Impact of IEC 61850-9-2 process bus

System design and experiences with
IEC 61850-9-2 and NCITs

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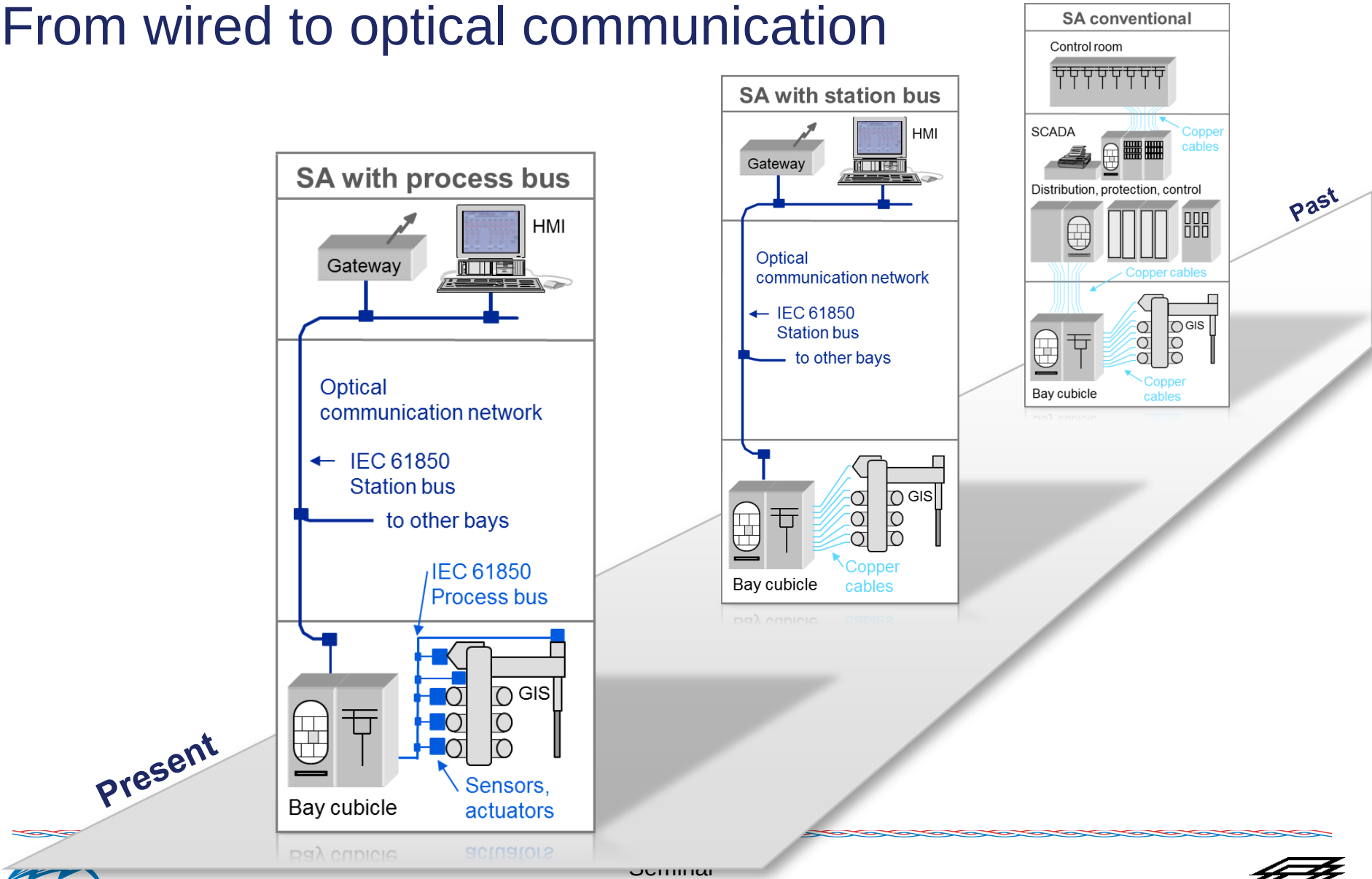
Contents

- Introduction to process bus
- Process bus system design
- Maintainability
- Service experience
- Conclusion

