus can be terminated directly at SAM600 modules mounted in the station panels. This deployment option is ideal for retrofit projects where copper cabling already exists and is not exchanged in a retrofit project.
- A SAM600-TS module is optional in a SAM600 system setup and is required for redundant uplink communications (PRP, HSR) and for 1PPS synchronization requirements. For IEEE 1588 synchronization, SAM600 can directly synchronize without a SAM600-TS module ([Figure 1a](#), [Figure 1d](#)). Up to three SAM600-TS modules can be integrated into a SAM600 chain or ring.

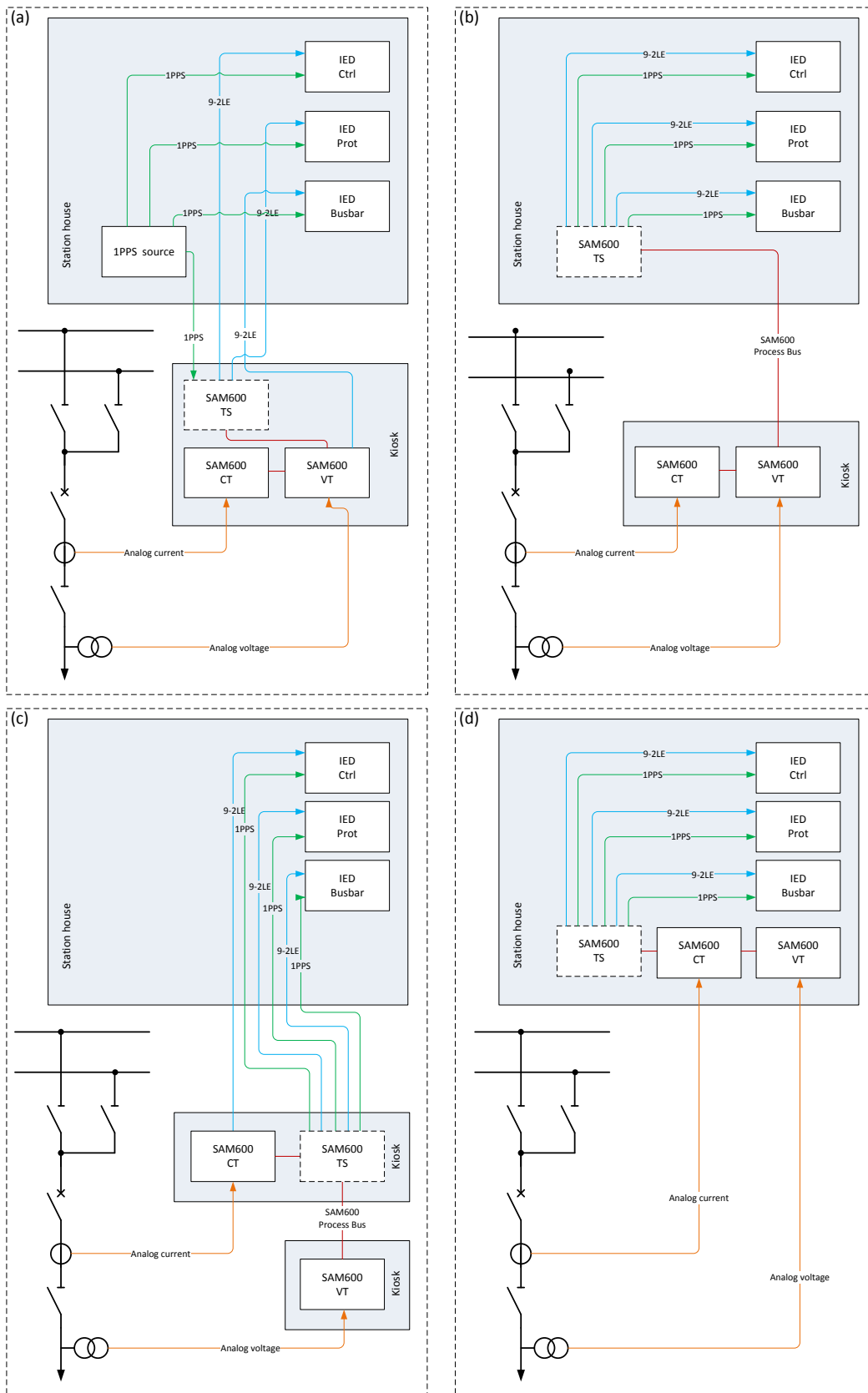


Figure 1. Installation options of SAM600 process bus I/O system

5. SAM600 system design

SAM600 process bus I/O system is a modular system allowing for optimal adaption to different primary application types.

The SAM600 family consists of three different types of hardware modules. Each module provides distinct functionality:

- *Analog input modules for current and voltage measurements SAM600-CT and SAM600-VT* – The two modules acquire analog data from instrument transformers (currents and voltages), perform the analog to digital conversion and generate IEC/UCA 61850-9-2LE conformant data streams on the IEC 61850 access points.
- *Time synchronization and IEC 61850 redundant communication gateway module SAM600-TS* – The module provides up to four additional IEC 61850 access points. The module provides communication redundancy functionality according to IEC 62439-3 (PRP, HSR) for uplink communication. It also acts as a time synchronization conversion unit providing different mechanisms to synchronize against time synchronization protocols, such as IEEE 1588 and 1PPS. SAM600-TS provides 1PPS outputs which can be used to synchronize other devices in the secondary system setup.
- Up to 10 SAM600 modules can be chained into a SAM600 system in order to scale and configure IEC 61850 access points. Up to three SAM600 modules in a chain or ring can be SAM600-TS modules for creating redundant uplink communication according to HSR or PRP.

