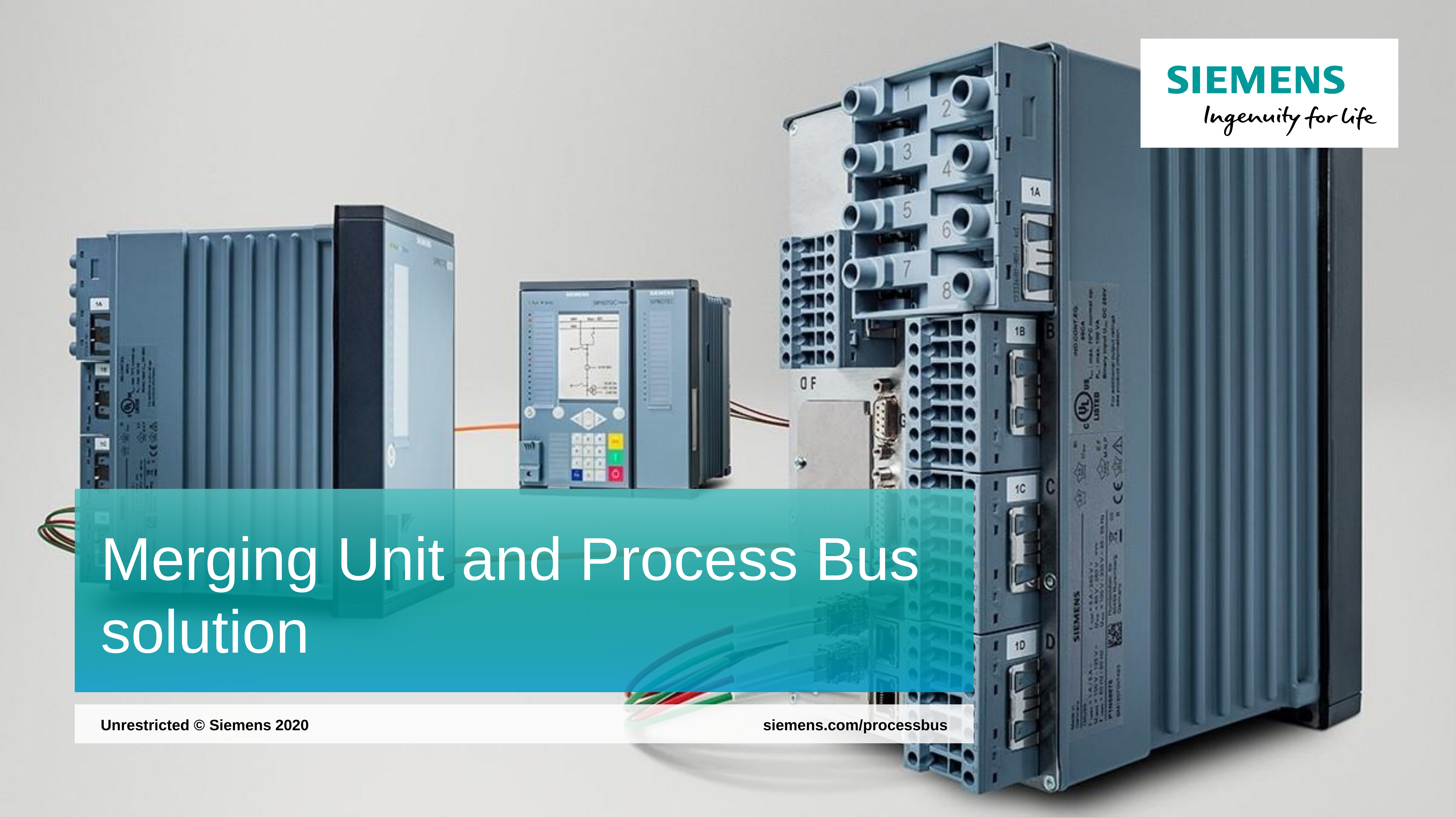
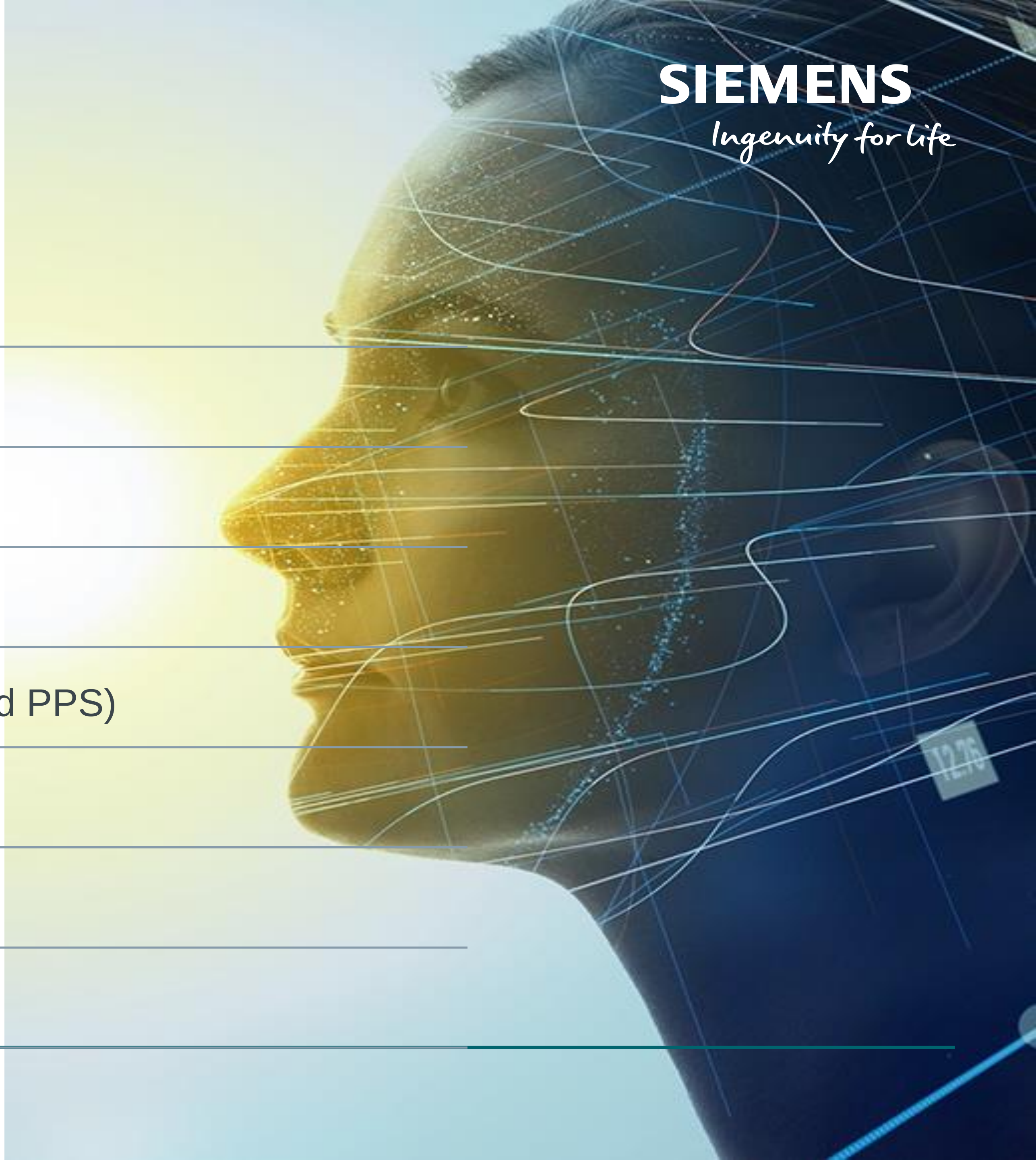
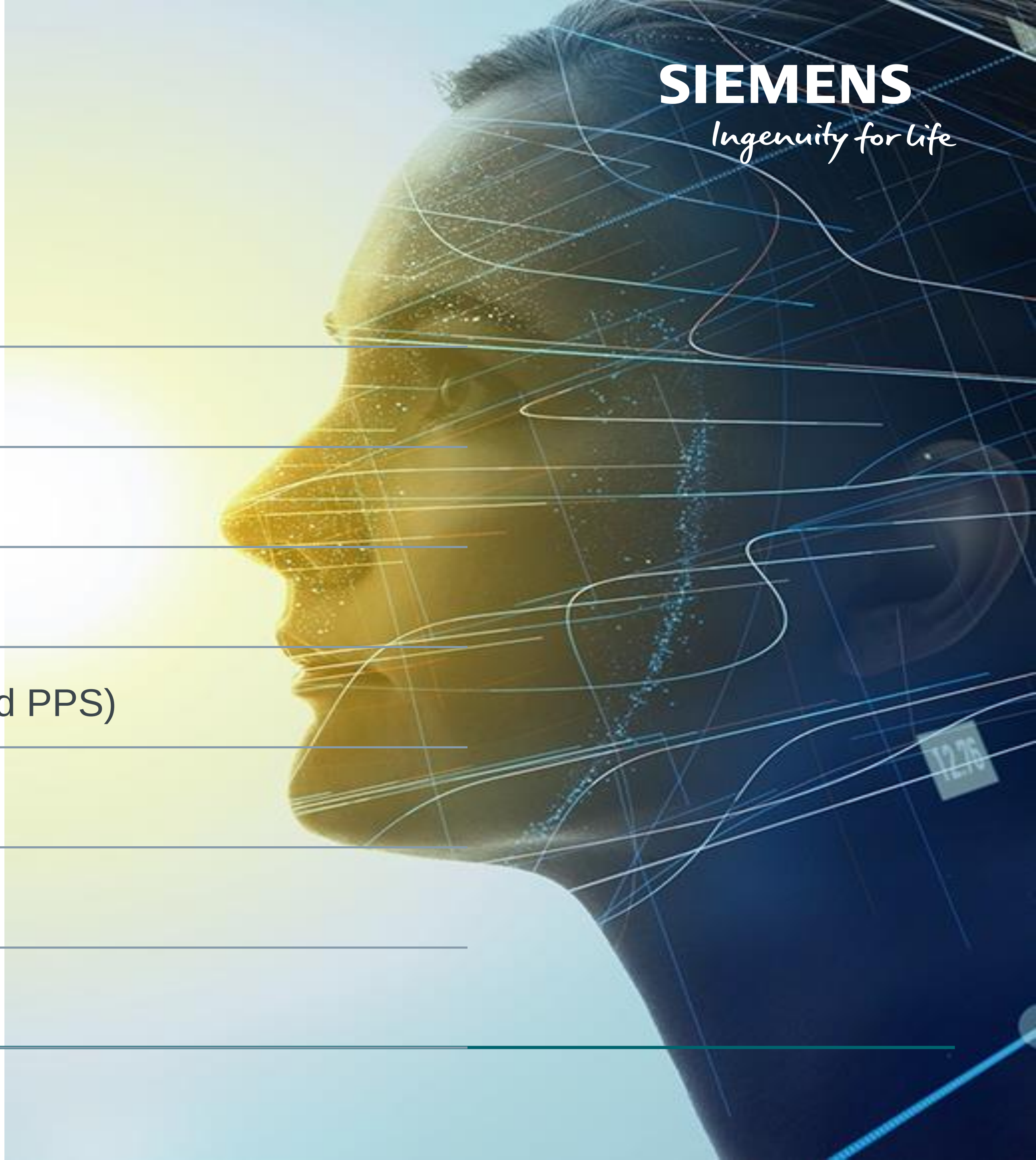


Merging Unit and Process Bus solution

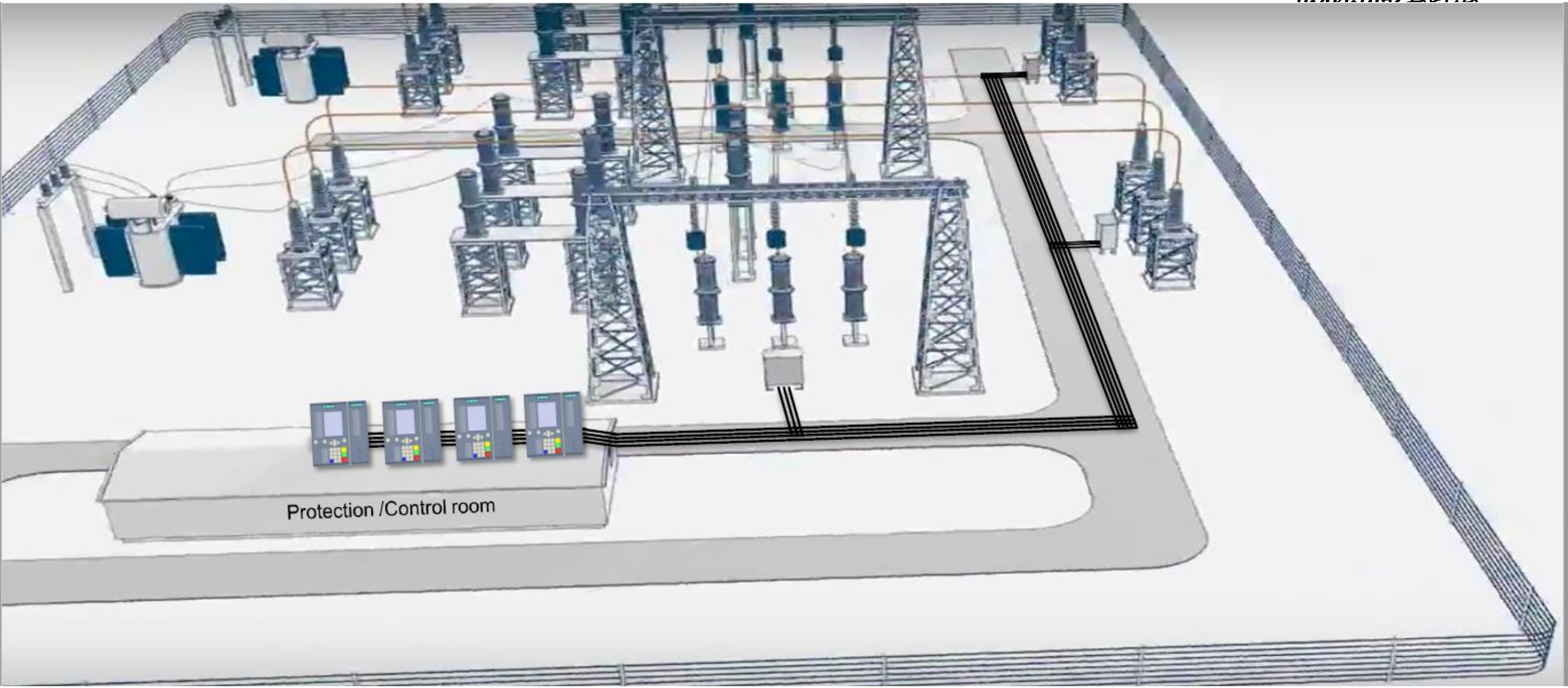
Content



Content



Conventional solution



Conventional Technology

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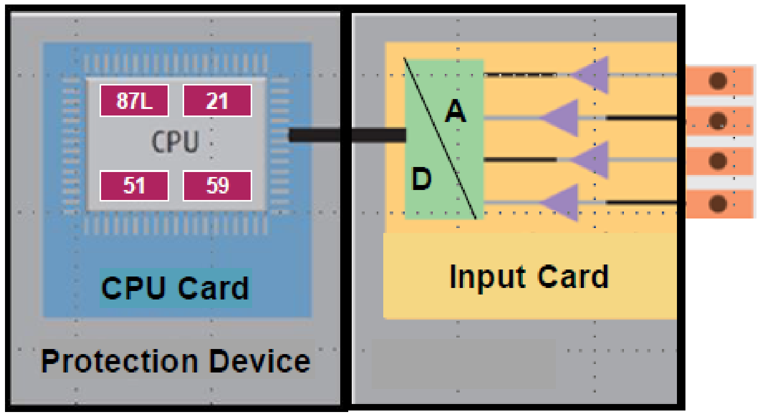
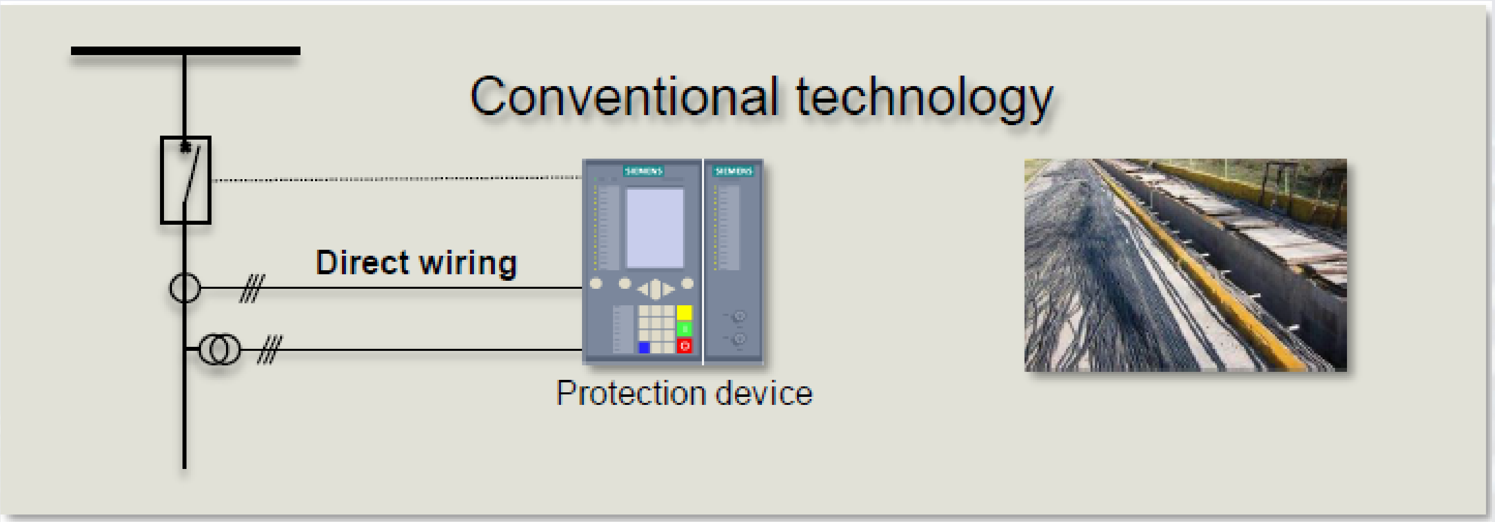
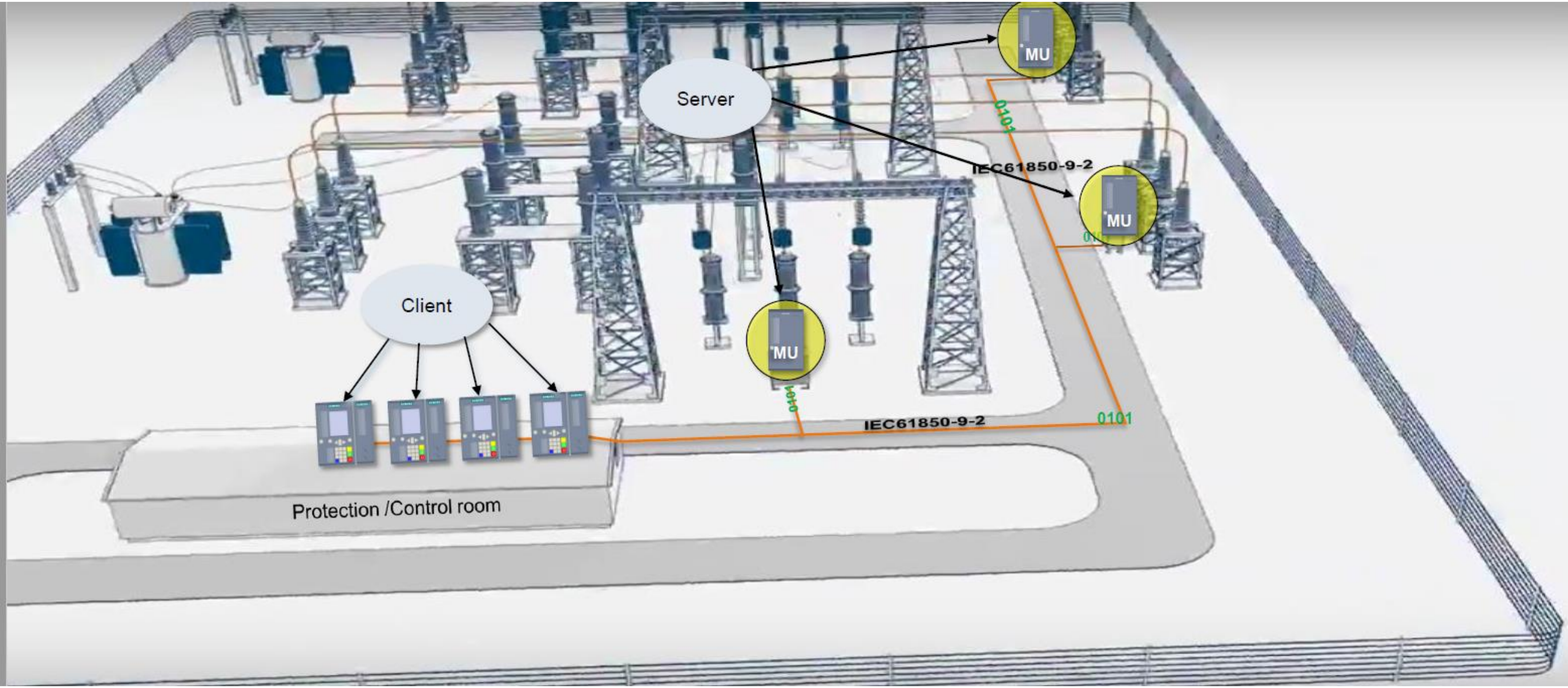
Conventional technology



