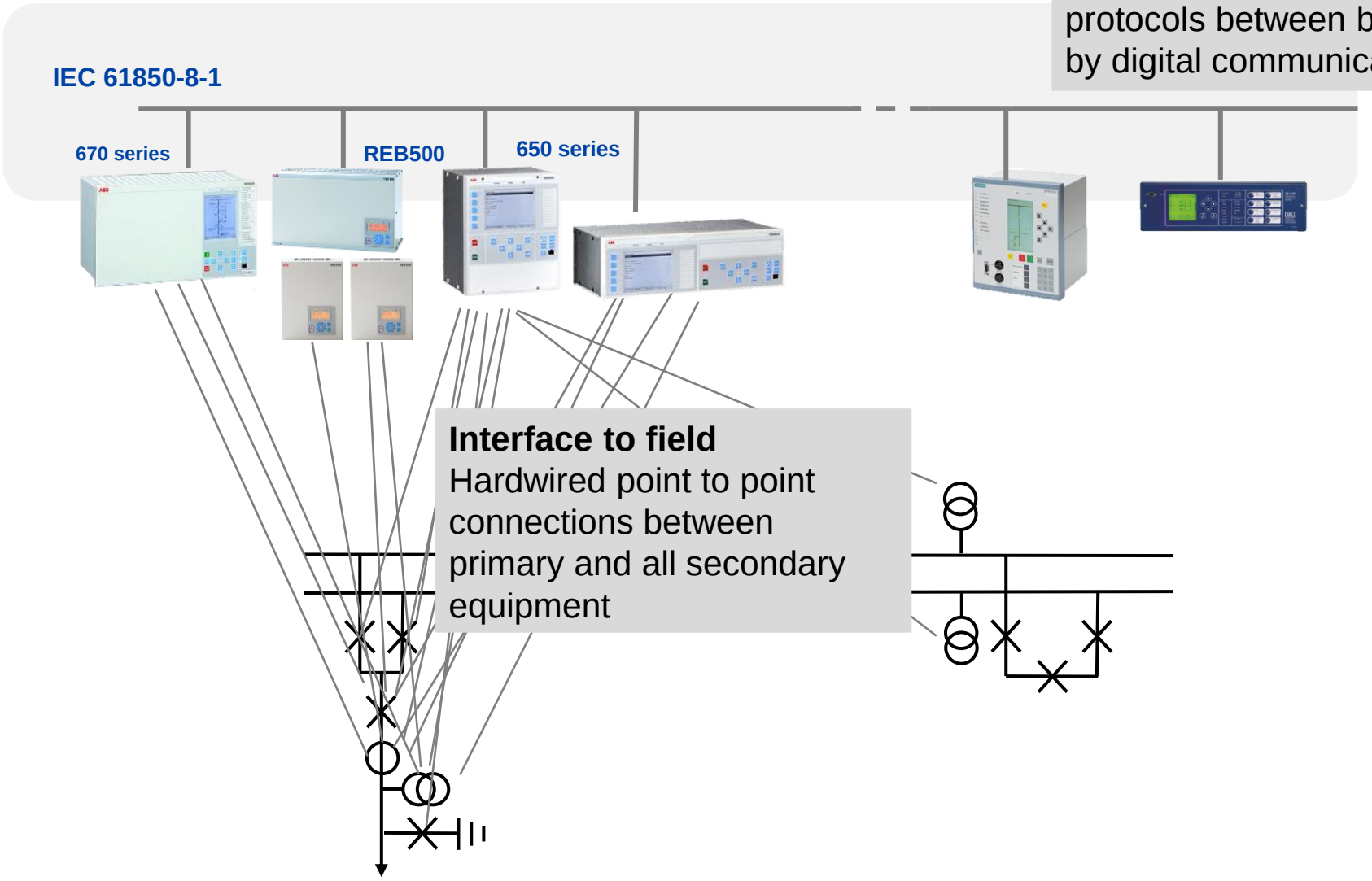
陳建良, 艾波比股份有限公司

Merging Unit在智慧變電所之應用

Substations
From conventional to digital

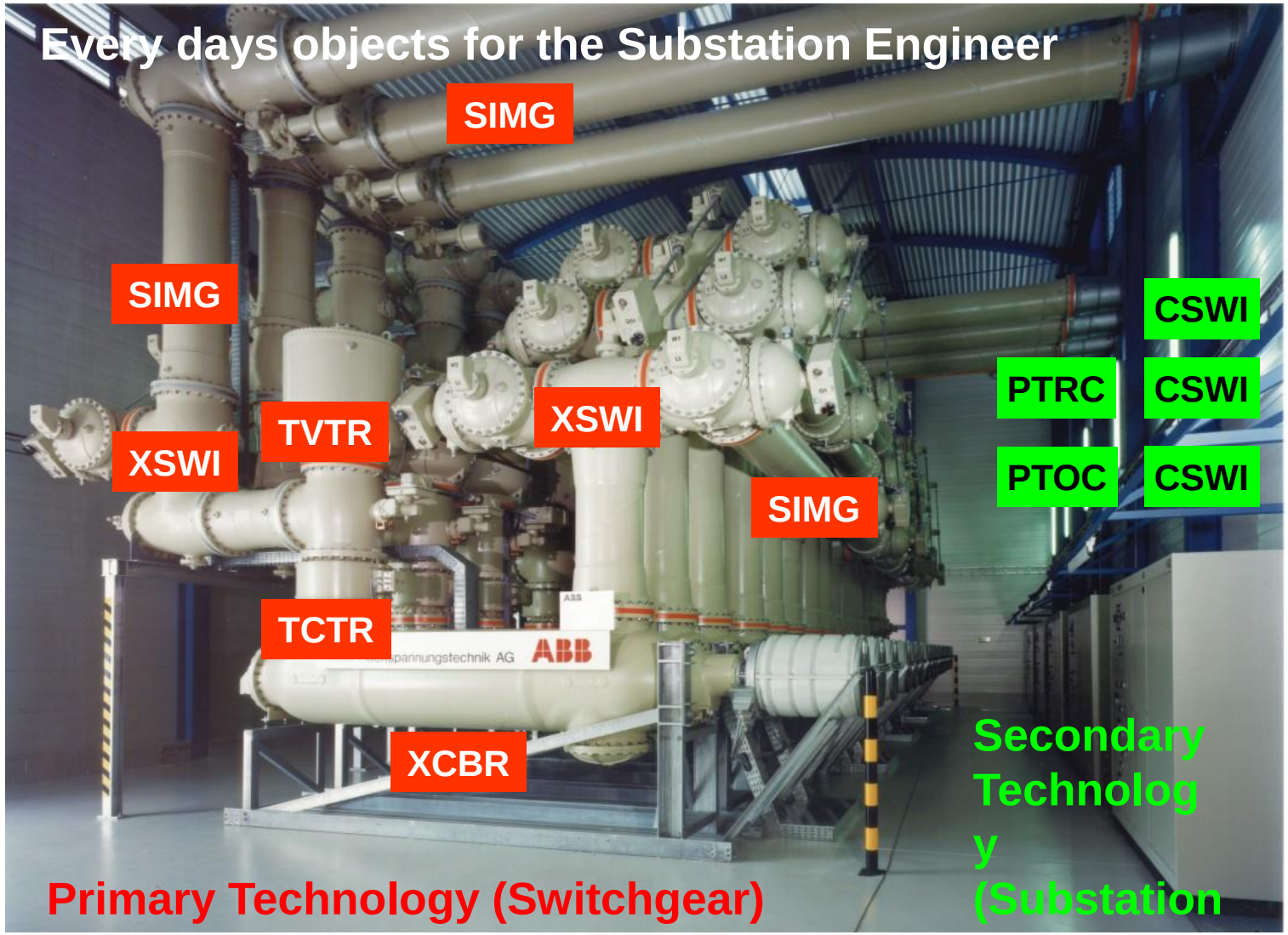
Digital Substation and IEC61850
Today

IEC 61850 Station Bus
Replace wiring and legacy protocols between bays by digital communication



Interface to field
Hardwired point to point connections between primary and all secondary equipment

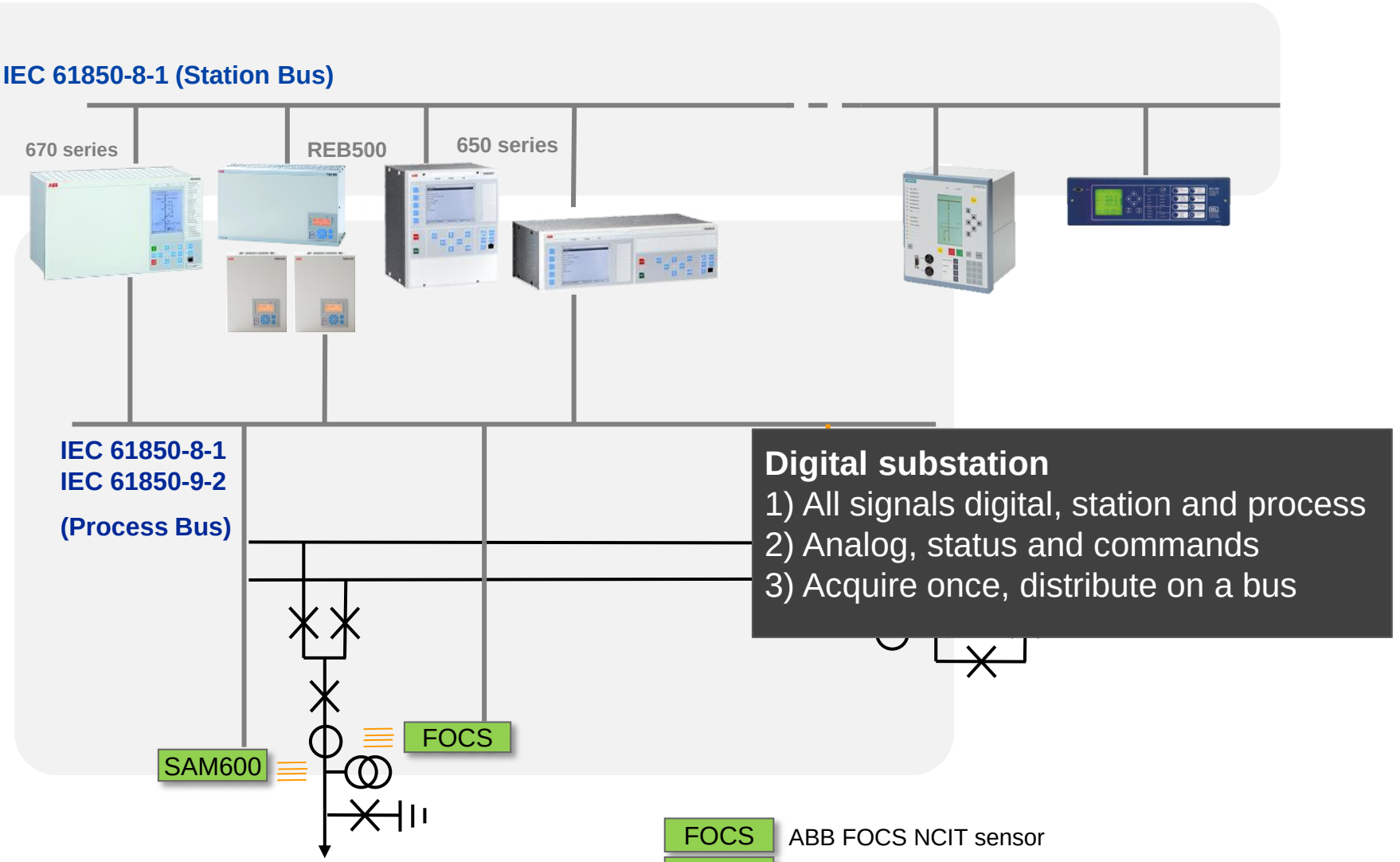
Aspects of IEC 61850 System Integration
Standardized Data Model for every Object & Function



Example :
Object Current Breaker *XCBR*
What data belong to this object ?