Evolution of substation automation

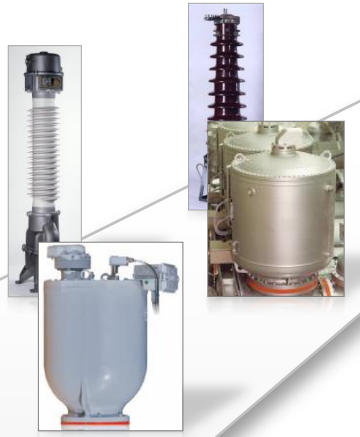
From wired to optical communication



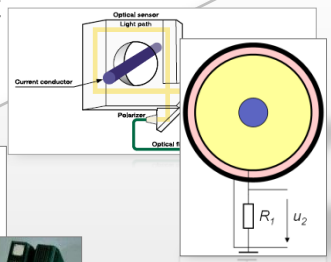
Evolution substation automation

From conventional CTs and VTs to NCITs*

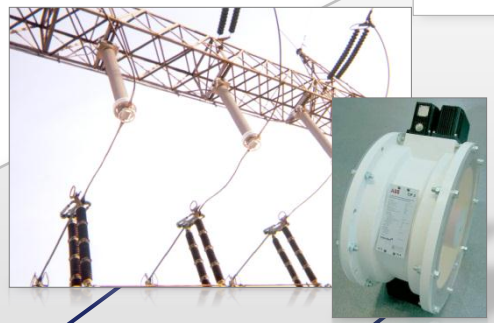
Evolution of conventional VTs and CTs



Sensors for current and voltage



New applications like combined current and voltage NCITs for metering and protection



Standardized integration of protection, control and metering with **IEC 61850**

Present

Advantages over conventional technology

Non-conventional instrument transformers

Increased operational safety

- Total absence of oil, NCITs can not explode
- No CT circuits that can induce hazardous voltages

Lower environmental impact

- No oil and reduced volume of SF_6
- Lower power consumption

Reduced life-cycle costs

- Permanent and comprehensive system supervision supports efficient maintenance
- Software-configurable nominal values

High accuracy for protection and metering

- A single device for protection and metering applications

Simplified project execution

- No CT calculations
- Simplified switchgear design because of standardized device dimensions

Advantages over conventional technology

Process bus

Increased operational safety

- Handling of CT and VT circuits is obsolete
- Isolation from process

Reduced life cycle costs

- Computer based tools enable simple measurement, eg, without the need to short circuit and disconnect CT terminals

Reduced copper cabling

- By replacing parallel copper wires with optical process bus

Simpler system design

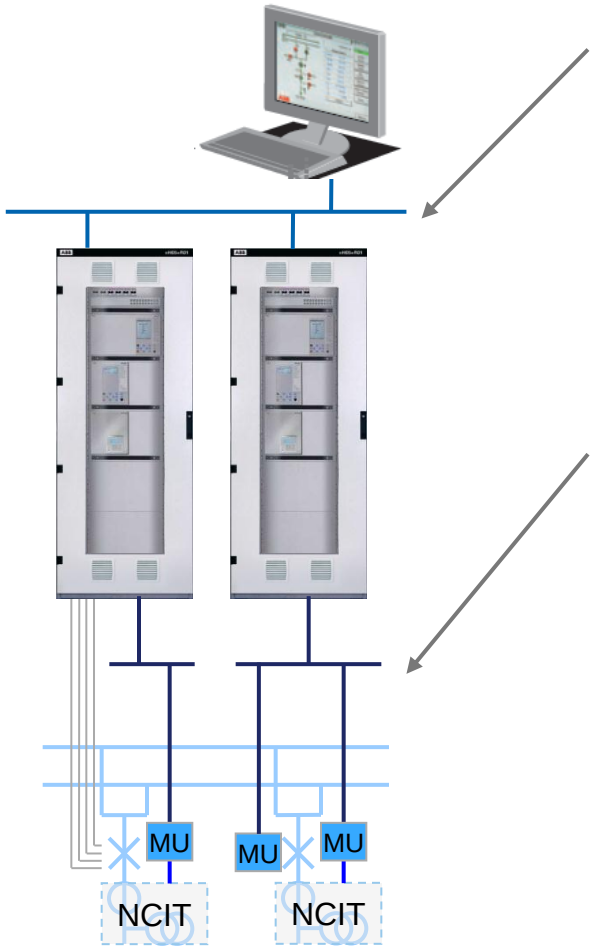
- Signal distribution is virtually independent of cable length
- CT burden is independent from connected devices

Future-proof interoperable design

- By applying the established IEC 61850 standard

Overview

Station and process bus



- The station bus connects IEDs and substation automation system
- It transmits information between the station level and the bay level as well as between IEDs (GOOSE)

