# Merging Unit and Process Bus solution

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# **Conventional solution**





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# **Conventional Technology**



### **Conventional technology**



- Analog Input card inside device
- Proprietary bus for connection IO <-> CPU



## **Process Bus solution**





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# **Process Bus Technology**



### Process bus technology



- Converting Analog data to digital data
- Sending of SMV via IEC 61850-9-2



# **Digital Substation** Process Bus Overview





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# **Principle and benefits of process bus**





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# SIPROTEC Merging Unit One base module adapts to all sensor types



### **Principle of a Process Bus** Stand-Alone merging unit Copper wires via short distances Conventional Digital interface for instrument transformers IEC 61869-9 LPIT Merging unit as part of switchgear Low power stand alone current, Rogowski coil voltage and combined sensors IEC 61869-10 and 11 Process bus FO Ethernet LPIT C divider R divider\* **RC** divider\* LPIT Optical HSR\* or PRP Network current sensor' **IEC 61869** IEC 61850-9-2

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IEC 61850-8-1

# SIPROTEC 6MU85 Merging Unit

# Digitalization of all primary data close to the process





## **Merging Unit – SIPROTEC 6MU85**

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Unrestricted © Siemens 2020 January 21 Up to 4 plug-in communication modules to enable connection to:

Process bus communication

 SMV: IEC 61850-9-2 / IEC 61850-9-2 LE / IEC 61869-9, GOOSE, MMS: IEC 61850-8-1

Scada communication

IEC 61850-8-1 MMS & GOOSE, DNP3, IEC 60870-5-104, Modbus IP, Profinet IO

Redundant communication

- IEC 62439-3.4 PRP, IEC 62439-3.5 HSR, RSTP, dual homing (Scada)
- IEC 62439-3.4 PRP, dual homing (process bus)

PMU Data Concentrator

Synchrophasor (IEEE C37.118)

Time synchronization

 IEEE 1588V2 IEC 61850-9-3 and IEEE C37.238:2017 (redundant with IEC 62439-3.4 PRP) and dual homing)

Additional applications

- Slave Unit Protocol for external temperature or 4-20 mA measuring devices
- Arc sensors for arc flash protection

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# **Merging Unit – SIPROTEC 6MU85**





### **Benefits**

- Long-term flexibility even after shipping
- Simple exchangeability and retrofitting
- Adding and removing functions throughout the entire life cycle
- Reduced number of device versions due to flexibility
- Minimization of space requirements
- Agile adaptation to future requirements
- Investment security

Ð

# SIPROTEC 6MU85 Merging Unit Protection Functions



ANSI	Function	Abbr.	ANSI	Function	Abbr.
	Protection functions for 1 and 3-pole tripping	3-pole	POW	Point on Wave Switching	POW
	Hardware quantity structure expandable	I/O	DMII	Synchrophasor measurement (1 PMU can be used for max. 8	
25	Synchrocheck, synchronizing function	Sync	FINIO	voltages and 8 currents)	FINO
07	Undervoltage protection: "3-phase" or "pos.seq. V1" or	N/ a	AFD	Arc-protection (only with plug-in module ARC-CD-3FO)	
21	"universal Vx"	V<		Measured values, standard	
38	Temperature Supervision	θ>		Measured values, extended: Min, Max, Avg	
47	Overvoltage protection, negative-sequence system	V2>		Switching statistic counters	
50/51 TD	Overcurrent protection, phases	>		Circuit breaker wear monitoring	Σlx, I²t, 2F
50N/ 51N TD	Overcurrent protection, ground	IN>		CFC (Standard, Control)	
	Instantaneous tripping at switch onto fault	SOTF		CFC arithmetic	
50HS	High speed instantaneous overcurrent protection	>>>		Switching sequences function	
50BF	Circuit-breaker failure protection, 3-pole	CBFP		Inrush current detection	
50RS	Circuit-breaker restrike protection	CBRS		External trip initiation	
	Overvoltage protection: "3-phase" or "zero seq. V0" or	14		Control	
59, 59N	"pos.seq. V1" or "universal Vx"	V>		Fault recording of analog and binary signals	
67	Directional overcurrent protection, phases	l>, ∠(V,I)		Monitoring and supervision	
67N	Directional overcurrent protection, ground	IN>, ∠(V,I)		Protection interface, serial	
74TC	Trip circuit supervision	TCS		Circuit Breaker	
79	Automatic reclosing, 3-pole	AR		Disconnector	
86	Lockout				
90V	Automatic voltage control for 2 winding transformer				
90V	Automatic voltage control for 2 winding transformer with parallel operation				
90V	Automatic voltage control for 3 winding transformer				
90V	Automatic voltage control for grid coupling transformer				