These Objects are called *Logical Nodes*.

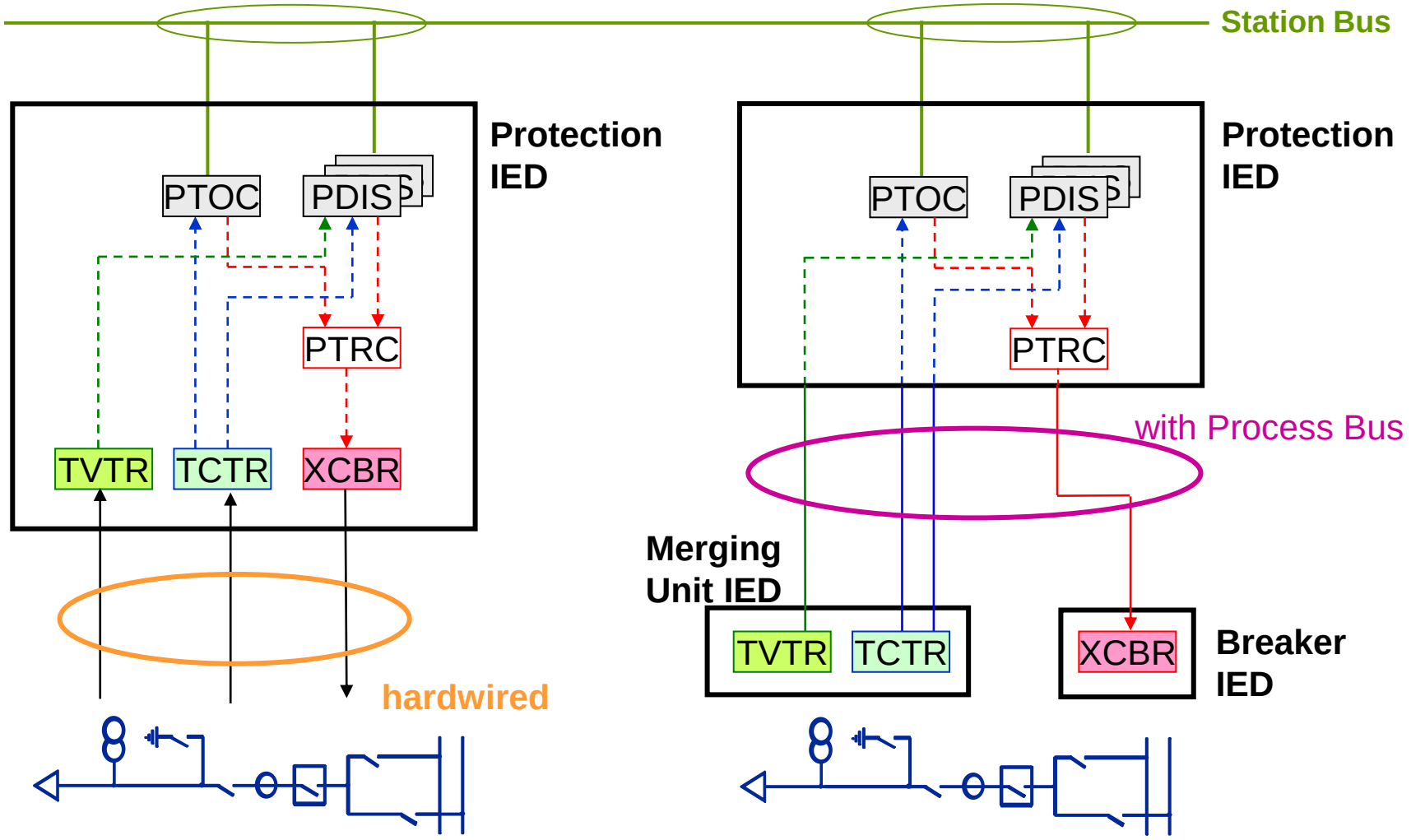
Digital Substation and IEC61850 Tomorrow



FOCS ABB FOCS NCIT sensor

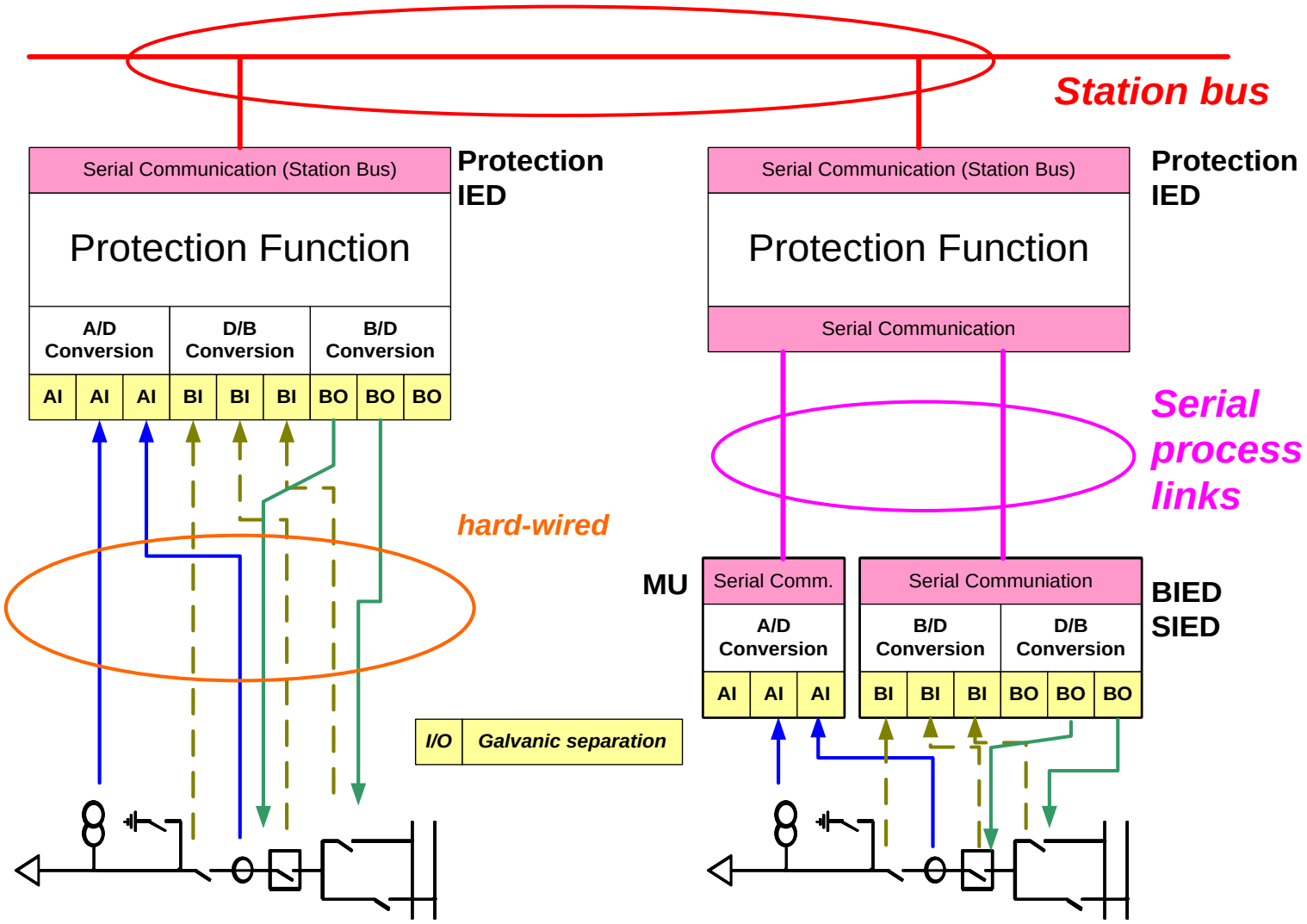
SAM600 SAM600 – Standalone merging unit

Introduction to process bus
Allocation of logical nodes



IEC61850 supports free allocation of functions

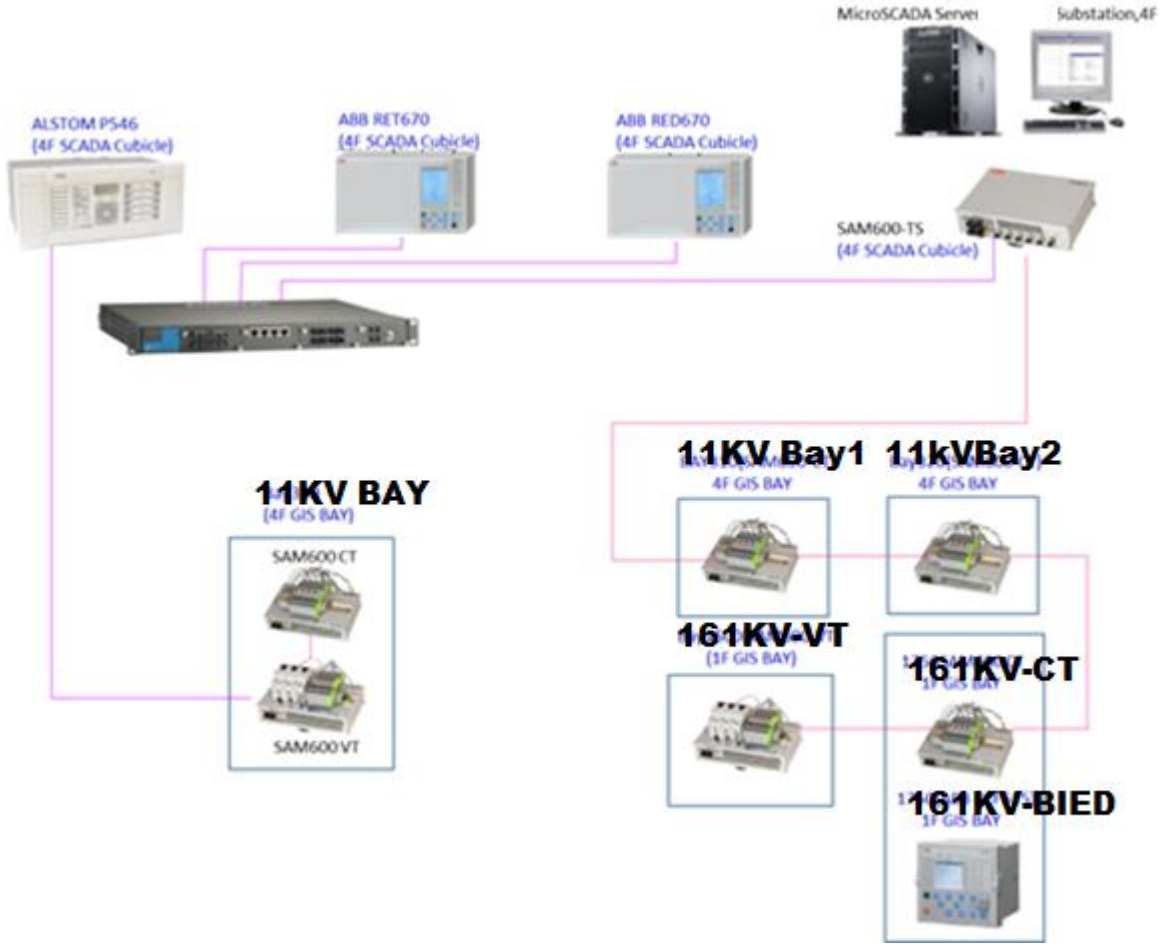
From hardwired process connection to Process Bus Hardware view