- The process bus connects the process to the bay level
- Binary data as GOOSE messages between merging units and IEDs
- Sampled analog values are transferred via Ethernet according IEC 61850-9-2

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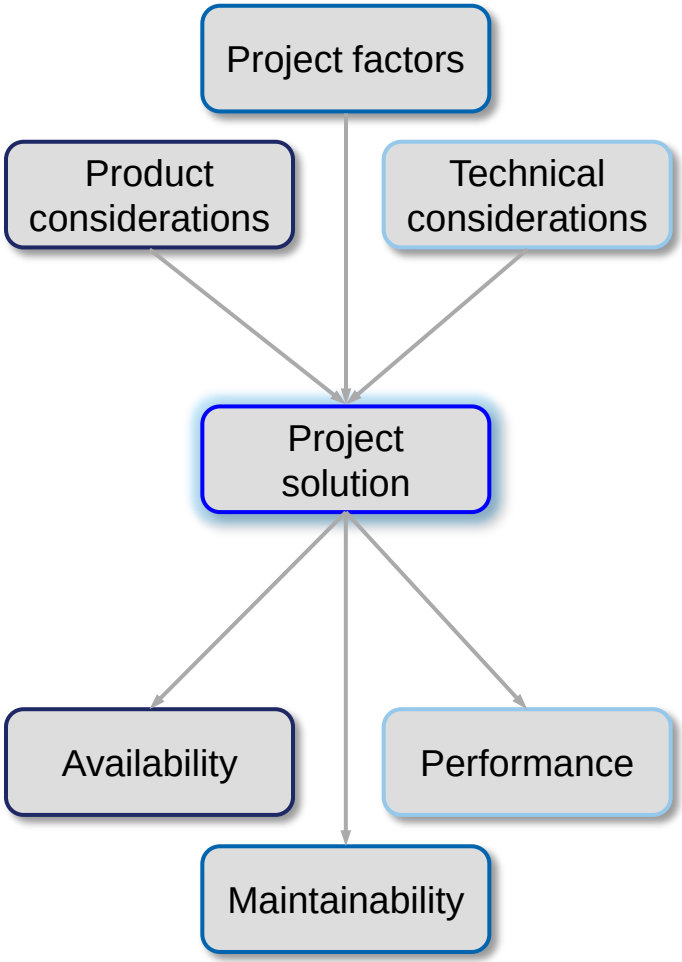
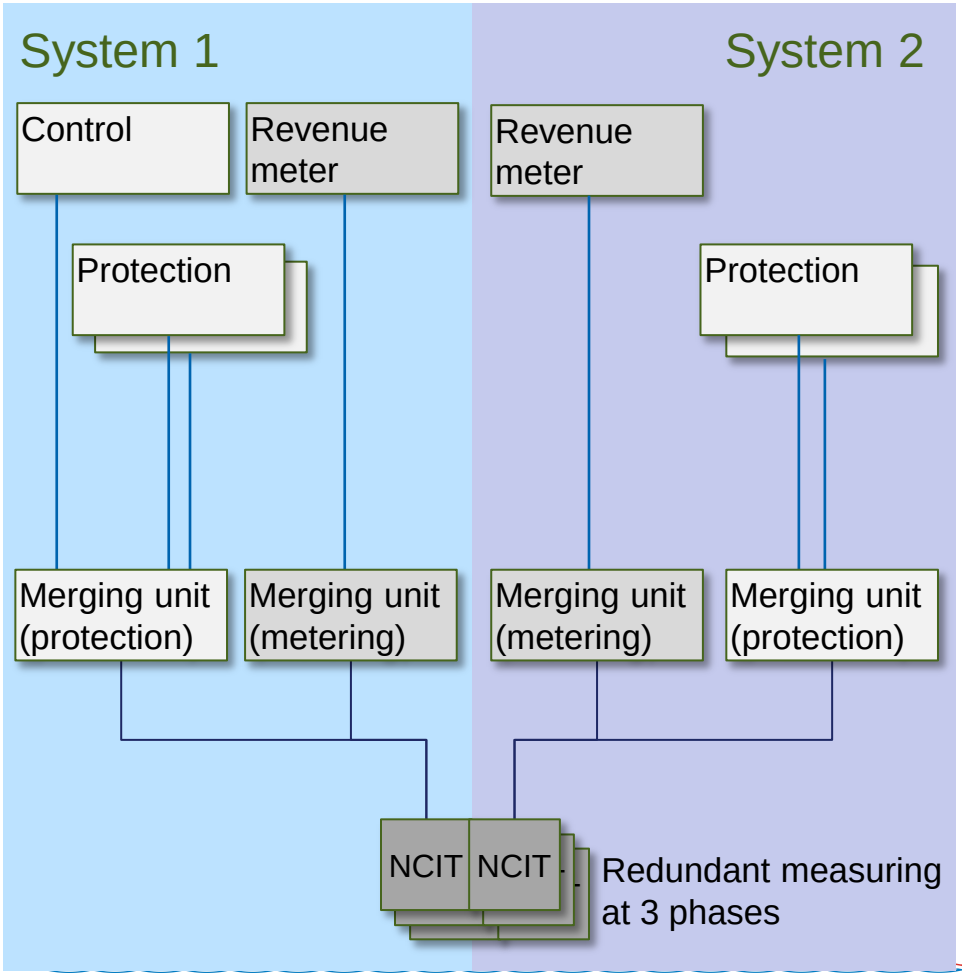
Process bus system design
Basic considerations