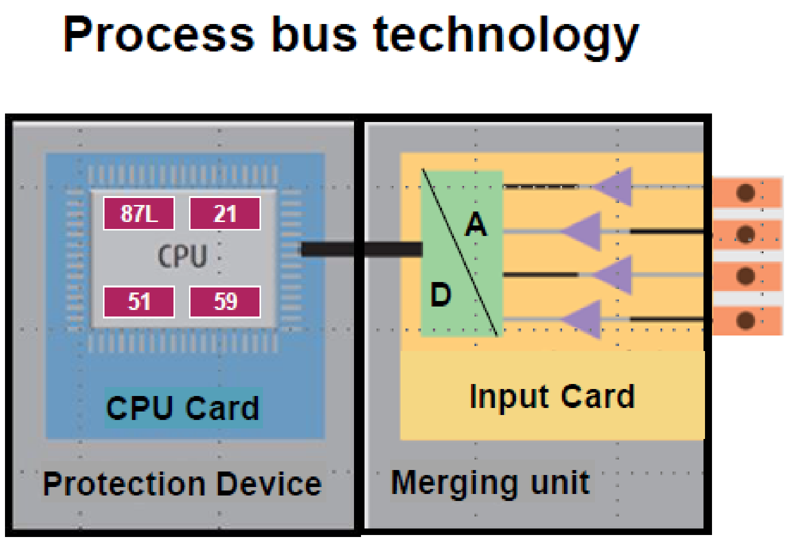
- Analog Input card inside device
- Proprietary bus for connection IO <-> CPU



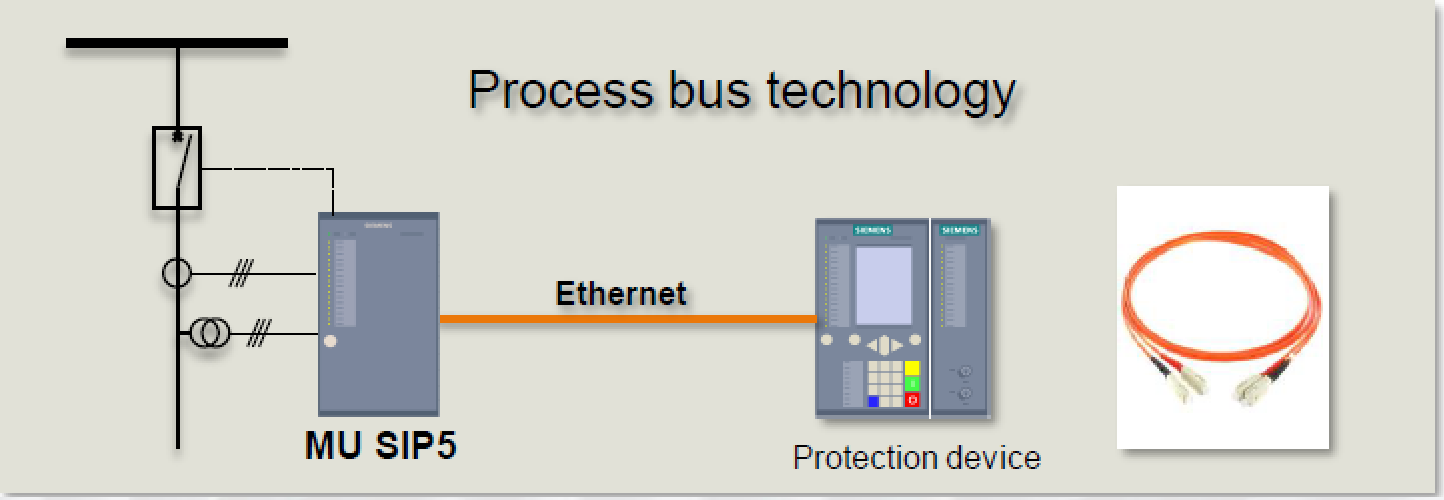
Process Bus solution



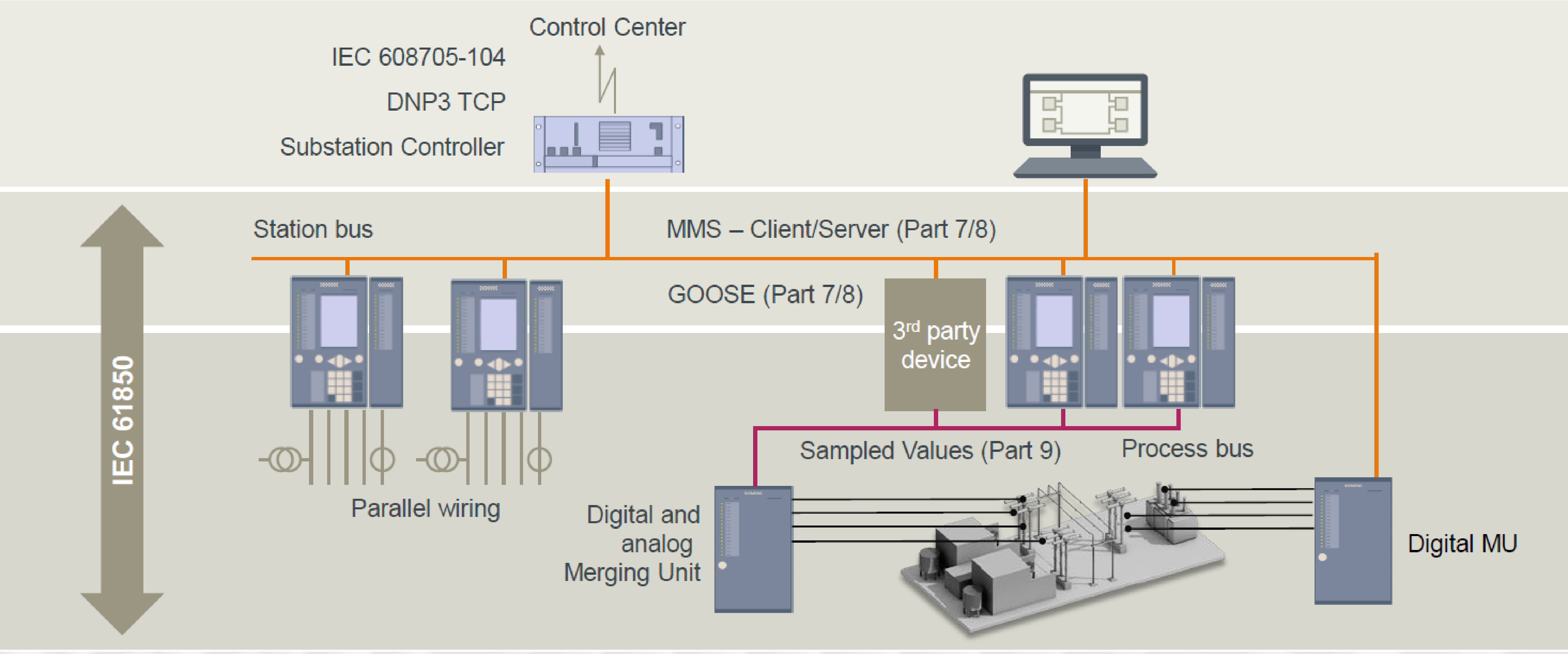
Process Bus Technology



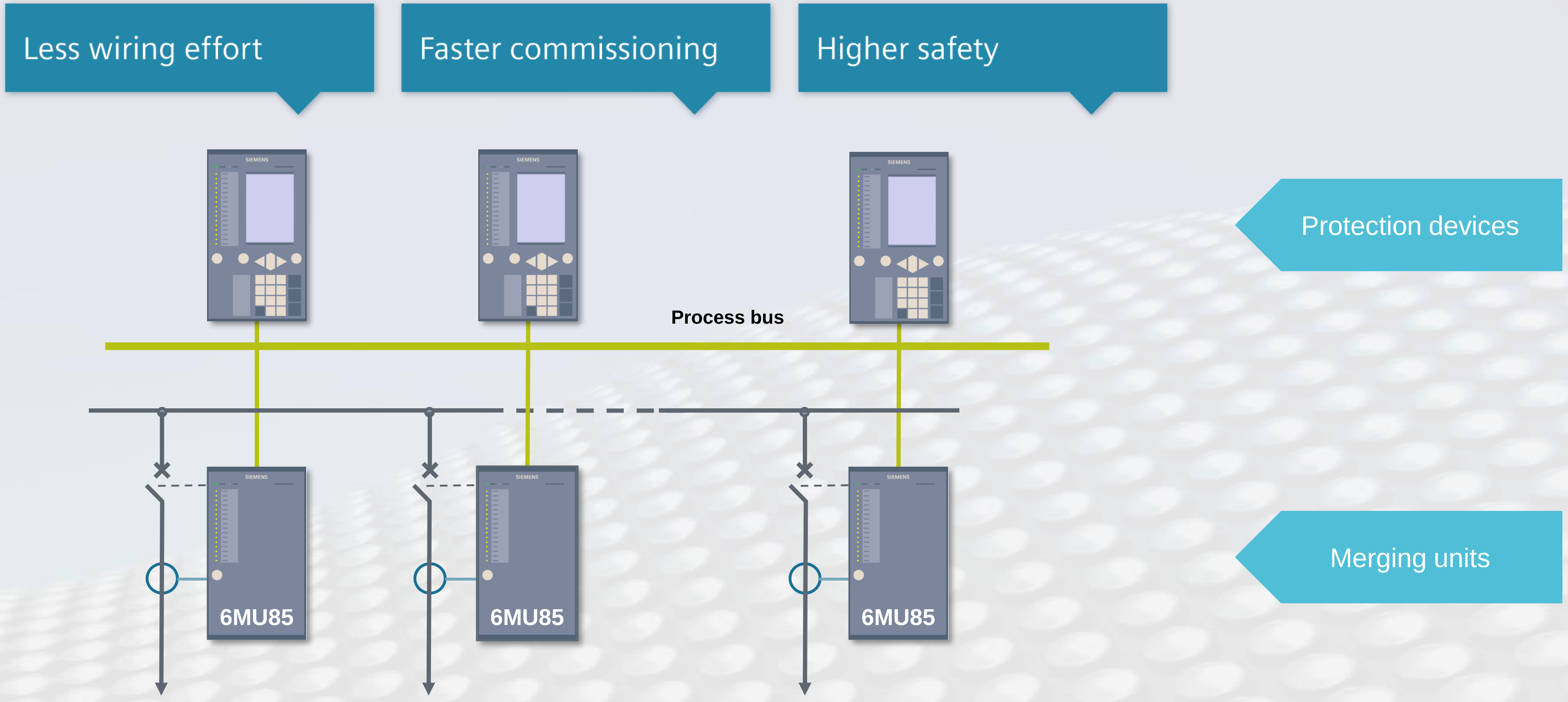
- Converting Analog data to digital data
- Sending of SMV via IEC 61850-9-2