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# Merging Unit – SIPROTEC 6MU85 Integrated cyber security







**Product Security** 

System Security

**Operational Security** 

### **Features**

- Customer-authorized DIGSI 5 Instances
- Role-based Access Control
- Authenticated network
   access for COM-Modules
- Use of customer certificates
- Recording of securityrelevant events and alarms
- Confirmation codes for safety-critical operations
- Crypto-chip for secure information storage
- Siemens CERT and Patch management



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# **Cyber Security**





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# Merging Unit – SIPROTEC 6MU85 Redundant power supply





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# **Merging Unit – SIPROTEC 6MU85**

# Easy, fast and secure access to device with Web Browser





# Monitoring of

- Measurements
- Logs
- Settings
- Device information

# Download of

 Logs as CSV or COMFEDE file (log dependent)

# Secure

- https connection
- Access defined per port
- Controlled by RBAC

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# Merging Unit – SIPROTEC 6MU85

Easy, fast and secure access to device with Web Browser



Runtime	data Dircuit break	Circuit break.		
Health	ENS		cik	good (process) - 27 03 2019 17:22:46 535
Position	DPC		intermediate	good (process) - 27 03 2019 17 22 46 535
Trip/open cmd.	SPS		off	good (process) - 27.03.2019 17.22.46.535
Close command	SPS		off	good (process) - 27.03.2019 17.22.46.535
Command active	SPS		off	good (process) - 27 03 2019 17 22 46 535

	Runtime di	sta 🜔 Line 1 🜔 💯 OvervoltSpit 1 🕩 🗠	rinke T 1		
•	Inputs				
	>Block stage	SPS		tho	invalid (process) - 27 03 2019 17:33 32 606
	Inactive	SPS		flo	good (process) - 27.03.2019 17.22.47.033
	Behavior	ENS		on	good (process) - 27.03.2019 17:22:47.033
	Health	ENS		warning	good (process) - 27.03.2019 17:33:32.606
	Pickup	ACD		off	good (process) - 27.03.2019 17.22.47.033

	• • •	• 🖈		SIEMENS SIPROTE Siprotec 5, admini
50 of 162 logs	loaded	Operational log	downloa	ad as file $\rightarrow$ $\bigcirc$ (
Date	Time	Functions structure	Name	Value
18.04.2018	16:39:59.891	Circuit breaker 1	74TC sup.1BI 1:Trip-circuit failure	on
18.04.2018	16:35:10.077	VI 1ph 1:Rotor gnd. fault -I 1	General:Failure RGF frated	on
18.04.2018	16:35:03.369	E:ETH-BA-2EL:Channel 1	Line Mode:Redund. Channel Live	on
18.04.2018	16:35:03.346	E:ETH-BA-2EL:Channel 1	Line Mode:Channel Live	on
18.04.2018	16:35:00.088	Generator stator:SGF 90% MP-1ph 1	General:Health	ok
18.04.2018	16:35:00.079	Generator stator:81 UnderfreqA 1	General:Undervoltage blocking	on
18.04.2018	16:35:00.079	Generator stator:81 OverfreqA 1	General:Undervoltage blocking	on
18.04.2018	16:35:00.079	Generator stator:32R Revers.pow. 1	General:Undervoltage blocking	on
18.04.2018	16:35:00.079	Generator stator:SGF 90% MP-1ph 1	General:Health	alarm
18.04.2018	16:34:59.919	Recording	Grndfit log:Fault number	0

# Recording

 Download, Delete and Trigger of Fault Records

# Parameterization

Change of settings within an active setting-group

# Display all signal state

- Indication of all information
- Centralized view on warnings, alarms and inactive functions