- Technical considerations
  - Ethernet load limitations
  - Time synchronization
  - Availability, dependability
- Product considerations
  - Number of ports of IEDs and merging units
  - Supported standards and services
  - Supported functions
- Factors given by the project
  - Station layout and type
  - Function and device allocation

Process bus system design

Independent, redundant protection systems



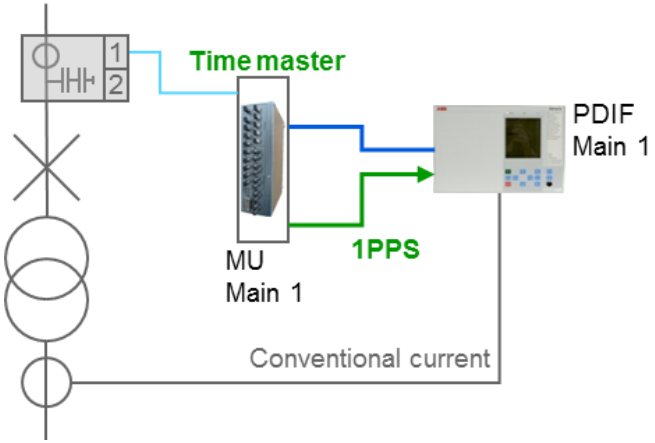
- Follow the traditional philosophy to separate first and second main protections
- Independent process bus systems from primary sensor to merging units and IEDs

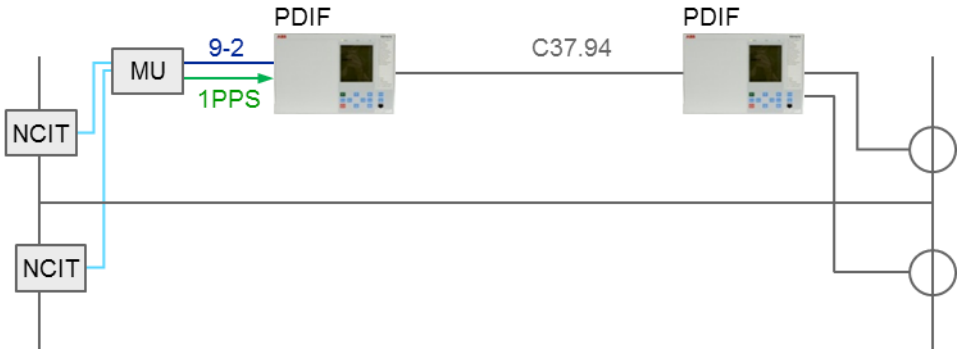
➢This increases system availability and simplifies maintenance of individual system components