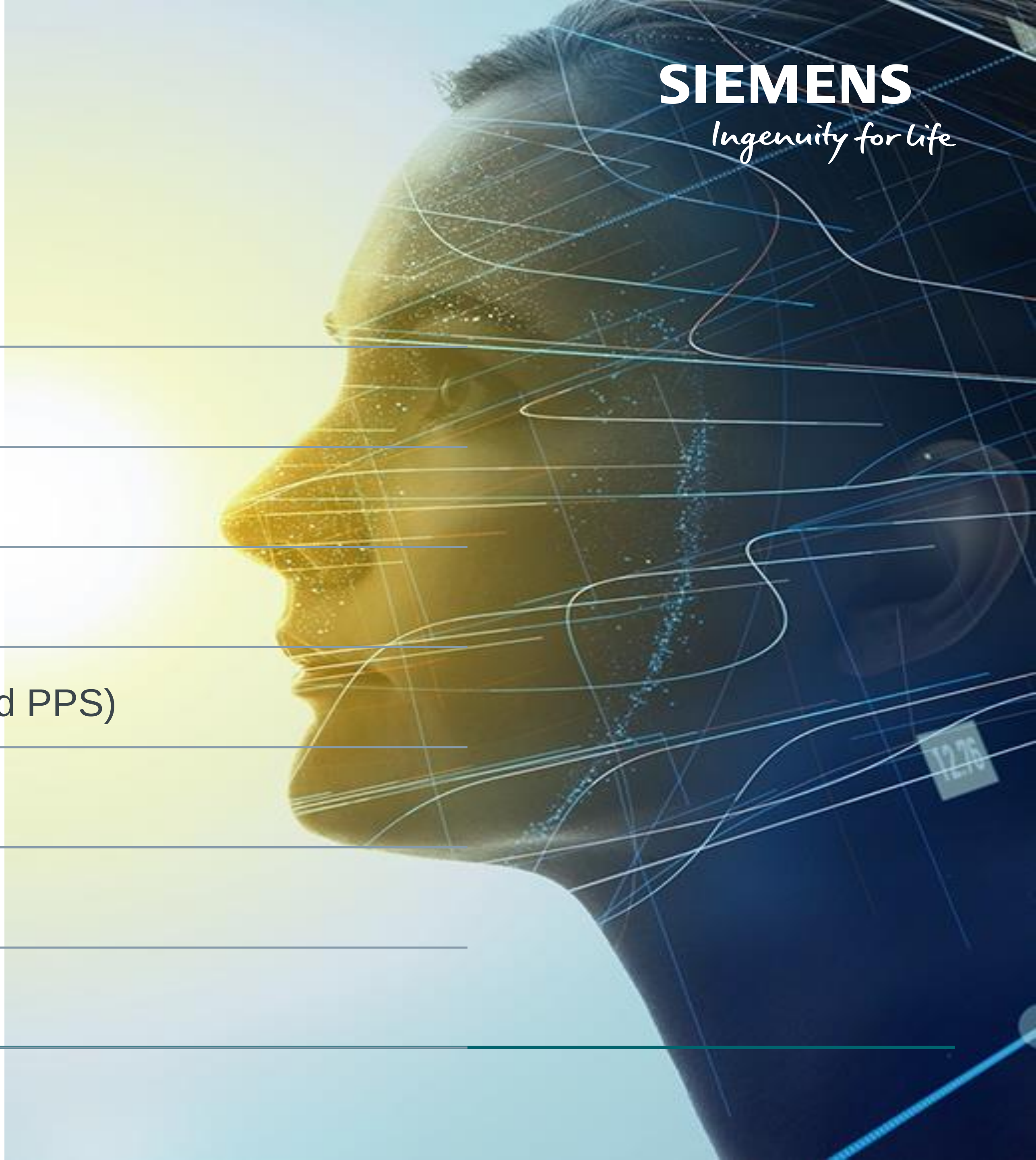


Digital Substation
Process Bus Overview



Principle and benefits of process bus





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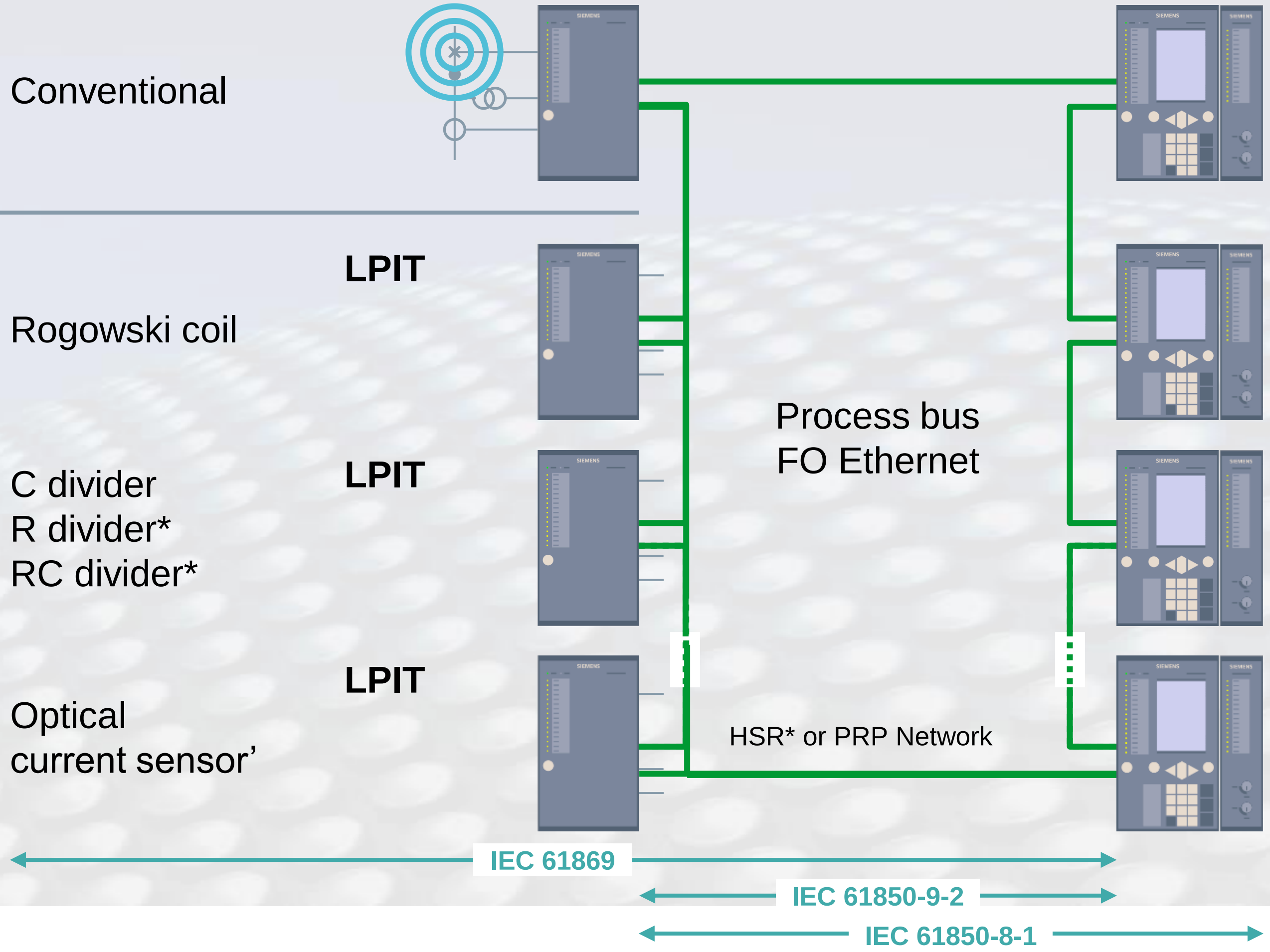
Content

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
- Digital interface for instrument transformers **IEC 61869-9**

- Merging unit as part of switchgear
- Low power stand alone current, voltage and combined sensors
- **IEC 61869-10 and 11**



SIPROTEC 6MU85 Merging Unit

Digitalization of all primary data close to the process

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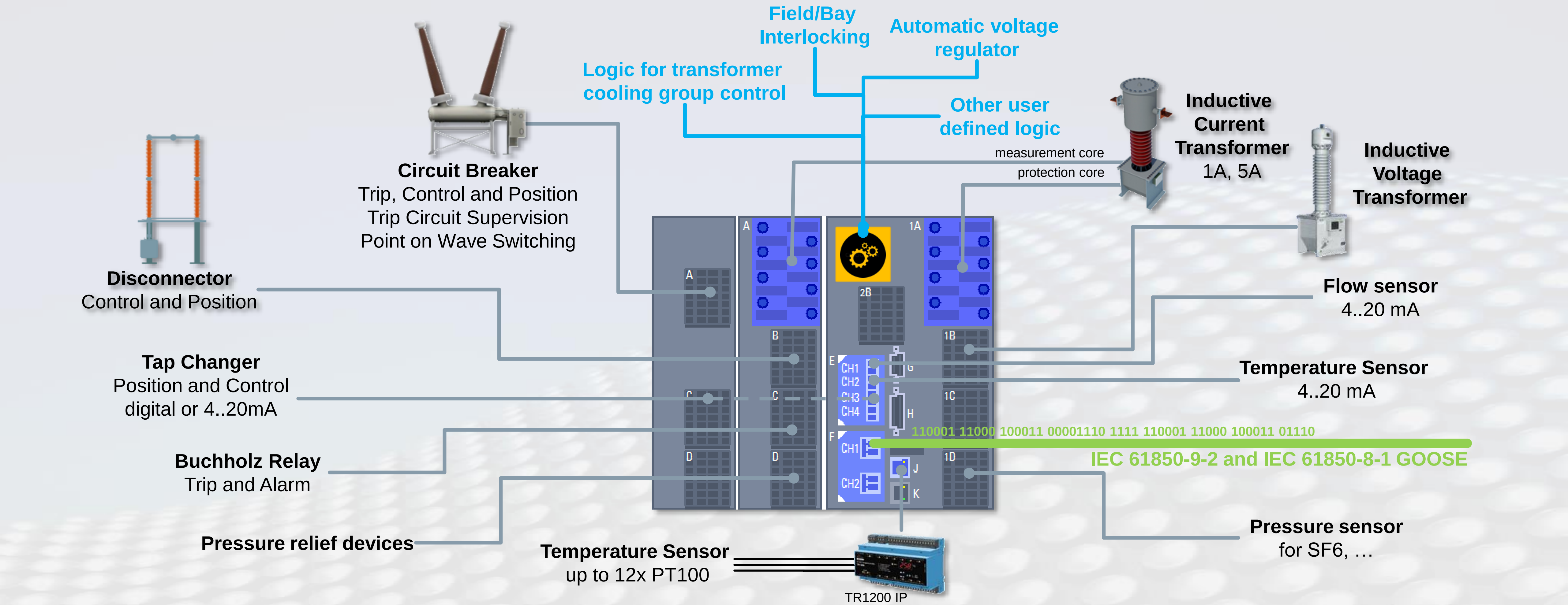

Merging Unit – SIPROTEC 6MU85

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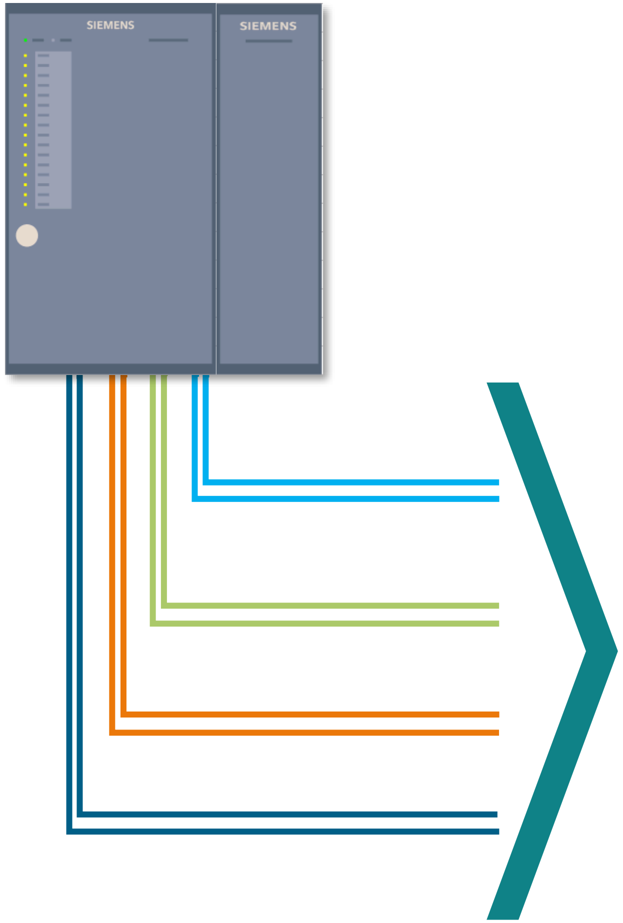


Up to 4 plug-in communication modules to enable connection to:

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)

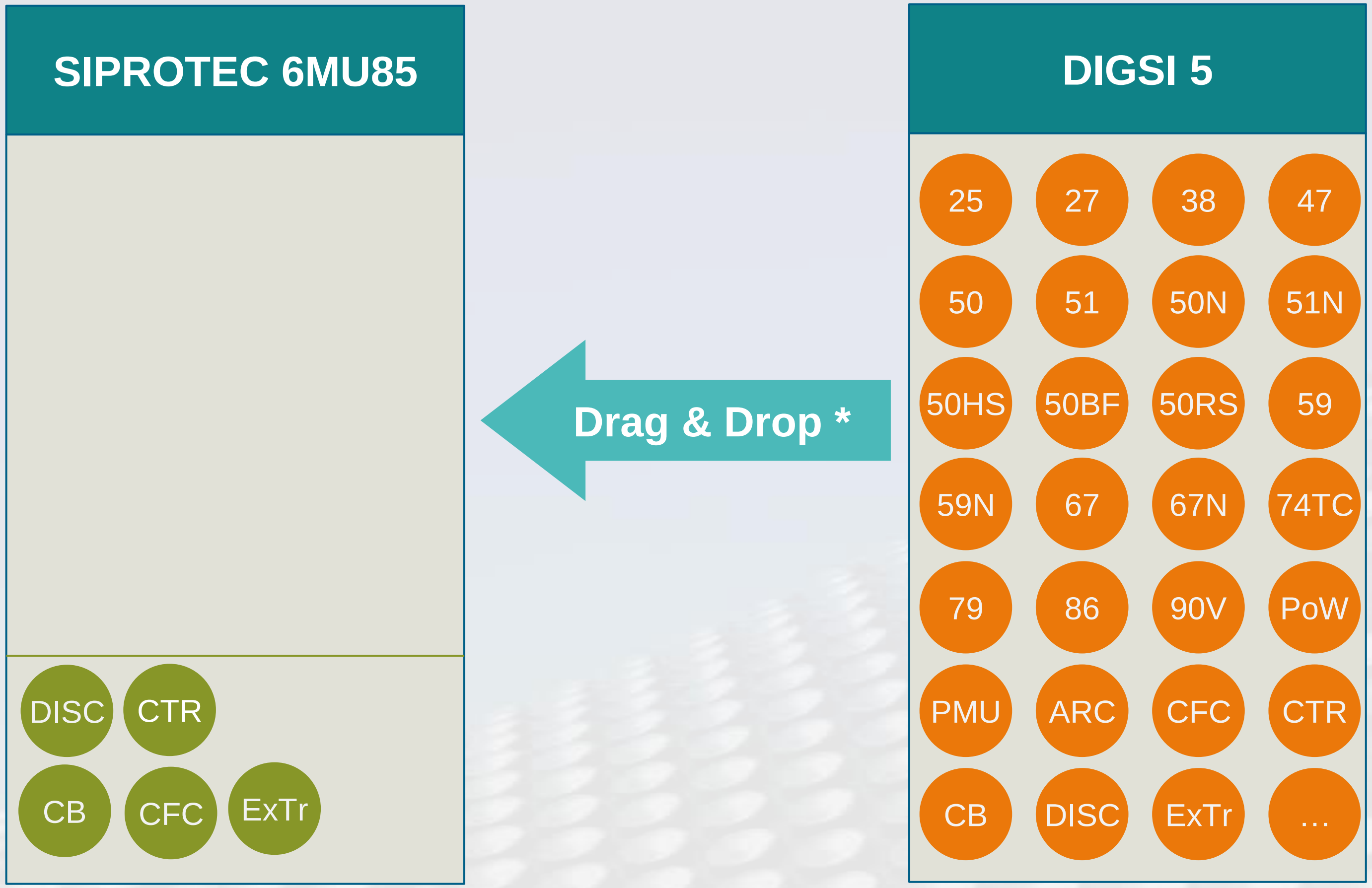
Time synchronization

- 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

Merging Unit – SIPROTEC 6MU85



* Function points might be required

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

SIPROTEC 6MU85 Merging Unit
Protection Functions

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ANSI	Function	Abbr.
	Protection functions for 1 and 3-pole tripping	3-pole
	Hardware quantity structure expandable	I/O
25	Synchrocheck, synchronizing function	Sync
27	Undervoltage protection: "3-phase" or "pos.seq. V1" or "universal Vx"	V<
38	Temperature Supervision	θ>
47	Overvoltage protection, negative-sequence system	V2>
50/51 TD	Overcurrent protection, phases	I>
50N/ 51N TD	Overcurrent protection, ground	IN>
	Instantaneous tripping at switch onto fault	SOTF
50HS	High speed instantaneous overcurrent protection	I>>>
50BF	Circuit-breaker failure protection, 3-pole	CBFP
50RS	Circuit-breaker restrike protection	CBRS
59, 59N	Overvoltage protection: "3-phase" or "zero seq. V0" or "pos.seq. V1" or "universal Vx"	V>
67	Directional overcurrent protection, phases	I>, ∠(V,I)
67N	Directional overcurrent protection, ground	IN>, ∠(V,I)
74TC	Trip circuit supervision	TCS
79	Automatic reclosing, 3-pole	AR
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	

ANSI	Function	Abbr.
POW	Point on Wave Switching	POW
PMU	Synchrophasor measurement (1 PMU can be used for max. 8 voltages and 8 currents)	PMU
AFD	Arc-protection (only with plug-in module ARC-CD-3FO)	
	Measured values, standard	
	Measured values, extended: Min, Max, Avg	
	Switching statistic counters	
	Circuit breaker wear monitoring	ΣIx, I^2t, 2P
	CFC (Standard, Control)	
	CFC arithmetic	
	Switching sequences function	
	Inrush current detection	
	External trip initiation	
	Control	
	Fault recording of analog and binary signals	
	Monitoring and supervision	
	Protection interface, serial	
	Circuit Breaker	
	Disconnector	

Merging Unit – SIPROTEC 6MU85

Integrated cyber security

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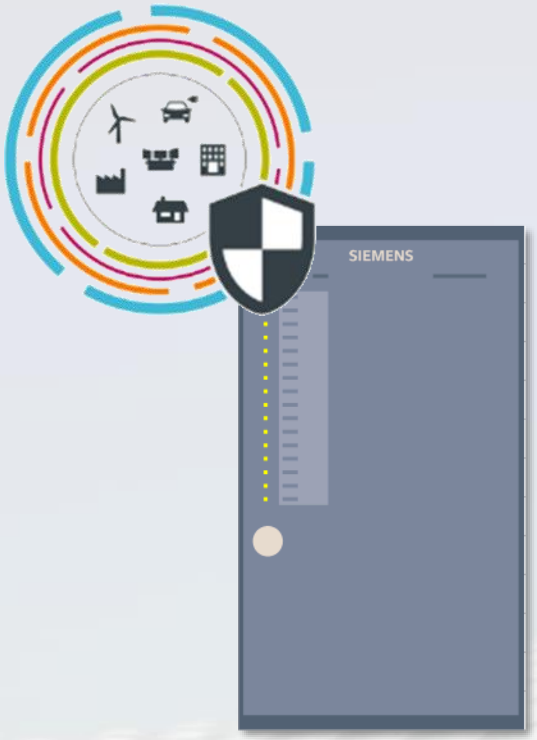


Trusted Partner

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 security-relevant events and alarms
- Confirmation codes for safety-critical operations
- Crypto-chip for secure information storage
- Siemens CERT and Patch management

Cyber Security

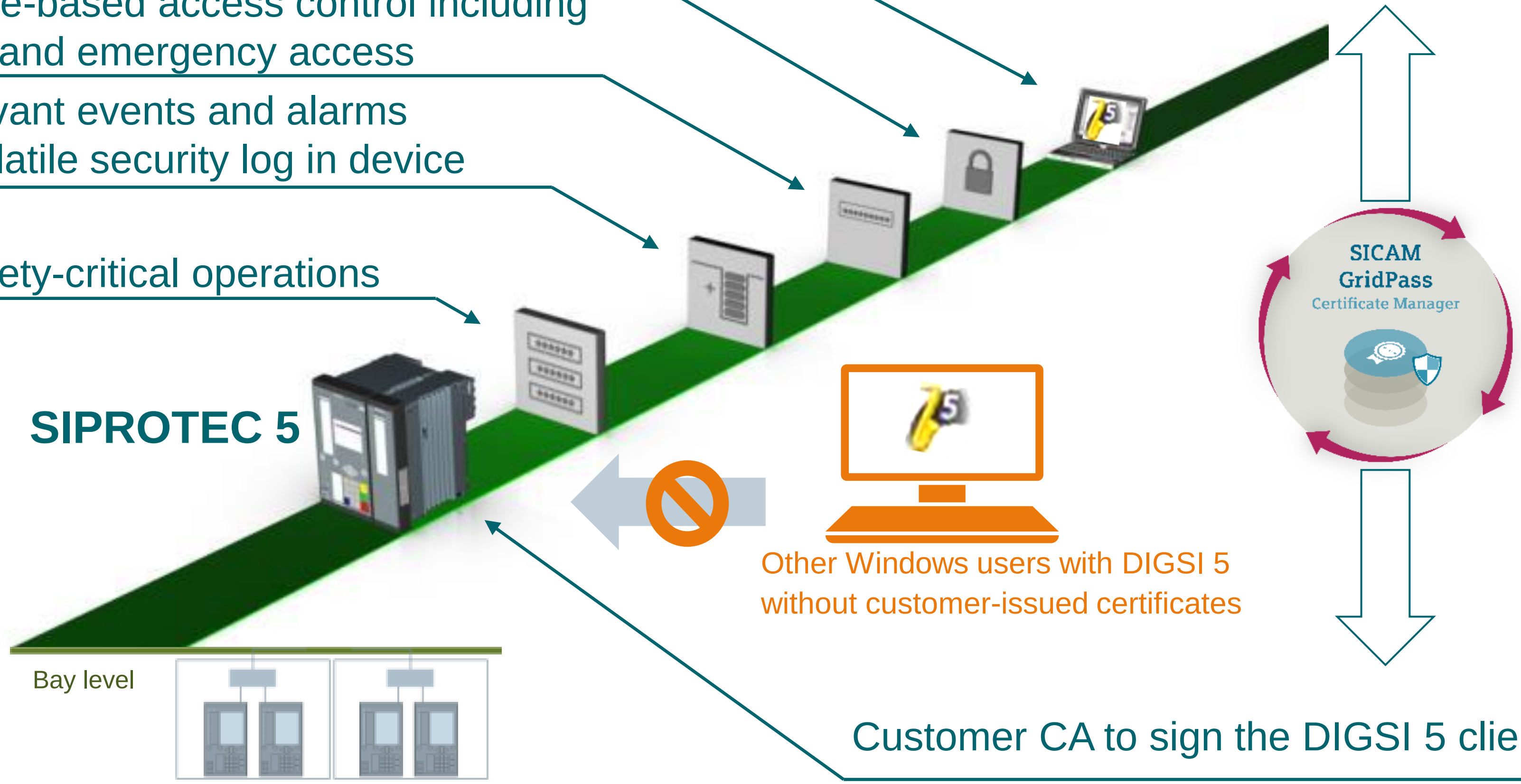
Mutually authenticated and encrypted communication between DIGSI 5 and the SIPROTEC 5 device
Only DIGSI 5 installations that connect using certificates signed by customer's CA are permitted

