

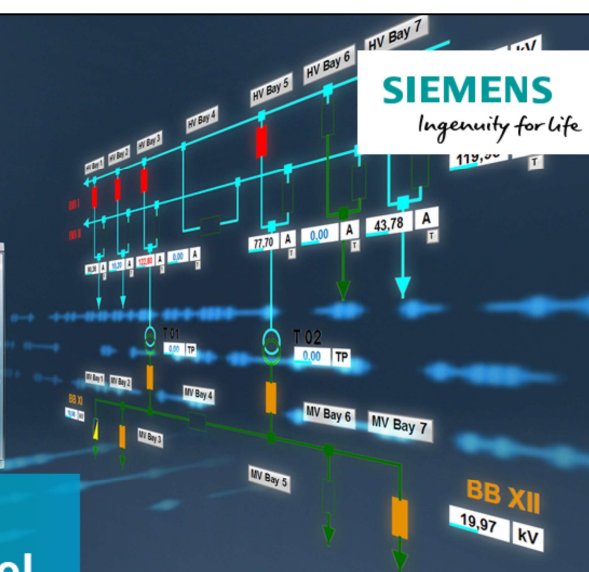
Digital Substation: Digitalization of Process Level

Substation Automation & Protection brugermøde 2020

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[siemens.com/digital-grid](https://www.siemens.com/digital-grid)

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Indholdsfortegnelse



- What is process bus?
- Why to use process bus?
- How can we implement process bus?



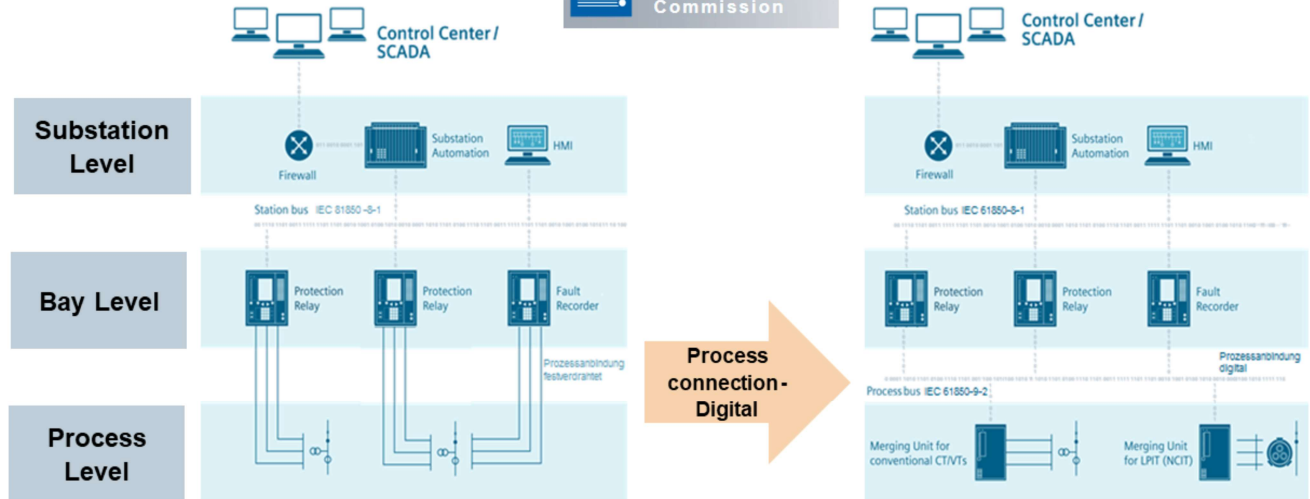
What is Process Bus

- Process Signals are getting Digital
- Process Bus - a brief look insight
- IEC Standards
- Technical Requirements of a Process Bus Network
- Summary

Process Signals are getting Digital (1/2)

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IEC International
Electrotechnical
Commission

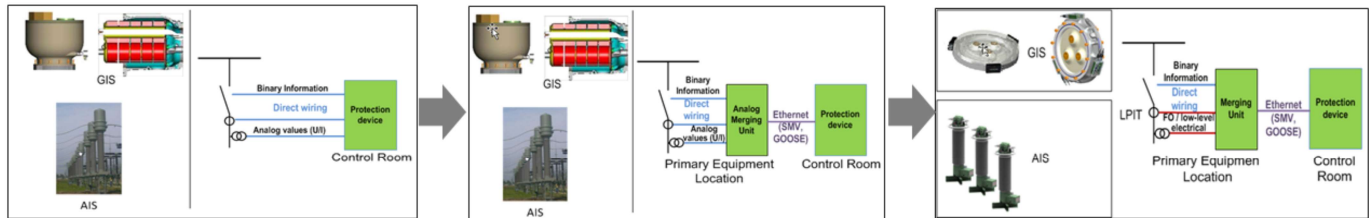


Side 4

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Process Signal are getting Digital (2/2)

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Substation Automation goes digital - hardwired process signals are digitalized and Low Power Instrument Transformer are used

Side 5

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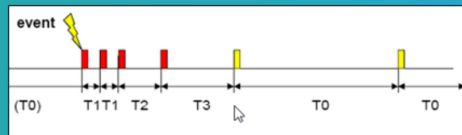
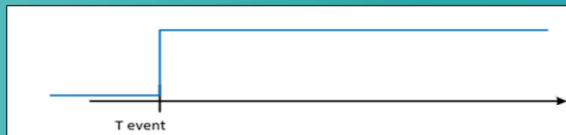
- 1
Conventional all measurements and signals hardwired
high cabling efforts
- 2
Process bus and Standalone Merging Unit with CTs/VTs - signals through process bus
all process signals hardwired to process bus and made available through process bus – cabling effort reduced
- 3
Process bus and Merging Unit with Low Power Instrument Transformer (LPIT)- signals through process bus
additional LPIT are used with better measurement characteristics and reduced size (big advantage for GIS)

Substation Automation goes digital:

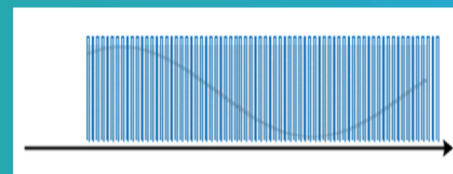
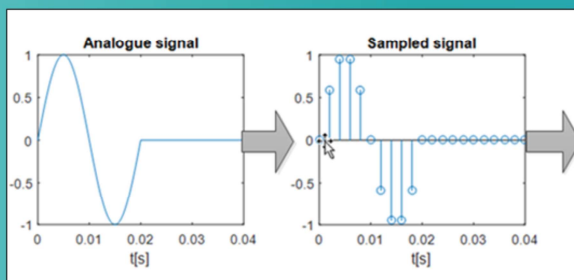
- new designs and concepts are now possible
- skills shift from electrical to digital
- new tools, procedures, etc. are need for configuration, commissioning and maintenance

Process Bus IEC61850-9-2 – a brief look insight

GOOSE



Sample Measurement Values (SMV)

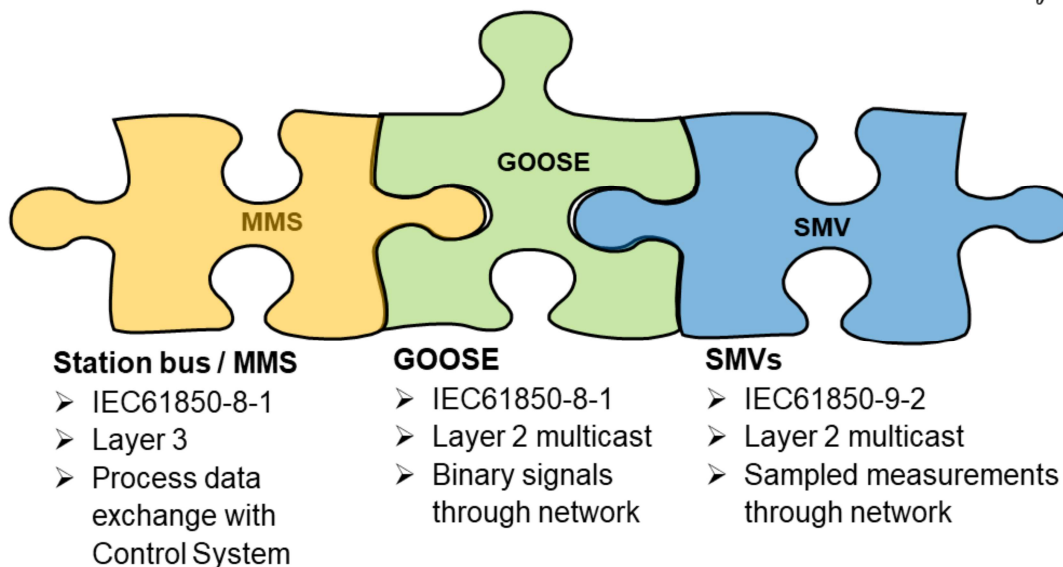


GOOSE - Telegram periodically send starting with a minimum repetition rate and then increased by doubling until a defined maximum repetition rate is achieved

SMVs - Measurements are sampled; for each sample a telegram is send through the network; telegram is no repeated

Note: there is a variation: to send samples may be packed in a telegram ('2 ASDUs')

IEC Standards applicable for Digital Substation (1/3)