Fault recorder Fault recorder						
]	Fault number	File Name	Trigger Date	Trigger Time	State	
	1	FRA00001	2019-03-27	08:57:10.709	Downloaded	
		FRA00002	2019-03-27	14:25:29.669	Downloaded	
	3	FRA00003	2019-03-27	14:31:30.661	New	

of 3 logs loaded	Time	Function	Function block	State
27.03.2019	17:33:32.606		General	warning
27.03.2019	17:33:32.606	Line 1:	General	warning
27.03.2019	17:33:32.606	Line 1::59 Overvolt3ph 1	Definite-T 1	warning

🛢 🕑 😳 🚯 🕤 😒									SIEMENS
Generator stator									Sipe
Primary 🚇 Secondary 😱 Percentage 🤇	%								
Vpp.e									
Vph:A	57.698	/ 0*	Iph:A	0.999	A 0"	Vpp:AB	99.943	v 30°	
Vph:B	57.702	/ -120*	lph:B	1.000	A -120"	Vpp:BC	99.942	V -90*	
Ipn:A VplVph:C	57.696	/ 120*	lph:C	1.000	A. 120°	Vpp:CA	99.926	V 150°	
						Vseq:0	0.000	V 0°	
April						Vseq:1	57.699	V 0*	
Pph B						Vseq:2	0.000	V 0"	
Iseq:0	0.000 4	a 0*							
Iseq:1	1.000 /	4 0°							
lseq:2	0.000 /	4 0°							

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# Merging Unit – SIPROTEC 6MU85 Diagnosis homepage of ETH-BD-2FO module



Overview	Overview > Health	_
Health		
Module Info	Health Informa	tion
Network Status	Madula	01
Application Diagnosis	Module	UK
Network Protocols	Channel #1	ок
IEEE 1588	IEC61850_8_1	ОК
SNTP	PRP	ок
Communication Protocols	IEEE1588	ОК
IEC61850	SNTP	ОК
IEC61850 - GOOSE	PBMu	ОК
PB-MU		

Overview	Application Diagnostic > IEEE 15	588	_		-
Health	FIF General				
Module Info	PTP enable	Yes			
Network Status	PTP profile	IEC 61850-9-3:2016			
Application Diagnosis	Transport protocol	Layer 2 Multicast			
Network Protocols	VLAN tag	Not Support			
IEEE 1588	Clock type	Ordinary clock			
SNTP	Slave only	Yes			
Communication Protocols					
IEC61850	Slave Clock				
IEC61850 - GOOSE	General				
PB-MU	Clock ID	B4:B1:5A:FF:FE:09:B5:46			
	Domain number	0			
	Path delay mechanism	Peer-to-Peer			
	P2P request interval	1		seconds	
	Announce receipt timeout	3		seconds	
	Steps	2			
	Servo status	Locked			
	Channel live states	On			
		CH1	CH2		
	Port state	SLAVE			
	Offset	-36	+0	nanoseconds	
	Mean path delay	1411	0	nanoseconds	
	Current Master Clock Info				
		CH1	CH2		
	Clock ID	94:B8:C5:FF:FE:6A:61:40			
	Port number	1	0		
	Steps	2	0		
	Domain number	0	0		
	GM priority1	128	0		
	GM priority2	128	0		
	GM clock class	248	0		
	GM clock accuracy	47	0		
	GM clock ID	94:B8:C5:FF:FE:6A:61:40			
	Current UTC offset	37	0	seconds	
	CurrentUtcOffsetValid	True			
	Traceable	False			

Easy and fast access to detailed communication status

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# Intuitive setting of Merging Unit functionality, redundancy and synchronization with DIGSI 5



Protocols _				
Communicati	on			
IEC61850				
Select	Protocols	Mapping	Settings	E: ETH-BD-2FO
Image: A start of the start	IEC 61850-8-1		Settings	
	9-2 Client			
	9-2 Merg.unit		Not Applicable	
Redundancy Protocols PRP	/ Mapping	Settings Not Appli	cable	<ul> <li>Enable the Merging Unit functionality</li> <li>Select the type of redundancy</li> <li>Enable the IEEE 1588 synchronization</li> </ul>
Network				IEEE 1588
Select	Protocols	Mapping	Settings	IEEE 1588 settings
	DCP		<ul> <li>Not Applicable</li> </ul>	102.1031.0.108 Clock type: OC Slave Only
	SNTP			102.1031.0.110 Profile: IEC 61850-9-3:2016
	IEEE 1588		Settings	102.1031.0.111 Domain number: 0