Client authorization: Customer-issued Client certificate in the Windows User account

Device-side support for role-based access control including central user management and emergency access

Recording of security-relevant events and alarms over Syslog and in non-volatile security log in device

Confirmation codes for safety-critical operations

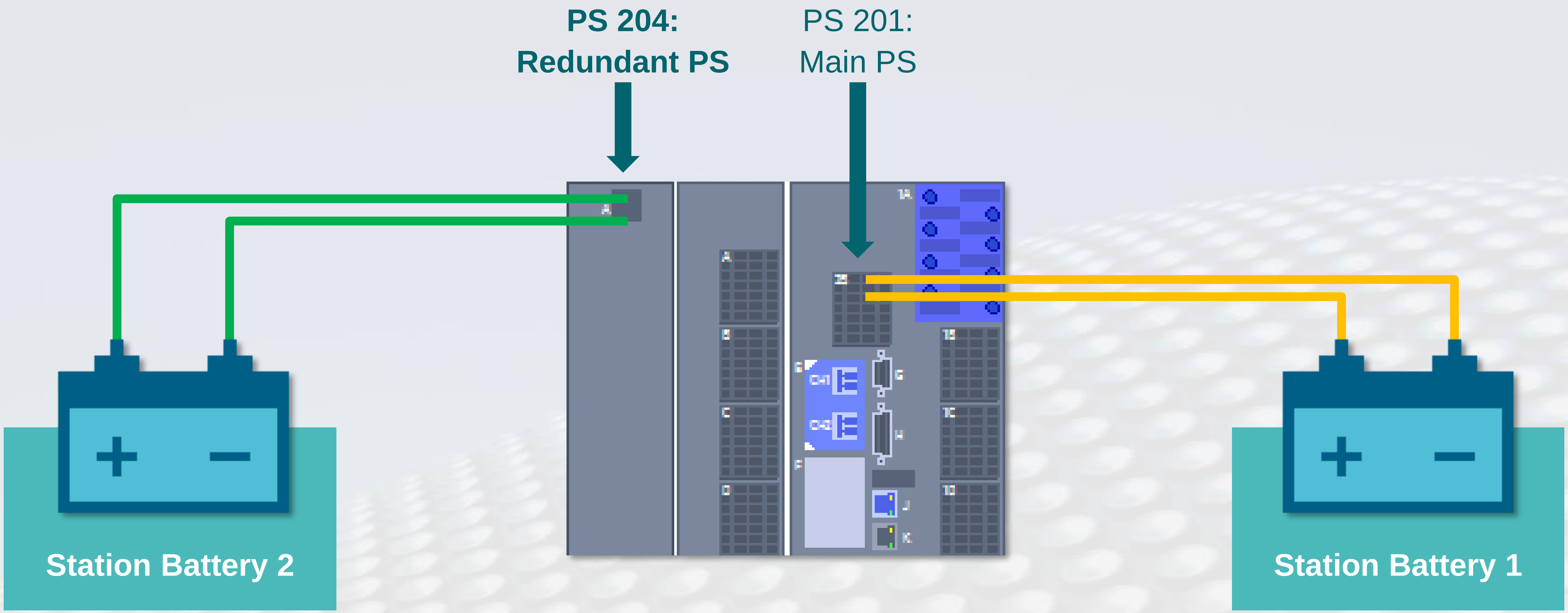


Customer CA and certificates can be issued using SICAM GridPass

Customer CA to sign the DIGSI 5 client certificates

Merging Unit – SIPROTEC 6MU85

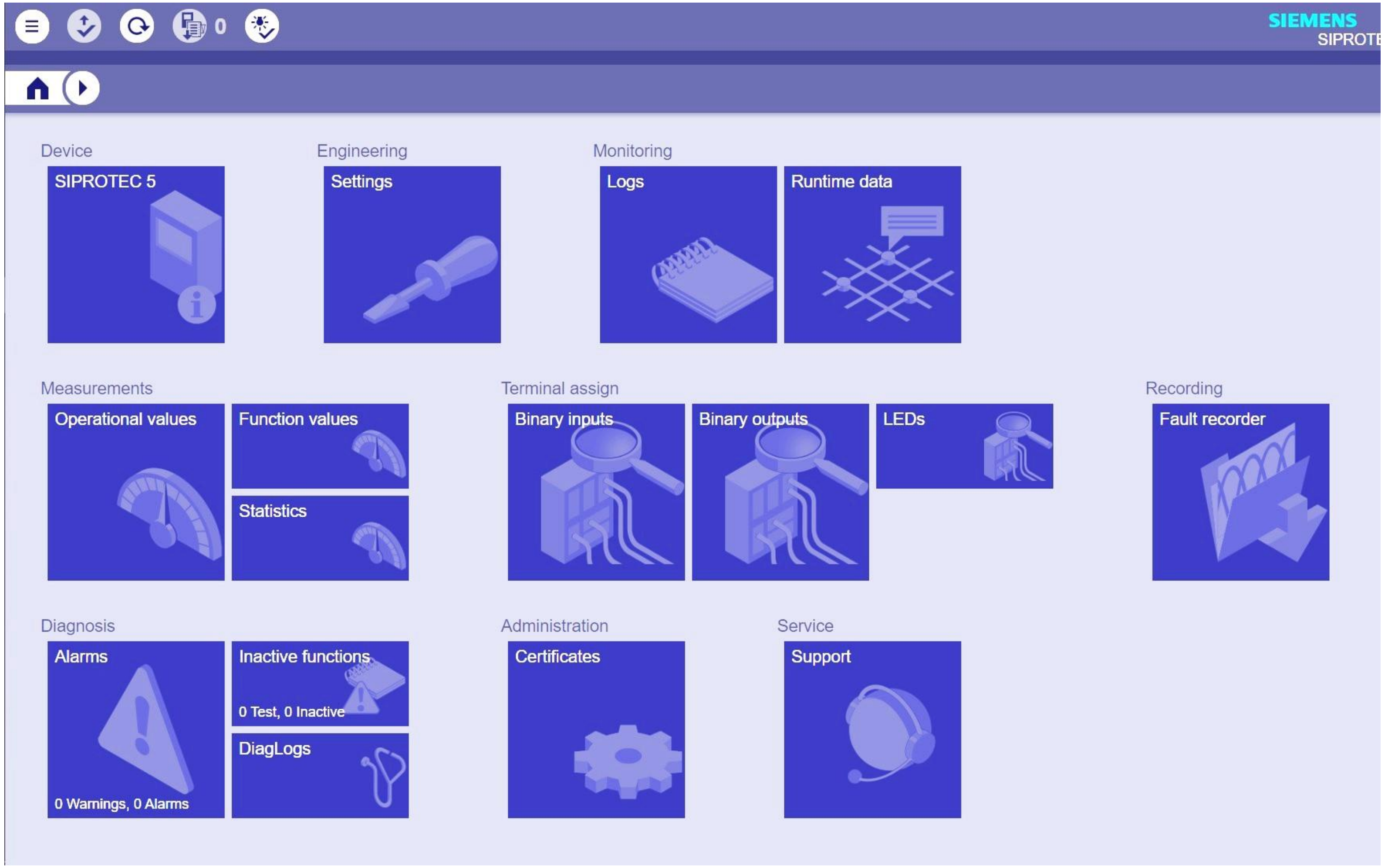
Redundant power supply



PS = Power Supply

Merging Unit – SIPROTEC 6MU85

Easy, fast and secure access to device with Web Browser



Monitoring of

- Measurements
- Logs
- Settings
- Device information

Download of

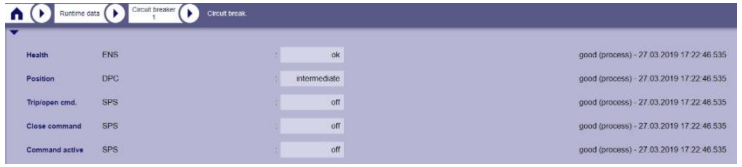
- Logs as CSV or COMFEDE file (log dependent)

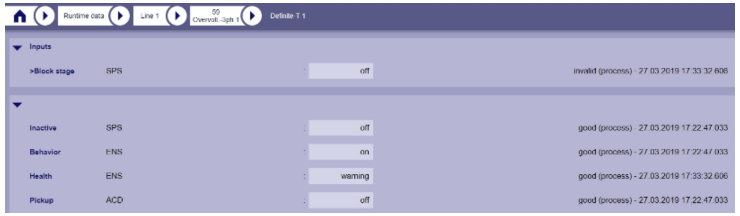
Secure

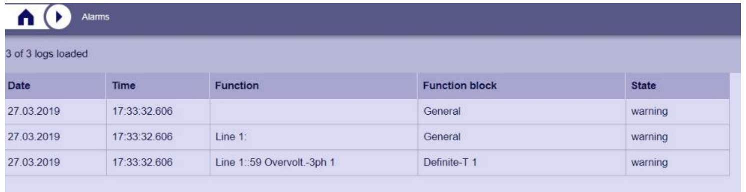
- https connection
- Access defined per port
- Controlled by RBAC

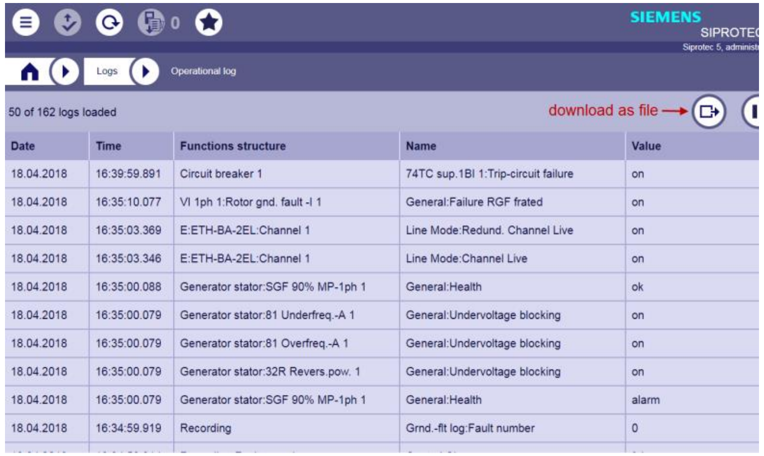
Merging Unit – SIPROTEC 6MU85

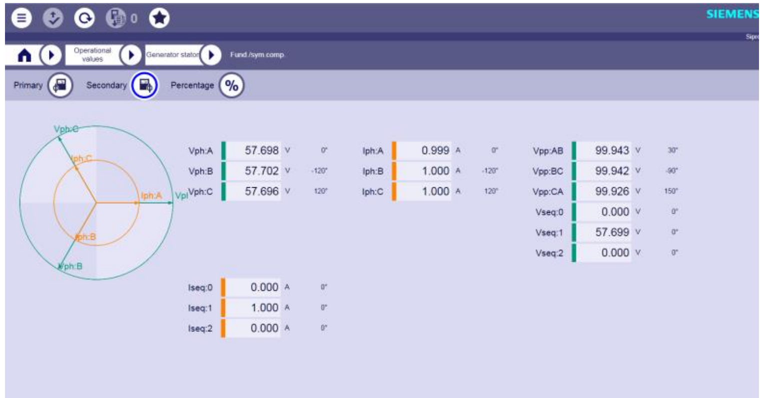
Easy, fast and secure access to device with Web Browser











Recording

- Download, Delete and Trigger of Fault Records

Parameterization

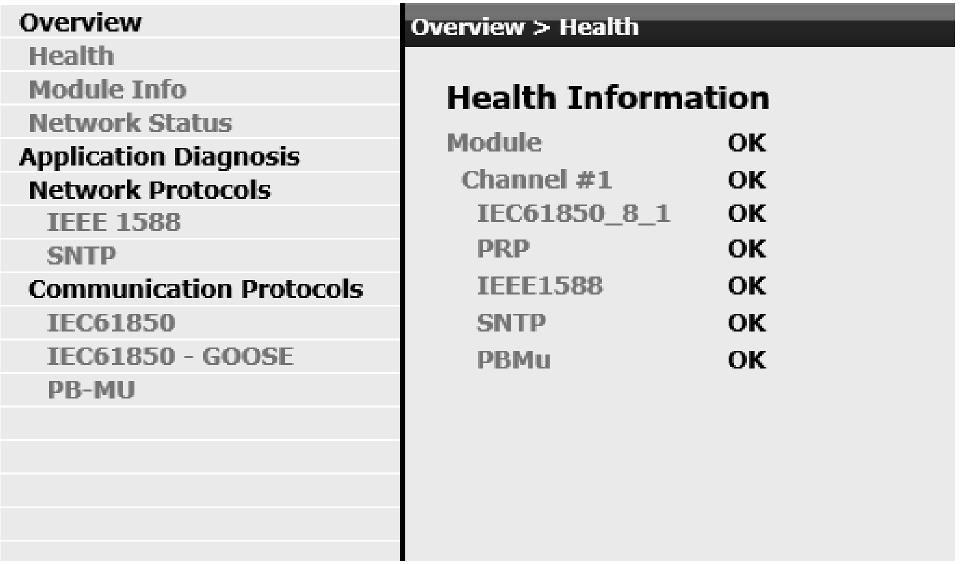
- Change of settings within an active setting-group

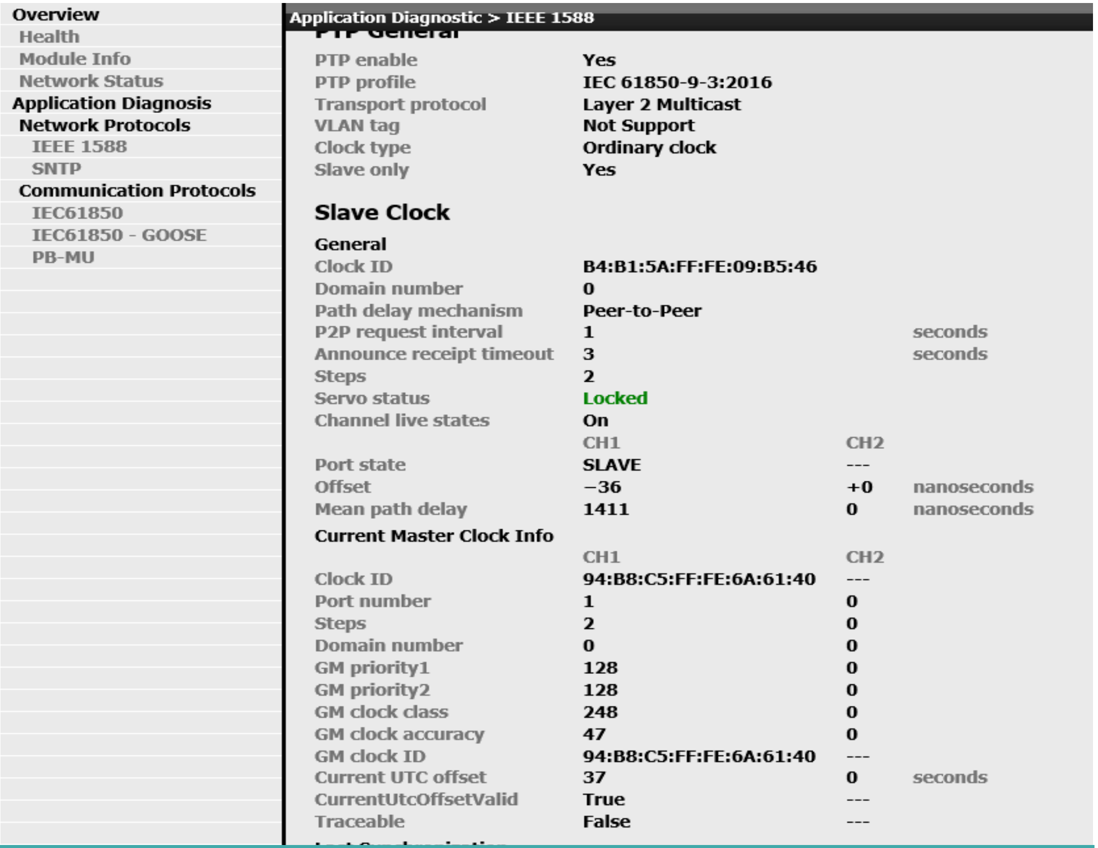
Display all signal state

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

Merging Unit – SIPROTEC 6MU85

Diagnosis homepage of ETH-BD-2FO module





Easy and fast access to detailed communication status

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

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Protocols

Communication

IEC61850

Select	Protocols	Mapping	Settings
☑	IEC 61850-8-1		Settings
☐	9-2 Client		
☑	9-2 Merg.unit		Not Applicable

Redundancy

Protocols	Mapping	Settings
PRP		Not Applicable

Network

Select	Protocols	Mapping	Settings
☑	DCP		Not Applicable
☐	SNTP		
☑	IEEE 1588		Settings

Click on the properties of the ETH-BD-2FO in "hardware configuration":