SAM600 common design features

SAM600 modules with a compact form factor are suited for marshalling kiosk or panel mounting using standard DIN-rail. Each SAM600 module terminates the secondary side of the primary equipment for both main and auxiliary signals.

Power supply voltage of SAM600 modules is 24 VDC. This supply voltage is typically retrieved from the station battery through a DC/DC converter (available as separate accessory). All SAM600 modules carry two power supply connectors in order to allow for redundant power supply setups.

Each SAM600 module has four communication ports, two 100BASE-TX and two 100BASE-FX (SFP).

Two of the ports are used to connect SAM600 modules with each other to a SAM600 IEC 61850-compliant system bus in a chain or in a ring according to IEC 62439-3 HSR. The other two communication ports are available as IEC 61850 access points for bay level protection and control devices.

All SAM600 modules are natively synchronized through IEEE 1588 (profile IEC/IEEE 61850-9-3).

A SAM600 system is configured through PCM600 Protection and Control IED manager software and a SAM600 specific Connectivity Package.

SAM600-CT

A SAM600-CT module has four analog input measurement channels and interfaces conventional current transformers with a 1A or 5A secondary interface (order variant). The measurement chain is calibrated and temperature compensated. Interposing CTs are not required and different ratios can be set as settings in PCM600.

The neutral current as provided in the IEC/UCA 61850-9-2LE stream can either be measured or calculated as sum of the three phase values.

A pre-assigned binary input can be directly wired to a test switch. The input signals a test condition in the IEC/UCA 61850-9-2LE stream through a corresponding quality bit in order to allow for blocking conditions in the IEDs receiving the data stream. The polarity of the binary input is configurable.

SAM600-VT

A SAM600-VT module has four analog input measurement channels and interfaces conventional voltage transformers with a configurable input voltage between 100V – 125V AC (phase-phase) on the secondary interface. The measurement chain is calibrated and temperature compensated.

The neutral voltage as provided in the IEC/UCA 61850-9-2LE stream can either be measured or calculated as sum of the three phase values.

Binary inputs are provided to signal fuse failure and test conditions in the IEC/UCA 61850-9-2LE stream through a corresponding quality bit in order to allow for blocking conditions in the IEDs receiving the data stream. Three inputs which can be wired to the secondary contacts of MCBs are pre-assigned to signal a fuse failure per phase. A fourth input is provided to signal a test condition in the stream. The polarities of the binary inputs are configurable.

SAM600-TS

A SAM600-TS module provides IEC 61850 access point functionality, including redundant communication according to IEC 62439-3, as well as time synchronization functionality. The module also has a hardware watchdog functionality.

A SAM600-TS module includes two additional IEC 61850 access points which can receive and publish IEC/UCA 61850-9-2LE streams from and to the SAM600 system to bay level protection and control devices.

Two of the access points can be configured to create a chain or a SAM600 system bus ring, and two additional access points provide either two separate IEC 61850

access points for point to point uplink connections to IEDs or the IEC 61850 station bus, or one IEC 61850 access point configured according to IEC 62439-3 as PRP or HSR functionality.

A SAM600 system can run in a free-running mode or synchronize with IEEE 1588 (profile IEC/IEEE 61850-9-3) or 1PPS signal. Conversely, SAM600 can synchronize through SAM600-TS other merging units or IED devices through the five 1PPS outputs available.

A SAM600-TS module is optional in a SAM600 system. Maximum three SAM600-TS modules can be chained into a SAM600 system, each of them providing point-to-point or redundant uplink communication.

6. Functionality

Scalable SAM600 system and system size

Each SAM600 module with analog inputs (SAM600-VT and SAM600-CT) is a self-contained SAMU and can be used in different process bus architectures. Two independent IEC 61850 access points are available in order to publish analog measurements according to IEC/UCA 61850-9-2LE and to synchronize the device by means of IEEE 1588 to external clocks.

Redundant uplink communication (HSR, PRP)

A SAM600-TS module in a SAM600 chain or SAM600 ring can be configured with up to two IEC 61850 access points for uplink communication in a point-to-point mode, or with one IEC 61850 access point with redundant communication according to IEC 62439-3 (HSR or PRP) (Figure 2a and Figure 2b). If a SAM600 system needs to participate in several redundant communication schemes (such as PRP for IEC 61850 station bus, and HSR for IEC 61850 process bus), then several SAM600-TS modules can be used for this purpose, each of those modules creating a separate redundant uplink communication (Figure 2c).

A SAM600 system consists of at least one module of any type (SAM600-CT or SAM600-VT or SAM600-TS) and can have up to 10 SAM600 modules. The amount of analog processing modules (SAM600-CT, SAM600-VT) per

SAM600 system is limited to 7. The amount of time synchronization modules (SAM600-TS) is limited to 3 per SAM600 system.

The chained SAM600 modules act as a single SAMU with scalable and configurable IEC 61850 access points.

Sample value bridging

The ports of a SAM600-TS module can be configured for bridging incoming IEC/UCA 61850-9-2LE traffic into a SAM600 system to outgoing IEC 61850 access points in the SAM600 system. A SAM600 system does not modify the payload of any bridged messages.

Merging of IEC/UCA 61850-9-2LE streams

With a SAM600 system, IEC/UCA 61850-9-2LE based streams that consist of information provided by individual SAM600 modules can be configured and published on all IEC 61850 access points. This allows to adapt to various communication architectures and performance requirements of client devices such as IEDs.