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# **SIPROTEC 5** Process Bus Client (1/2)

Process Bus Client functionality is available in every SIPROTEC 5 device except 7ST85, 6MD89 and non-modular devices (7SJ81, 7Sx82)

- Ethernet communication module ETH-BD-2FO necessary
- Up to 40 (80)<sup>1</sup> channels per SIPROTEC5 (7SS85) Client using 2x ETH-BD-2FO
- 3x ETH-BD-2FO modules with PB client supported, up to 64 analogue values per module
- Up to 16 streams per ETH-BD-2FO accepted
- Support of IEC 61850-9-2 LE streams
- Support of IEC 61869 flexible streams

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- IEC 61850-8-1 GOOSE, MMS and Process Bus Client protocol on the same module
- Supported protection functions 87B, 87L, 87T, 21, 67/67N, 50/50N, 51/51N, ... <sup>2)</sup>
- Support of IEEE C37.118 (PMU) sourced by sampled measured values

Limitations: network bandwidth of 100 Mbit/s and device specific limit of 40 analog values per SIPROTEC 5 device (except 7SS85 limit of 80 values)
 87L supports two terminals

2) 87L supports two terminals Unrestricted © Siemens 2020

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# **SIPROTEC 5** Process Bus Client (2/2)

Process Bus Client functionality is available in every SIPROTEC 5 device except 7ST85, 6MD89 and non-modular devices (7SJ81, 7Sx82)

- Acceptance of SMV with 4,0 / 4,8 / 12,8 / 14,4 / 15,36 kHz sampling frequency according to IEC 61869-9 (see details at merging unit chapter)
- Synchronization via IEEE 1588v2/PTP
- Interoperability with multivendor merging units <sup>1)</sup>
- Mixed configurations of direct connected instrument transformers and SMV
- LSVS diagnosis support (Sampled value supervision)
- Support for Edition 2.1 SynchSrcIdentity attribute
- Test- and simulation bit support

1) Interoperability is regulated in IEC 61850-9-2 Edition 2.1, use of 3rd party MU must be coordinated with DG SA&P headquarter

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# **Multi feeder protection with SIPROTEC 7SJ85**

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# Highlights 7SJ85

12 feeder protection incl.

- Overcurrent protection
- Directional overcurrent protection
- Frequency protection

# **Central protection of small substations –** Mix of analog measurements and SMVs





\*for simplification the required IEEE 1588v2/PTP master clock is not shown

# Highlights 7UT8

Transformer protection

Line protection

Feeder protection

- Overcurrent protection
- Directional overcurrent
   protection
- Frequency protection

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# **Central protection of small substations –** Back-up protection in the merging units





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# Transformer protection with dedicated merging unit per transformer side





# **Transformer protection with only 1 merging unit**

![](_page_30_Picture_1.jpeg)

![](_page_30_Figure_2.jpeg)

\*for simplification the required IEEE 1588v2/PTP master clock is not shown

# 6MU85 Integrated functionality

- tap changer controller
- flow sensor
- temperature sensors
- pressure sensor
- Buchholz relay
- pressure relief devices
- automatic voltage regulator
- transformer cooling control
- Switching devices control

# Line differential protection – SMVs at both line ends

![](_page_31_Picture_1.jpeg)

![](_page_31_Figure_2.jpeg)

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# Line differential protection – Mix of analog measurements and SMVs

![](_page_32_Picture_1.jpeg)

![](_page_32_Figure_2.jpeg)

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# **Distributed busbar protection –** Using SIPROTEC 5 protection devices as bay unit

![](_page_33_Picture_1.jpeg)

![](_page_33_Figure_2.jpeg)

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![](_page_34_Figure_0.jpeg)

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# **IEC 61850** Full digital Energy Automation System

![](_page_35_Picture_1.jpeg)

![](_page_35_Figure_2.jpeg)

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5 6 7	Sample Synchronization (IEEE 1588v2/PTP and PPS)         Network architectures         Definitions

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# Sample synchronization vs. time synchronization

![](_page_37_Picture_1.jpeg)

### **Sample Synchronization**

- Relative reference used to align or synchronize several signals among each other
- It can be provided by a pulse or by a time signal
- Used to synchronize the sampled values (1µs)