Source : Electra 255 (2011)

SAM600 1.0
Taiwan pilot installation

IEC 61850-9-2 process bus with SAM600 - Taiwan
Pilot Installation

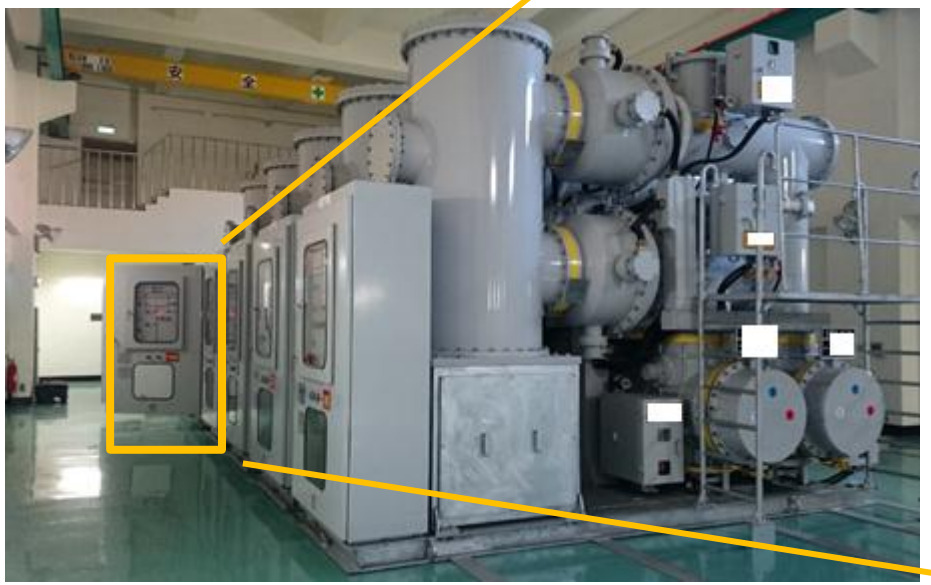


SAM600 piggy-back installation at a 161kV/11kV transformer feeder

- Station level
  - MicroSCADA Pro HMI
- Bay level with IEC 61850-9-2LE
  - RED670, RET670 Version 2.0
  - Alstom P546
- Process level
  - SAM600 process IO system for integration of conventional CT and VT
  - REF615 for integration of binary signals

IEC 61850-9-2 process bus with SAM600 - Taiwan
Pilot Installation

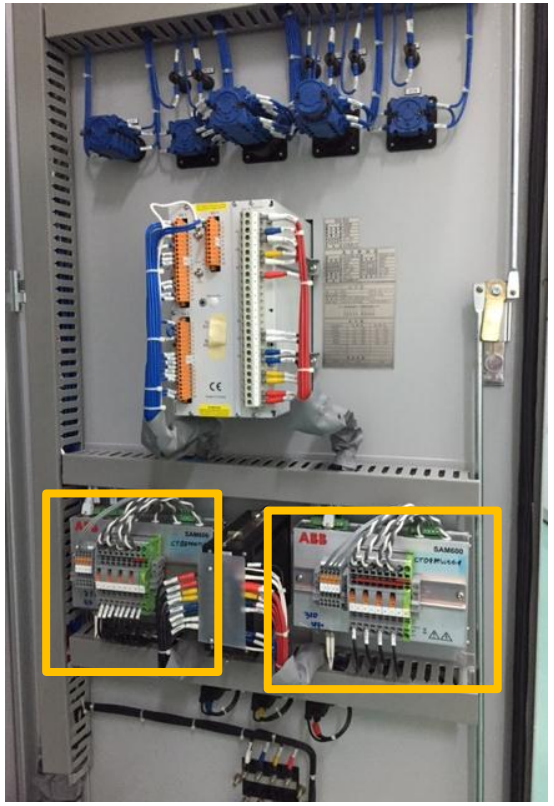
- SAM600 modules flexibly placed with minimum impact on existing system
- 161kV GIS local control cubicle:



IEC 61850-9-2 process bus with SAM600 - Taiwan
Pilot Installation

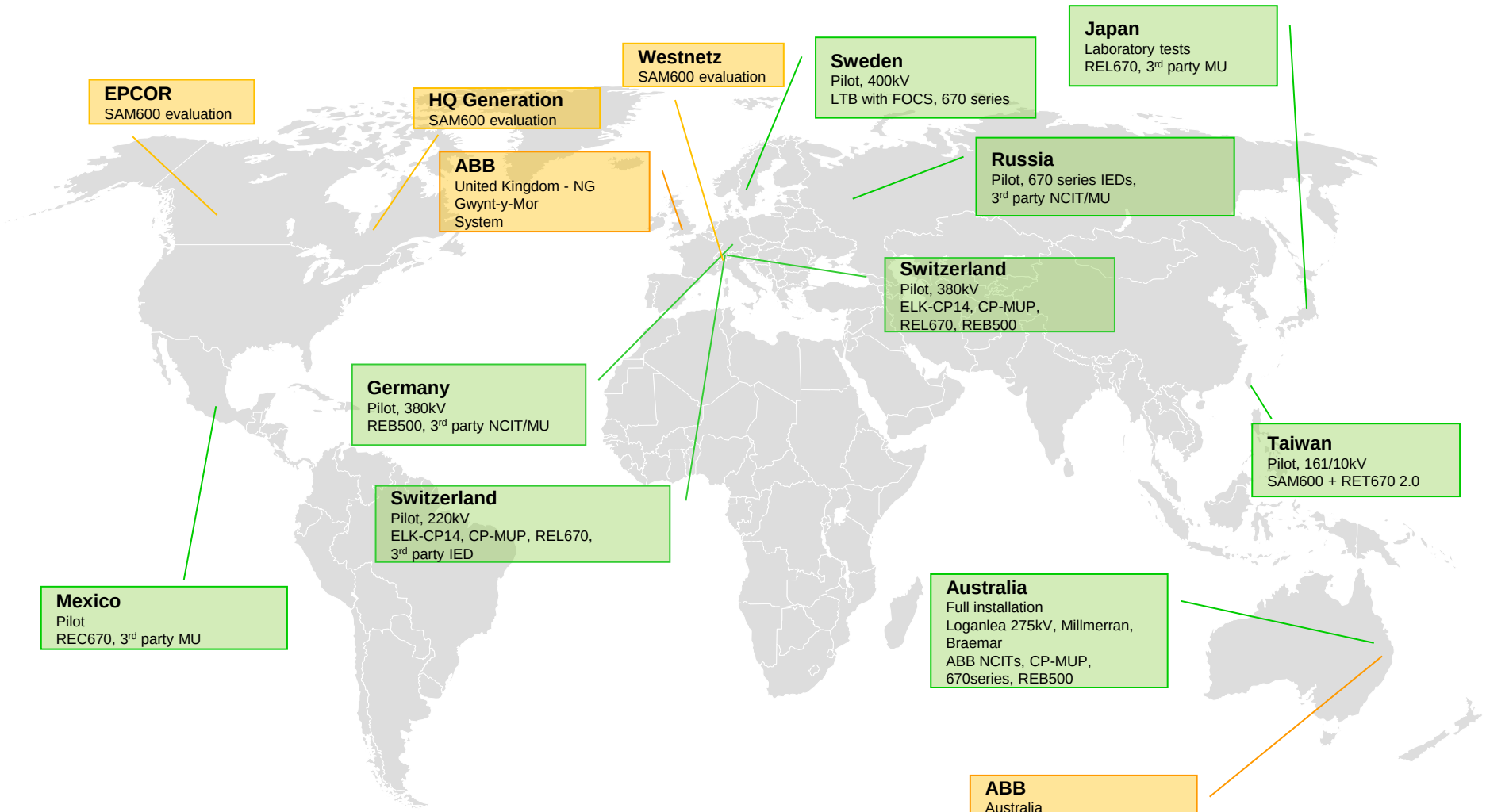
- SAM600-CT modules installed on mounting rails installed in…

… 11kV local control and protection panel



… 161kV protection panel

ABB's experience with IEC 61850-9-2 process bus
Overview



ABB’s experience with IEC 61850-9-2 process bus
Completed projects (highlights)

Real experience through real projects

SAM600 1.0
Module overview
Features

SAM600 – the digital substation enabler

Outdoor cubicle with SAM600 system

- Modular IO system for process bus applications
- Optimized form factor
- Customizable termination of primary signals
- Fully compliant to standards

SAM600 – the digital substation enabler

SAM600-CT

SAM600-VT

SAM600-TS

Modular IO system for interfacing primary equipment to IEC 61850 process bus

- Connects to any conventional current or voltage transformers
- Provides time synchronization
- Optimally adapt to different application types by chanining SAM600 modules into a system

Compact and optimized form factor

- DIN-rail mountable for fast installation and replacement
- Installation in station panel or marshalling kiosks

Termination of primary cabling on SAM600 modules

- Termination of process and auxiliary signals
- Customizable terminals and standard cabling

SAM600 – the digital substation enabler

SAM600-CT

SAM600-VT

SAM600-TS

IEC61850-9-2LE

- 9-2LE with 80 samples/cycle for protection and operational metering
- Quality indication for test switch and fuse failure
- Simulation mode

Time synchronization

- Synchronizes with 1PPS or runs in free-running mode
- Provides 1PPS outputs for synchronizing bay level devices
- Accuracy 1us or better

Communication

- Two IEC 61850 access points for IEC 61850-9-2LE traffic
- Each SAM600 module „merges“ local

Environmental

- Operating temp range: -40°C .. +70°C ambient
- IP class: IP20

Analog measurements
SAM600-CT, SAM600-VT

SAM600-CT

SAM600-VT

SAM600-CT

- 4 measurement channels @ 1A/5A nom, up to 100x In
  - 1A or 5A order variant
  - Indivdiually calibrated and temperature-compensated
- 1 test switch indication input
  - Indication via 9-2LE quality information

SAM600-VT

- 3 measurement channels @ 110V nom, up to 2x Un
  - Indivdiually calibrated and temperature-compensated
- 3 fuse failure inputs directly wired via MCBs on the module
  - Indication via 9-2LE quality information

Communication

- 2 ports for IEC 61850 process bus
- 2 ports for SAM600 system bus
- SAM600 time synchronization via IEEE 1588

Time synchronization and field gateway
SAM600-TS

SAM600-TS

Time synchronization and gateway functionality

- Synchronize SAM600 to GPS via 1PPS
- Synchronize bay level IEDs via 1PPS
- Synchronize SAM600 system via IEEE1588