Process bus system design

Minimal dependencies, avoid common time source

Merging units acting individually as time master



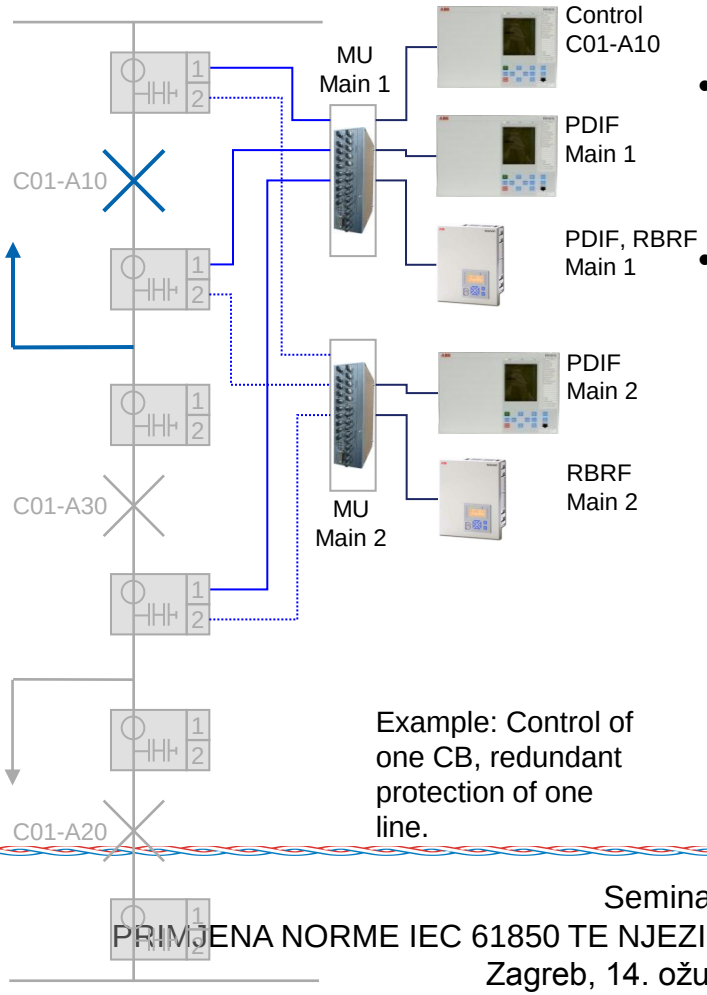


- Dependencies shall be minimized wherever possible, to maximize system availability
- Protection related synchronization system independent of GPS where possible
- Synchronization of analog sampling
  - IEC 61850-9-2LE defines 1PPS (1 pulse per second) for synchronization of sampling
  - The 1PPS does not need to be synchronous to the station clock

Process bus system design

Reduced number of components Ethernet switches

MUs interfacing to multiple measuring points



Example: Control of one CB, redundant protection of one line.

- System availability can be increased by minimizing number of devices
- Eg, by designing process bus without Ethernet switches
- Whether this is possible depends on the switchgear arrangement and location of CTs and VTs