### **Time Synchronization**

- Universal time reference signal, provided by a master clock
- Absolute time stamp which contains exact date and time
- Used for data fault analysis (1ms)

Synch. Method	Distribution	Typical Accuracy	Synchronization Application
IRIG-B	Separate wiring	10µs – 1ms	Time Synchronization
1 PPS	Separate wiring	<1µs	Sample Synchronization
NTP	Network	1ms – 10ms	Time Synchronization
IEEE 1588 PTP	Network	<1µs	Time and Sample Synchronization

\* Some IRIG-B telegrams contain the PPS pulse and can be used for SV synch. as well

![](_page_38_Picture_1.jpeg)

### If the sampled values are not synchronized, the protection functions will be blocked to avoid maloperation

The samples values contain information about its synchronization status. This information depends on the synchronization method and the communication protocol used:

PPS or PTP Synchronization with IEC 61850 Ed. 2.0 or IEC 61850-9-2 LE streams

A merging unit sends only the synchronization state:

- 0: internally synchronized
- 1: local synchronization
- 2: global synchronization

PTP Synchronization with IEC 61850 Ed. 2.1 streams

A merging unit can, in addition, send the grandmaster clock ID of the PTP master clock used for synchronization of samples

It increases the availability of the system when all SV are synchronized by the same master although the master does not receive the global synch. signal

# IEEE 1588V2 Status Response of the SIPROTEC 5 Client

![](_page_39_Picture_1.jpeg)

PPS or PTP Synchronization with IEC 61850 Ed. 2.0 or IEC 61850-9-2 LE streams

### 2: global synchronization

All protection functions are operative

### 1: local synchronization

After the holdover time\* the protection functions using more than one value are blocked\*\*.

### 0: internally synchronized

After the holdover time\* the protection functions using more than one value are blocked\*\*.

PTP Synchronization with IEC 61850 Ed. 2.1 streams

### 2: global synchronization

All protection functions are operative

### 1: local synchronization

After the holdover time\* protection functions using SV being synchronized by the same Master Clock ID are operative. Protection functions using SV being synchronized by different Master Clock IDs are blocked\*\* (example line differential protection).

### • 0: internally synchronized

After the holdover time\* the protection functions using more than one value are blocked\*\*

 <sup>\*</sup> Holdover time depends on the initial synchronization status of the devices. It is automatically set between 5 and 25 seconds

 <sup>\*\*</sup> Overcurrent protection will continue working while the counter difference from merging unit and client is smaller smaller than 1 count.

### **IEEE 1588 – Master Clock**

![](_page_40_Picture_1.jpeg)

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\*\*

![](_page_40_Picture_2.jpeg)

# **RUGGEDCOM RSG2488**

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### TEKRON- NTS 03-G+

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# Network architectures Network redundancy for process bus

![](_page_42_Picture_1.jpeg)

![](_page_42_Figure_2.jpeg)

PRP LAN B

New on ETH-BD-2FO module: HSR\* ring with clients and server connected to PRP LANs Sample synchronization for HSR must be realized with PPS

\* Support of IEEE 1588v2/PTP (transparent clock) in preparation

PRP redundancy with clients and server for station and process bus

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# Network architectures Physically network segregation

![](_page_43_Picture_1.jpeg)

![](_page_43_Figure_2.jpeg)

# Simplify complexity

Use of more than one redundant process bus network reduces the network engineering

Increase the bandwidth with additional Ethernet interfaces

Efficient use of network bandwidth with customization of the analog values per SMV streams (not only IEC 61850-9-2LE data set)

Note: Seamless networks redundancy recommended

# Network architectures Virtual network segregation (VLAN)

![](_page_44_Picture_1.jpeg)

![](_page_44_Figure_2.jpeg)

# Simplify complexity

Segregation of one redundant process bus network into several virtual LANs reduces load

One physical network reduces network costs

VLAN 1-4:	CT, VT values for feeder protection
VLAN 5:	Feeder CT values for busbar protection and fault recorder
VLAN 6:	Bus VT for central fault recorder and feeder protection
Note: Seam	less networks redundancy recommended

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# **Network architectures** Example: VLAN for busbar protection with 24 bays

![](_page_45_Picture_1.jpeg)

![](_page_45_Figure_2.jpeg)