Communication

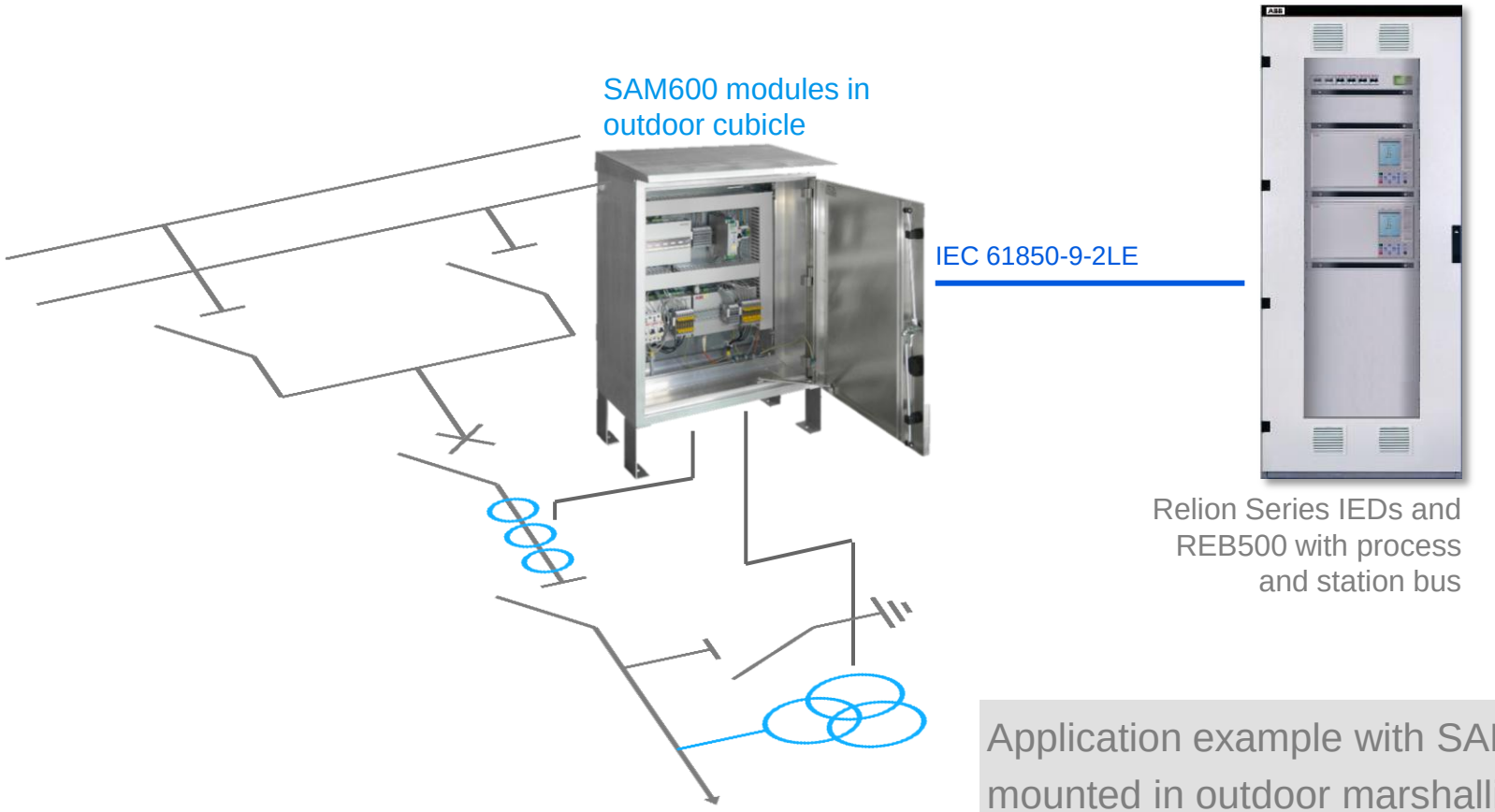
- 4 ports for IEC 61850 process bus
- 2 ports for SAM600 system bus
- SAM600 time synchronization via IEEE 1588

IEC 61850-9-2LE gateway

- Receive and forward IEC 61850-9-2LE traffic

SAM6001.0
Application examples

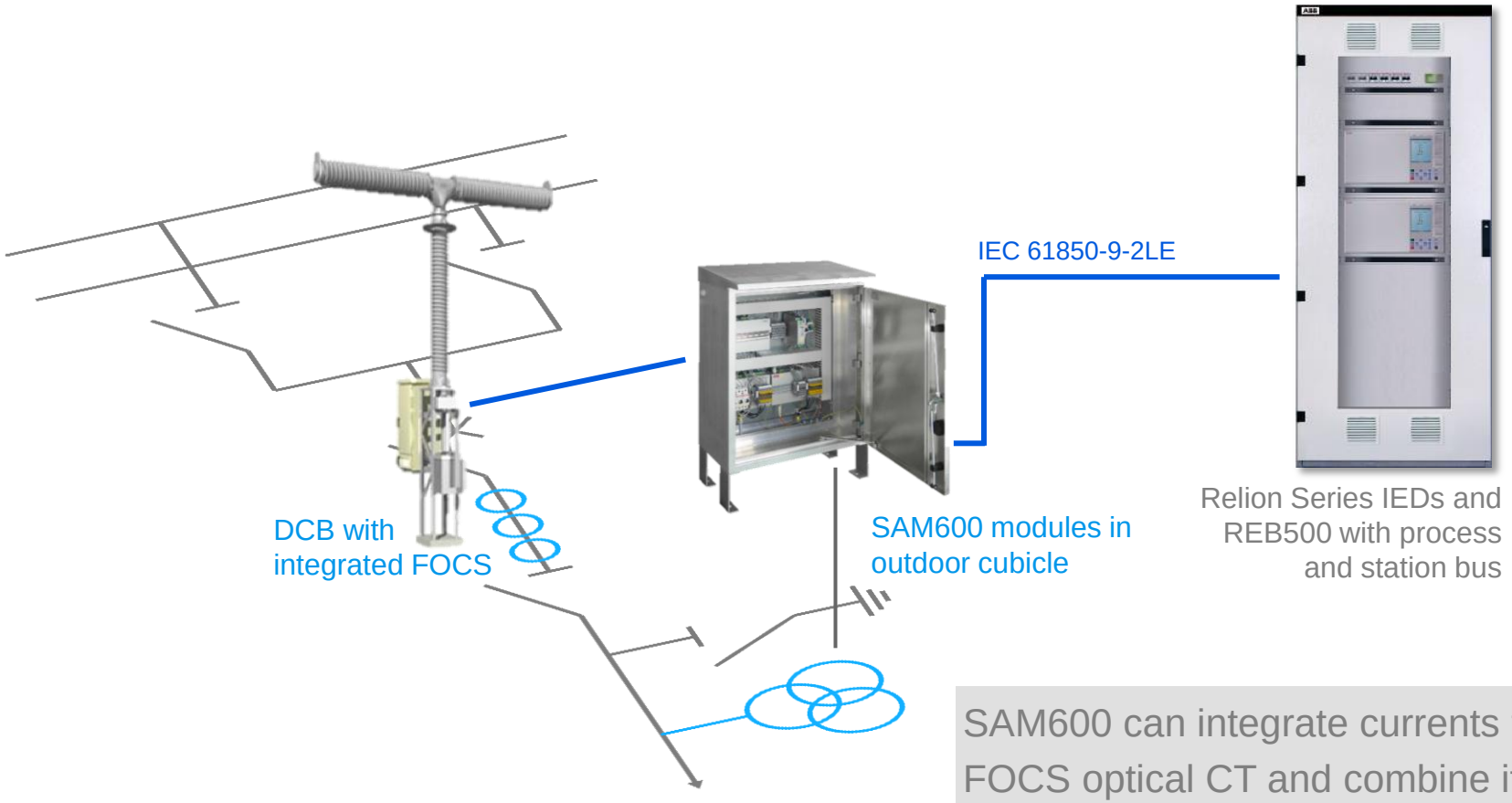
SAM600 – the digital substation enabler
Efficient upgrade for conventional substations



Application example with SAM600 modules mounted in outdoor marshalling kiosk.

© ABB

SAM600 – the digital substation enabler
Integrates with modern sensors



SAM600 can integrate currents from ABBs FOCS optical CT and combine it with conventional voltage measurements.

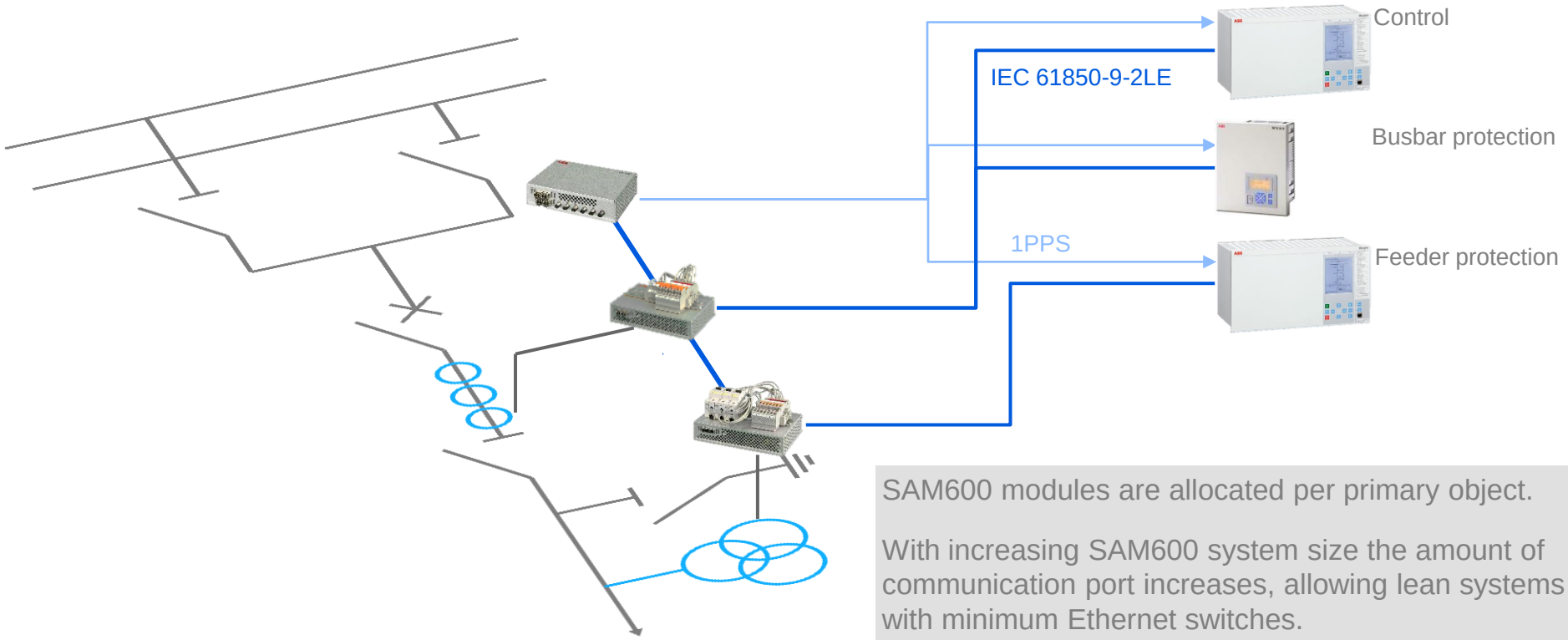
© ABB

SAM600 – flexible placement, scalable communication
Application example – line feeder

SAM600 modules per primary object

IEC 61850-9-2LE process bus

Protection and control IEDs



SAM600 modules are allocated per primary object.