Side 7

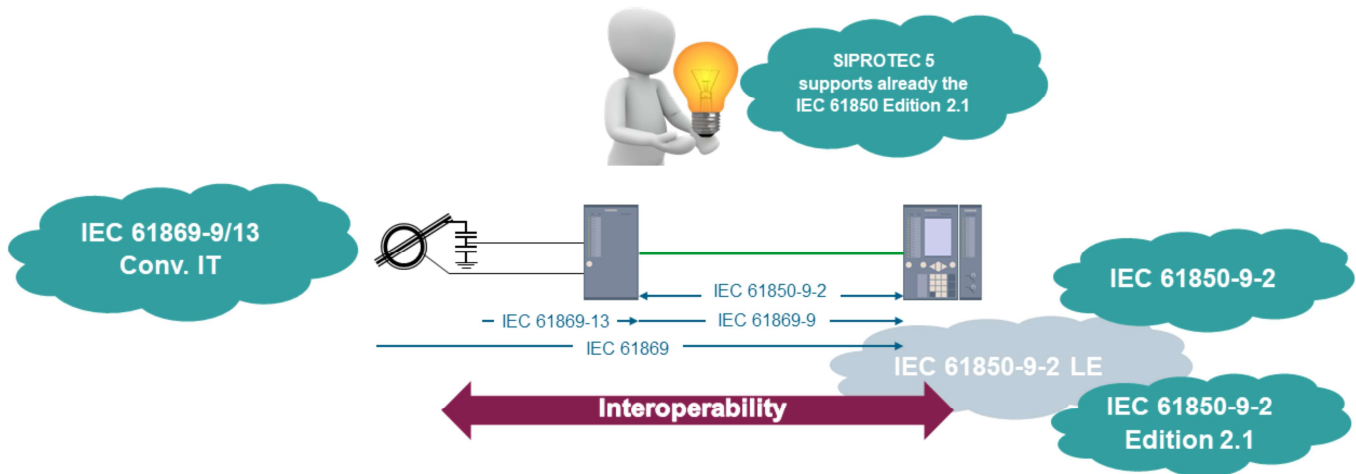
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Station bus Client/Server – Signals from IED to Substation CC oder Control Center

GOOSE Signal exchange through network replacing hardwired signals

SMVs Sampled analog signal replace hardwired measurements

IEC Standards applicable for Digital Substation (2/3)



Side 8

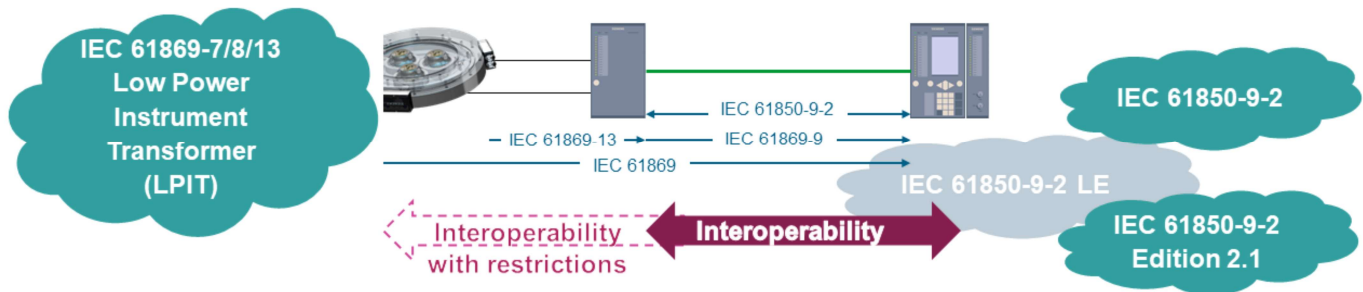
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IEC 61869-1 as part of the IEC 61869 is applicable for all Instrument Transformers. Following additional standards are of importance for LPITs and Merging Units:

- IEC 61869-9 describes the digital interface (process bus interface) that has to be implemented by Merging Units. The requirements of this substandard includes the communication interface that has to be implemented as per communication standard IEC 61850-9-2
- IEC 61869-13 specifies implementation rules that are applicable for Standalone Merging Units interfacing conventional Instrument Transformer like 6MU85 having an IO20x mounted. In this substandard fulfillment of IEC 61869-9 is included.
- IEC 61869-7 and IEC 61869-8 are applicable for the LPIT solutions for GIS with IO240 and AIS with IO245 (here only for the current LPIT); it specifies implementation of LPIT in combination with electronic processing logic.
- IEC 61869-10 and IEC 61869-11 specify the implementation of passive (= no electronic components) Low Power Voltage and Currents sensors; these both standards are including the specification of the signal range of the LPITs; this implies, if arbitrary MUs and LPITs from different supplier fulfil these standards they can be combined. Such kind of passive LPIT solutions are often used in Medium Voltage Switchgears; also the RC divider solution for AIS as described above is in line with IEC 61869-11.

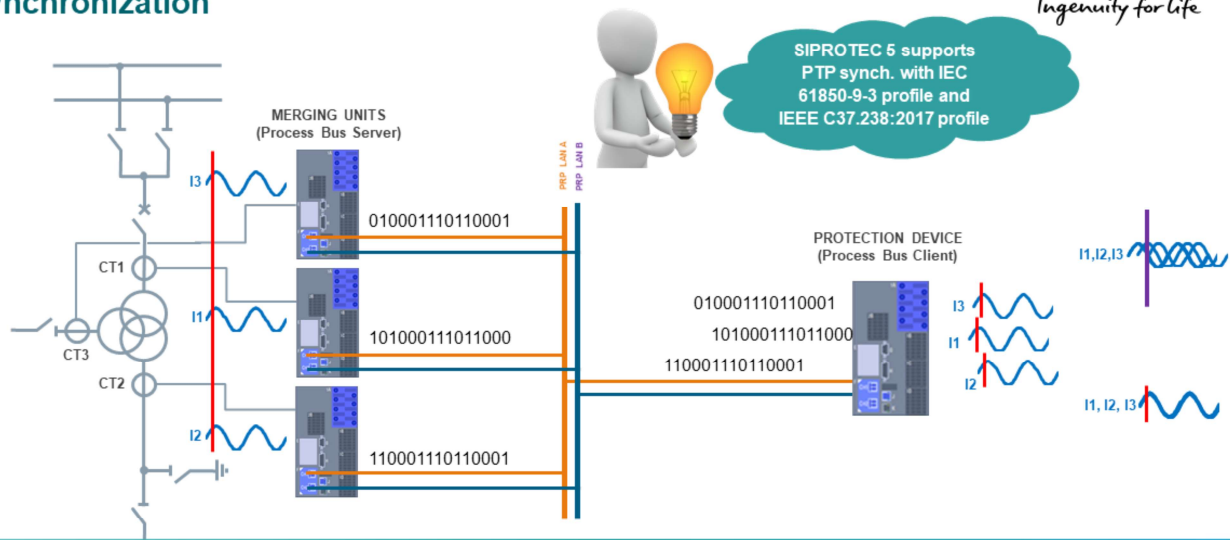
IEC Standards applicable for Digital Substation (3/3)

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Technical Requirements of a Process Bus Network – Time Synchronization

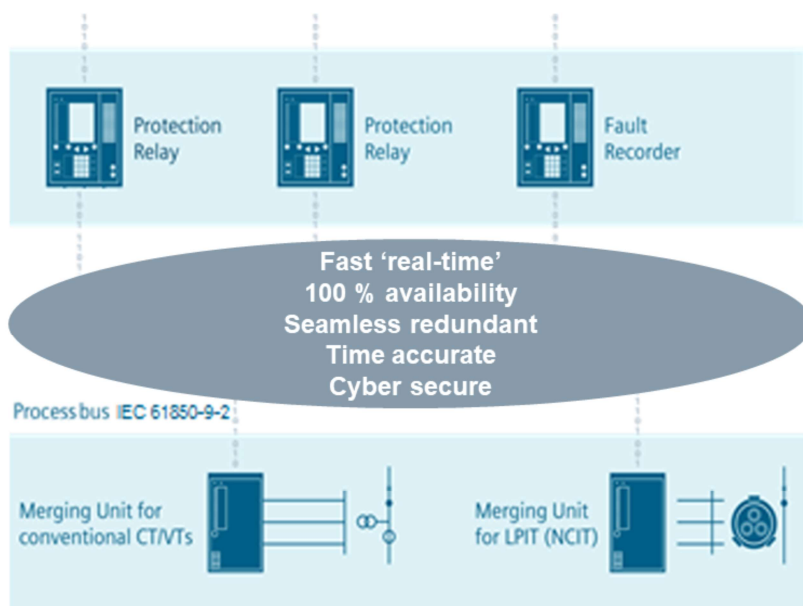
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If the sampled values are not synchronized the protection functions are blocked to avoid maloperation!

Technical Requirements of a Process Bus Network – Network Equipment

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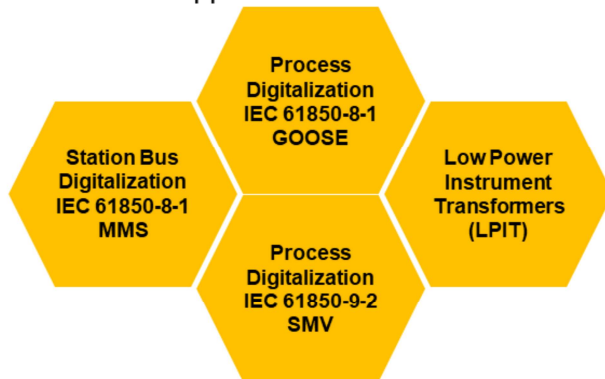
Side 11

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Instead of hardwired signals now a Process bus LAN provides the process image to the IEDs – this has to happen in real-time and with highest reliability.
Hence the network must implement high requirements.
Suitable managed switches, which support PTP time synchronisation are required.