Each SAM600 module provides its measurements as IEC/UCA 61850-9-2LE compatible stream on the SAM600 system bus. With PCM600, streams can be created with the SV Configurator Tool and are assigned to the available IEC 61850 access points of a SAM600 system.

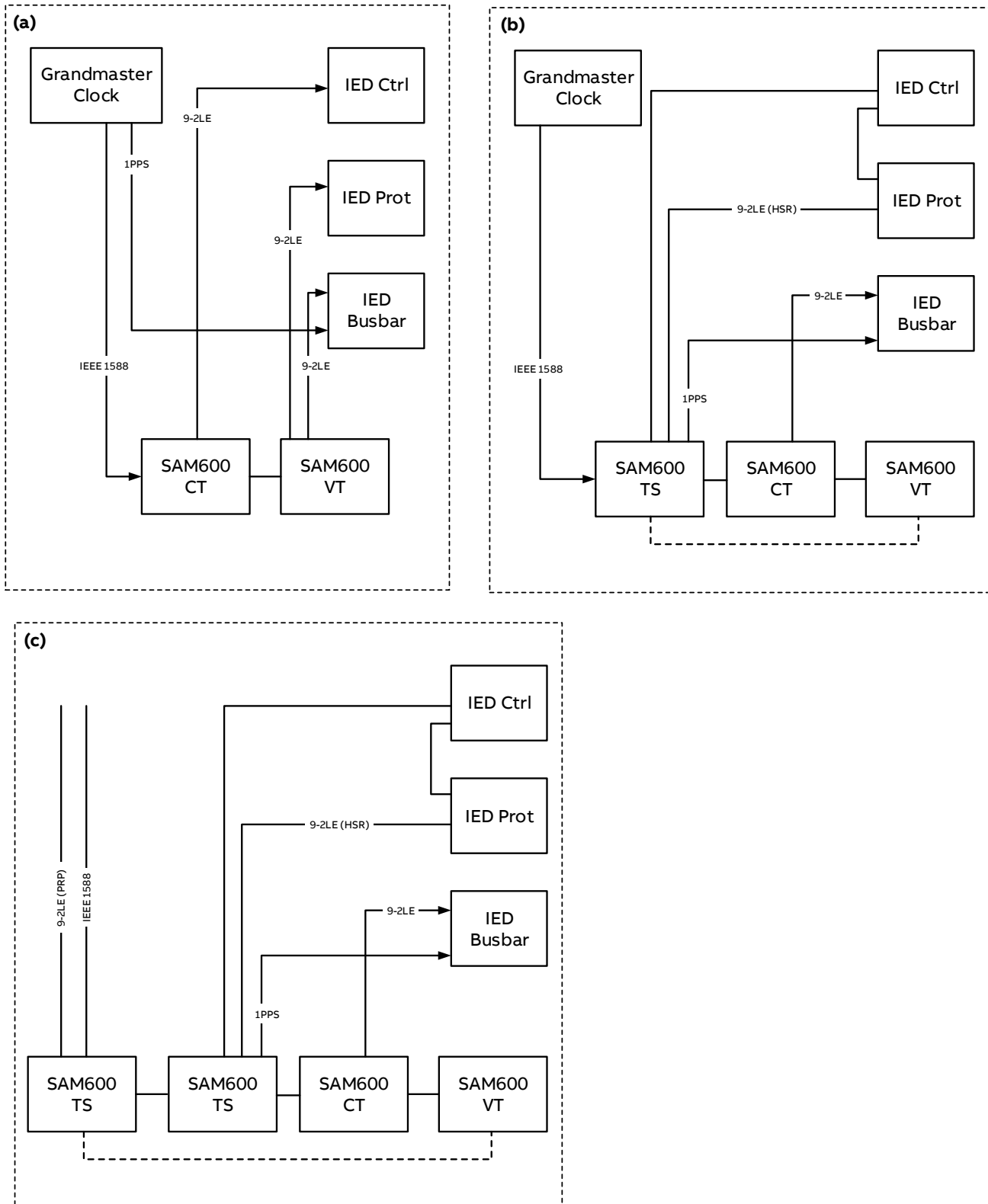


Figure 2. SAM600 communication architectures

Usage of electrical or optical communication ports

SAM600 modules can be placed in a single marshaling kiosk or in separate housings in order to achieve close

proximity to primary equipment (see Figure 1) and minimize cabling to primary apparatus.

When installed in the same kiosk, a SAM600 system bus is typically realized through 100BASE-TX ports. When installed in different compartments in the field, the system bus through which SAM600 modules communicate with each other must be realized by 100BASE-FX ports.

A redundant uplink communication on SAM600-TS requires the same physical ports to be used as pair.

Binary inputs

Binary inputs on SAM600 modules are used for secondary system supervision. The inputs are pre-assigned with test switch indication (SAM600-VT and SAM600-CT) and fuse failure indication (SAM600-VT only). Information acquired through these inputs is reflected in the quality information in the IEC/UCA 61850-9-2LE streams.

The polarity and the input level of the binary inputs are configurable.

Neutral behavior

The IEC/UCA 61850-9-2LE telegram definition contains a fourth measurement for both currents and voltages. Depending on the primary equipment and user requirements, SAM600 modules can be configured individually on how the fourth measurement is acquired. Both, measurements of the primary value and summation of measured phases are available. The quality information in the IEC/UCA 61850-9-2LE stream will reflect the setting.

Time synchronization

Analog samples are time synchronized in order to provide the phase accuracy required by IEC 61869-9. Synchronization of a SAM600 system with IEDs is achieved by IEEE 1588 (profile IEC/IEEE 61850-9-3) or using a SAM600-TS device through a 1PPS signal. Internally, a SAM600 system always synchronizes using IEEE 1588.