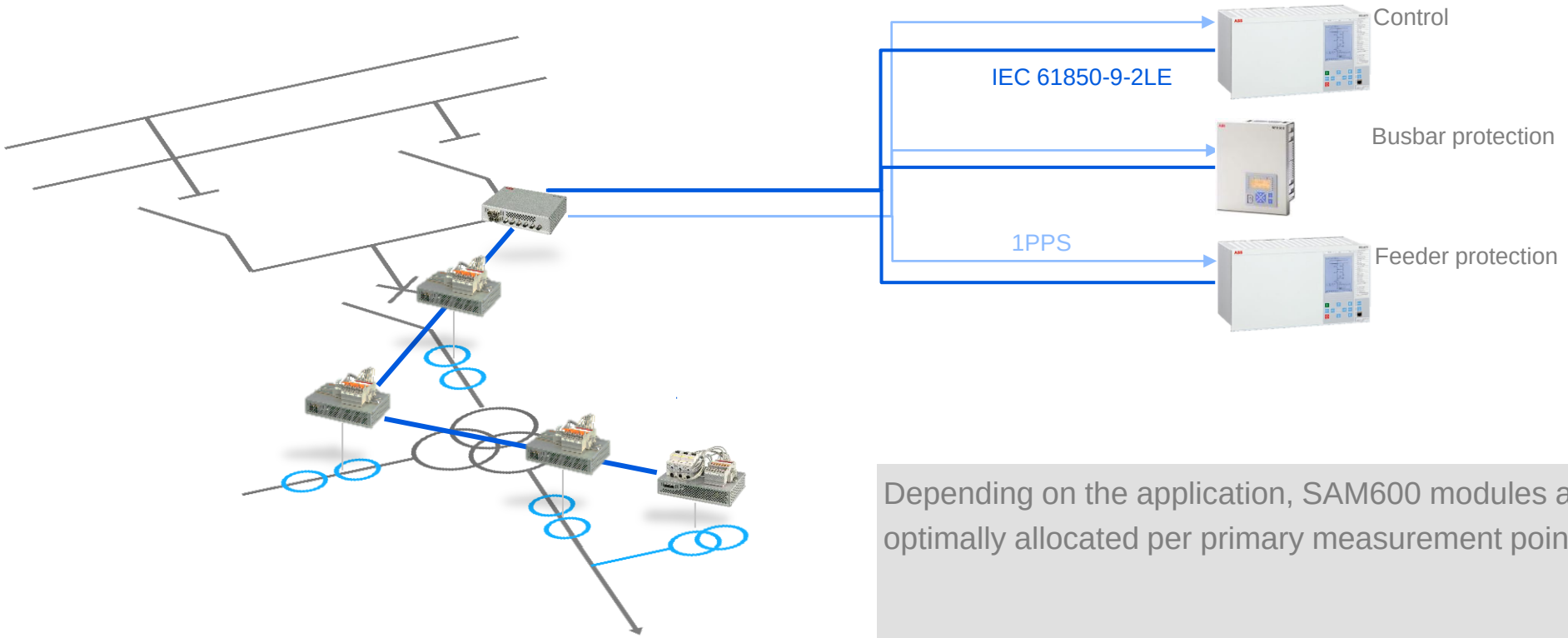
With increasing SAM600 system size the amount of communication port increases, allowing lean systems with minimum Ethernet switches.

SAM600 – flexible placement, scalable communication
Application example – transformer feeder

SAM600 modules per primary object

IEC 61850-9-2LE process bus

Protection and control IEDs



Depending on the application, SAM600 modules are optimally allocated per primary measurement points

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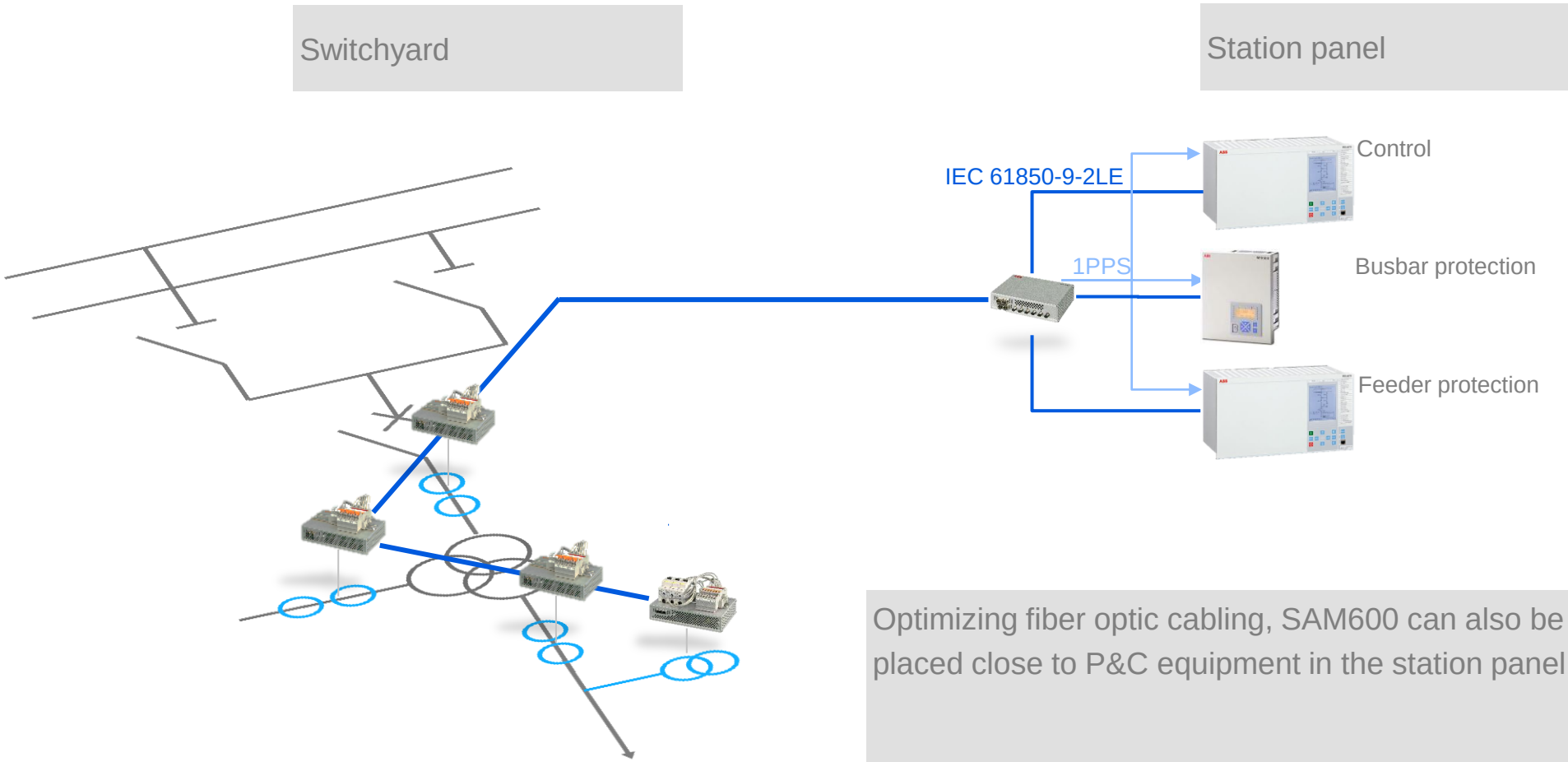
SAM600 – flexible placement, scalable communication
Application example – split SAM600 setup

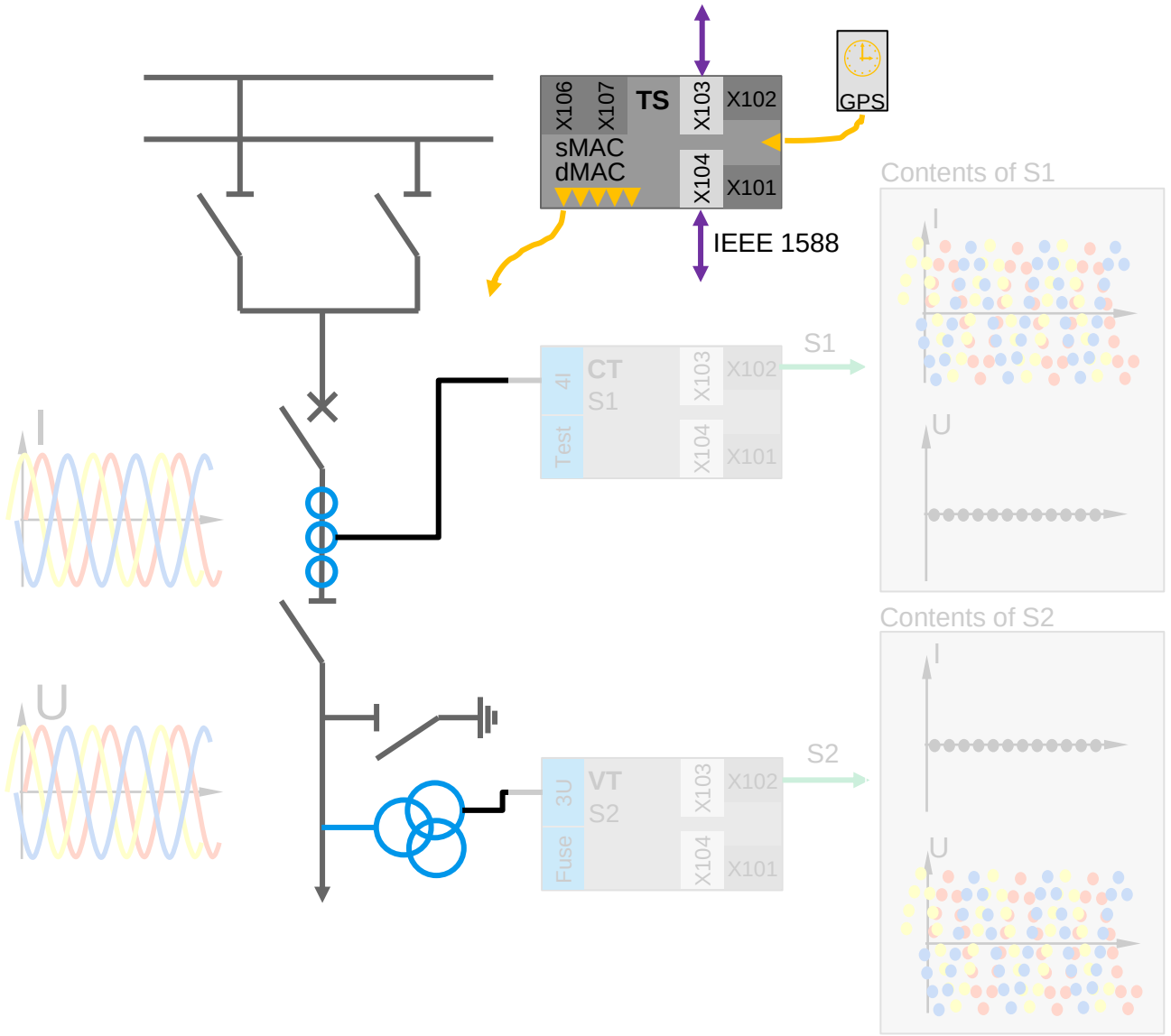


Optimizing fiber optic cabling, SAM600 can also be placed close to P&C equipment in the station panel

© ABB

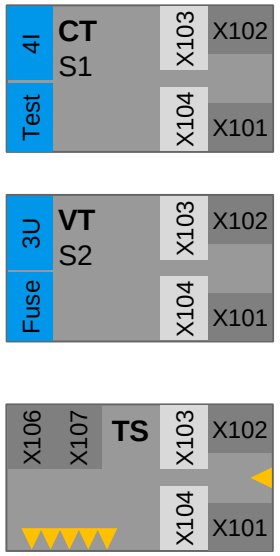
SAM600 1.0
How it works

SAM600 provides synchronization mechanisms



- SAM600-TS converts time
  - PPS in → IEEE 1588
  - IEEE 1588 → PPS out
- Synchronize SAM600 against a GPS grandmaster
- Synchronize IEDs or other merging units with via PPS