Summary Take Away

- Process bus means digitalization of process signals and transport to the processing devices by network instead of copper cables



- In addition to MMS & GOOSE with Sampled Measurement Values (SMVs) digitalization is complete
- In combination with LPITs better measurement characteristics and smaller size of switchgears can be achieved

Side 12

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- Process bus is nothing else the digitalization of process signals and transport to the processing devices by high performant and reliable network instead of copper cables
- First steps already done with MMS and GOOSE, now digitalization complete with digitalized measurements (SMVs)
- In combination with LPIT solutions (for GIS and AIS) in addition better measurement characteristics and smaller size of switchgears can be achieved



Why Process Bus

- Estimated cost savings
- Reduced Wiring
- Benefits of LPITs
- Reduce amount of Instrument Transformer cores
- Busbar Protection using Merging Units
- Less Complexity and Standardization
- Work smarter, not harder
- Increased Safety
- Increase Future Flexibility

Estimated cost savings - Siemens Internal Calculations



Air Insulated Switchgears

Field savings

- Civil works – up to 5 %
- Concrete cable trays – up to 100 %
- Transportation (reduction of CO2)
- Secondary copper cables – up to 75 %
- Commissioning – up to 10 %
- Maintenance up to 25 %
- Space – up to 10 %

Control room savings

- Civil works – up to 5 %
- Secondary copper cables – up to 95 %
- Relay cabinets – up to 50 %
- Space – up to 35 %
- Maintenance - up to 15 %

Gas Insulated Switchgears

Field savings

- Space – up to 30 % (in special applications for example oil or gas see platforms)

Control room savings

- Civil works – up to 5 %
- Secondary copper cables – up to 95 %
- Relay cabinets – up to 50 %
- Space – up to 35 %
- Maintenance - up to 15 %

Estimated cost savings - Calculation by a Customer



Reduced lifecycle cost compared

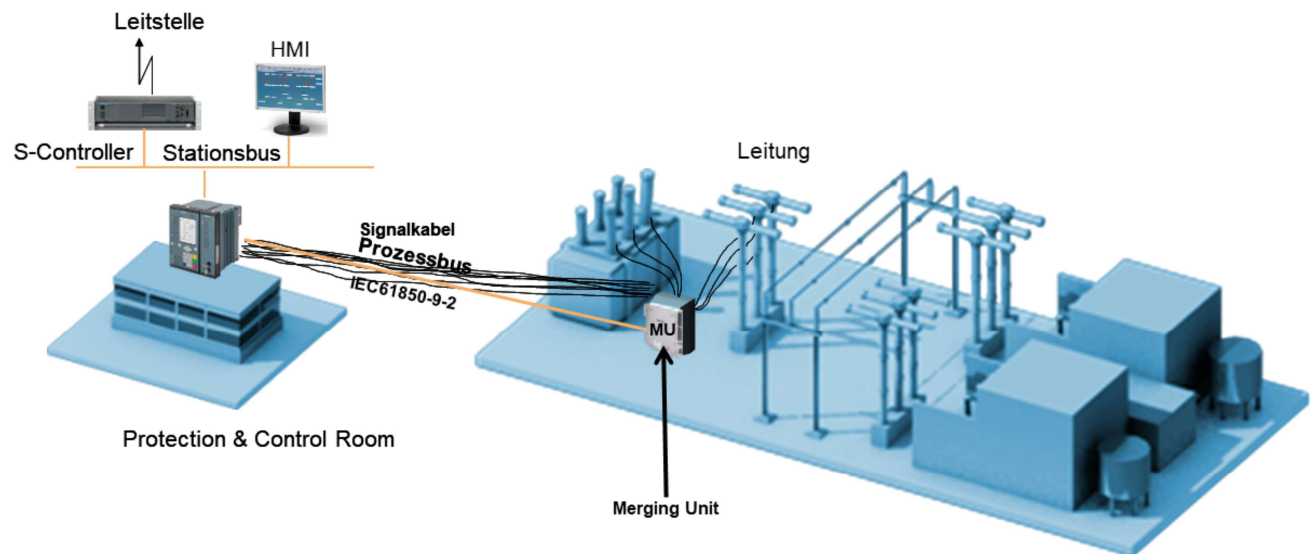
- Brownfield installations (only Substation Automation System): **6..12% savings**
- Greenfield installations: **13..19% savings**

Resulting from

- Smaller building area, cable channels, reduced number of cabinets, local HMI, etc
- Reduced engineering efforts
- Reduced installation efforts (less cabling, cabinets, etc.)
- Less time for testing FAT/SAT, etc

Reduced Wiring

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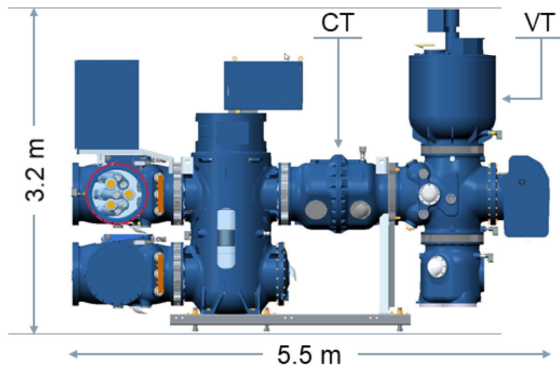
Side 16

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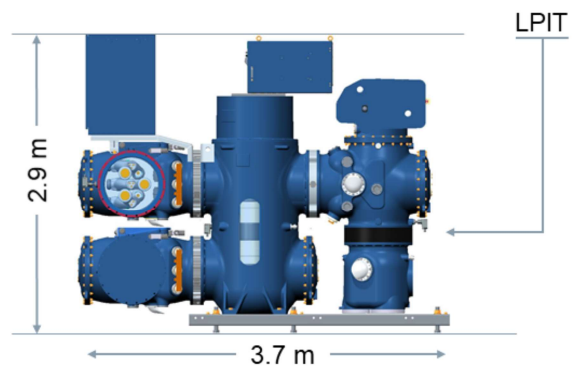
Benefits of Low Power Instrument Transformer (1/2)

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Inductive Current and Voltage Transformers (conventional)



Current and Voltage Sensors (non-conventional)



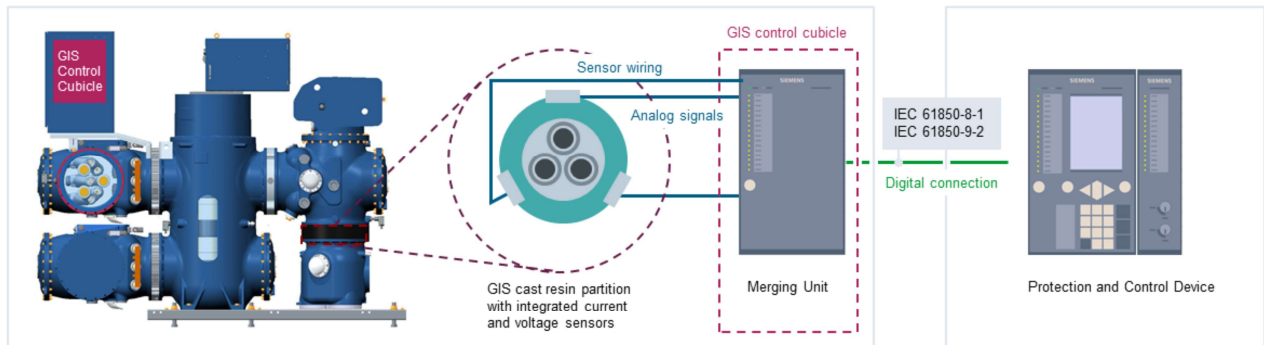
Basis size reduction of 30% and weight -1,500 kg
Example shown: GIS Clean Air 72,5 – 145 kV

Side 17

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Benefits of Low Power Instrument Transformer (2/2)

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- Combined electronic voltage and current sensor (EVT/ECT)
- Redundancy included
- One LPIT type for protection and measurement
- Higher performances in measurements and harmonics
- Improved safety

Side 18

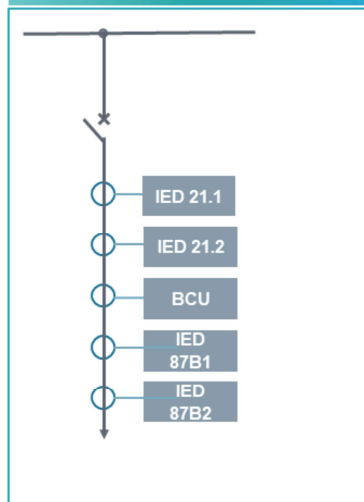
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- Combined and compact electronic voltage and current sensor (EVT/ECT) according to IEC/IEEE
- Redundancy included 2 x CT coils and 1 VT (2 x VT planned for future)
- One LPIT type for protection and measurement in all feeders because of the wide dynamic range
- Higher performances in measurements and harmonics (no magnetic losses, and no ferro-resonance effects)
- Improved safety: Danger of open CT circuits obsolete and minimized risk of internal arc

LPITs (previously NCIT / Non-conventional Instrument Transformers) that replace conventional CTs (current transformers) and VTs (voltage transformers), using new measurement principles and showing an improved measurement performance, namely avoiding ferro-resonance effects and covering a very wide measuring range (there is no ratio to be considered). If used in GIS switchgears, their size and weight are reduced significantly compared with conventional CTs and VTs.