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Maintainability

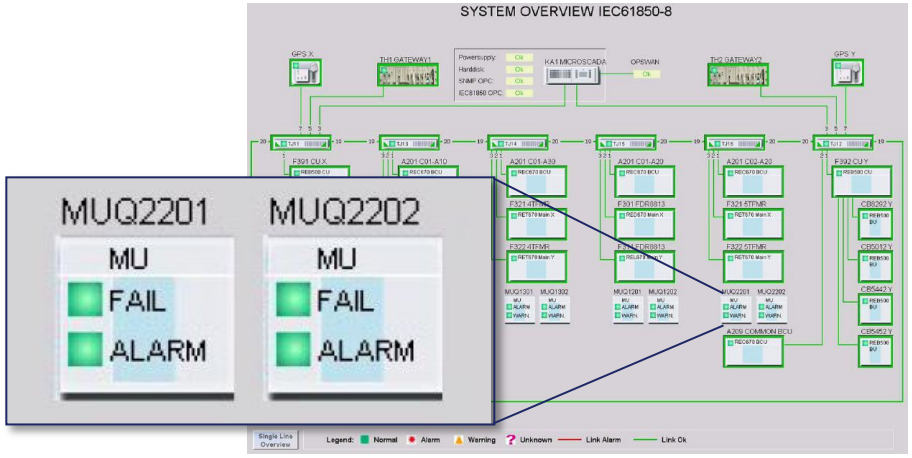
Workforce challenges

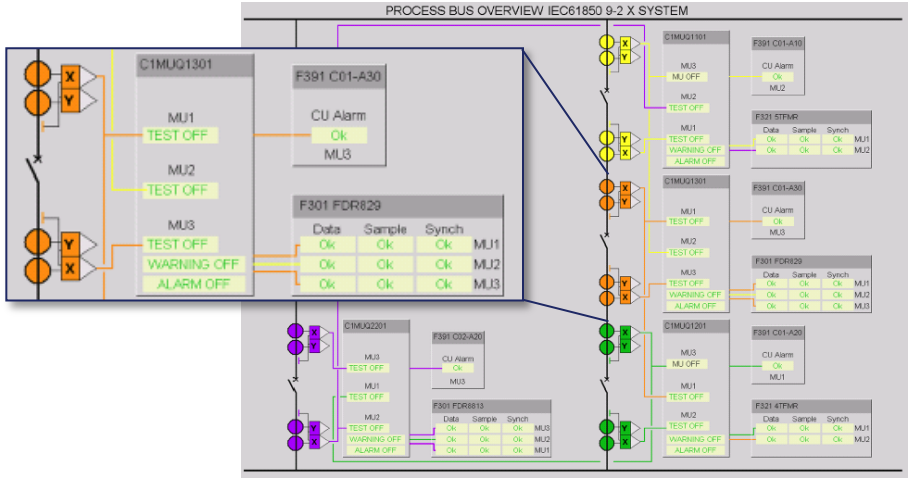
- IEC 61850 at a working level
- Cross skilling of workforce
- New design considerations
- Change to the test equipment and testing methods
- Fault finding techniques

- System design, functions and tools need to support efficient maintenance

Maintainability

Complete system supervision

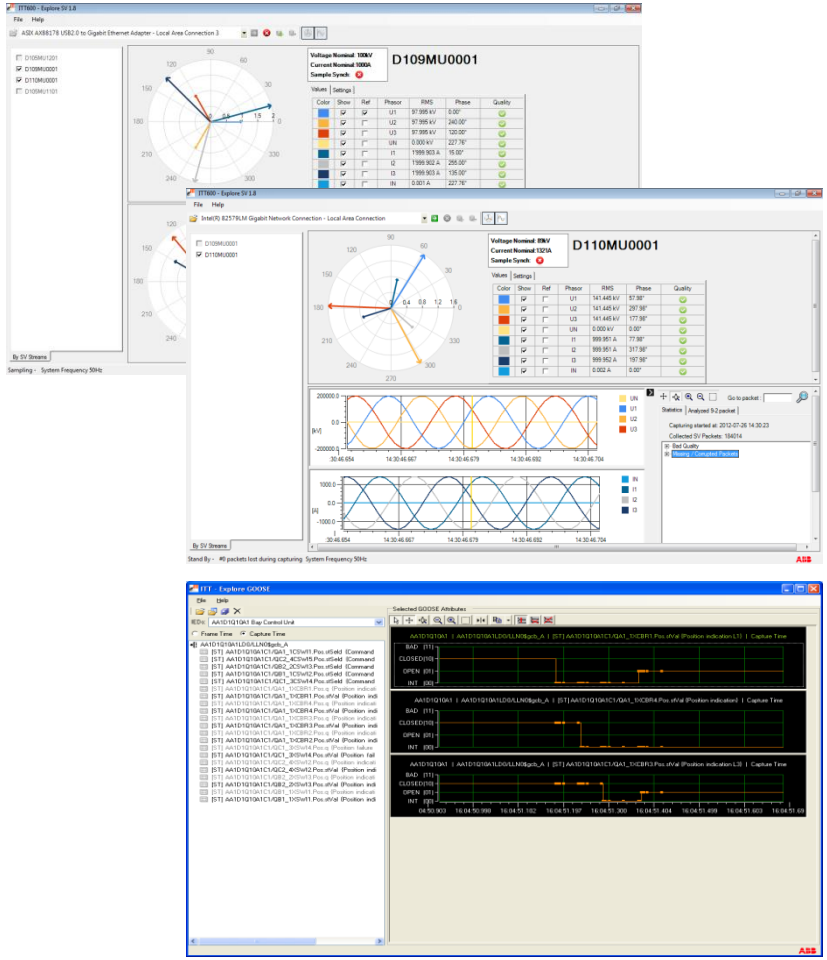




- Permanent system supervision of all intelligent electronic devices
- Supervision diagrams for fast overview of the substation health
  - System overview with all substation automation, protection and control equipment as well as merging units
  - Process bus overview with more detailed information about merging units and NCITs

Maintainability

Testing tools



Software replaces multimeter

- Intelligent software for the collection, display and evaluation of sampled-value streams
  - Oscilloscope display of U/I values
  - Phasor diagram
  - Quality information of all values
- IEC 61850 – same toolset can visualize GOOSE and events, as well as station integrity

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Service experience

ELK-CP NCITs for metal-clad switchgear

Nominal values:
100 … 4000A
ELK-CP14:
175 … 300 kV/√3
ELK-CP3:
330 … 550 kV/√3

- Fully redundant, combined current and voltage sensor with Rogowski coils for current and capacitive dividers for voltage
- Redundant secondary converter (sensor electronics) can be replaced during operation, no calibration necessary
- Configurable current ratings enable future adaptation of CT ratios without the need to replace CT cores or to open gas compartments
- Covers metering, protection and control accuracy in a single device