Communication ports of SAM600

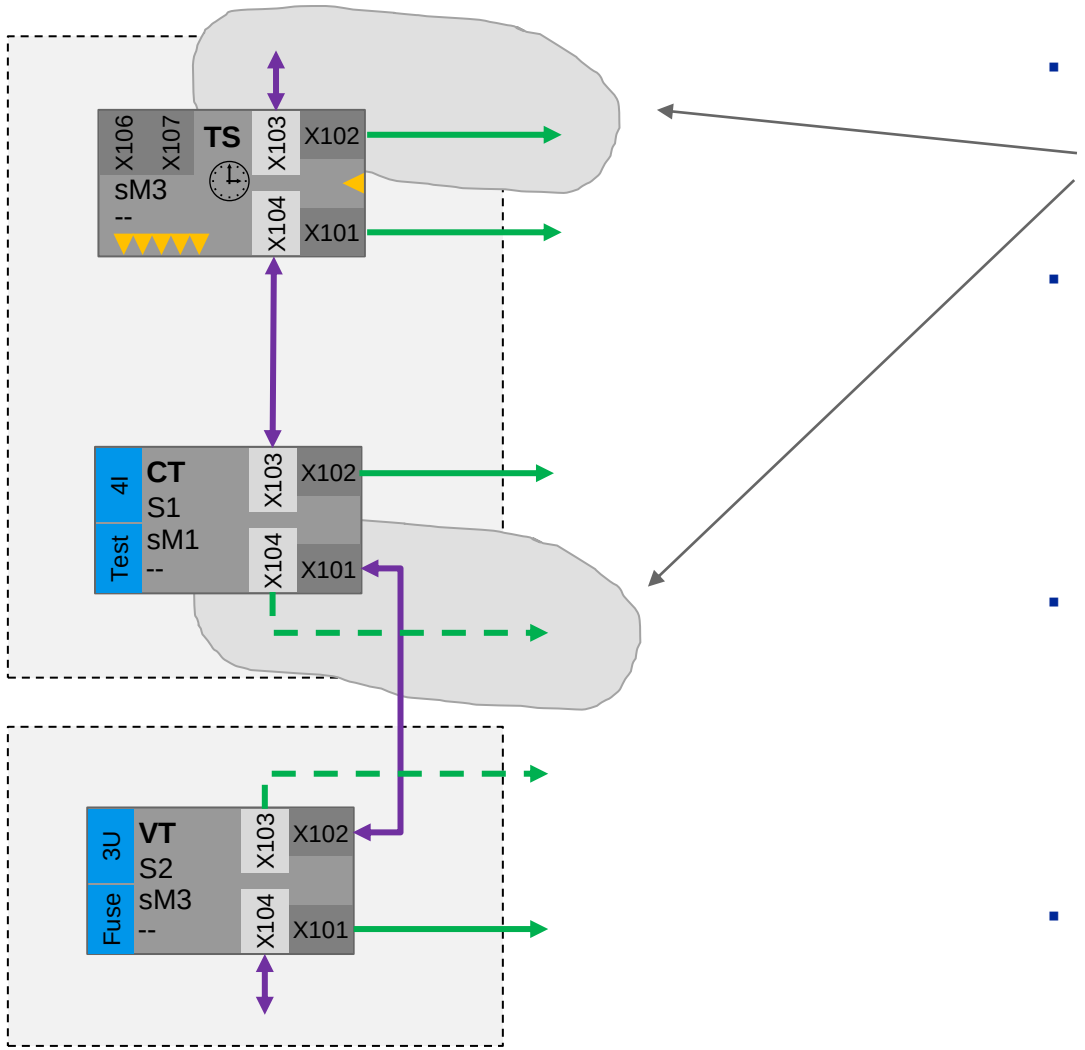


Optical port

Electrical port

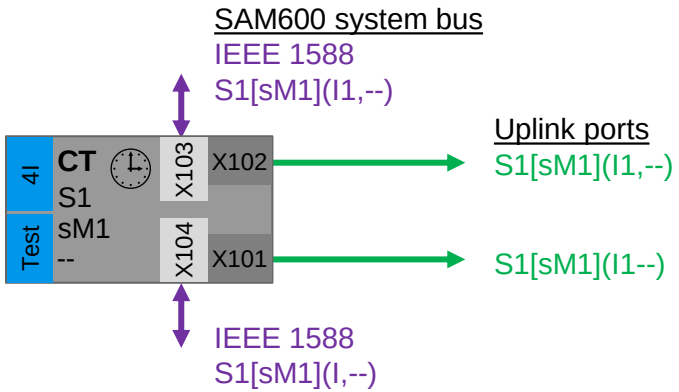
- Each SAM600 module has 4 communication ports
- SAM600 system bus
  - 2 ports, default: X103/X104
  - Tx/Rx, 9-2LE, IEEE 1588
- SAM600 uplink ports to IED
  - 2 ports, default: X101/X102
  - Tx only, 9-2LE
- System bus and uplink ports work in pairs. Their behavior can be swapped
- SAM600 bridge-in ports
  - X106/X107 on SAM600-TS
  - Rx only, 9-2LE

SAM600 modules in different compartments



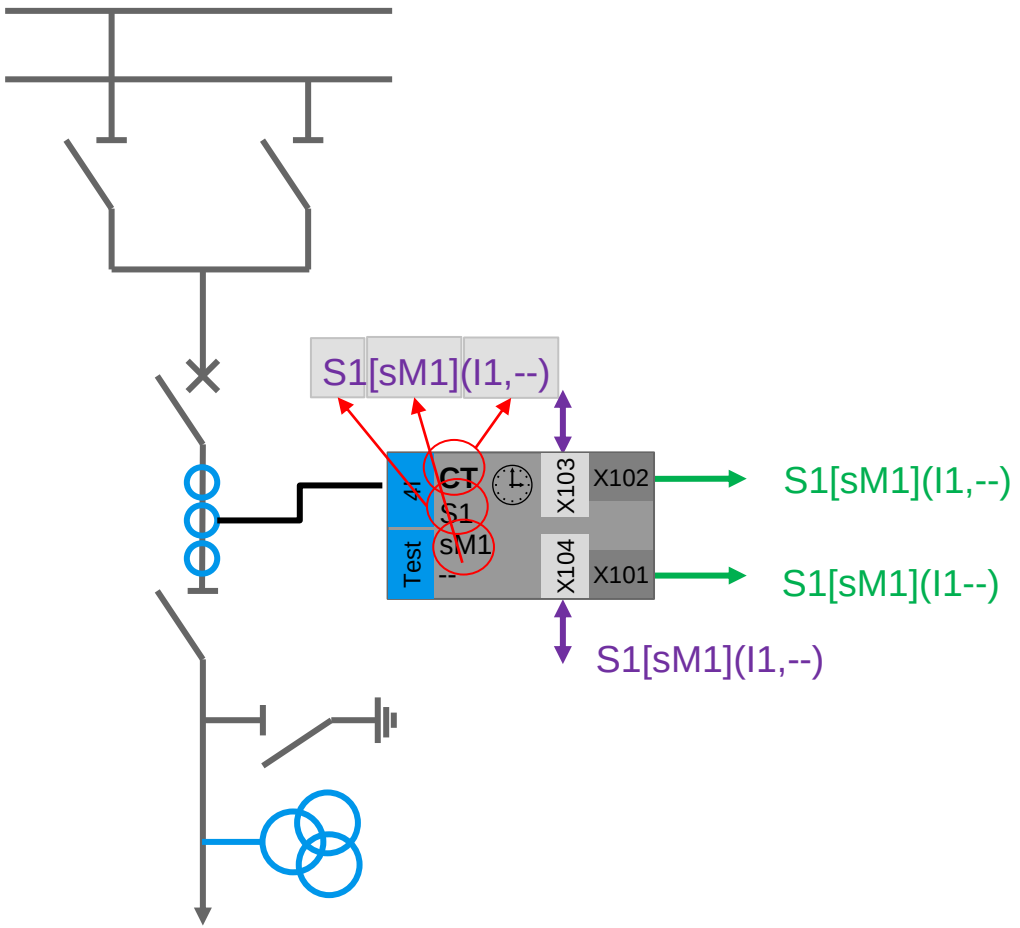
- Each RJ45/SFP is a port pair
  - Those pairs can be switched in their behavior
- Default settings
  - ~~System bus = RJ45~~
  - ~~Uplink ports = SFP~~
- SAM600 modules in same physical compartment
  - Use the system bus over RJ45 in order to chain SAM600 modules
- SAM600 modules located in physically different compartments
  - Use port switch on two modules in order to run system bus over SFP

SAM600 system bus and SAM600 uplink ports
Definition



- SAM600 system bus
  - Synchronize several SAM600 modules via IEEE 1588
  - Each SAM600 puts its local stream on the system bus
  - Tx and Rx
- Uplink ports
  - Only 9-2LE streams are sent on these ports, Tx only
  - Each uplink can connect to an IED or a switch

Understanding the nomenclature

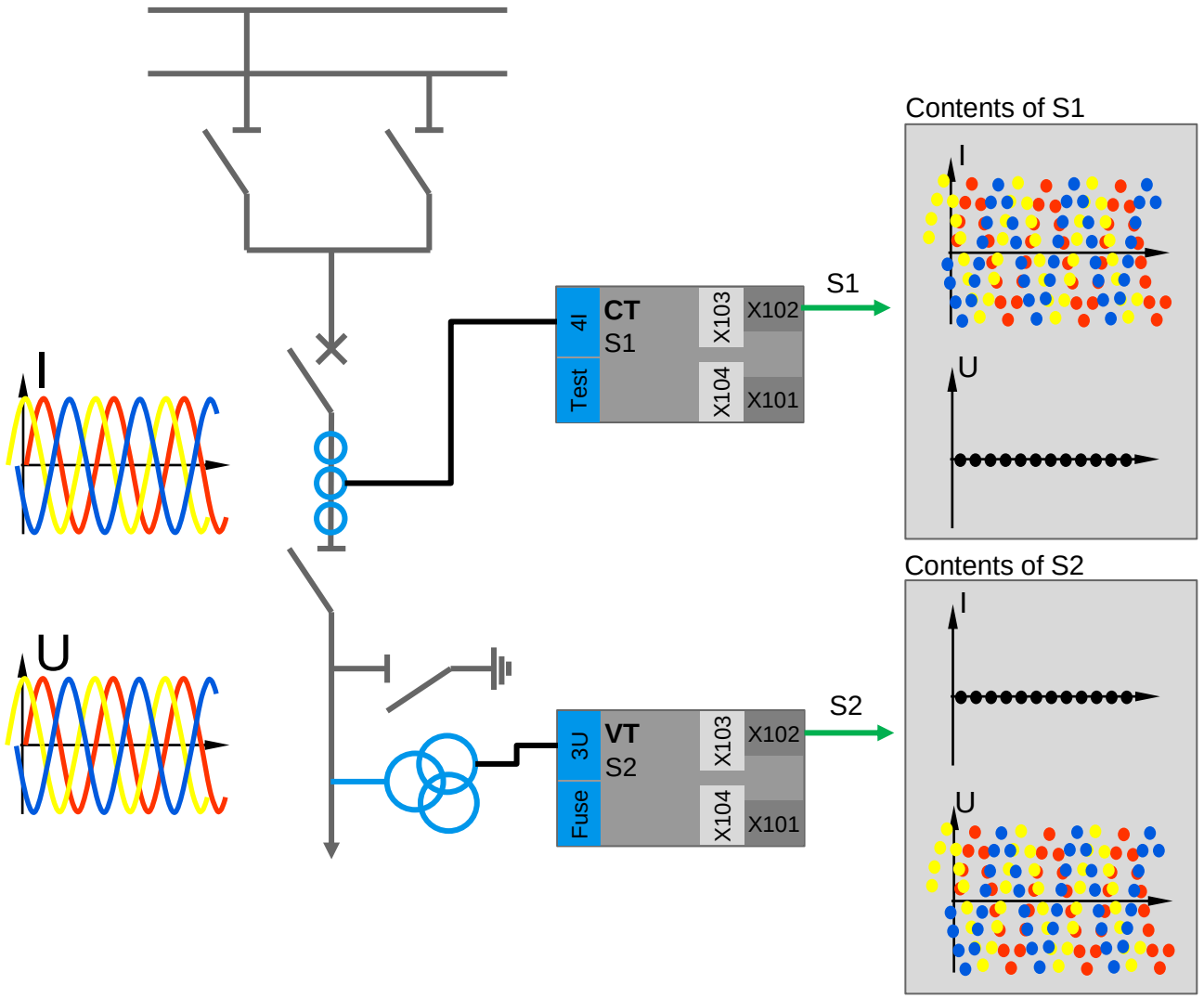


S1	-- svID
[sM1]	– sourceMAC
(I1,--)	– content of 9-2LE dataset Currents I1, no voltages