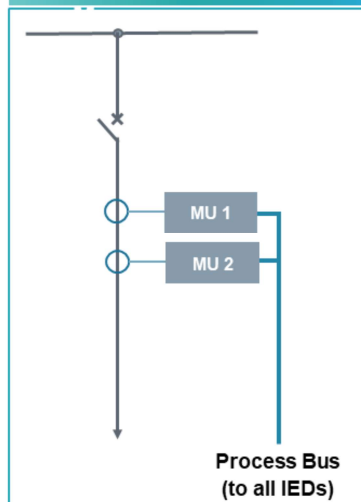
Reduce amount of Instrument Transformer cores

Conventional



Side 19

MUs with process bus



**Merging Units provide
SMVs to all IEDs
connected to process
bus network**

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Busbar Protection goes process bus

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SIPROTEC 4 BBP with Bay Units



SIPROTEC 5 BBP with Merging Units & Process Bus



Side 20

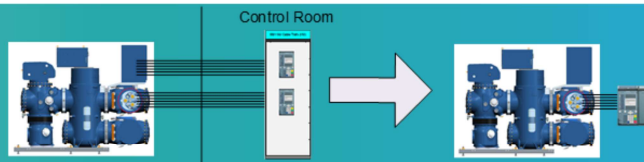
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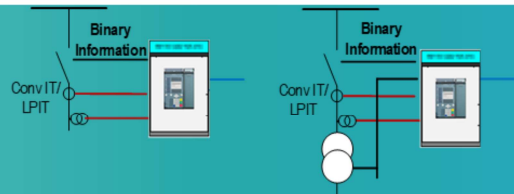
Less Complexity and Standardization results in less Documentation and Costs (1/2)

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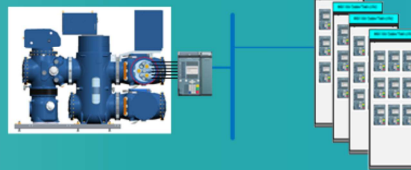
**Less cabling,
less complex
schematics**



**MU Panels can
be partly
standardized**



**Standardized
Protection
Panels**



Side 21

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Standardized Protection Panels differ only in installed devices

Less Complexity and Standardization results in less Documentation and Costs (2/2)



Cost Reduction by:

- Less complex schematics
- Standard drawings – not substation specific
 - standardized MU cabinets
 - standardized protection cabinets
- Shorter design, installation and test process due to standard concept
- Improved quality with fewer errors because of standard systems
- Possibility to buy batches of standard cabinets

Side 22

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Less complex schematics

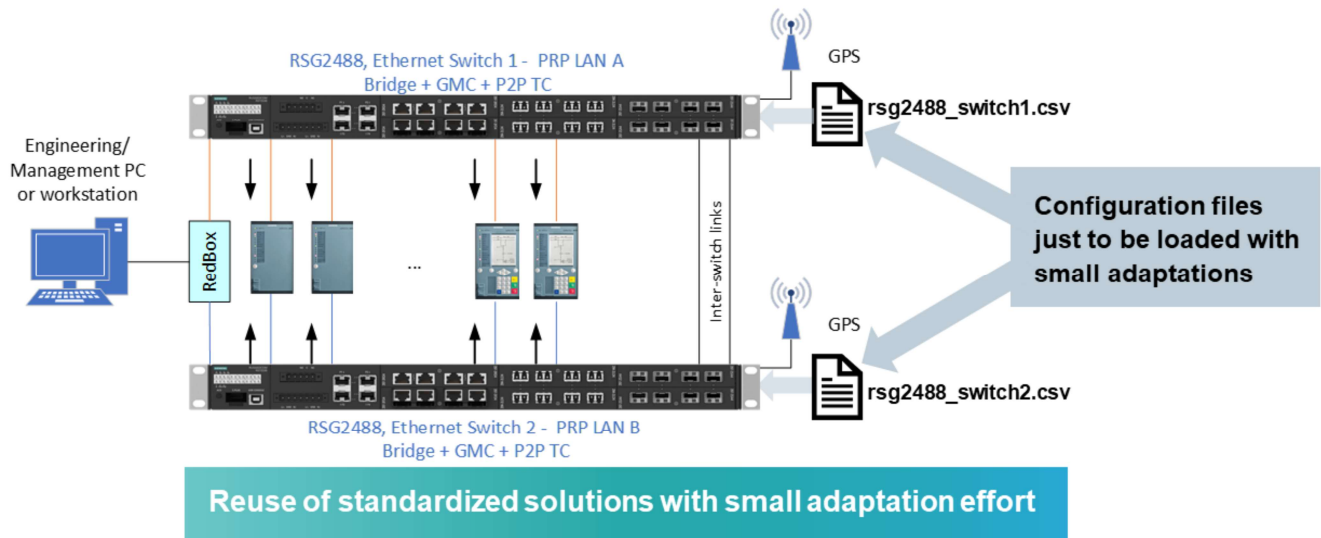
Digital signals and logic replacing wires and analog logic
errors not to be corrected in drawings

Standardized Protection Panels differ only in installed devices

MU cabinet type independent of protection application

Work smarter, not harder (1/2) Engineering is done once and can be copied

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Side 23

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Network, time sync, engineering is done once and can be copied

Work smarter, not harder (2/2) More comfortable Test Concepts

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Digital Interfaces allow new test approaches with reduced effort (no / reduced cabling):

- GOOSE signal injection instead of signal generation on BI
- SMV signal injection instead of secondary injection
- Remote testing
- Automatic test routines



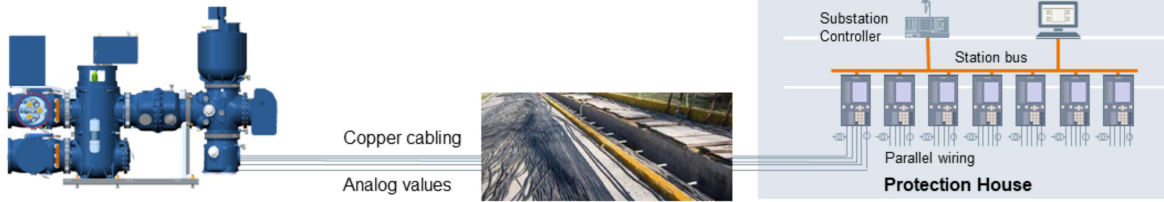
Side 24

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Increased Safety

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Previously



Digital

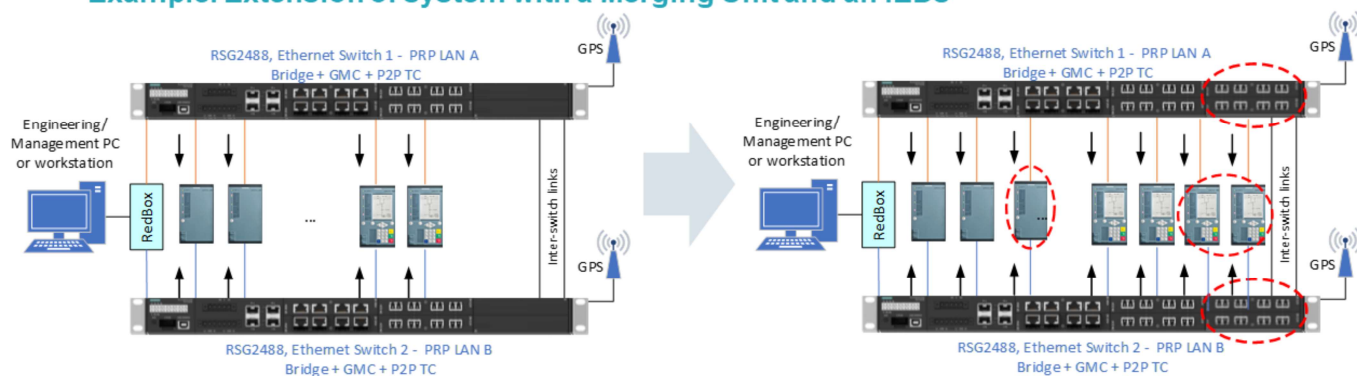


- No or short secondary CT & VT circuits
- Fewer cables and terminals

Increase Future Flexibility (1/2) Extension of a Substation

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Example: Extension of system with a Merging Unit and an IEDs



- Add new ports in switch
- Connect new Merging Units and IEDs
- Adapt configuration with new 'digital dataflow' by software

(configuration details of above example in application note APN073 available on www.siprotec.com)

Side 26

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Increase Future Flexibility (2/2) Ready for new Features, Technologies, etc.