# **Process bus communication network**

![](_page_46_Picture_1.jpeg)

![](_page_46_Picture_2.jpeg)

- Requires higher bandwidth
  - A merging unit requires approx. 4.4 5.2 Mbit / s of bandwidth with 80 samples per nominal network frequency cycle according to IEC 61850-9-2 LE.
  - It is recommended not to use more than 60% of the available bandwidth for the SV streams in a segment.
  - For a 100 Mbit / s network, it is recommended not to have more than 12 MUs according to IEC 61850-9-2 LE with 80 samples per nominal network frequency cycle (50Hz).
  - For 1Gbit/s network, the limit is 120 MUs according to IEC 61850-9-2 LE with 80 samples per nominal network frequency cycle.
    - The recommendation for the backbone is 1Gbit / s.
- Process bus networks must be available. Individual errors should not lead to the failure of the protection system.
  - Network redundancy HSR / PRP according to IEC 62439-3 is recommended

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# **SIPROTEC 5 – Process Bus** Definitions

![](_page_48_Picture_1.jpeg)

SMV Stream	SMV stream is a set of current and voltage values which is transferred fast and cyclic. The information exchange is based on a publisher/subscriber mechanism. The transfer of SMV is a continuous one way stream of layer 2 Ethernet telegrams. According to IEC 61869-9 the content of a SMV stream can be freely configured. The IEC 61850-9-2 LE defines a fixed set of 4 voltage and 4 current values per SMV stream.
Merging Unit (MU)	The publisher/server of Sampled Measured Values is called Merging Unit.
PB Client	The subscriber of Sampled Measured Values can be called also Process Bus Client.
Sampling Rate	In signal processing, sampling is the reduction of a continuous-time signal (e.g. current and voltages) to a discrete- time signal. A common example is the conversion of a sound wave (a continuous signal) to a sequence of samples (a discrete-time signal). A sample is a value or set of values at a point in time. Commonly seen unit of sampling rate is Hz and means "samples per second". As an example, for most of the protection functions 4,8 kHz (4800 samples per second) is foreseen.
ASDU	Application Service Data Unit (ASDU) One ASDU contains one set of sampled measured values and related quality information from the same sampling time. The mapping provides the capability to link multiple ASDU's from subsequent sampling times into a SMV frame. The numbers of ASDUs contained in a SMV telegram is configurable and related to the sample rate.

# **SIPROTEC 5 – Process Bus** Definitions

![](_page_49_Picture_1.jpeg)

IEEE1588v2/PTP	The Precision Time Protocol (PTP) is a protocol used to synchronize clocks throughout a computer network. On a local area network, it achieves clock accuracy in the sub-microsecond range, making it suitable for measurement and control systems. PTP was originally defined in the IEEE 1588-2002 standard, officially entitled "Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems" and published in 2002. In 2008, <b>IEEE 1588-2008</b> was released as a revised standard; also known as PTP Version 2, it improves accuracy, precision and robustness but is not backward compatible with the original 2002 version.
IEEE1588v2/PTP Profiles	PTP has many optional features, and often more than one way to do things. This means PTP devices do not necessarily work together. Not unless they are configured with a compatible set of choices for 1588 options and settings. The solutions is profiles. Profiles are a set of rules which place restrictions on PTP, intended to meet the needs of a specific application or set of similar applications. The IEEE 1588 standard itself only defines one profile, referred to as the "default profile". In power industry there are two profiles used: IEC 61850-9-3 (Power Utility Profile) and C37.238-2017 (Power Profile).
PPS	Pulse per Second
CIT	Conventional Instrument Transformer
LPIT	Low Power Instrument Transformer (LPIT) – Also know as NCIT (Non Conventional Instrument Transformer). Examples are Rogowski Coil, C-Divider, R-Divider, RC-Divider, Optical sensors,
LSVS	Sampled Value Supervision

Sources: Meinberg, Wikipedia, IEC 61869, IEC 61850

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### Contact

![](_page_50_Picture_1.jpeg)

![](_page_50_Picture_2.jpeg)

# **Evandro de Oliveira** RC-US EM EA PRO ENG

7000 Siemens Road Wendell – NC - 27591 Phone: (919) 670-8234 E-mail: evandro.Oliveira@siemens.com

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