SAM600 system bus. Tx/Rx

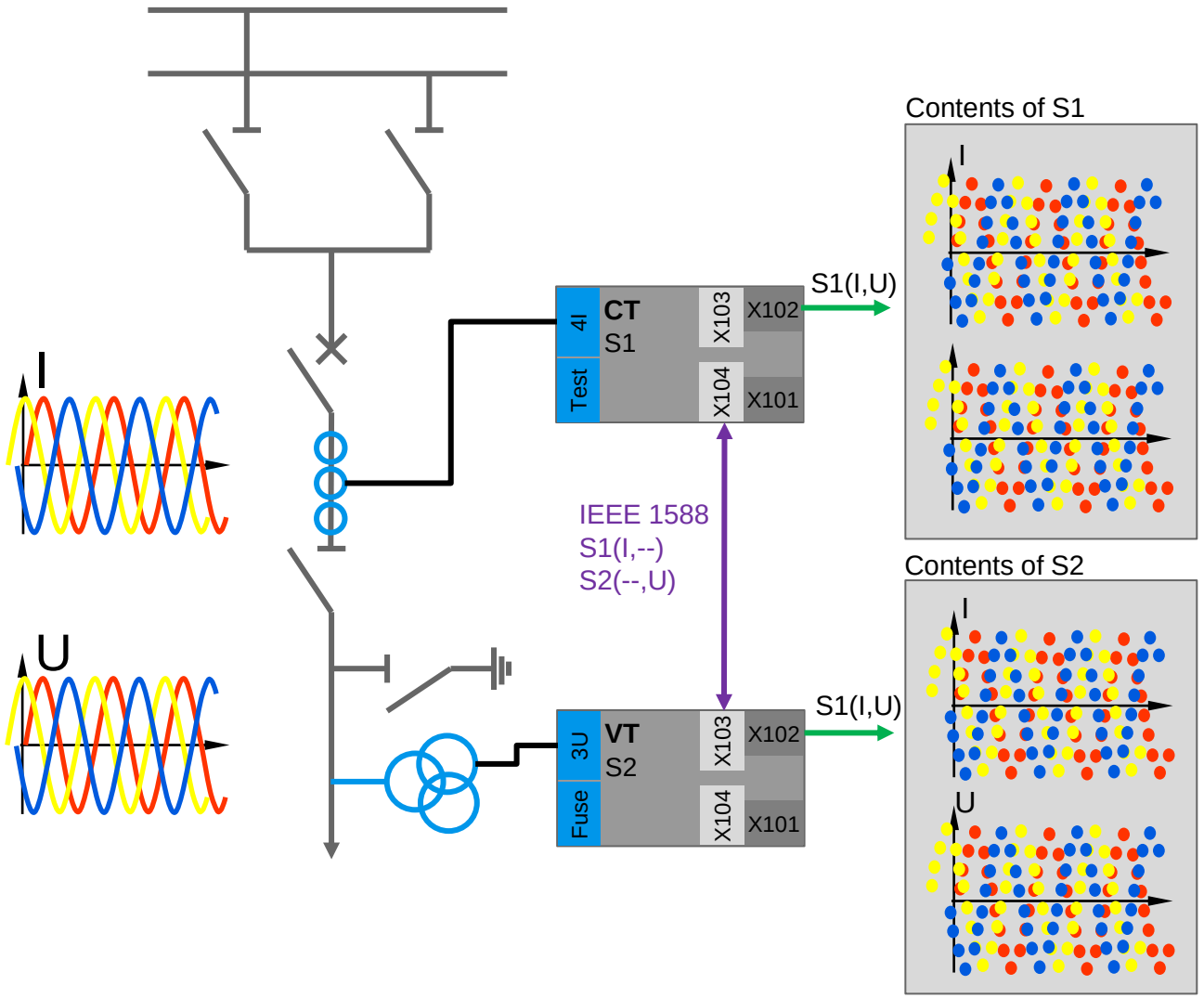
SAM600 uplink port. Tx

SAM600 converts analog input to IEC 61850-9-2LE



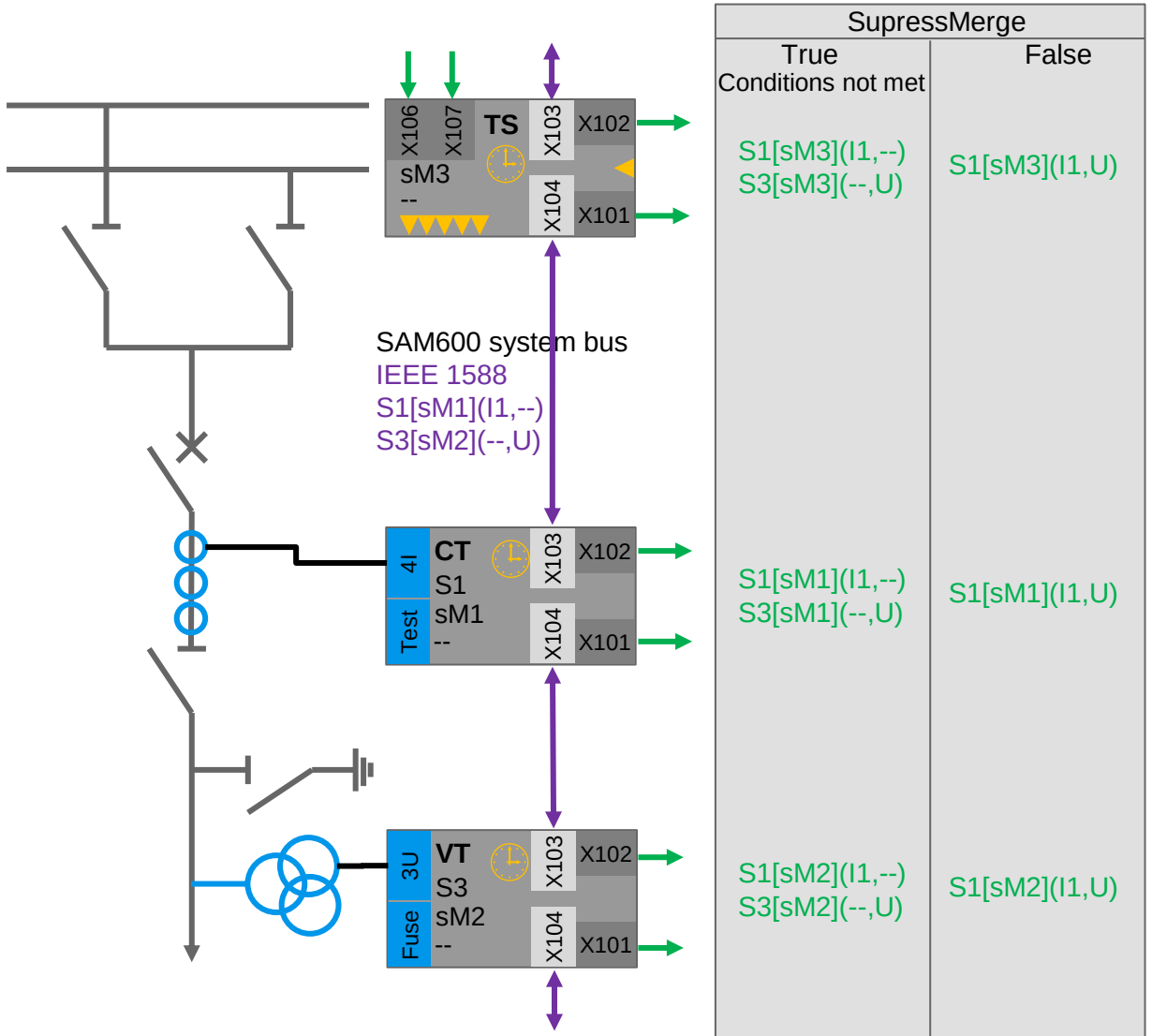
- Each SAM600 module is a self-contained standalone merging unit
- Analog → digital conversion
  - SAM600-CT: currents
  - SAM600-VT: voltages

SAM600 merges IEC 61850-9-2LE streams



- If chained to a SAM600 system, SAM600 modules merge „opposite“ 9-2LE streams on the uplink ports
  - Certain conditions apply
- Usage
  - Directly connect IED devices on uplink ports, not using switches
  - Reduce # of streams send to the IED

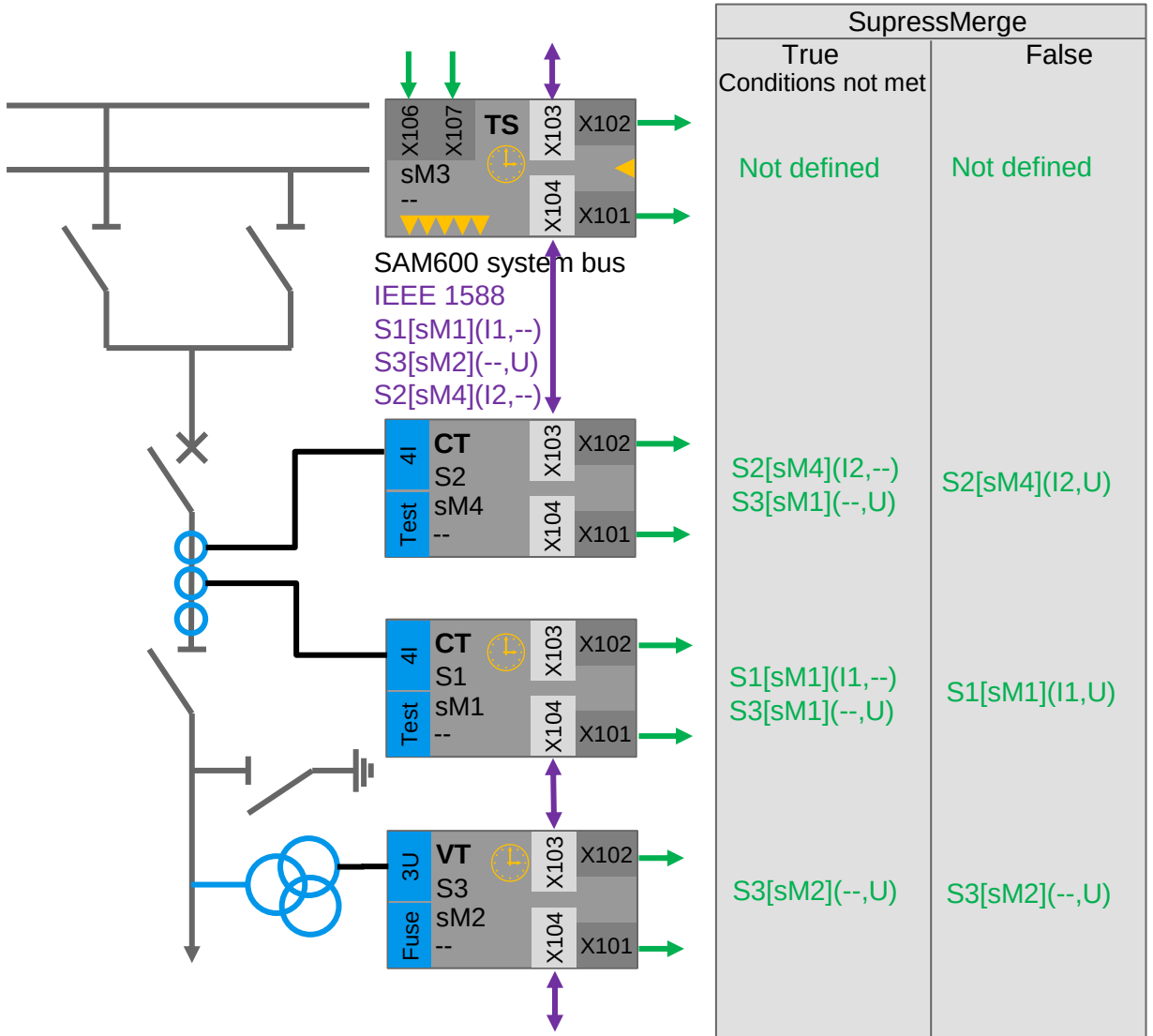
SAM600 merges IEC 61850-9-2LE streams
Standard behavior