Service experience

CP-MU merging unit

IEC 61850 Certificate Level A[1]

KEMA

The product has not shown to be non-conforming to:

IEC 61850-6, 7-2 and 9-2

Communication networks and systems in substations

The world's first UCA-certified merging unit

- IEC 61850-9-2LE-compliant
- Interfaces with ELK-CP14/ ELK-CP3 sensors
- Merges the U and I values from the individual phases into a IEC 61850-9-2 stream
- Multiple Ethernet ports and connections to NCITs offer high flexibility to system design
  - Reducing the need for Ethernet switches in protection circuits

Service experience

670 series protection and control IEDs

- 670 series high-end protection and control IEDs with IEC 61850-9-2LE:
  - Bay control IED REC670
  - Line distance protection REL670
  - Line differential RED670
  - Transformer protection RET670
- All IEDs can have a 1PPS input for synchronized sampling
- All devices support mixed mode with conventional CT and VT interfaces eg, transformer low-voltage side for transformer differential protection
- Line differential protection runs with conventional and 9-2 remote-end substations

Service experience

REB500 busbar and breaker failure protection

- REB500 decentralized busbar protection system is fully compliant with IEC 61850-9-2LE
  - Busbar protection
  - Breaker failure protection
  - End-fault protection
- Seamless combination of bay units with IEC 61850-9-2LE and conventional bay units in one system
  - This allows flexible extension of conventional substations

Service experience

Process bus pilots with NCITs, protection and metering

- For customers and suppliers site trials are aimed to:
  - Assess performance and capabilities
  - Reflect the learning into future customer's policies
  - Build confidence in technology
  - Gain experience under real substation conditions

➢ Pilots are the base for complete process bus installations

Service experience

Overview

2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012

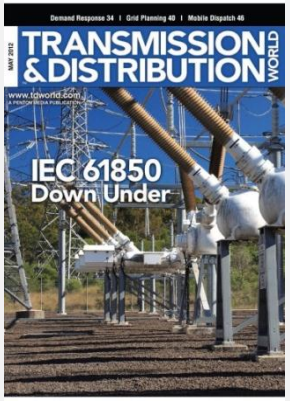
First commercial process bus installations (with proprietary communication)

First pilot installation with IEC 61850-9-1, NCITs and metering

First pilot installations with IEC 61850-9-2, NCITs and protection

Pilot installations with optical CT, integrated in life-tank breaker and IEC 61850-9-2

First commercial full NCIT and IEC 61850-9-2 process bus installation



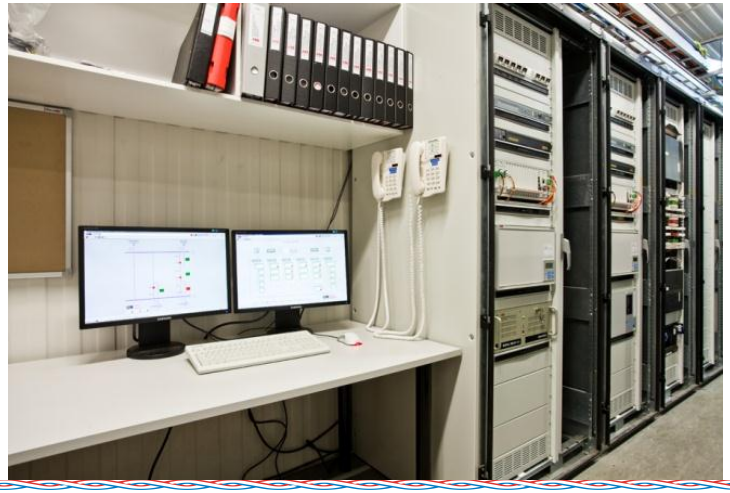
Service experience

Complete process bus and NCIT systems

- Between 1998 and 2001, ABB and Powerlink Queensland, AU commissioned substations equipped with NCITs and IEDs with proprietary process bus
- The systems, with over 300 NCITs, have been in continuous operation for more than 12 years
- Refurbish the substations to IEC 61850 compliant systems with process bus