The following synchronization methods are supported:

- *Synchronization by IEEE 1588* – Any SAM600 module can synchronize against an external IEEE 1588 master clock (see Figure 3) with an accuracy of 1µs in order to ensure synchronous sampling. If a SAM600-TS device is available in the system chain, then the 1PPS outputs are synchronized against the IEEE 1588 signal and can be used for synchronizing client devices such as IEDs.

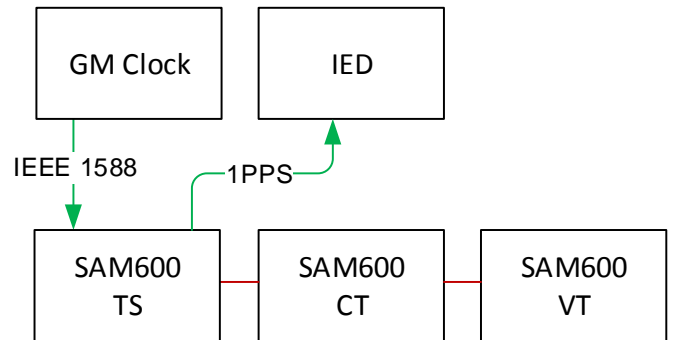


Figure 3. SAM600 IEEE 1588 synchronization

- *Free-running* – A SAM600 system can operate in a free-running mode (see Figure 4) with no external time synchronization. The SAM600 system itself synchronizes internally by means of IEEE 1588 in order to ensure synchronous sampling of the analog data.

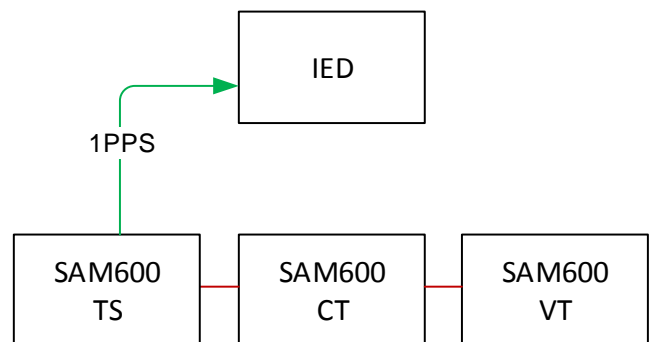


Figure 4. SAM600 free-running

- *Synchronization by 1PPS* - A PPS from an external clock is used to synchronize a SAM600 system (see Figure 5) through SAM600-TS with an accuracy of 1µs in order to ensure synchronous sampling. The SAM600-TS module replicates the 1PPS information to the 1PPS outputs and synchronizes the SAM600 system internally through IEEE 1588 against the 1PPS input.

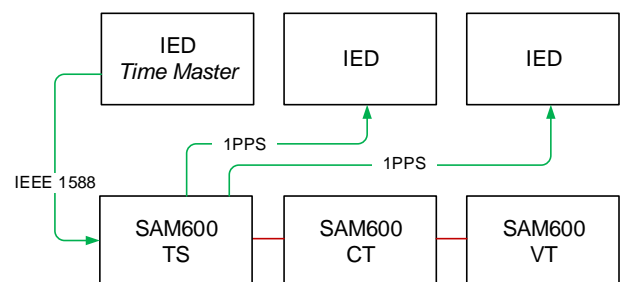


Figure 5. PPS synchronization

SAM600 configuration with PCM600

PCM600 Protection and Control IED Manager Software is used for configuring SAM600 modules and SAM600

systems. A SAM600 Connectivity Package provides the user with a wizard-based configuration approach for SAM600 system setup, such as SAM600 module types and topology configuration.

IEC 61850 access points and relevant IEC/UCA 61850-9-2LE stream configurations, as well as specific SAM600 module and system settings are configurable by the user.

PCM600 generates a SAM600 system configuration which is downloaded to a SAM600 system by connecting to any SAM600 module through USB and then replicated to the other SAM600 modules in the system chain. The IEC 61850 configuration of a SAM600 system can also be exported and used in IEC 61850 system engineering tools.

Backward compatibility

SAM600 Connectivity Package provides a migration assistant which allows to migrate SAM600 configurations.

Watchdog

The SAM600-TS module provides watchdog functionality. The watchdog is activated during critical system states.

Cyber security

SAM600 modules provide means for minimizing the impact of cyber security attacks such as denial of service or network flooding.

By default all unused physical ports and services are disabled in a SAM600 system configuration.

For more information refer to 1MRK 511 430-UEN SAM600 Cyber Security Deployment Guideline document.

7. Hardware

General description

SAM600 modules come with a compact form factor and are mounted on standard DIN-rails (see [Figure 6](#)). SAM600

modules can be mounted both in horizontal or vertical orientation. All SAM600 modules are equipped with a marked safety GND connection point on the left side of the module.



Figure 6. SAM600 module (SAM600-VT)

Dimensions and weights

[Table 1](#) provides an overview of the dimensions and weights of the SAM600 modules.

Table 1. Dimensions and weights of SAM600 modules

Dimensions and weights	SAM600-CT	SAM600-VT	SAM600-TS
Length (mm)	233	233	233
Width (mm) (with/without connectors)	157/132	144/132	157/132
Height (mm) (with DIN-rail clamp)	60	60	60
Weight (kg)	< 1.30	< 1.00	< 1.30
Minimum horizontal space (mm)	20 (between modules or cable duct)		
Minimum vertical space (mm)	50 (between modules or cable duct)		

8. Connection diagrams

SAM600-CT

Sideplate connector positions

[Figure 7](#) and [Figure 8](#) depict the position and numbering of connectors of the SAM600-CT module.