Near future

- Compatibility between Merging Unit and IED from different suppliers
- Meter systems using process bus data (possibly on a central metering processing unit instead on dedicate Metering devices)
- Power Quality Application based on higher sampling rates in Merging Units
- PMU application in combination with Merging Units and process bus
- New optimized workflows / procedures in project execution (especially testing)

First steps for future developments

- IOT application for maintenance and service
- Big Data possible using the SMV data available on process bus
- Centralized protection



How Process Bus

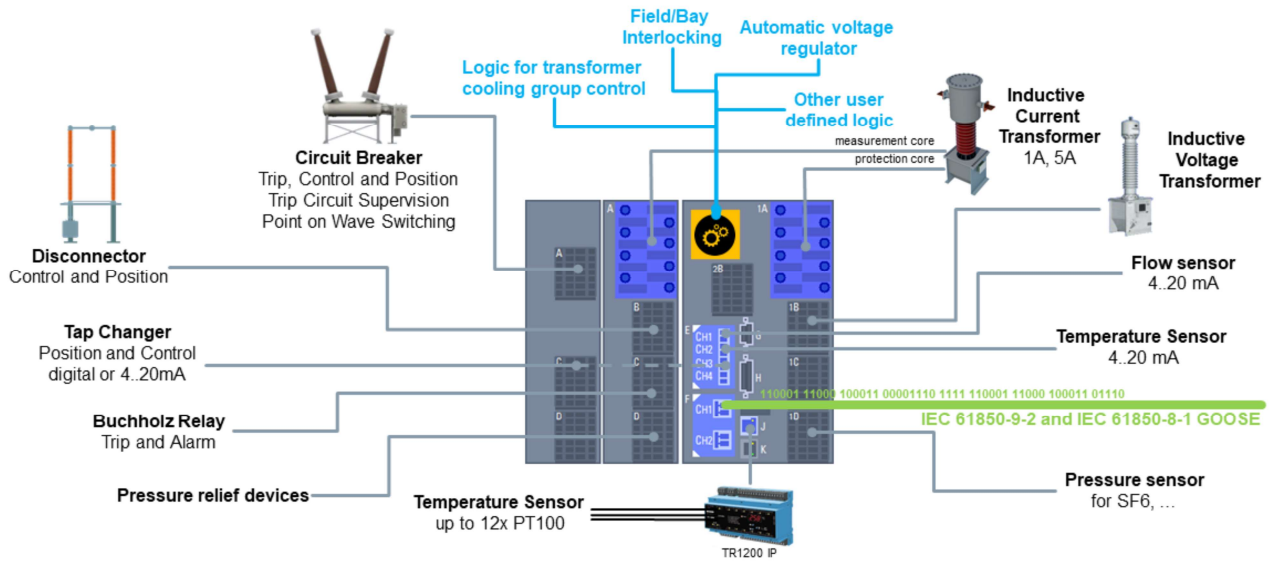
- SIPROTEC 5 Merging Unit
- SIPROTEC 5 Process Bus Client
- Digitalization from Process Level to Station Level
- Configuration Workflow
- Installation of Merging Units
- Reduce amount of IEDs and CT cores
- Network Architectures
- Integrated Cyber Security
- Flexibility of Process Bus Solutions
- Process bus becomes reality

SIPROTEC 6MU85 Merging Unit (1/3)

Digitalization of all primary data close to the process

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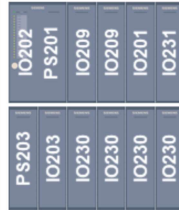
SIPROTEC 6MU85 Merging Unit (2/3)

Perfectly tailored fit to your requirements (configuration examples)

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CT	4 protection
VT	0
BI	19
BO-STD	3
BO-Fast	6
BO-HS	4



CT	12 protection 4 measurement
VT	4
BI	255
BO-STD	27
BO-Fast	16
BO-HS	8
4 ... 20 mA	4



CT	8 protection
VT	4
BI	59
BO-STD	27
BO-Fast	12
BO-HS	8
RTD	12



CT	4 protection
VT	4
BI	11
BO-STD	3
BO-Fast	6

Perfectly tailored fit

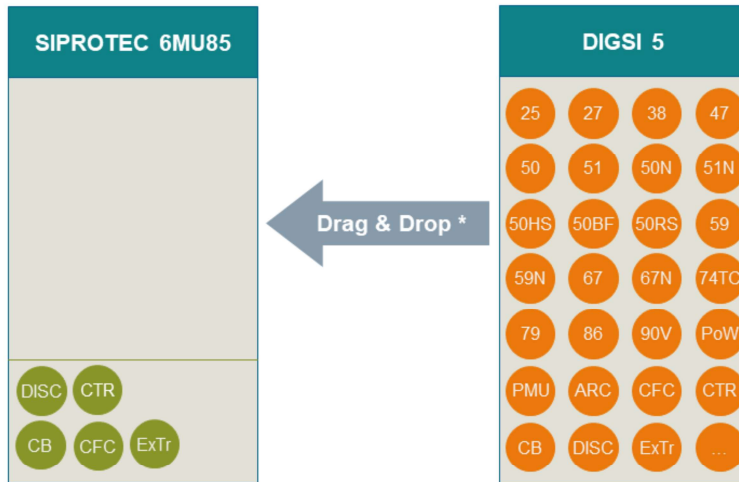
- Adaptable to multiple CT, VT, LPIT inputs
- Scalable BI and BO
- Direct "high speed" tripping of circuit breaker <1 ms
- Collection of additional data (temperature, pressure, tap changer positions, ...)
- Redundant power supply
- Expandable by a 2nd row



Merging Unit – SIPROTEC 6MU85 (3/3)

Optional protection, control and automation functions

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* 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



Side 31

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PoW Point of Wave
AFD Arc flash protection
CTR Control
ETI External Trip Initiation
DISC Disconnector

SIPROTEC 5 Process Bus Client (1/2)

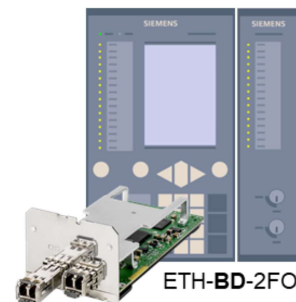


Process Bus Client functionality is available in most SIPROTEC 5 device

except 7ST85, 6MD89 and non-modular devices (7SJ81, 7Sx82)

- ❖ Ethernet communication module **ETH-BD-2FO** necessary
- ❖ 3x ETH-BD-2FO modules with PB client supported
- ❖ 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, ... ¹⁾

1) 87L supports two terminals



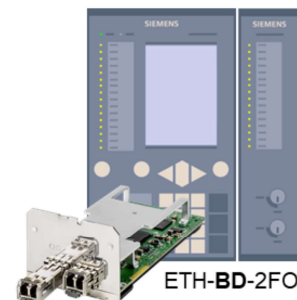
SIPROTEC 5 Process Bus Client (2/2)



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

- ❖ Acceptance of SMV with sampling frequencies according to IEC 61869-9
- ❖ Time Sync 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 IEC61850 Edition 2.1

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

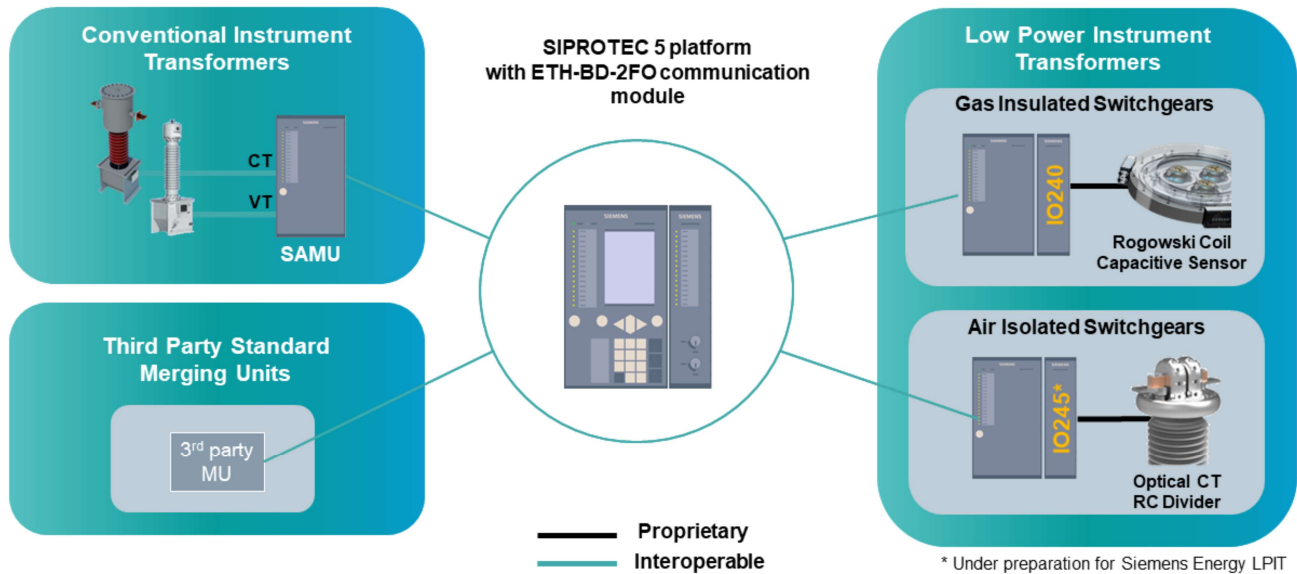


Acceptance of SMV with 4,0 / 4,8 / 12,8 / 15,36 kHz sampling frequency according to IEC 61869-9

Digitalization from Process Level to Station Level (1/2)

SIPROTEC 5 based MU's and SIPROTEC 5 protection devices

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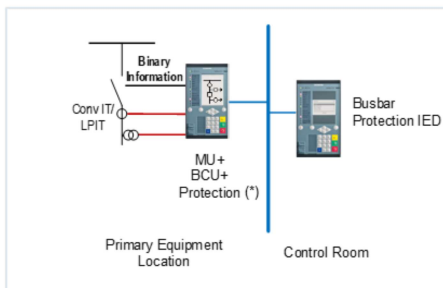
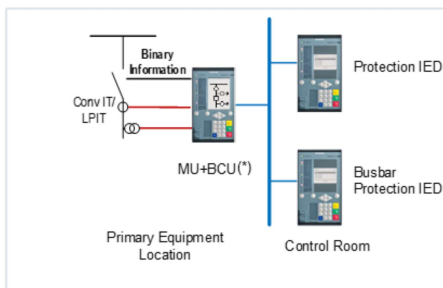
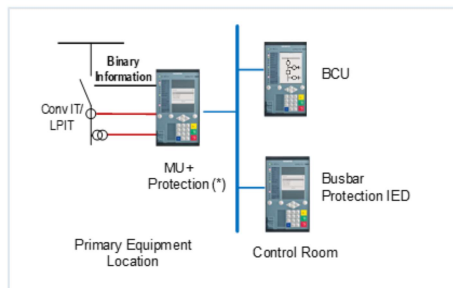
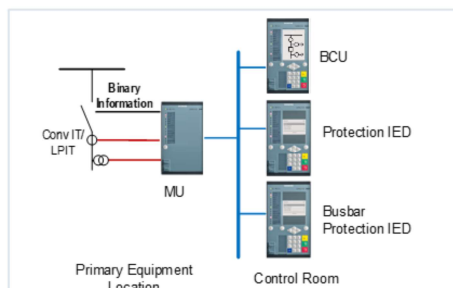
Side 34