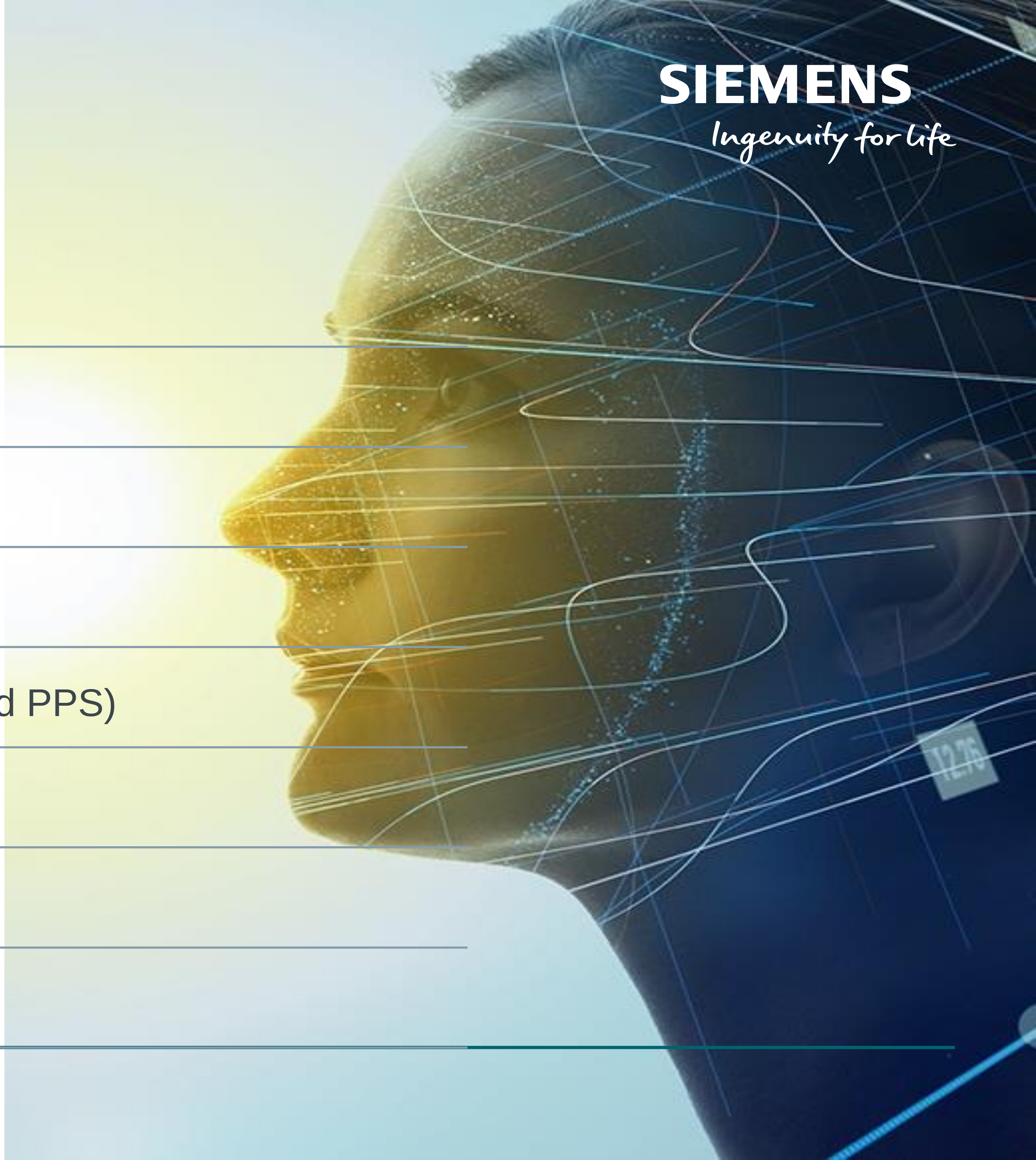
- Enable the Merging Unit functionality
- Select the type of redundancy
- Enable the IEEE 1588 synchronization

IEEE 1588

IEEE 1588 settings

102.1031.0.108	Clock type:	OC Slave Only
102.1031.0.110	Profile:	IEC 61850-9-3:2016
102.1031.0.111	Domain number:	0

Content



SIPROTEC 5
Process Bus Client (1/2)

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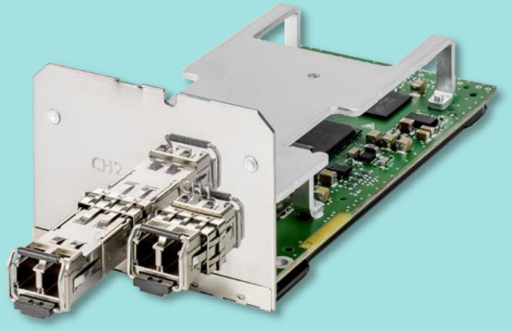
Process Bus Client functionality is available in every SIPROTEC 5 device except 7ST85, 6MD89 and non-modular devices (7SJ81, 7Sx82)

- Ethernet communication module **ETH-BD-2FO** necessary
- Up to 40 (80)[1] 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
- 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, … [2)]
- Support of IEEE C37.118 (PMU) sourced by sampled measured values

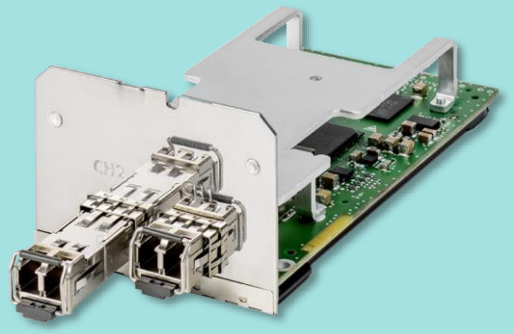


1) Limitations: network bandwidth of 100 Mbit/s and device specific limit of 40 analog values per SIPROTEC 5 device (except 7SS85 limit of 80 values)
2) 87L supports two terminals

SIPROTEC 5
Process Bus Client (2/2)

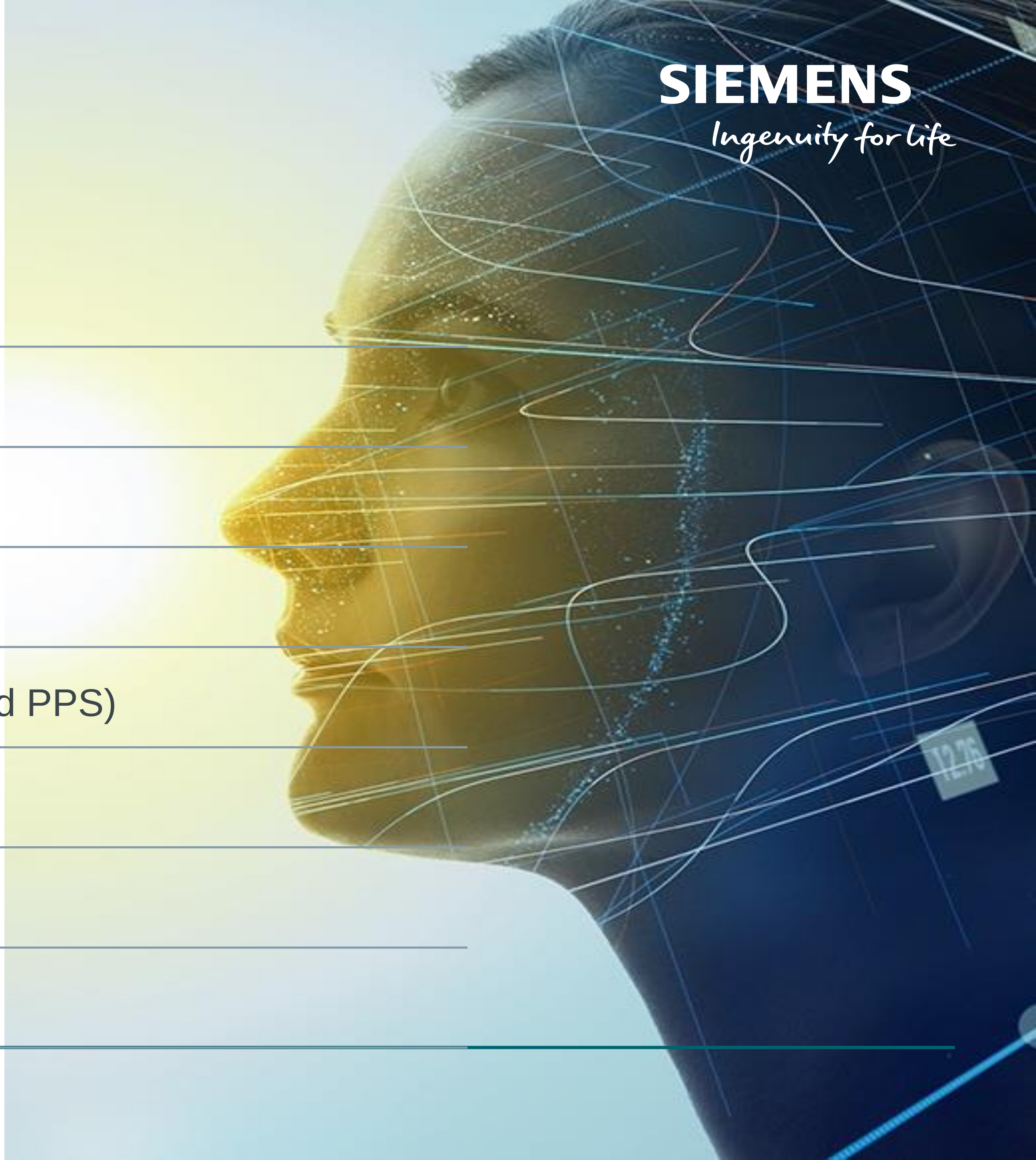
Process Bus Client functionality is available in every SIPROTEC 5 device except 7ST85, 6MD89 and non-modular devices (7SJ81, 7Sx82)

- 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 [1)]
- 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

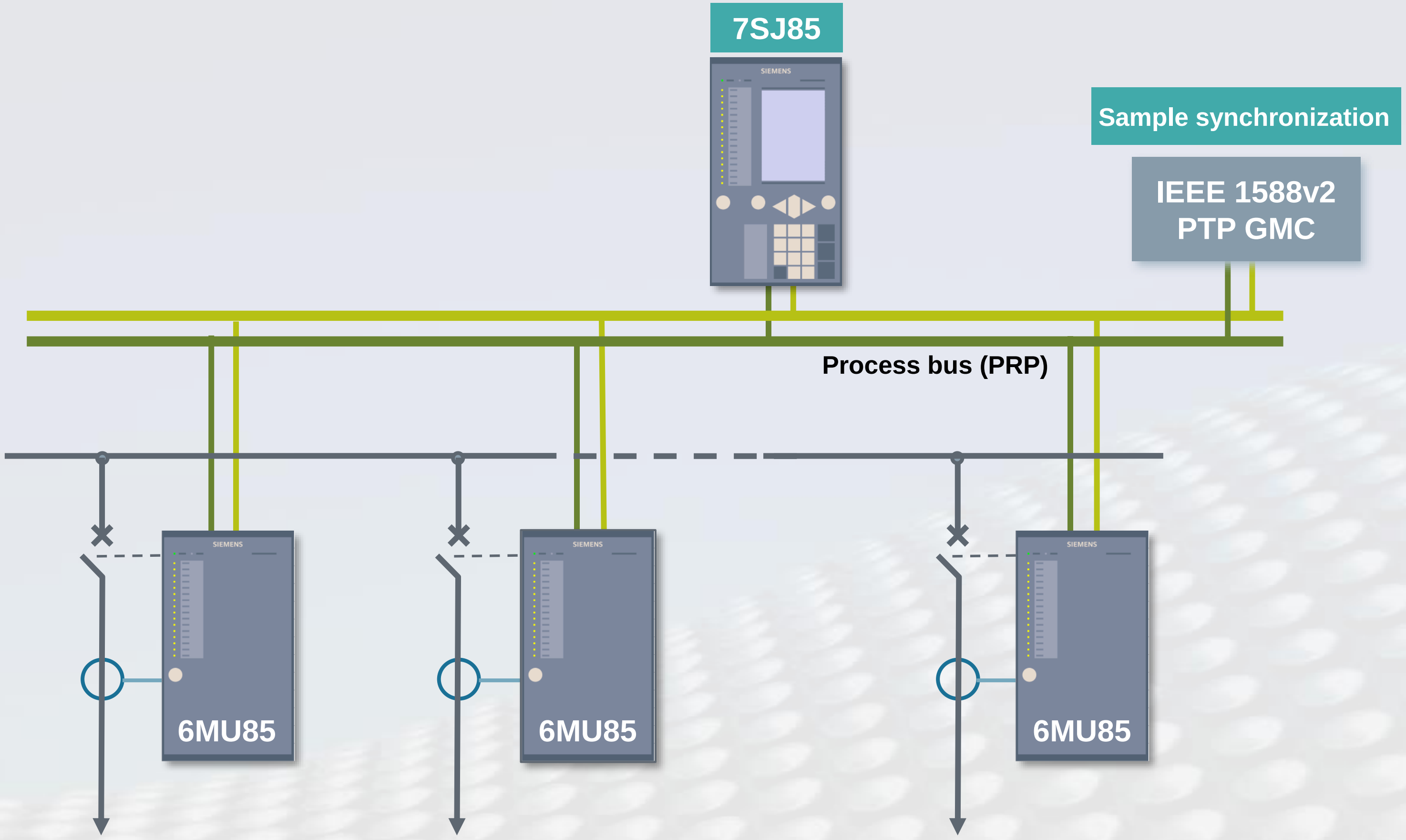


1) Interoperability is regulated in IEC 61850-9-2 Edition 2.1, use of 3rd party MU must be coordinated with DG SA&P headquarter

Content



Multi feeder protection with SIPROTEC 7SJ85

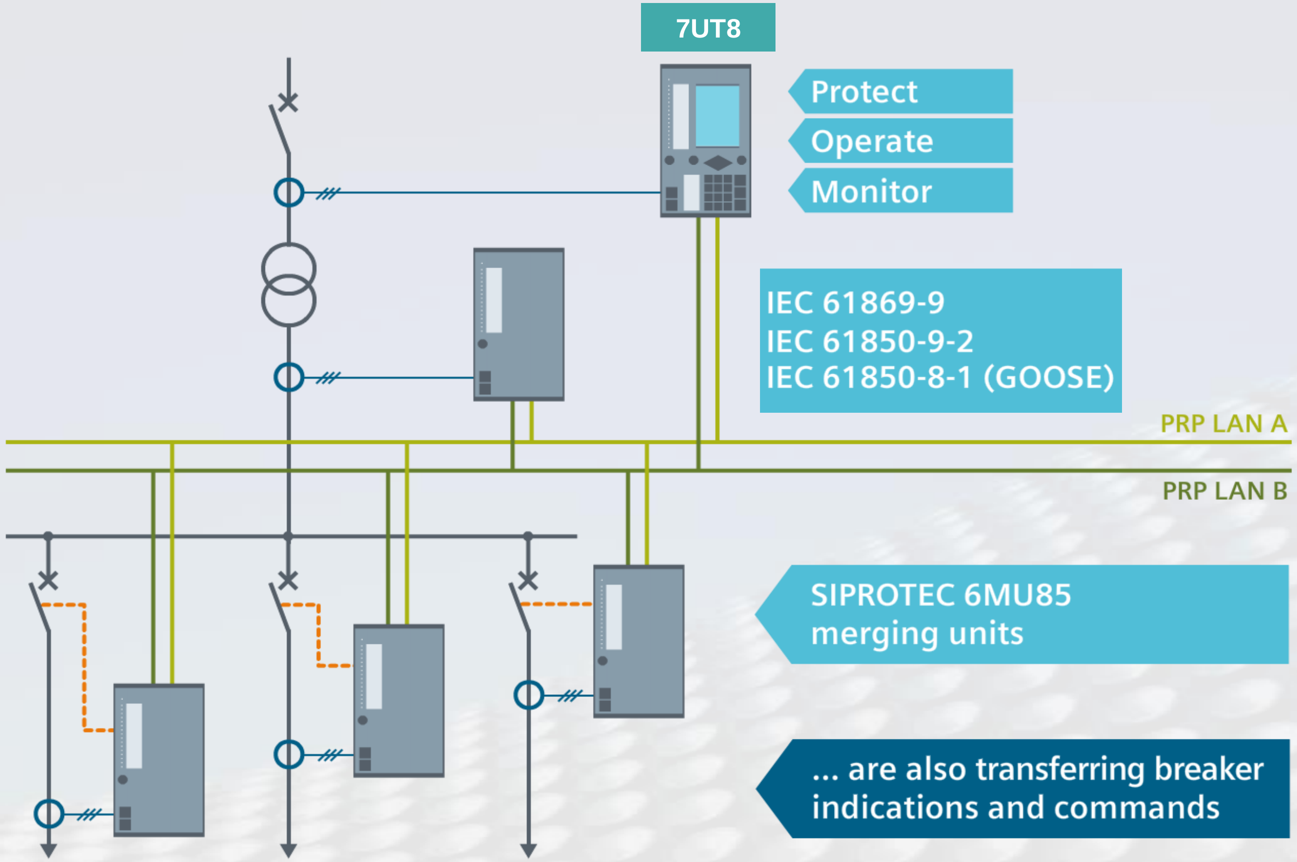


Highlights 7SJ85

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

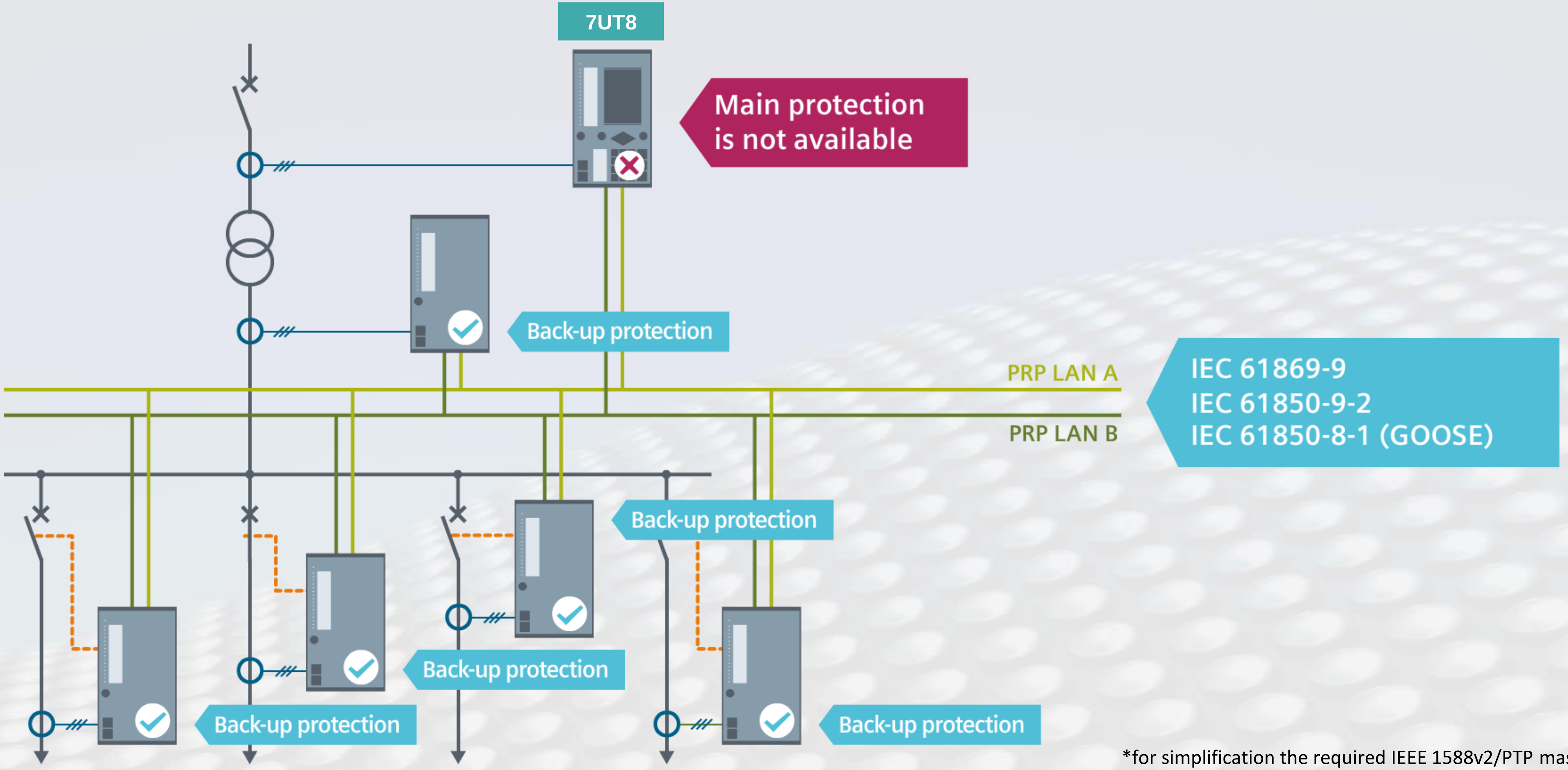
Transformer protection

Line protection

Feeder protection

- Overcurrent protection
- Directional overcurrent protection
- Frequency protection
- ….