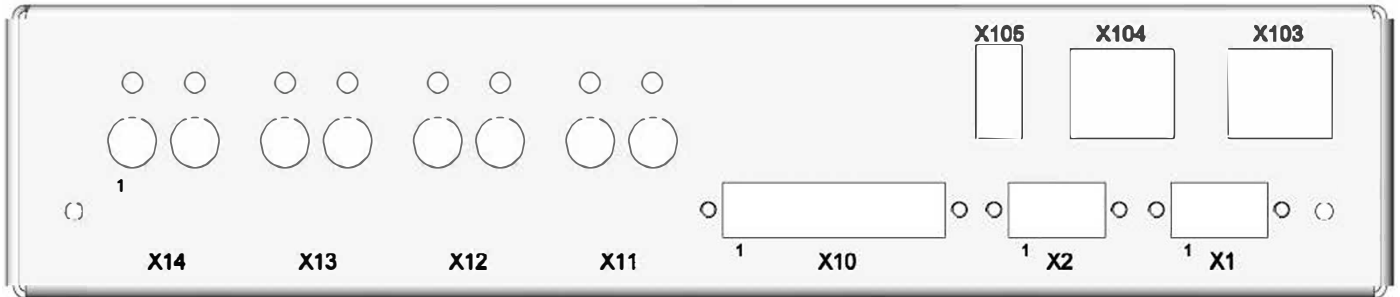


Figure 7. SAM600-CT module electrical Ethernet side view



Figure 8. SAM600-CT module fiber optical Ethernet side view

Wiring diagrams

Refer to Section 10 for additional documentation.

Connector descriptions

[Table 2](#) lists the interface descriptions for the SAM600-CT module.

Table 2. Interfaces for SAM600-CT

Interface	Connector	Pin	Remark
Power supply interface	X1/X2		
Power supply - VDC	X1	1	
Power supply +24 VDC	X1	2	main power
Power supply - VDC	X1	3	
Power supply - VDC	X2	1	
Power supply +24 VDC	X2	2	redundant power
Power supply - VDC	X2	3	
Digital interface	X10		
Test switch indication	X10	1	
Not used	X10	2	
Not used	X10	3	
Not used	X10	4	
Binary input common GND	X10	5	
Shielding GND	X10	6	leave open (internally connected to shielding GND)
Shielding GND	X10	7	leave open (internally connected to shielding GND)
Analog interface	X11-X14		
Current phase L1-	X14	1	
Current phase L1+	X14	2	
Current phase L2-	X13	1	
Current phase L2+	X13	2	
Current phase L3-	X12	1	
Current phase L3+	X12	2	
Current phase N-	X11	1	
Current phase N+	X11	2	
Optical network interface	X101/X102		
IEC/UCA 61850-9-2LE process bus/system bus	X101	NA	SFP cage for optional 100Base-FX SFP module
IEC/UCA 61850-9-2LE process bus/system bus	X102	NA	SFP cage for optional 100Base-FX SFP module
Electrical network interface	X103/X104		
IEC/UCA 61850-9-2LE process bus/ system bus	X103	NA	100Base-TX
IEC/UCA 61850-9-2LE process bus/ system bus	X104	NA	100Base-TX
Configuration interface	X105		

Table 2. Interfaces for SAM600-CT, continued

Interface	Connector	Pin	Remark
Connection to SAM600 configuration tool	X105	NA	USB-A/USB-A cable
LED status indication	D2		
Status indications	D2.1-D2.4	NA	For more details refer to 1MRK 511 429-UEN SAM600 Operation Manual

SAM600-VT

Sideplate connector positions

[Figure 9](#) and [Figure 10](#) depict the position and numbering of connectors of the SAM600-VT module.



Figure 9. SAM600-VT module electrical Ethernet side view



Figure 10. SAM600-VT module fiber optical Ethernet side view

Wiring diagrams

Refer to Section 10 for additional documentation.

Connector descriptions

[Table 3](#) lists the interface descriptions for the SAM600-VT module.

Table 3. Interfaces for SAM600-VT

Interface	Connector	Pin	Remark
Power supply interface	X1/X2		
Power supply - VDC	X1	1	
Power supply +24 VDC	X1	2	main power
Power supply - VDC	X1	3	
Power supply - VDC	X2	1	
Power supply +24 VDC	X2	2	redundant power
Power supply - VDC	X2	3	
Digital interface	X10		
Test switch indication	X10	1	
Fuse failure phase 1	X10	2	
Fuse failure phase 2	X10	3	
Fuse failure phase 3	X10	4	
Binary input common GND	X10	5	
Shielding GND	X10	6	leave open (internally connected to shielding GND)
Shielding GND	X10	7	leave open (internally connected to shielding GND)
Analog inputs	X20		
Voltage phase L1-	X20	1	
Voltage phase L1+	X20	2	
Voltage phase L2-	X20	3	
Voltage phase L2+	X20	4	
Voltage phase L3-	X20	5	
Voltage phase L3+	X20	6	
Voltage phase N-	X20	7	
Voltage phase N+	X20	8	
Optical network interface	X101/X102		
IEC/UCA 61850-9-2LE process bus/system bus	X101	NA	SFP cage for optional 100Base-FX SFP module
IEC/UCA 61850-9-2LE process bus/system bus	X102	NA	SFP cage for optional 100Base-FX SFP module
Electrical network interface	X103/X104		
IEC/UCA 61850-9-2LE process bus/system bus	X103	NA	100Base-TX
IEC/UCA 61850-9-2LE process bus/system bus	X104	NA	100Base-TX
Configuration interface	X105		

Table 3. Interfaces for SAM600-VT, continued

Interface	Connector	Pin	Remark
Connection to SAM600 configuration tool	X105	NA	USB-A/USB-A cable
LED status indication	D2		
Status indications	D2.1-D2.4	NA	For more details refer to 1MRK 511 434-UEN SAM600 Operation Manual

SAM600-TS

Sideplate connector positions

[Figure 11](#) and [Figure 12](#) depict the position and numbering of connectors of the SAM600-TS module.