* Under preparation for Siemens Energy LPIT
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Digitalization from Process Level to Station Level (2/2)

Some examples to demonstrate the flexibility

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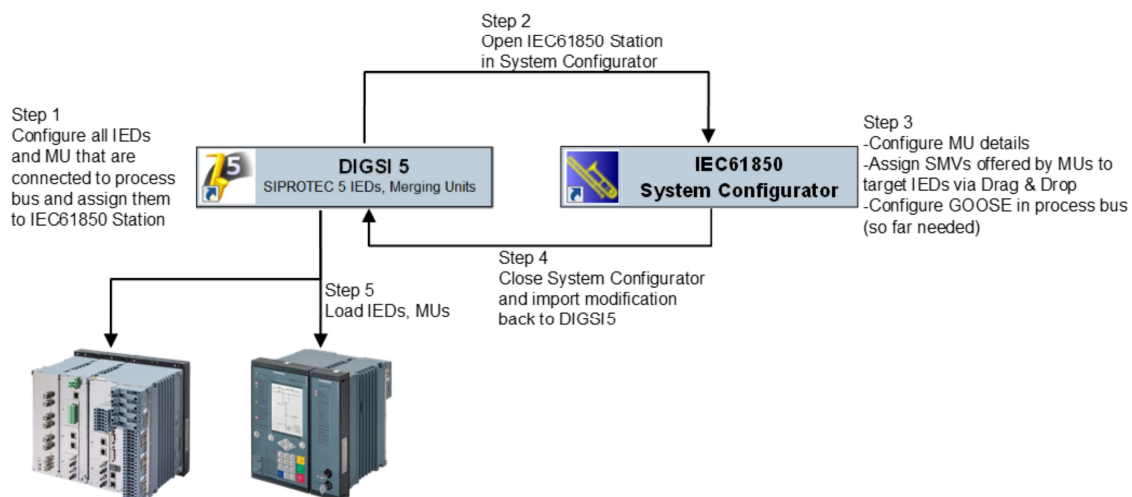


(*) Merging Unit combined with Protection Relay planned for future

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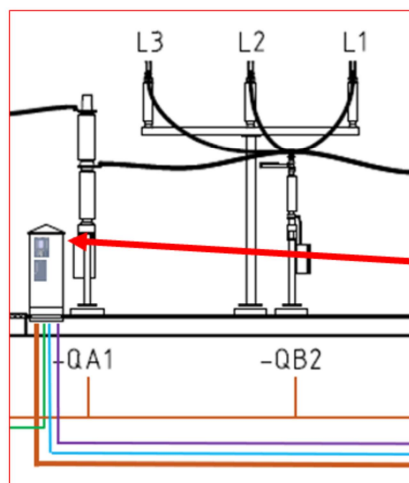
Side 35

Configuration Workflow of SIPROTEC 5 with Process Bus



Installation of Merging Units close to the switchgear

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BCMU



Control & U/I Measurements
Alarm & Indication
Trip, CB supervision, TCS

MU



I/U Measurements
TCS, Trip



Environmental Conditions for installation in the AIS field are given

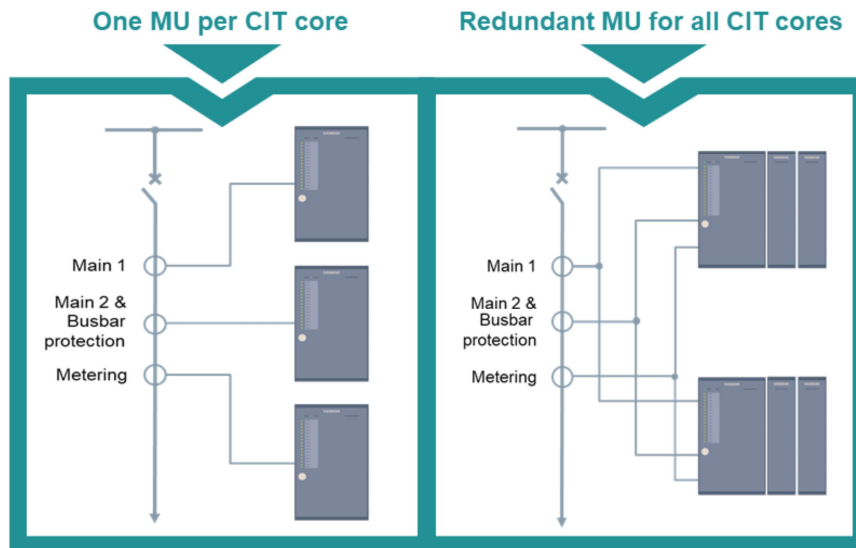
Side 37

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Environmental Conditions for installation in the AIS field are given:

- Temperature range: -10° to $+55^{\circ}$ C uninterrupted (IEC 60255-1) / -25° to $+85^{\circ}$ C for 16 hours (IEC 60068-2-1/2)
- Humidity: $\leq 75\%$ relative humidity (on the annual average as per IEC 60068-2-30)
- Full overview in 'SIPROTEC 5 Hardware - Manual' (www.siprotec5.com)

Reduce amount of IEDs and CT cores (1/2)



Till now the protection function worked with conventional treatment of measurement values using conventional instrument transformers.

With conventional wiring.

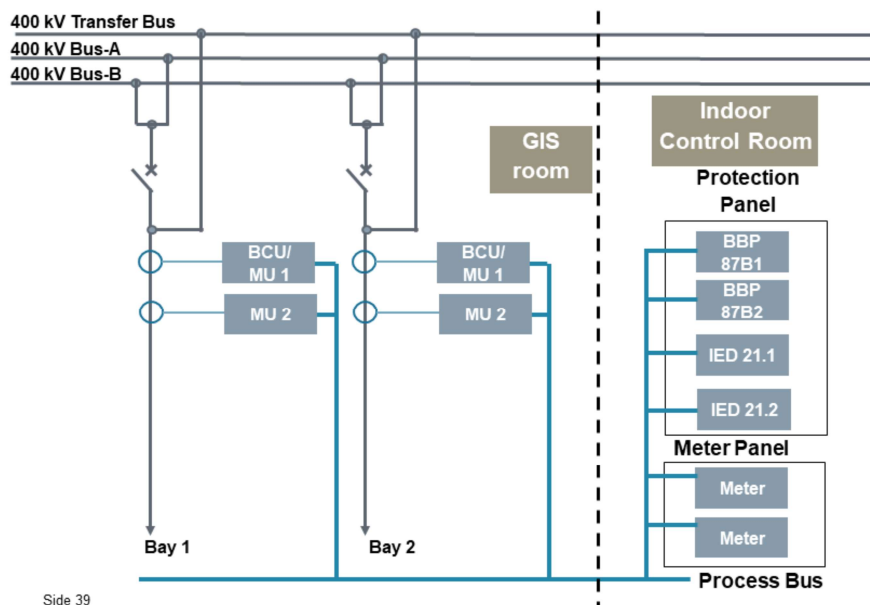
With process bus the analogue values are digitalized and transmitted to the protection devices.

With this approach the usage of data from one source for more than one device or system i. e. protection will be possible.

Reduce amount of IEDs and CT cores (2/2)

Process Bus inclusive Meter (optimized)

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- Protection redundancy by crosswise subscribed Merging Units
- LPIT with high accuracy as required for metering allow use of meter with process bus interface
- If required each MU can be redundant interface to Instrument Transformers

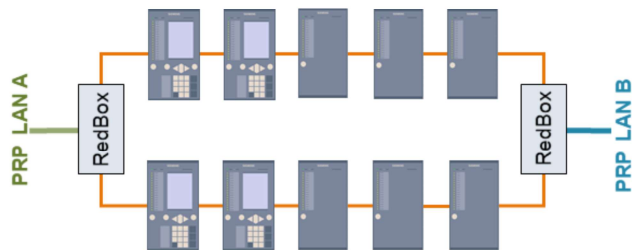
Side 39

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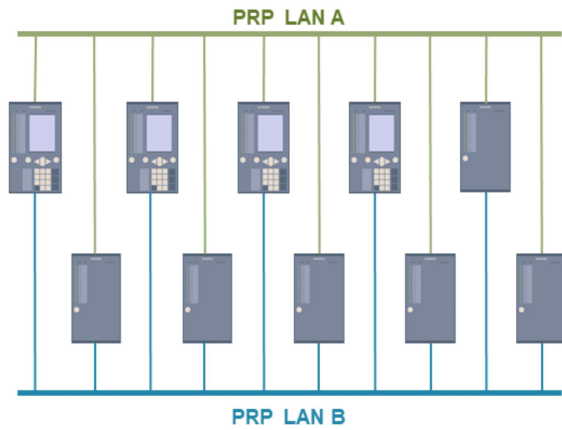
Network architectures (1/4)