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



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

Transformer protection with dedicated merging unit per transformer side

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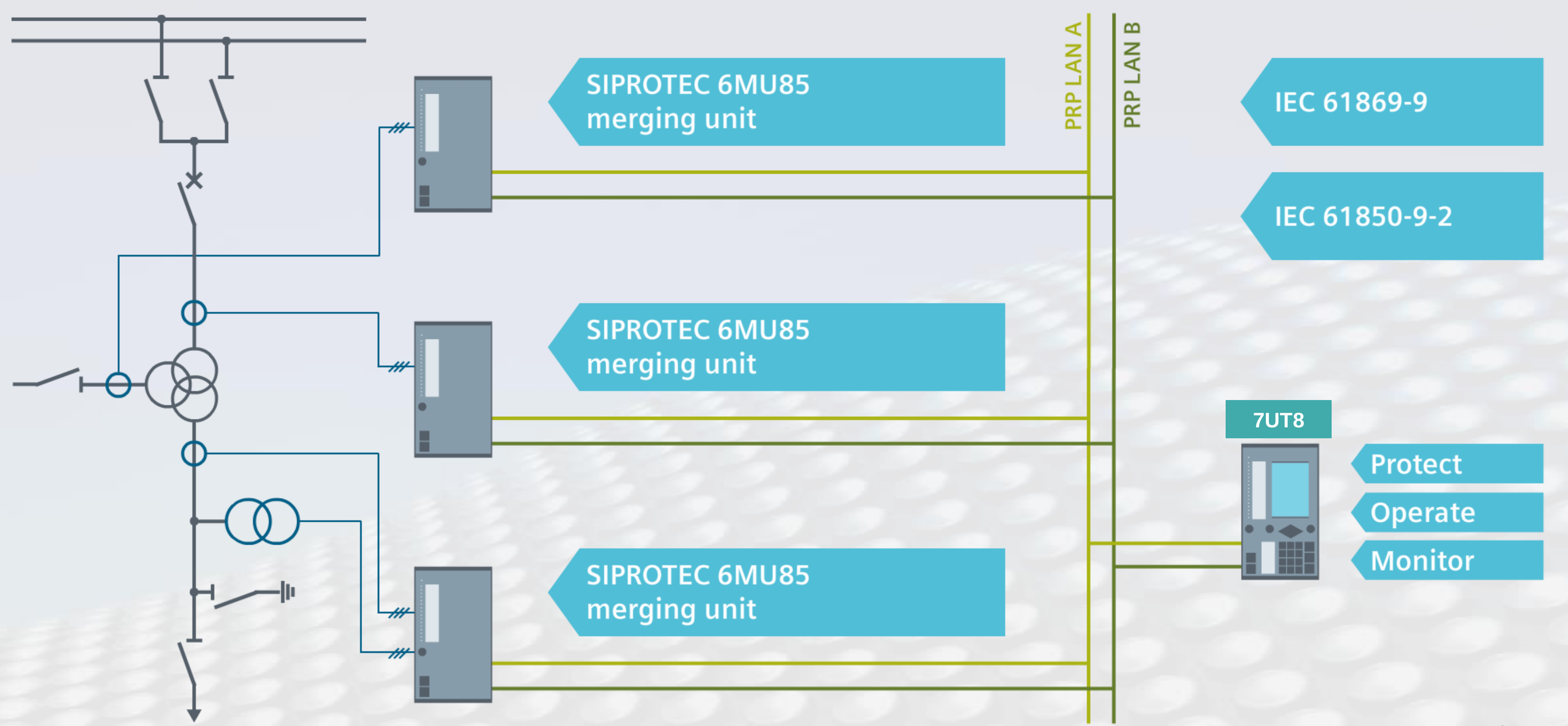
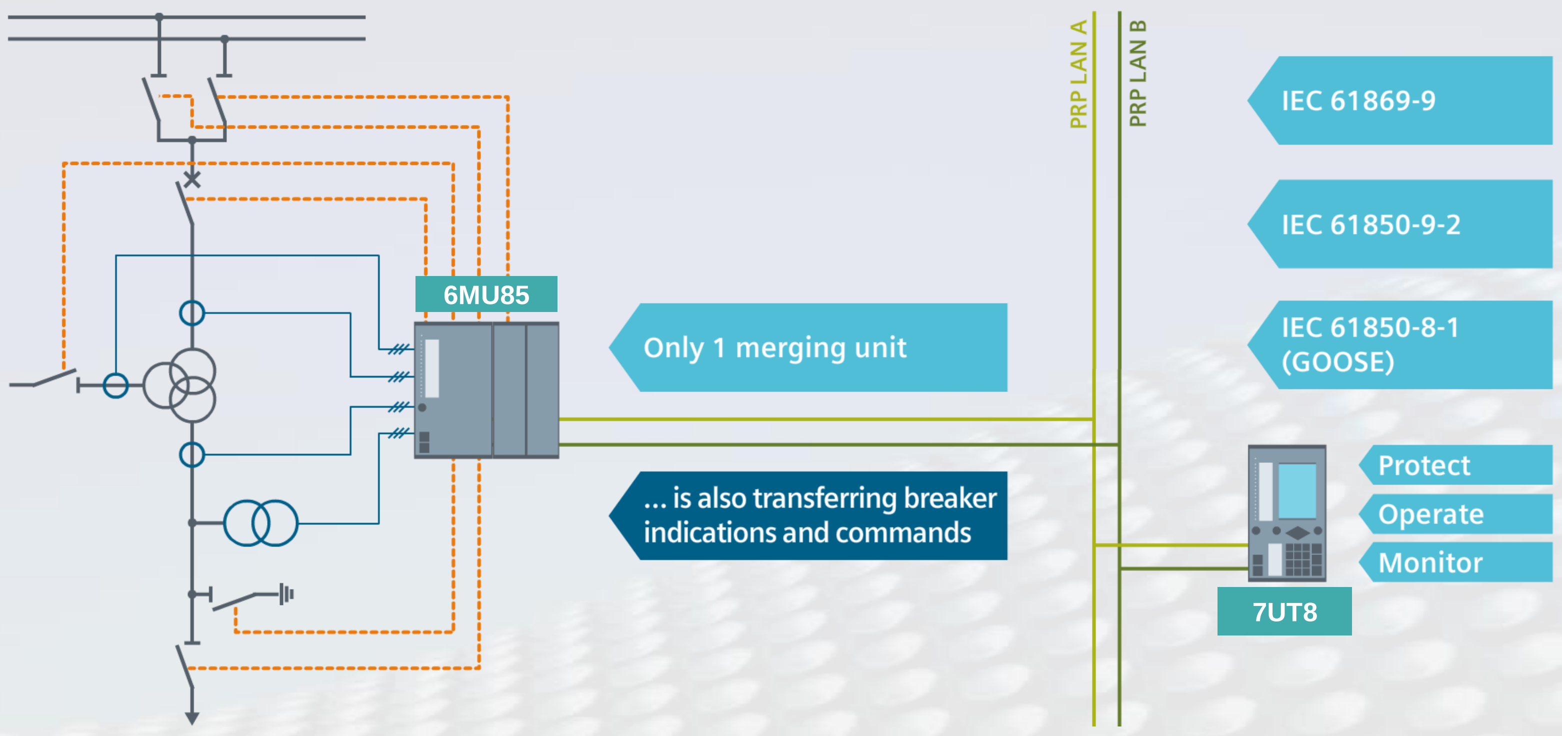