Figure 11. SAM600-TS module electrical Ethernet side view

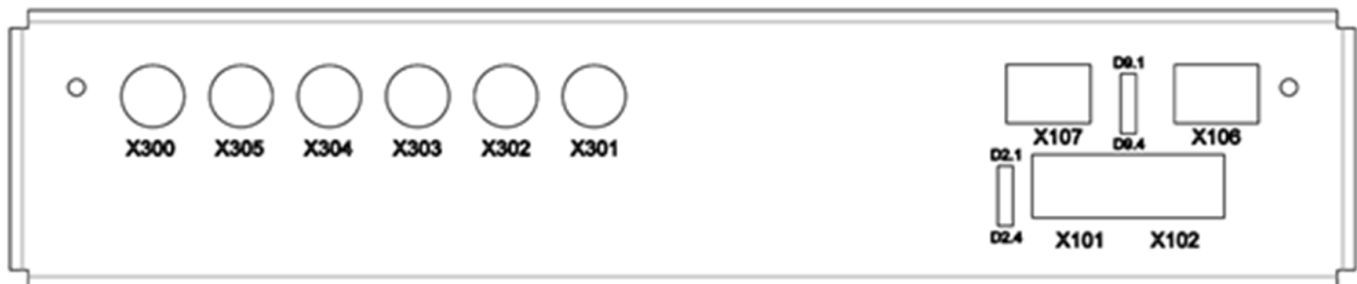


Figure 12. SAM600-TS module fiber optical Ethernet side view

Wiring diagrams

Refer to Section 10 for additional documentation.

Connector descriptions

[Table 4](#) lists the interface descriptions for the SAM600-TS module.

Table 4. Interfaces for SAM600-TS

Interface	Connector	Pin	Remark
Power supply interface (Not activated)	X1/X2		
Power supply - VDC	X1	1	
Power supply +24 VDC	X1	2	main power
Power supply - VDC	X1	3	
Power supply - VDC	X2	1	
Power supply +24 VDC	X2	2	redundant power
Power supply - VDC	X2	3	
Binary input interface	X10		
Binary input	X10	1	Not used
Binary input	X10	2	Not used
Binary input	X10	3	Not used
Binary input	X10	4	Not used
Binary input common GND	X10	5	Not used
Shielding GND	X10	6	Not used
Shielding GND	X10	7	Not used
Internal relay fault	X40		
Common	X40	1	
Normally closed	X40	2	
Normally open	X40	3	
Optical network interface	X101/X102		
IEC/UCA 61850-9-2LE process bus/system bus	X101	NA	SFP cage for optional 100Base-FX SFP module
IEC/UCA 61850-9-2LE process bus/system bus	X102	NA	SFP cage for optional 100Base-FX SFP module
Copper network interface	X103 / X104		
IEC/UCA 61850-9-2LE process bus/system bus	X103	NA	100Base-TX
IEC/UCA 61850-9-2LE process bus/system bu	X104	NA	100Base-TX
Configuration interface	X105		
USB 2.0 configuration interface (serial connection)	X105	NA	USB-A/USB-A cable
Optical network interface	X106/X107		
IEC/UCA 61850-9-2LE process bus	X106	NA	
IEC/UCA 61850-9-2LE process bus	X107	NA	
1PPS input interface	X300		
1PPS input	X300	NA	
1PPS output interface	X301-X305		

Table 4. Interfaces for SAM600-TS, continued

1PPS output	X301	NA	
1PPS output	X302	NA	
1PPS output	X303	NA	
1PPS output	X304	NA	
1PPS output	X305	NA	
LED status indication	D2/D9		
Status indications	D2.1-D2.4	NA	For more details refer to 1MRK 511 434-UEN SAM600 Operation Manual
Status indications	D9.1-D9.4	NA	For more details refer to 1MRK 511 434-UEN SAM600 Operation Manual

9. Technical data

IEC 61850 process bus interface

Table 5. Telegram definition

Description	Value
Sampled values telegram	IEC 61850-9-2
Implementation	UCAIug Implementation Guideline 2004 The sample synchronization indication is a single bit value according to UCAIug Implementation Guideline 2004. SAM600 indicates local and global synchronization in the sample synchronization information (two bit value). This extension is backward compatible to IEC 61850 First Edition and the UCAIug Implementation Guideline 2004.
Sampling rate	80 samples/cycle
Synchronization	IEC/IEEE 61850-9-3: Precision time protocol profile for power utility automation 1PPS: 1 Pulse Per Second (available on SAM600-TS)

IEC 62439-3 redundant communication

Table 6. Redundant communication

Description	Value
Implementation according to	IEC 62439-3 Clause 4 and Clause 5 (PRP and HSR)
Port availability	SAM600-TS, ports X101, X102, X106, X107
SAM600 system bus topology	chain or ring

Analog inputs

Relevant standard for the analog input accuracy is IEC 60044-8.