SupressMerge	
True Conditions not met	False
S1[sM3](I1,--) S3[sM3](--,U)	S1[sM3](I1,U)
S1[sM1](I1,--) S3[sM1](--,U)	S1[sM1](I1,U)
S1[sM2](I1,--) S3[sM2](--,U)	S1[sM2](I1,U)

- Each SAM600 module „merges“ opposite measurements and provides them on its uplink ports
- Rules
  - Samples must be in sync
  - Only „opposite“ measurements can be merged into a 9-2LE stream
  - svID from CT is used
  - sMAC from the module from where the stream „leaves“ is used
  - Merging can be suppressed per module
  - IEEE 1588 is not available on uplink ports
- Merging is suspended or resumed based on rules
- smpSync is set according to „RequirePPS“ parameter

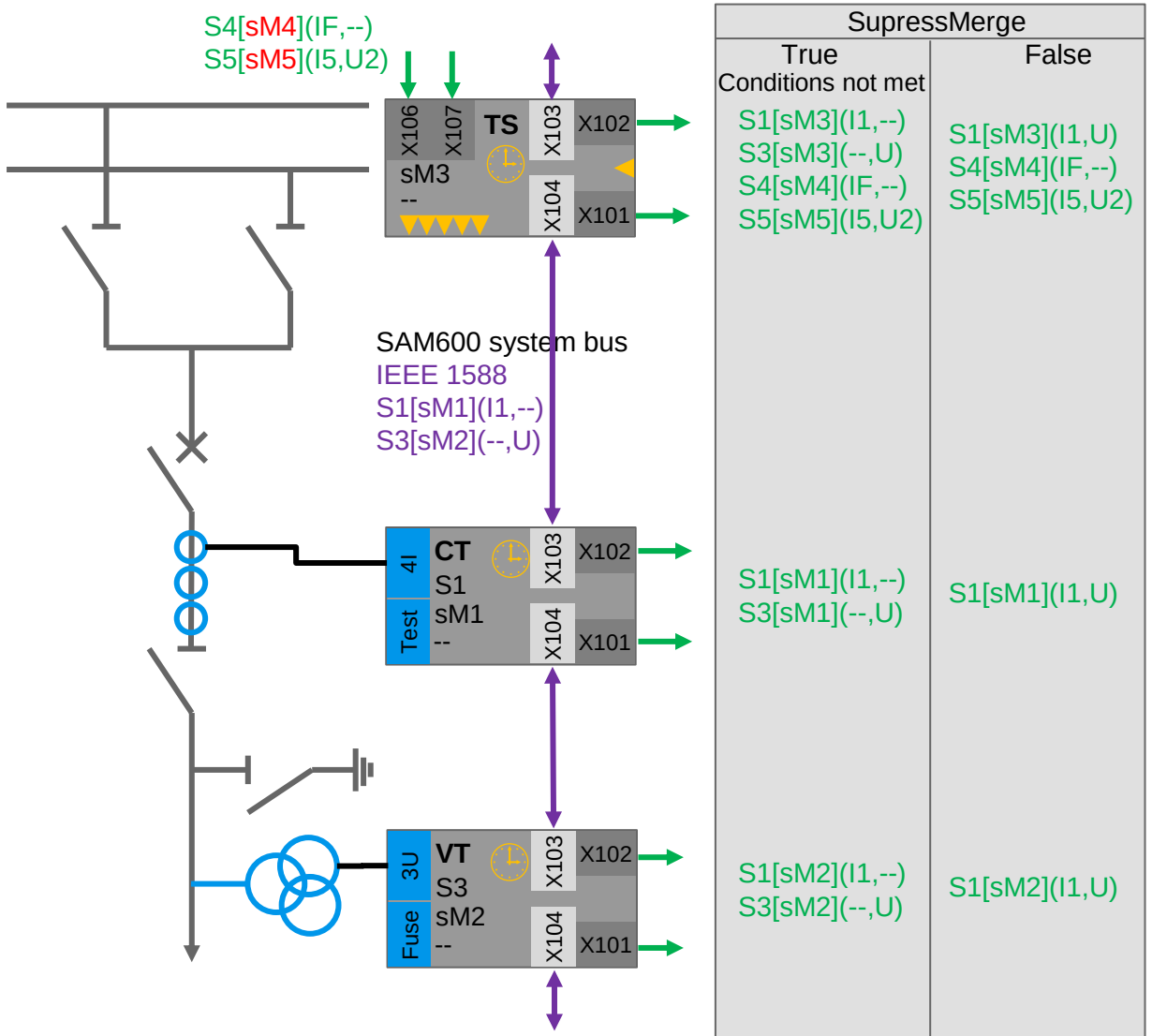
SAM600 merges IEC 61850-9-2LE traffic
More than one SAM600-CT module



SupressMerge	
True Conditions not met	False
Not defined	Not defined
S2[sM4](I2,--) S3[sM1](--,U)	S2[sM4](I2,U)
S1[sM1](I1,--) S3[sM1](--,U)	S1[sM1](I1,U)
S3[sM2](--,U)	S3[sM2](--,U)

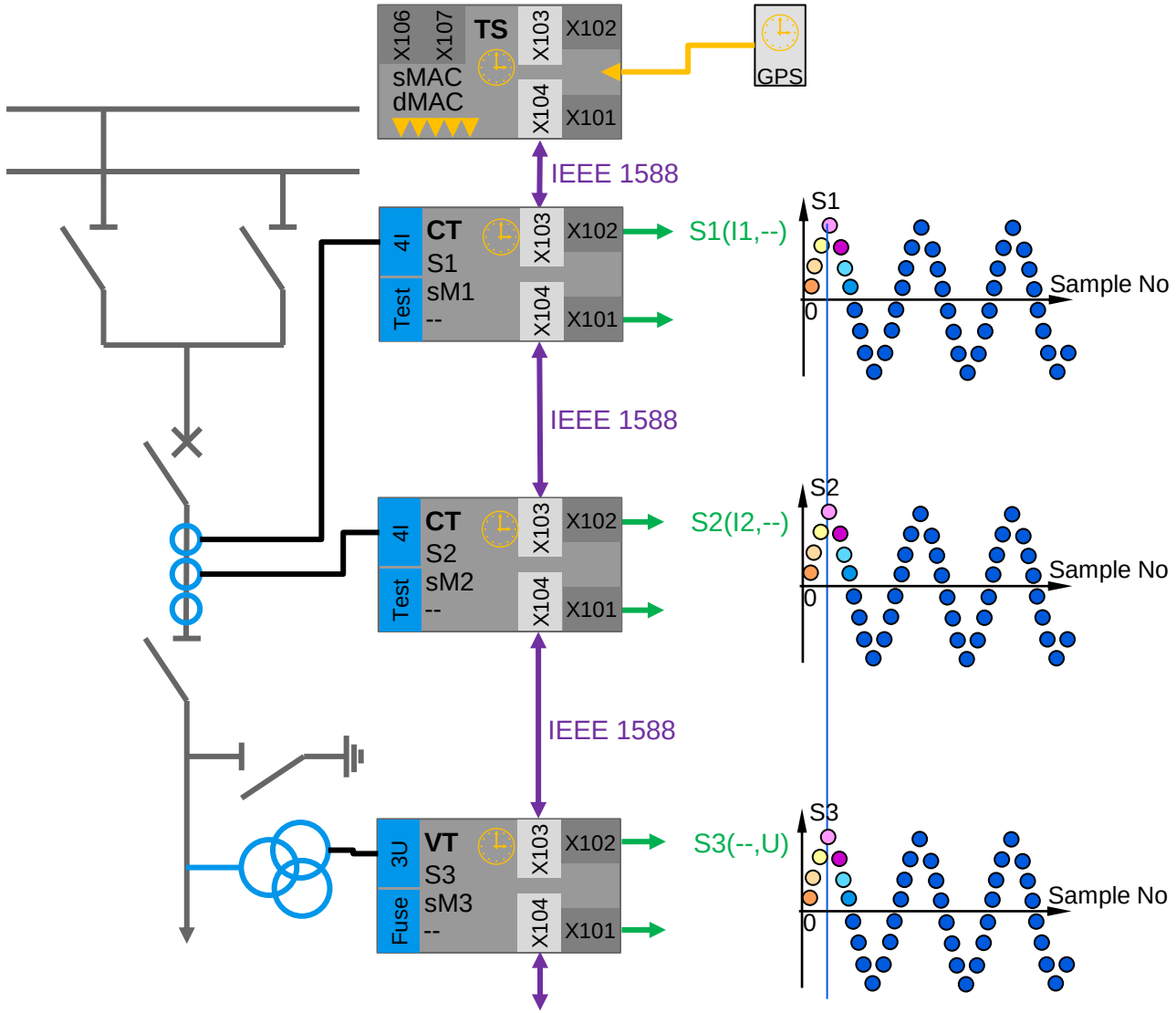
- Possible to chain multiple SAM600-CT modules
  - N SAM600-CT
  - 1 SAM600-VT
  - 1 SAM600-TS
- Each SAM600-CT provides its measurements together with voltage measurements
- SAM600-VT sends just its own measurements on the uplink
- Output on SAM600-TS is undefined
- <u>Alternatives</u>
  - Connect system bus to IED
  - smpSync is always true, irrespective of RequirePPS setting

SAM600 merges IEC 61850-9-2LE streams
Bridging in external 9-2LE traffic from sensors



- SAM600-TS has two additional bridging ports
  - X106, X107
  - 9-2LE traffic received on those ports is forwarded to the ports X101 and X102 of SAM600-TS
  - Traffic received on those ports is not shared on the SAM600 system bus
  - Traffic contents are not modified
  - Traffic contents are not merged
- Usage
  - Integration of a FOCS sensor
  - FOCS sensor must be synced with PPS to SAM600

Using SAM600-TS for synchronizing SAM600 system



- Synchronization is achieved via the SAM600-TS module
  - Translates between PPS and IEEE 1588
  - Chained SAM600 modules synchronize via the system bus through IEEE 1588
- All sampling across all modules is synchronized
  - Jitter <50ns
  - smpCnt = 0 on the receiver appears for all streams within the jitter window
  - → Protection ok
- Setting „RequirePPS“
  - If GPS connected → smpSync = true
  - If no GPS → smpSync = false

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