*for simplification the required IEEE 1588v2/PTP master clock is not shown

Transformer protection with only 1 merging unit

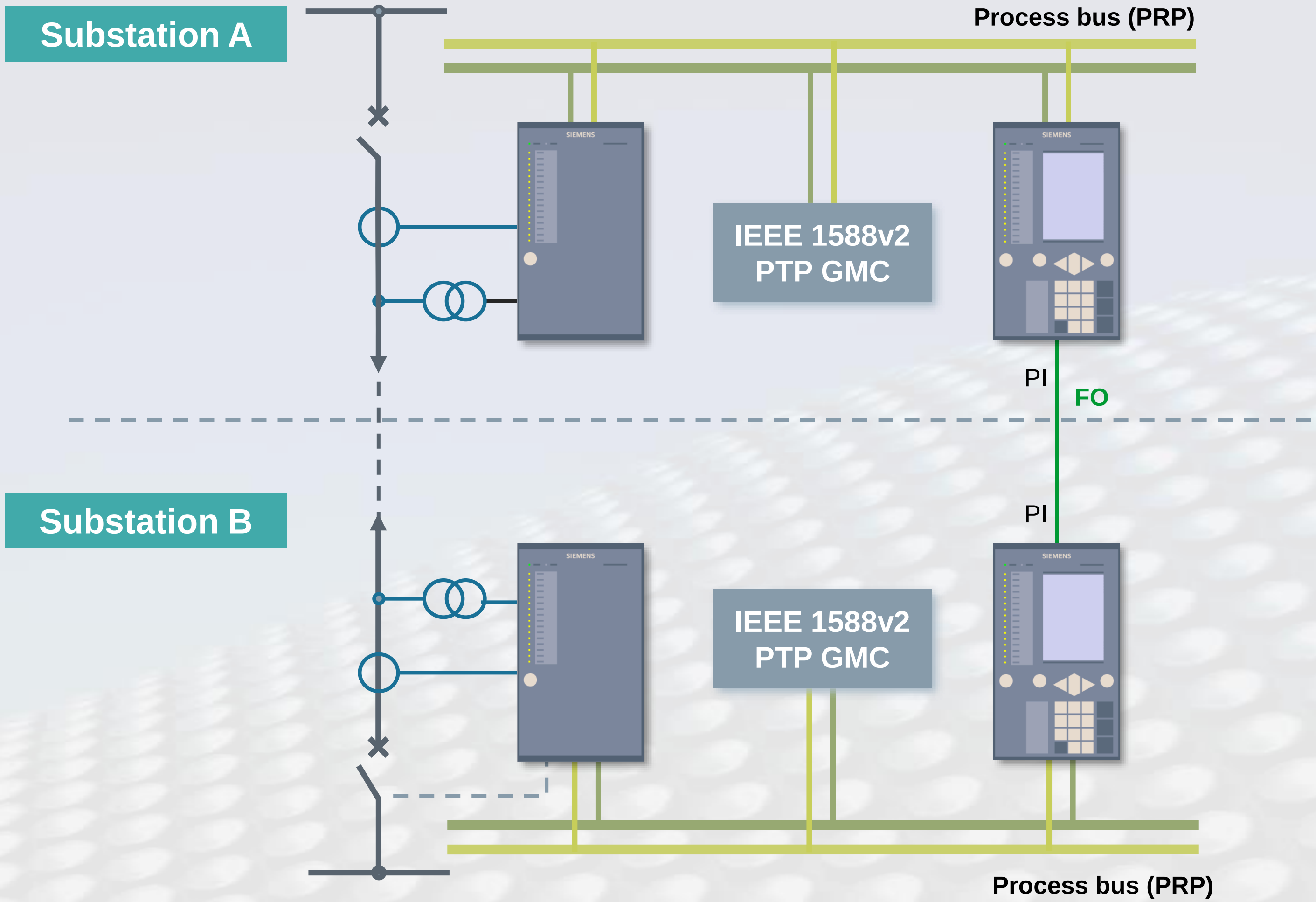


*for simplification the required IEEE 1588v2/PTP master clock is not shown

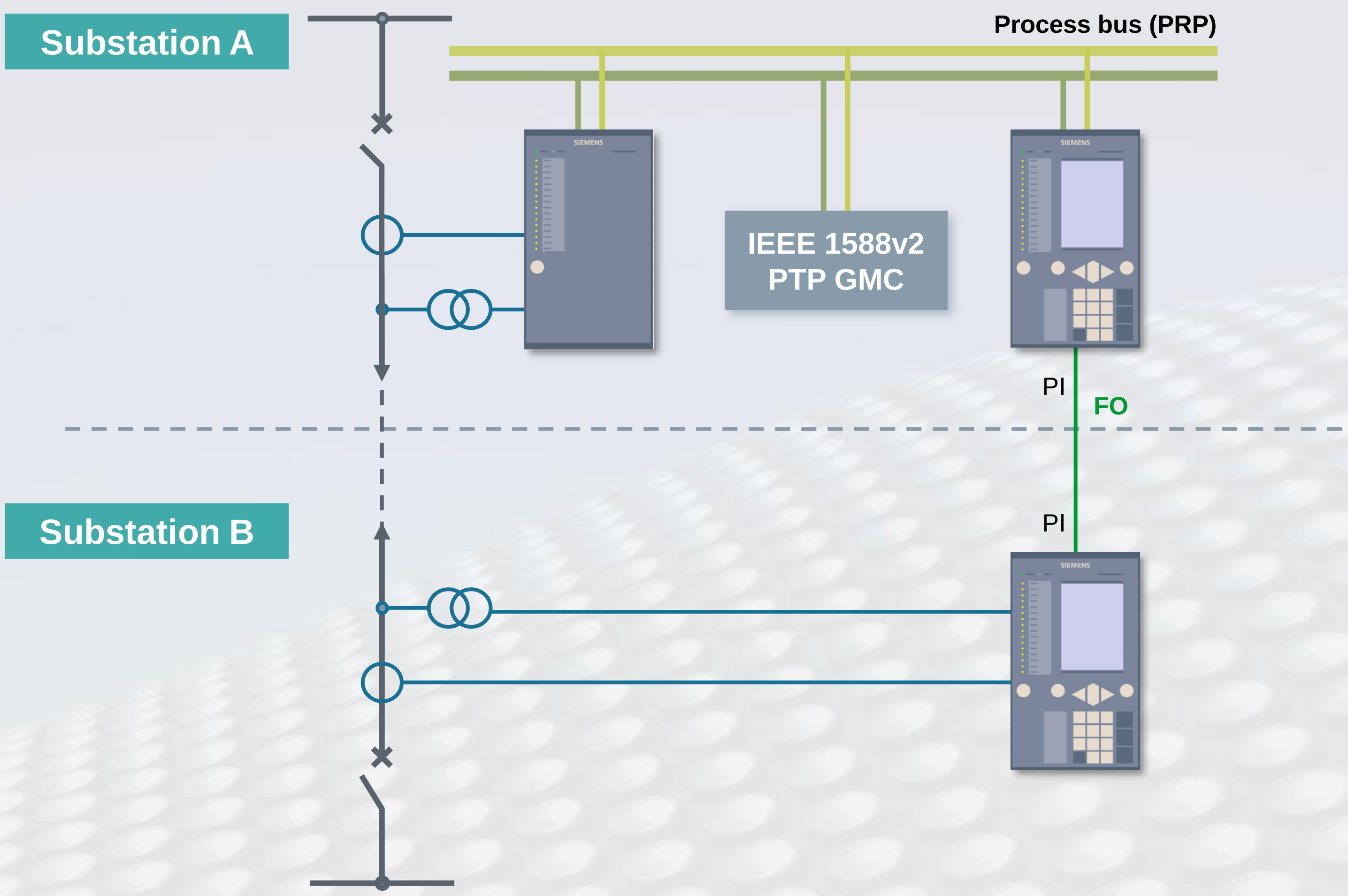
6MU85
Integrated functionality

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

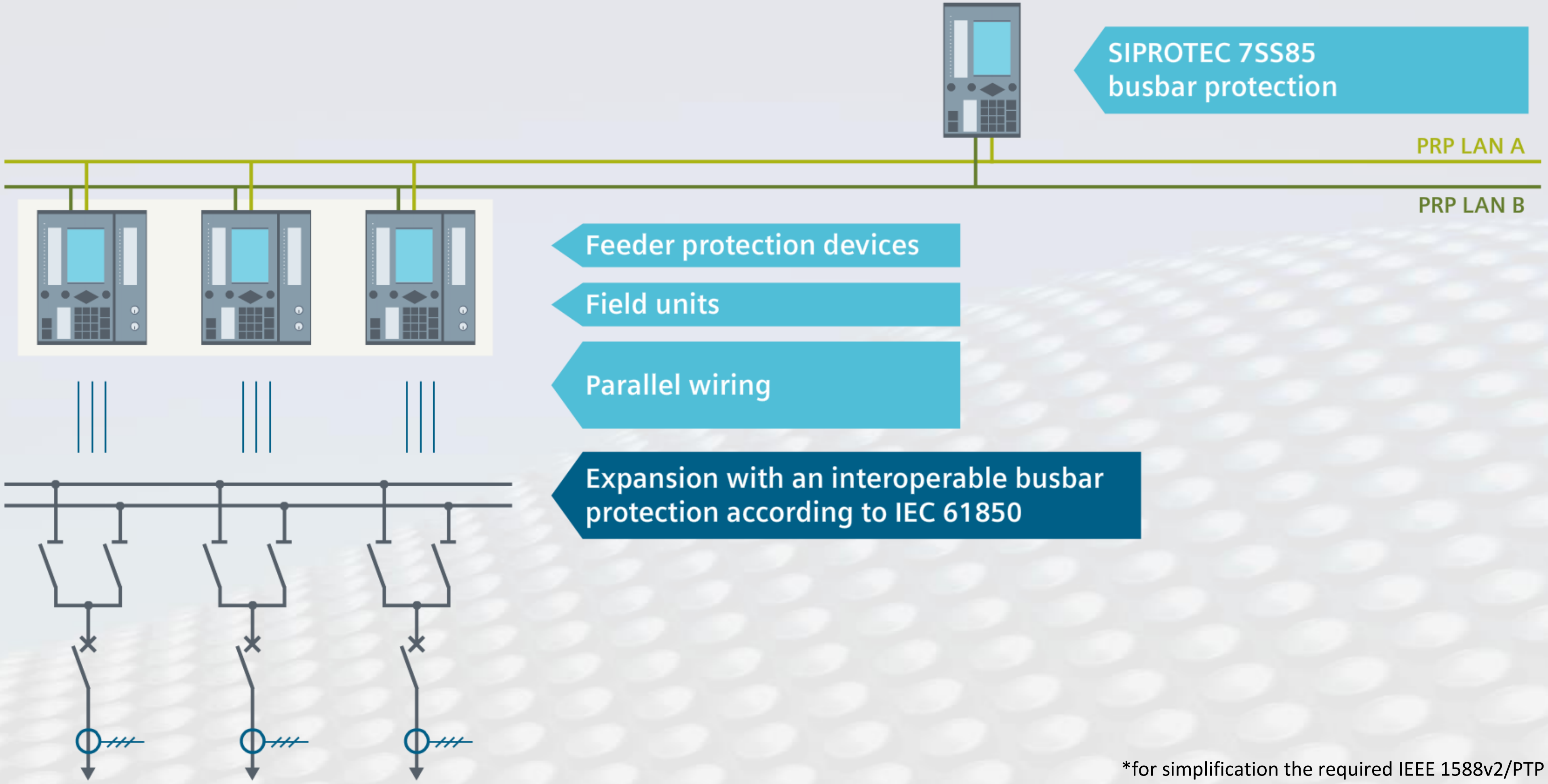
Line differential protection –
SMVs at both line ends



Line differential protection –
Mix of analog measurements and SMVs



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



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

Distributed busbar –
SIPROTEC 5 protection devices and 6MU85 as bay units

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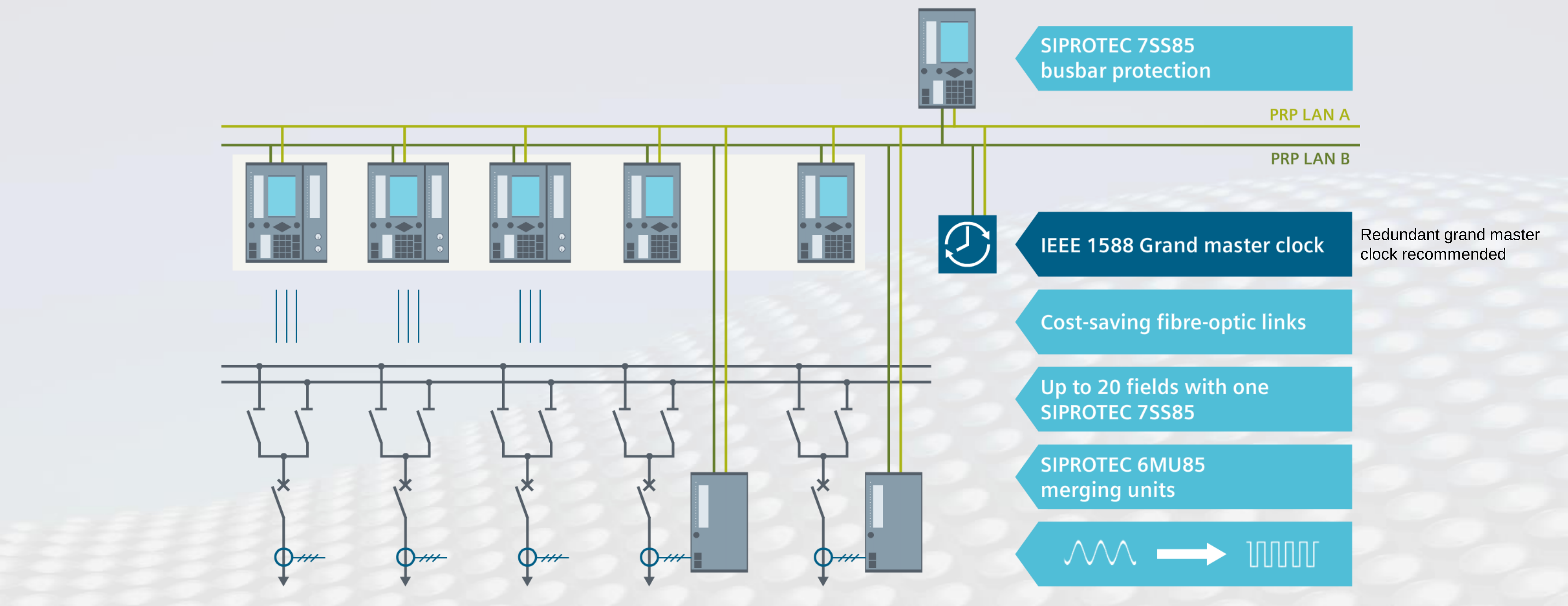

IEC 61850
Full digital Energy Automation System

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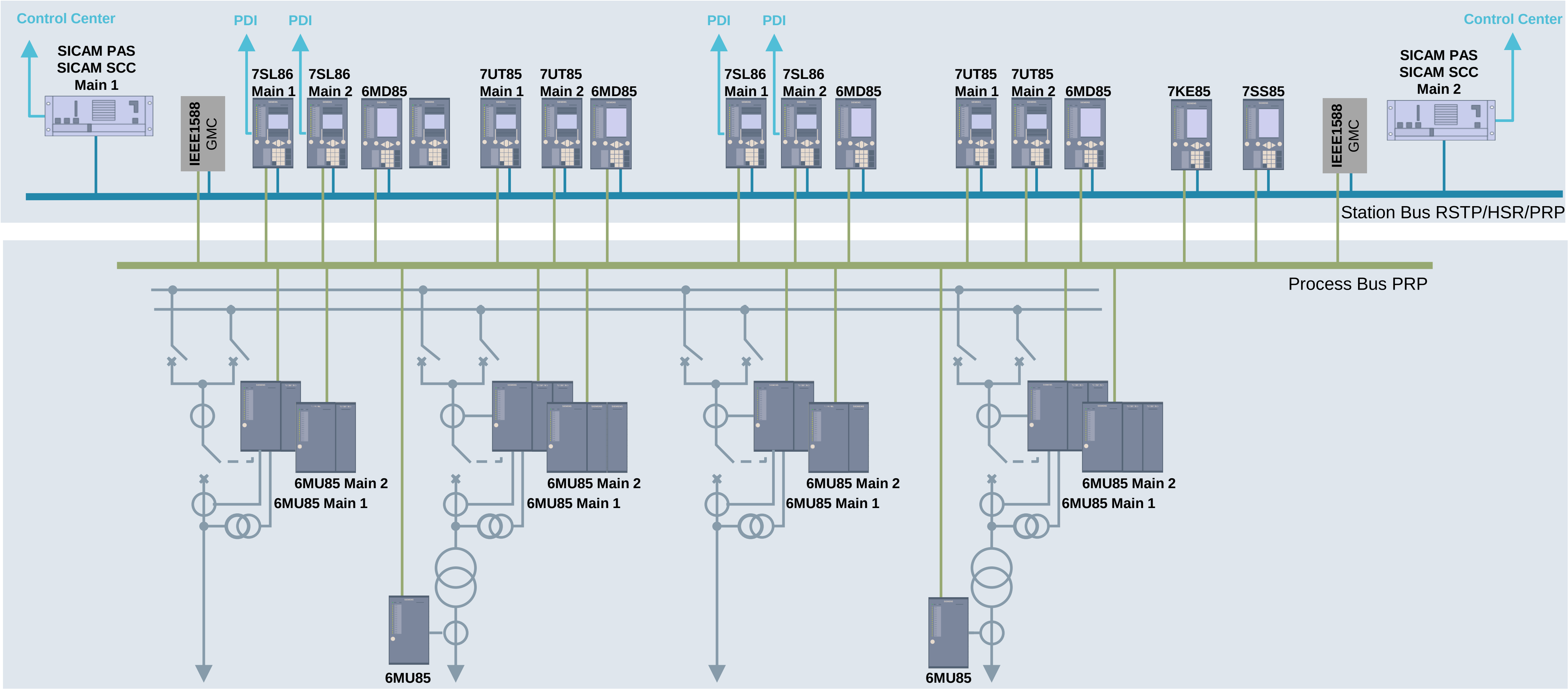
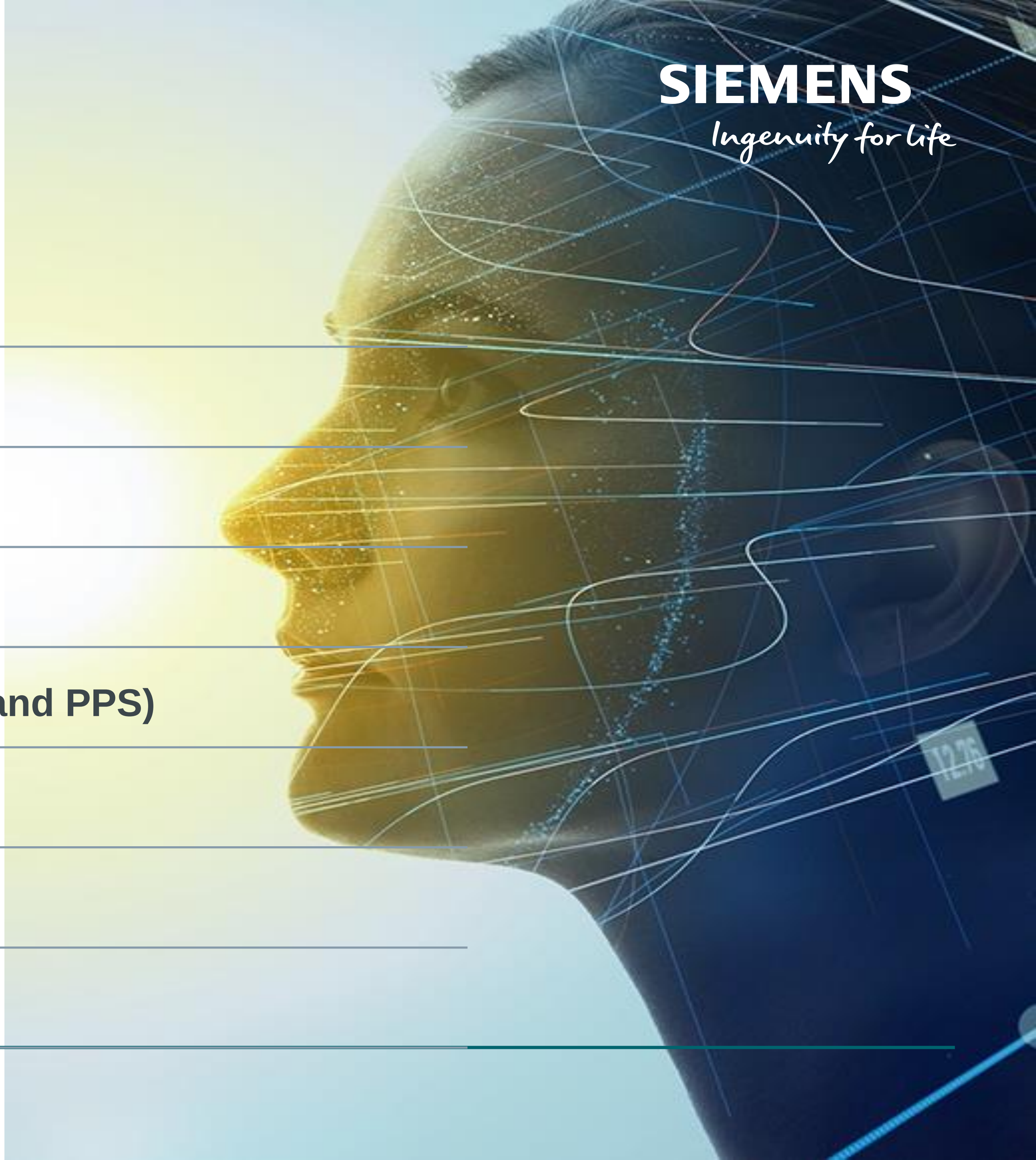


Content



Sample synchronization vs. time synchronization

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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

SV Synchronization

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

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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**

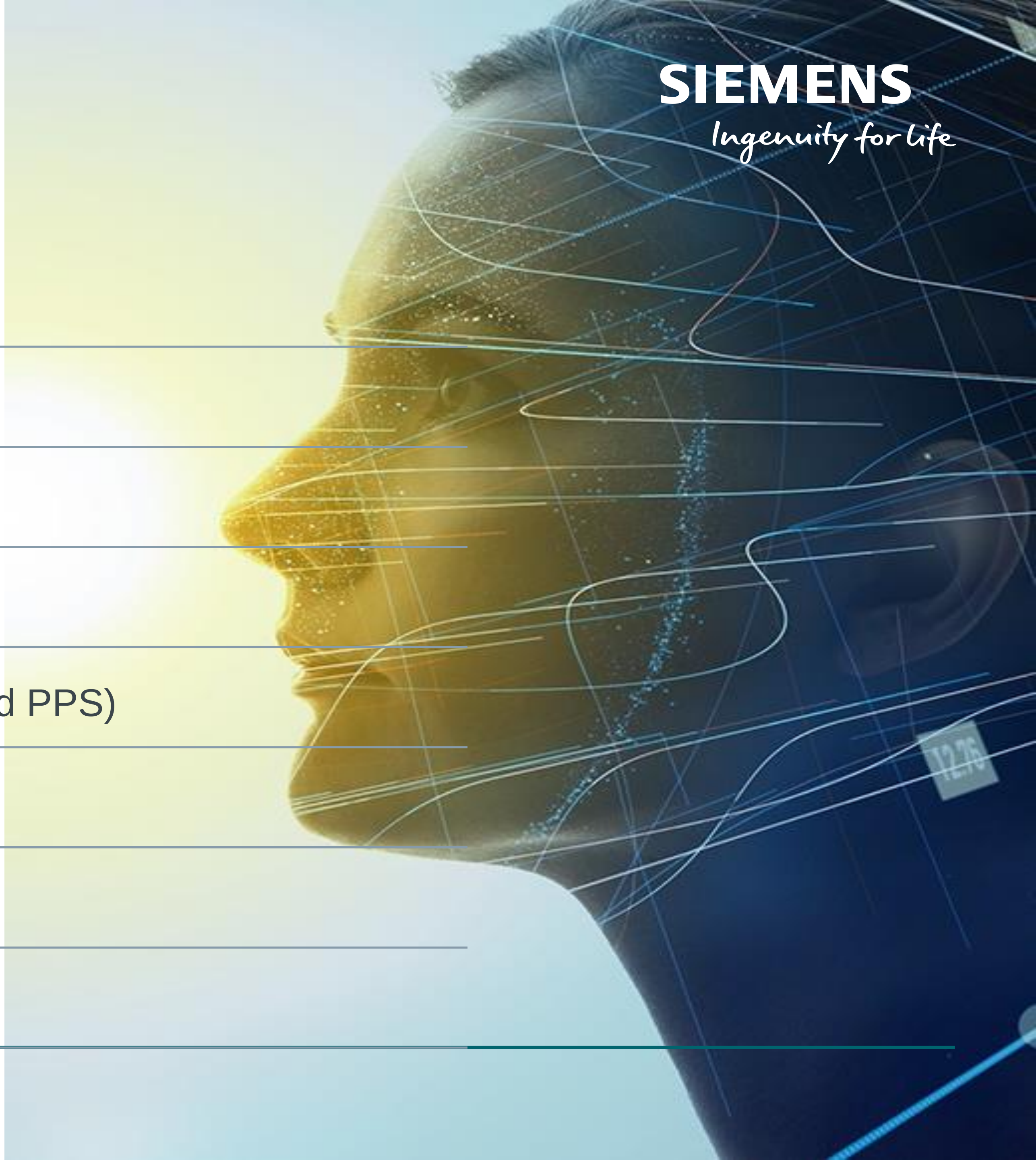
- * Holdover time depends on the initial synchronization status of the devices. It is automatically set between 5 and 25 seconds
- ** Overcurrent protection will continue working while the counter difference from merging unit and client is smaller smaller than 1 count.