Service experience

Complete process bus and NCIT systems

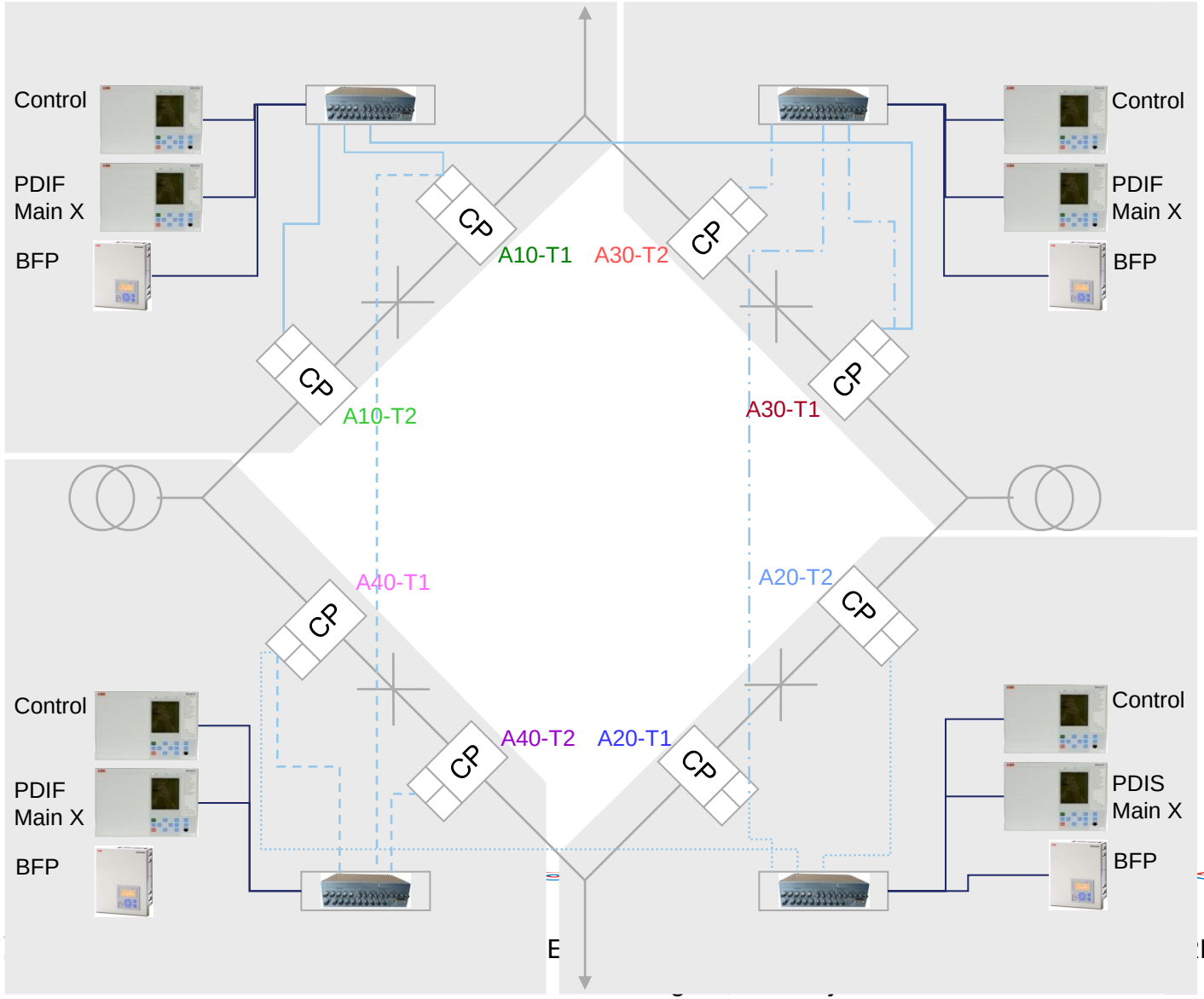


- Secondary system upgrade at Loganlea 275kV SS
- Upgrade to IEC 61850-9-2LE compliant system by keeping primary equipment
- Main functions:
  - Control
  - Line distance protection
  - Line differential protection
  - Transformer differential protection
  - Breaker failure protection

➢Commissioned December 2011

Service experience

Complete process bus and NCIT systems



The picture shows simplified one of two fully redundant protection systems

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Conclusion

- New solutions impact on design, testing, and commissioning activities - this requires a new set of competencies and skills at both utilities and suppliers
- Great care has to be taken to build reliable, maintainable and standard conform process bus systems
- With evolution of standards (eg, IEC 61869) and products more, also multi-vendor, installations can be expected

Thank you for your attention

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