Network redundancy for process bus

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HSR ring with clients and server
connected to PRP LANs
(for HSR rings PTP time
synchronization in development)

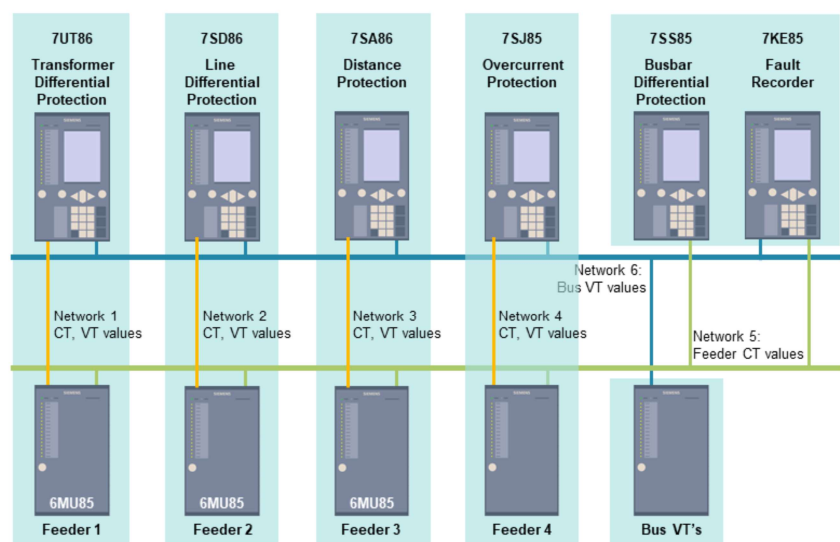


PRP redundancy with clients and
server

Network architectures (2/4)

Physically network segregation

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Simplify complexity

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

Note: Seamless networks redundancy recommended

Side 41

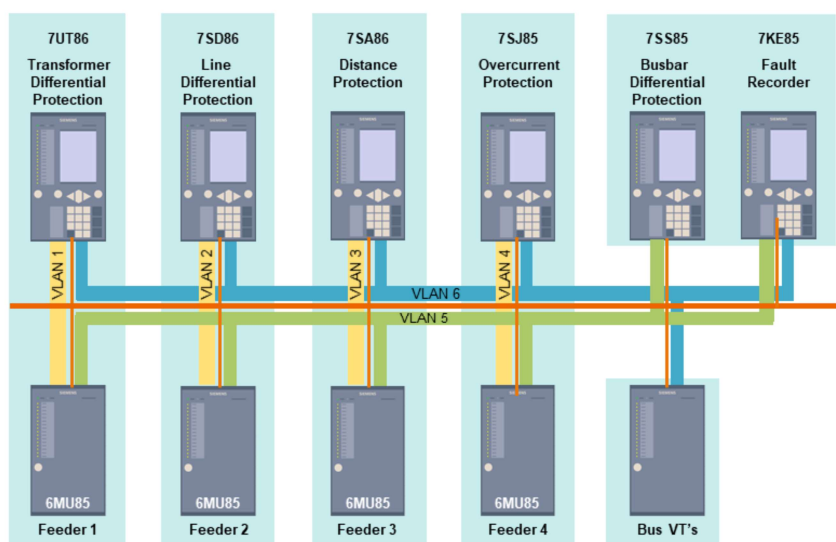
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- Increase the bandwidth with additional Ethernet interfaces
- Efficient use of network bandwidth with customization of the analog values per SMV streams (not only IEC 61850-9-2LE data set)

Network architectures (3/4)

Virtual network segregation (VLAN)

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Simplify complexity

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

Side 42

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One physical network reduces network costs

VLAN 1-4: CT, VT values for feeder protection

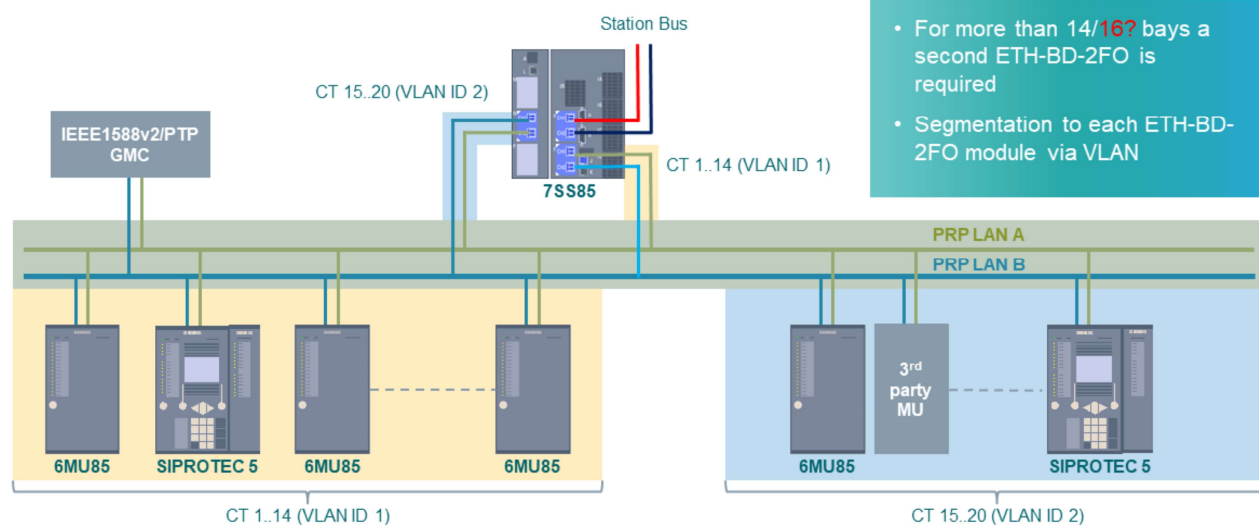
VLAN 5: Feeder CT values for busbar protection and fault recorder

VLAN 6: Bus VT for central fault recorder and feeder protection red text to notes

Network architectures (4/4)

Example: VLAN for busbar protection with 20 bays

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Side 43

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Integrated Cyber Security (1/2)

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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



Integrated Cyber Security (2/2)

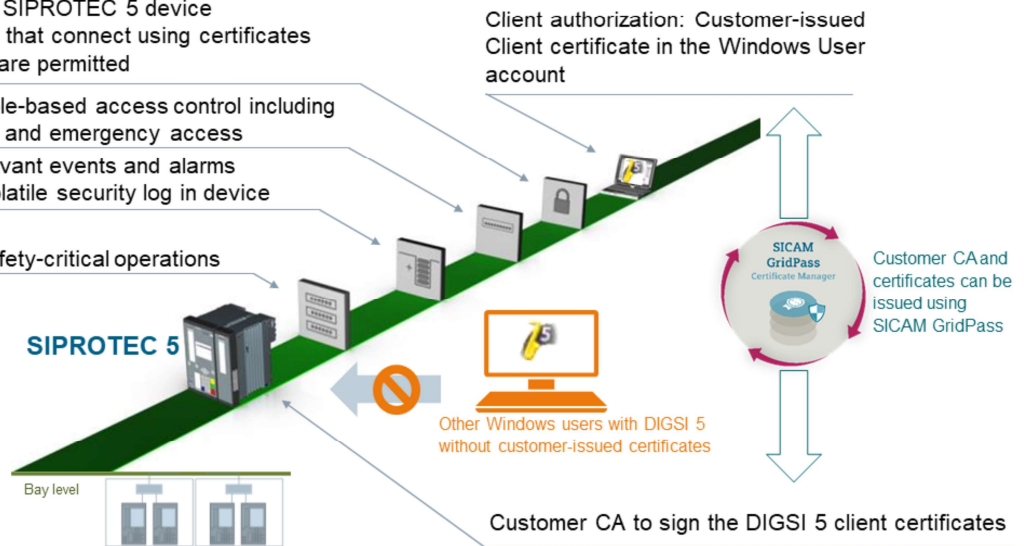


Mutually authenticated and encrypted communication between DIGSI 5 and the SIPROTEC 5 device
Only DIGSI 5 installations that connect using certificates signed by customer's CA are permitted

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



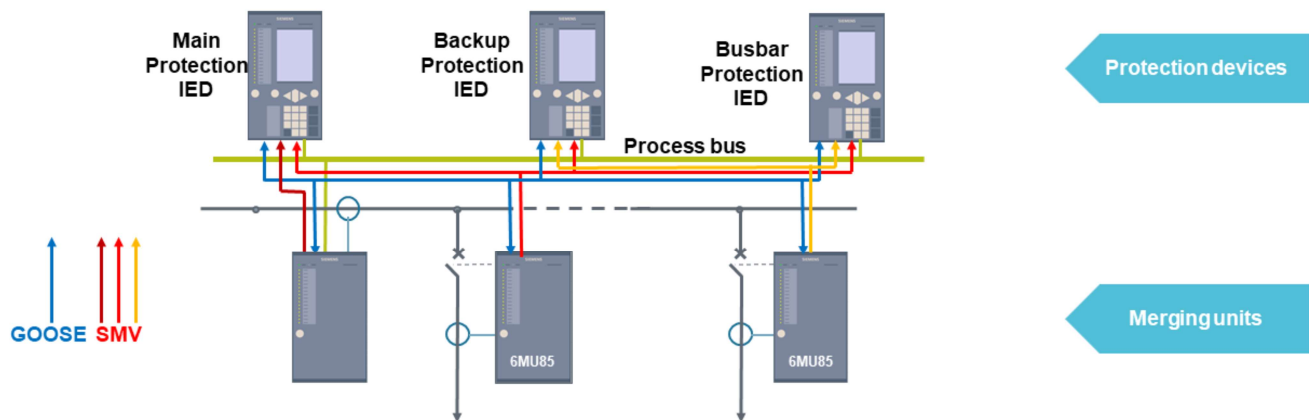
Side 45

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Flexibility of Process Bus Solutions