Table 7. Analog input rating for SAM600-CT

Description	Value															
Rated frequency	50 or 60Hz, settable															
Operating range	Rated frequency \pm 5Hz															
Nominal current, I_r	1A or 5A (RMS), order variant															
Measurement range	80 I_r , up to 20th harmonic															
Thermal withstand capability																
Continuously	4x I_r															
For 1 s	100x I_r															
For 10 s	20x I_r															
Dynamic current withstand capability	250 I_r															
Half-wave value																
Burden at rated current	< 0.1VA															
Measurement accuracy (amplitude/phase) across operating temperature range (-40°C ... +70°C)	<table border="1"> <tbody> <tr> <td>0.01 .. 0.2 I_r</td> <td>< 0.4% I_r</td> <td>< 30 arcmin</td> </tr> <tr> <td>0.2 .. 1.2 I_r</td> <td>< 0.1% I_r</td> <td>< 10 arcmin</td> </tr> <tr> <td>1.2 .. 2 I_r</td> <td>< 0.5% I_r</td> <td>< 10 arcmin</td> </tr> <tr> <td>2 .. 6 I_r</td> <td>< 1.0% I_r</td> <td>< 10 arcmin</td> </tr> <tr> <td>6 .. 80 I_r</td> <td>< 5.0% I_r</td> <td>< 30 arcmin</td> </tr> </tbody> </table>	0.01 .. 0.2 I_r	< 0.4% I_r	< 30 arcmin	0.2 .. 1.2 I_r	< 0.1% I_r	< 10 arcmin	1.2 .. 2 I_r	< 0.5% I_r	< 10 arcmin	2 .. 6 I_r	< 1.0% I_r	< 10 arcmin	6 .. 80 I_r	< 5.0% I_r	< 30 arcmin
0.01 .. 0.2 I_r	< 0.4% I_r	< 30 arcmin														
0.2 .. 1.2 I_r	< 0.1% I_r	< 10 arcmin														
1.2 .. 2 I_r	< 0.5% I_r	< 10 arcmin														
2 .. 6 I_r	< 1.0% I_r	< 10 arcmin														
6 .. 80 I_r	< 5.0% I_r	< 30 arcmin														
Protection accuracy across operating temperature range (-40°C ... +70°C)	For protective applications, SAM600 shall be operated together with protection and control IEDs. SAM600-CT device accuracy error is less than 4% over 1 period of the rated current.															

Table 8. Analog input rating SAM600-VT

Description	Value		
Rated frequency	50 or 60Hz, settable		
Operating range	Rated frequency \pm 5Hz		
Rated voltage (line-line), Ur	100V, 110V, 115V, 120V, 125V (RMS) settable		
Measurement range	2.5 Ur, up to 20th harmonic		
Voltage withstand capability			
Continuously	400V (RMS)		
For 10 s	600V (RMS)		
Burden at rated voltage	< 0.1VA		
Measurement accuracy (amplitude/phase) across operating temperature range (-40°C ... +70°C)	0 .. 0.2 Ur	< 0.4% Ur	< 15 arcmin
	0.2 .. 1.2 Ur	< 0.1% Ur	< 5 arcmin
	1.2 .. 2.5 Ur	< 0.2% Ur	< 60 arcmin
Protection accuracy across operating temperature range (-40°C ... +70°C)	For protective applications, SAM600 shall be operated together with protection and control IEDs. SAM600-VT device accuracy error is less than 4% over 1 period of the rated voltage.		

Digital inputs and power consumption

Table 9. Binary inputs

Description	Value
Operating range	0 to 250 V DC
Rated voltage	24 V, 48 V, 110 V, 125 V, 220 V DC settable
Typical power consumption per input	< 0.10 W at 110 V DC

Table 10. Power consumption

Description	Value
Power supply voltage	24 V DC
Maximum load on auxiliary voltage supply per SAM600 module	< 15 W

Interfaces

Table 11. Ethernet interface

Ethernet interfaces	Protocol	Cable	Data transfer rate
100BASE-TX	IEC 61850-9-2 IEC/IEEE 61850-9-3	CAT 5, CAT 6 STP or SFTP	100 MBit/s
100BASE-FX	IEC 61850-9-2 IEC/IEEE 61850-9-3	Fiber-optic cable with LC connector	100 MBit/s

Table 12. Fiber-optic communication link

Wave length	Fiber type	Connector type
1300 nm	MM 62.5/125 μ m MM 50/125 μ m glass fiber core	LC LC

Table 13. 1PPS inputs and outputs

Wave length	Fiber type	Connector type
850 nm	MM 62.5/125 µm MM 50/125 µm glass fiber core	ST ST

Table 14. Configuration interface

USB interface	USB driver	Connector type
USB 2.0	FTDI http://www.ftdichip.com/Drivers/VCP.htm	USB2.0 type A. This port is a USB slave port. The connector is used only with USB master (cable type USB 2.0 A-A).