IEEE 1588 – Master Clock

TEKRON- NTS 03-G+

RUGGEDCOM RSG2488

Content



Network architectures
Network redundancy for process bus

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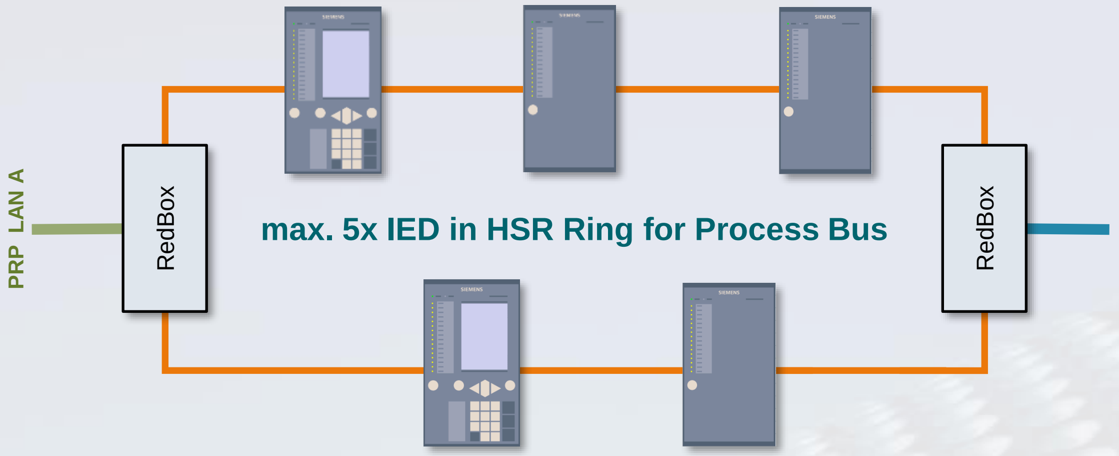

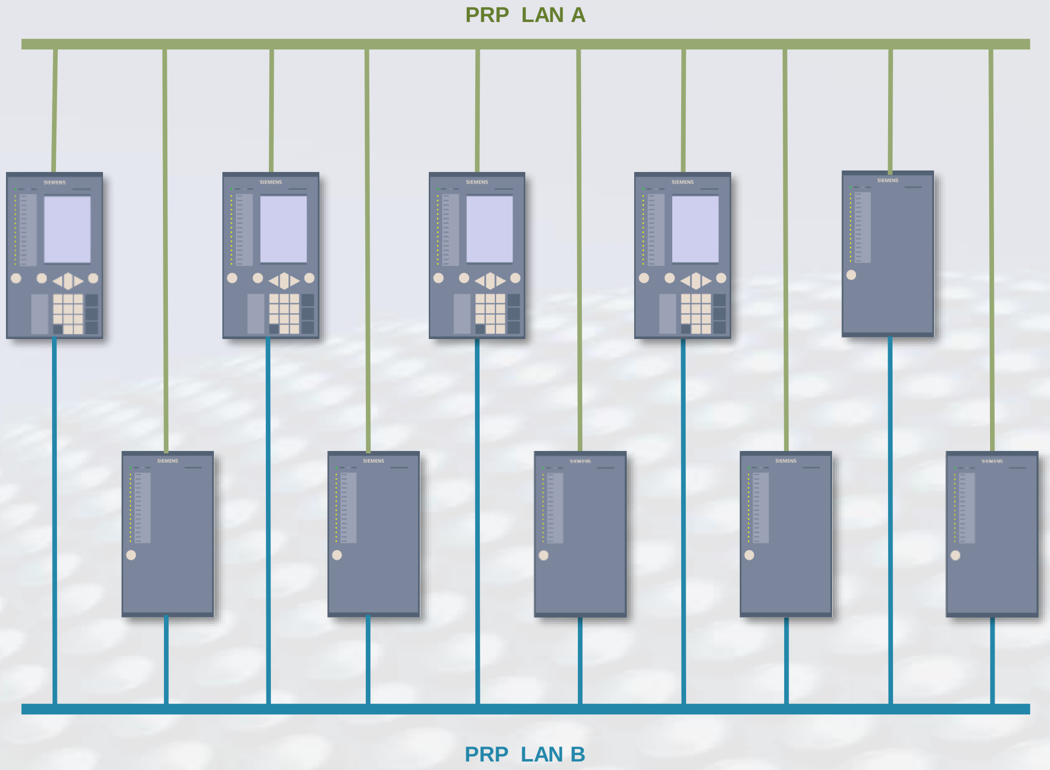

New on ETH-BD-2FO module:
HSR* ring with clients and server connected to PRP LANs
Sample synchronization for HSR must be realized with PPS

PRP redundancy with clients and server for station and process bus

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

Network architectures
Physically network segregation

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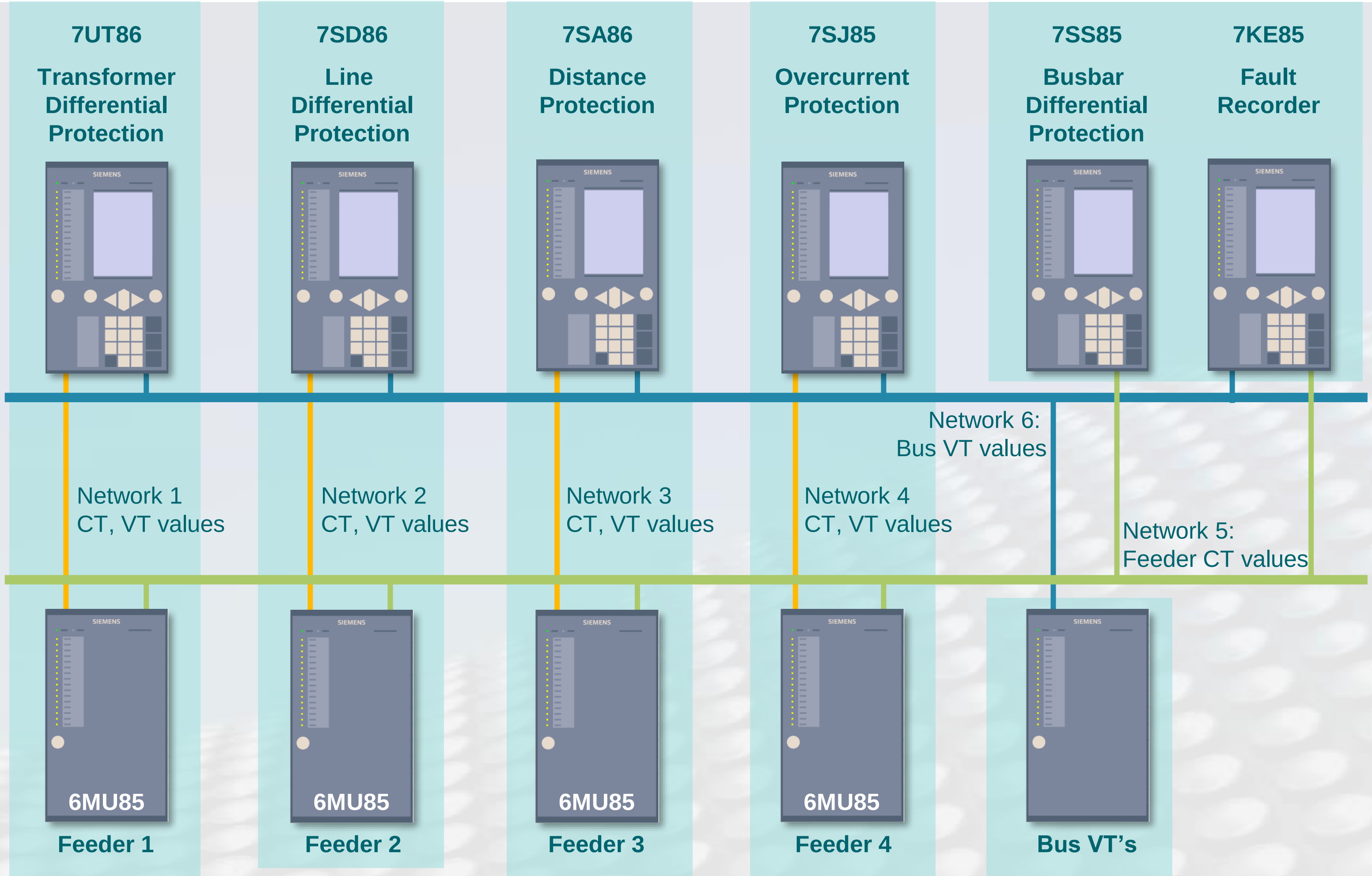


Simplify complexity

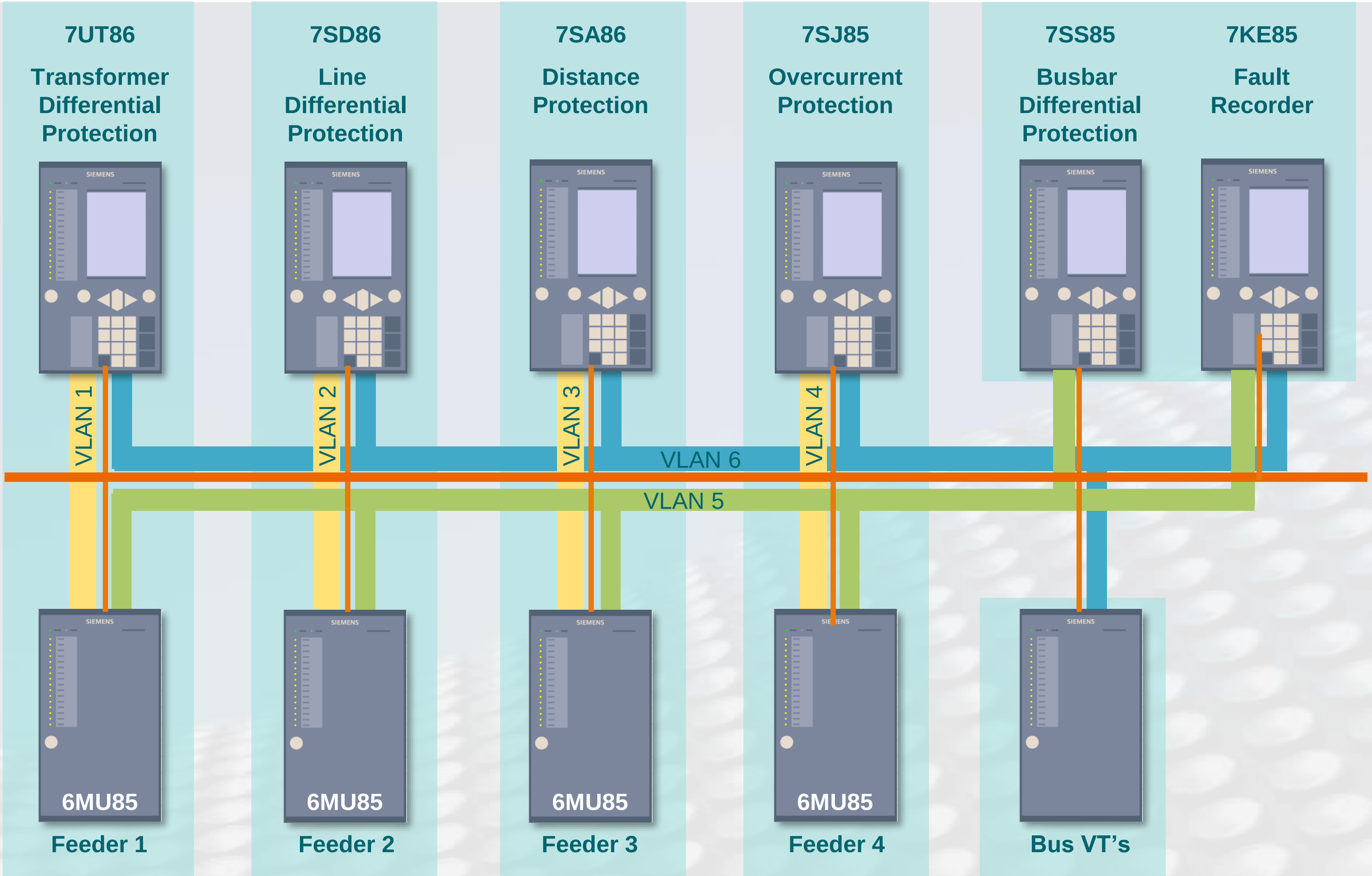
Use of more than one redundant process bus network reduces the network engineering

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)



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

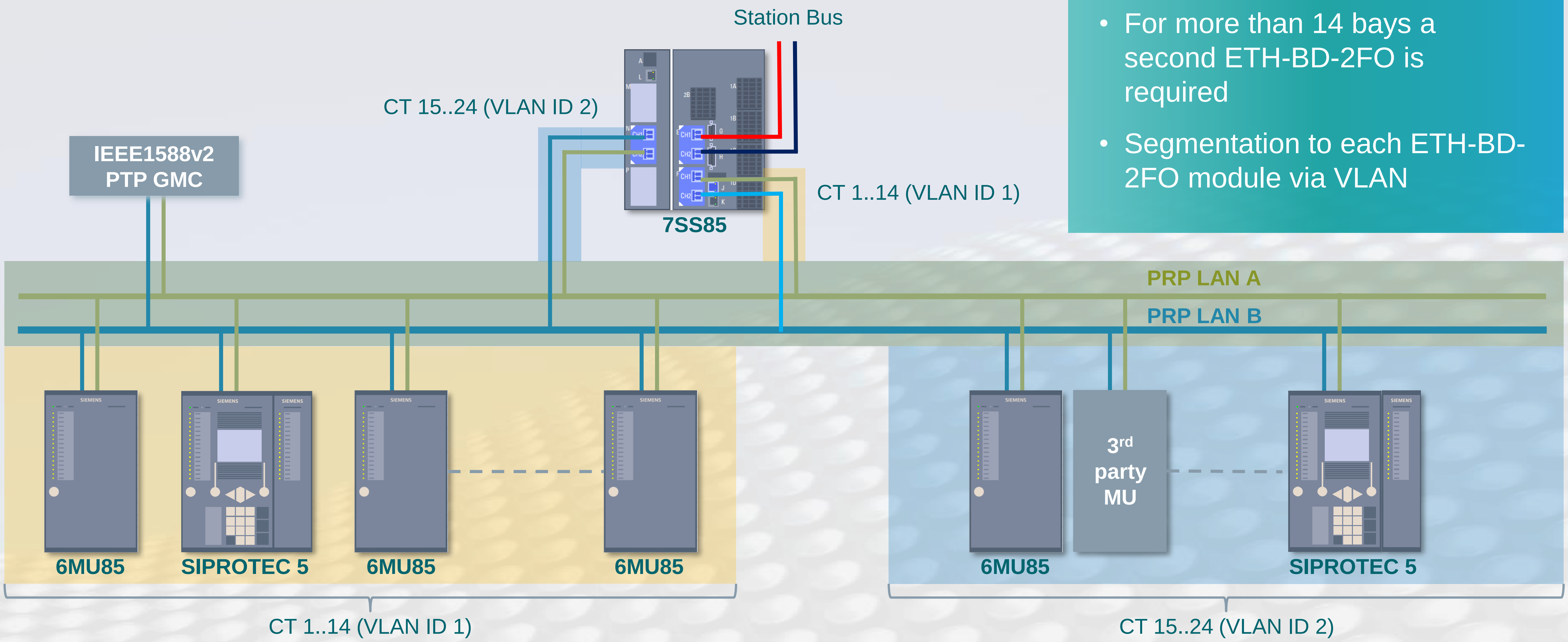
VLAN 6: Bus VT for central fault recorder and feeder protection

Note: Seamless networks redundancy recommended

Network architectures

Example: VLAN for busbar protection with 24 bays

- For more than 14 bays a second ETH-BD-2FO is required
- Segmentation to each ETH-BD-2FO module via VLAN

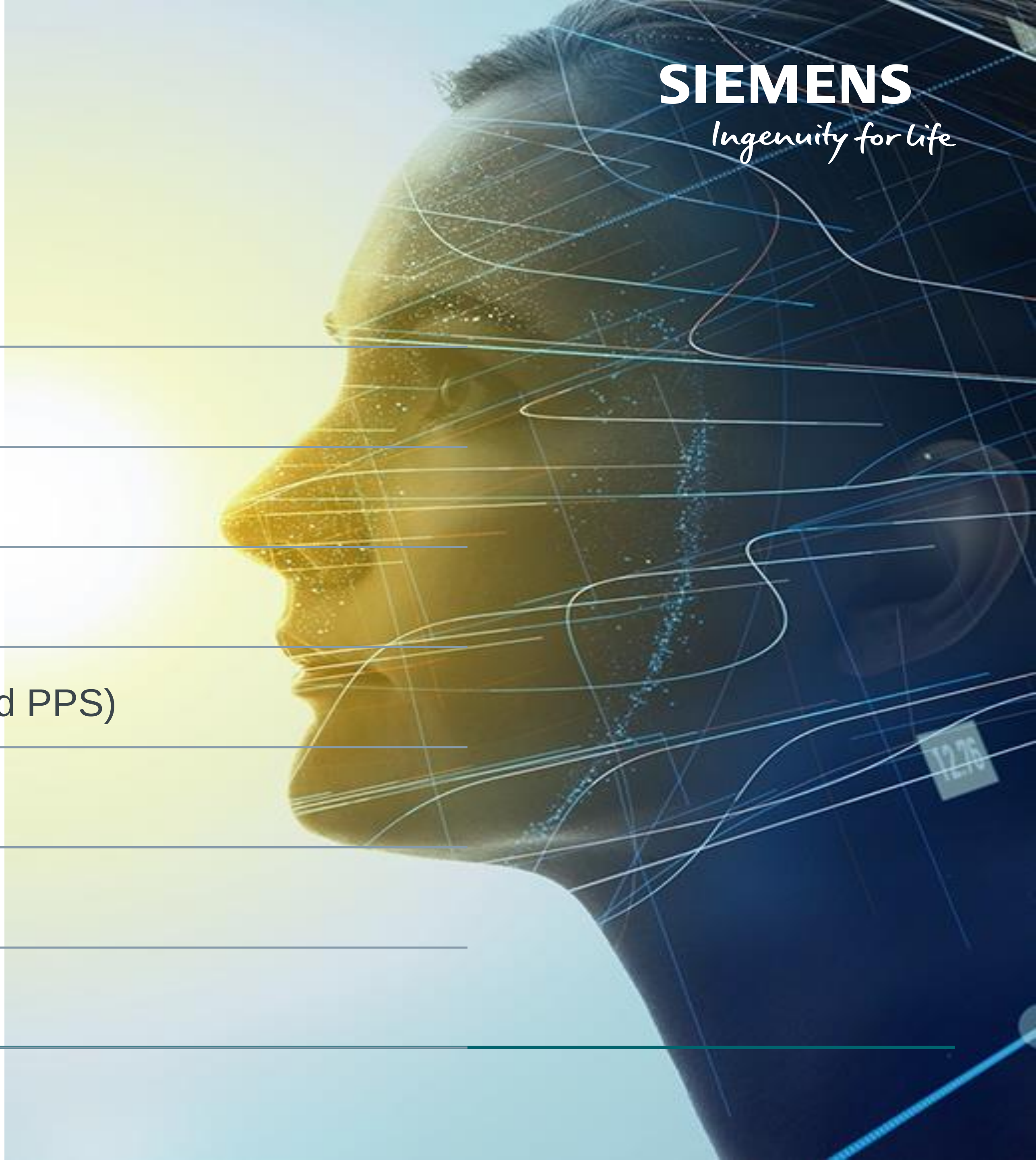


Process bus communication network

- 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

Content



SIPROTEC 5 – Process Bus
Definitions

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

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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, **IEEE 1588-2008** 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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