Merging Units can flexibly exchange data with clients

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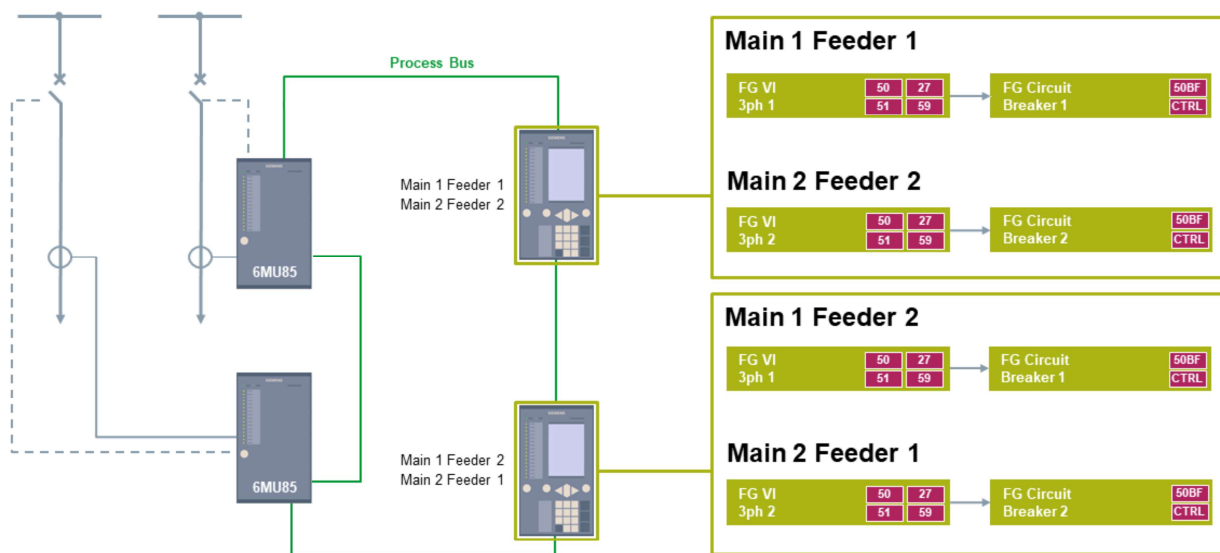
More flexible compared to conventional substation

Changes required to scheme will be configured by software in substation configuration description file (SCD) – no need of schematic adaptation and of physical rewiring

Flexibility of Process Bus Solutions

Redundant Protection via cross subscription of one IED to multiple feeders

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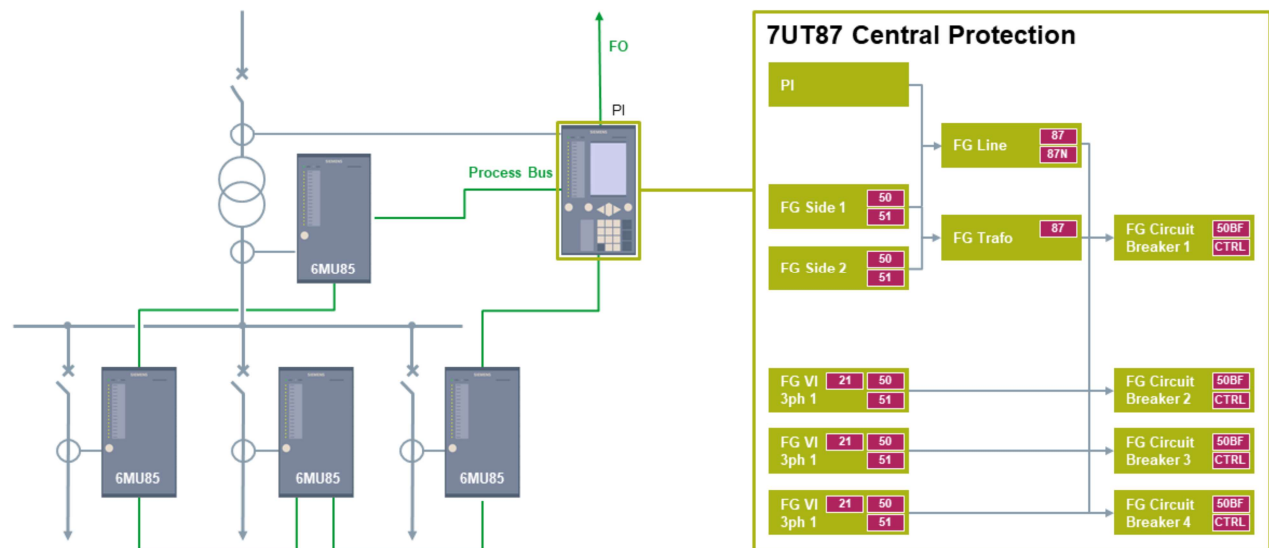
Side 47

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Flexibility of Process Bus Solutions

Central Protection for small substations and Line Protection

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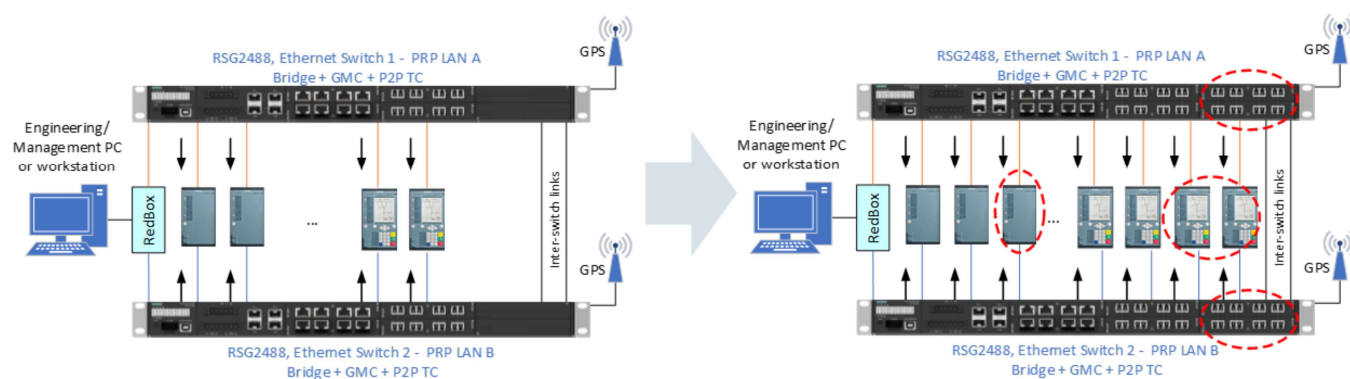


Side 48

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Flexibility of Process Bus Solutions Extension of a Substation

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1. Mount extension modules in the switch and install new Merging Unit / IED and
2. VLAN configuration on the switches to be extended
3. Configuration of new Merging Unit / IEDs
4. Adapt SMV dataflow
5. Adapt GOOSE dataflow

Side 49

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Flexibility of Process Bus Solutions

Overview



Flexibility of SIPROTEC 5 Family (Merging Unit / Protection IED)

- BI/BO scalable
- CT/VT inputs scalable
- Up to 4 ETH-BD-2FO
- Protection Functions

Flexibility in ETH-BD-2FO communication for process bus design

- 32 SMV channels (publisher/Merging Unit)
- Sample rates from 4 kHz (Protection) to 15.36 kHz (Power Quality)
- 2 streams per ETH-BD-2FO
- IEC 61850-9-2 / IEC 61850-8-1 GOOSE, MMS

Flexibility in Engineering

- Binary process signals as GOOSE by drag & drop in Station Configurator
- Measurements as SMV by drag & drop in Station Configurator
- No adaptations in schematics and cable wiring

Side 50

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Process bus becomes reality - Projects



Substations with conventional CTs/VTs and Process Bus

- Peru Transmission 'Luz del Sur' (Utility) Substation 'Sauces' 220 kV
- Germany Industry 'Mitnetz' Substation 'Sandersdorf' project
- Several sites under commissioning in South America and Asia

GIS Substations GIS with LPITs and Process Bus

- Various sites in Norway under commissioning or will be energized shortly (Distribution, Blue GIS)
- Several substations in Europa, Asia in execution

AIS Substations AIS with LPITs and Process Bus

- Various pilot systems in Germany and South America

Process bus becomes reality – What comes next



New features and improvement

- New functions in communication module ETH-BD-2FO module
- PMU function with process bus
- Meter standardization and implementation ongoing

Interoperability between MU and IED from different manufacturer in progress

AIS with LPIT planned for first half of 2021

For GIS the LPIT portfolio for further switchgear types under extension

Process bus becomes reality – Links



Link to Merging Unit trailer:

- <https://www.youtube.com/watch?v=nf9woT8U-Jk>

Siemens Digital Substation:

- www.siemens.com/digital-substation

Siemens Process Bus solution:

- <http://www.siemens.com/processbus>

Cyber Security energy infrastructures:

- www.siemens.com/energy-cybersecurity

SICAM GridPass Webpage:

- www.siemens.com/gridsecurity

Kontaktoplysninger

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