Influencing factors

Table 15. Environmental conditions

Description	Value
Operating temperature recommended for operation	-25°C .. +55°C
Permissible temporary temperature for operation (tested for 16h)	-40°C .. +70°C
Relative humidity	< 93%, non-condensing
Altitude	up to 2000 m
IP rating	IP20

Table 16. Environmental tests

Description	Type test value	Reference
Cold tests	operation	IEC 60068-2-1/ANSI C37.90-2005 (chapter 4)
	storage	
Dry heat tests	operation	IEC 60068-2-2/ANSI C37.90-2005 (chapter 4)
	storage	
Damp heat tests	steady state	IEC 60068-2-78 IEC 60068-2-30
	cyclic	

Type tests according to standards

Table 17. Electromagnetic compatibility tests





Description	Type test value	Reference
Electrostatic discharge test Contact discharge Air discharge	8 kV 15 kV	IEC 61000-4-2:2009
Radio frequency interference tests Conducted, common mode Radiated, amplitude-modulated	10 V (emf), f=150 kHz ... 80 MHz 20 V/m (rms), f=80 ... 1000 MHz 10 V/m (rms), f=1.4 ... 2.7 GHz	IEC 61000-4-6:2013 IEC 61000-4-3:2010
Fast transient disturbance tests Communication ports Other ports	4 kV, f=5 kHz 4 kV, f=5 kHz	IEC 61000-4-4:2012
Surge immunity test Communication Other ports	4 kV line-to-earth 4 kV line-to-earth	IEC 61000-4-5:2014
Power frequency immunity test Common mode Differential mode	300 V rms 150 V rms	IEC 61000-4-16:2011
DC input ripple immunity	15%	IEC 61000-4-17:2009
Burst disturbance test Common mode, 100KHz and 1MHz	2.5 kV	IEC 61000-4-18:2011

Table 18. Insulation tests

Description	Type test value	Reference
Dielectric tests	2 kV, 50 Hz, 1 min	IEC 60255-27:2013 ANSI C37.90-2005
Impulse voltage test	5 kV, unipolar impulses, waveform 1.2/50 μ s, source energy 0.5 J	IEC 60255-27:2013 ANSI C37.90-2005
Insulation resistance	>100 M Ω , 500 V DC	IEC 60255-27:2013 ANSI C37.90-2005
Protective bonding resistance	<0.1 Ω (60 s), I \geq 20 A	IEC 60255-27:2013

10. Ordering

Table 19. SAM600 order codes

Part number	Order code	Description	Pictures
1KHL150040R0110	SAM600*1.2-CT-DA-A	SAM600 current measurement unit 4 measurement channels, 1 A nominal	
1KHL150039R0110	SAM600*1.2-CT-DA-B	SAM600 current measurement unit, 5A 4 measurement channels, 5 A nominal	
1KHL150038R0110	SAM600*1.2-VT-DA-H	SAM600 voltage measurement unit 4 measurement channels, 110 V AC nominal	
1KHL150042R0110	SAM600*1.2-TS-DA-P2	SAM600 time synchronization and gateway unit	

11. Related documents

Table 20. Related documents

SAM600 Product Documentation	Document number
SAM600 Product Guide	1MRK 511 437-BEN
SAM600 Engineering Manual	1MRK 511 433-UEN
SAM600 Operation Manual	1MRK 511 434-UEN
SAM600 Cyber Security Deployment Guideline	1MRK 511 435-UEN
SAM600 Accessory List	1MRK 511 436-BEN
SAM600 Safety Leaflet	1KHL511872-UEN
SAM600-TS Wiring Diagram	1KHL511910
SAM600-VT Wiring Diagram	1KHL511911
SAM600-CT Wiring Diagram	1KHL511912
SAM600 1.2 PICS and PIXIT (IEC61580 Ed1)	1KHL516076
SAM600 1.2 MICS (IEC61850 Ed2)	1KHL516090
SAM600 1.2 IEC/IEEE 61850-9-3 PICS	1KHL516091
SAM600 1.2 TICS (IEC61850 Ed2)	1KHL516092

12. Appendix A

Open source software licenses

lwIP - A Lightweight TCP/IP stack, version 1.4.1

lwIP is licenced under the BSD licence:

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13. Glossary

Abbreviation	Description
1PPS	One Pulse Per Second
AC	Alternating Current
AIS	Air Isolated Switchgear
BMC	Best Master Clock
DC	Direct Current
FOCS	Fiber Optic Current Sensor
FTDI	Future Technology Devices International Ltd. (http://www.ftdichip.com/)
GIS	Gas Isolated Switchgear
ICT	IED Configuration Tool
IEC 61850	Substation Automation Communication Standard
IED	Intelligent Electronic Device
IID	Instantiated IED Description
LE	IEC/UCA 61850-9-2LE Light Edition
LED	Light Emitting Diode
MAC	Media Access Control
MSVCB	Multicast Sample Value Control Block
PCM600	Protection and Control IED Manager
PTP	IEEE 1588 Precision Time Protocol
RCB	Report Control Block
SAM600	SAM600 Standalone Merging Unit
SAMU	Standalone Merging Unit
Abbreviation	Description
1PPS	One Pulse Per Second
AC	Alternating Current
AIS	Air Isolated Switchgear
BMC	Best Master Clock
DC	Direct Current
FOCS	Fiber Optic Current Sensor
FTDI	Future Technology Devices International Ltd. (http://www.ftdichip.com/)
GIS	Gas Isolated Switchgear
ICT	IED Configuration Tool
IEC 61850	Substation Automation Communication Standard
IED	Intelligent Electronic Device
IID	Instantiated IED Description
LE	IEC/UCA 61850-9-2LE Light Edition
LED	Light Emitting Diode
MAC	Media Access Control

Abbreviation	Description
MSVCB	Multicast Sample Value Control Block
PCM600	Protection and Control IED Manager
PTP	IEEE 1588 Precision Time Protocol
RCB	Report Control Block
SAM600	SAM600 Standalone Merging Unit
SAMU	Standalone Merging Unit
SCD	Substation Communication Description
SCL	System Configuration Description Language
SCT	System Configuration Tool
SFP	Small Form-Factor Pluggable
SMVID	Sample Value Identifier
SST	System Specification Tool
SV	Sample Value
USB	Universal Serial Bus
UTC	Coordinated Universal Time

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